Improving Energy Efficiency in Belo Horizonte Brazil

TRACE City Energy Efficiency Assessment Report


Municipal Buildings


Water and Wastewater


Solid Waste Management


Public Transport


Public Lighting


Power and Heat

THE WORLD BANK

ESMAP
Energy Sector Management Assistance Program

TRACE
Tool for Rapid Assessment of City Energy

PREFEITURA BELO HORIZONTE

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Currency Equivalents: US$1.00 = R$1.80

Acknowledgements

Improving Energy Efficiency in Belo Horizonte is a product of a partnership between the Municipality of Belo Horizonte, and the World Bank's Energy Sector Management Assistance Program (ESMAP), Latin America and the Caribbean Environment Department, and Latin America and the Caribbean Disaster Risk Management and Urban Department. The publication has been produced thanks to the contribution of The Government of Spain, through the Spanish Fund for Latin America and the Caribbean.

The World Bank would like to thank the Mayor of Belo Horizonte, Marcio Araújo de Lacerda, for his support. The Belo Horizonte Department of the Environment coordinated this analytical work on behalf of the City and the World Bank thanks Secretary of the Environment Department - Vasco de Oliveira Araujo, Executive Secretary of the Municipal Committee on Climate Change and Eco-efficiency - Anna Maria Louzada Drummond, and Planning and Environmental Monitoring Manager - Weber Coutinho, for their effort in making this work possible. In addition, the World Bank would like to thank the following for providing data, facility tours and assistance with prioritizing the final set of recommendations: SLU Superintendent of Urban Cleaning - Wadson Vieira Dias; COPASA Superintendent of Environment and Water - Tales Heliodoro Viana; CEMIG Business Manager - Ezequiel Teodoro Elorde, BHTRANS Sustainability Coordinator - Marcelo Cintra do Amaral; and SUDECAP Maintenance Director - Augusto Cesar Pirassinunga.

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Abbreviations and Acronyms

ACR - *Ambiente de Contratação Regulada* –Regulated Contract Market
ANA - *Agência Nacional de Águas* - National Water Authority
ANEEL - *Agência Nacional de Energia Elétrica* -National Electric Energy Agency
ARSAE – MG - *Agência Reguladora de Serviços de Abastecimento de Água e de Esgotamento Sanitário do Estado de Minas Gerais* - Sanitation and Water Supply Service Regulating Authority of Minas Gerais
BEN - *Balanço Energético Nacional* - National Energy Balance
BHTRANS - *Empresa de Transportes de Trânsito de Belo Horizonte* -Transport and Transit Company of Belo Horizonte
BNDES - *Banco Nacional de Desenvolvimento Econômico e Social* - National Bank of Socio and Economic Development
CBTU - *Companhia Brasileira de Trens Urbanos*- Brazilian Company of Urban Trains
CCEE – *Câmara de Comercialização de Energia Elétrica* - Electric Energy Commercialization Chamber
CEMIG – *Companhia Energética de Minas Gerais* – Minas Gerais Energy Company
CICE – *Comissão Interna de Conservação de Energia* - Internal Commission for Energy Conservation
CONPET – *Programa Nacional da Racionalização do uso dos Derivados de Petróleo e do Gás Natural* - National Program for the Rational Use of Oil and Natural Gas
COPASA - *Companhia de Saneamento de Minas Gerais* - Sanitary Company of Minas Gerais
DETRAN-MG - *Departamento de Trânsito de Minas Gerais* -Traffic Department of Minas Gerais
EE-Energy Efficiency
EECI – Energy Efficient Cities Initiative
ESCO – Energy Services Company
ESMAP –Energy Sector Management Assistance Program
ETE - *Estação de Tratamento de Esgoto* - Wastewater Treatment Plant
FTU - *Fundo de Transporte Urbano* - Urban Transport Fund
GDP – Gross Domestic Product
GW – Giga Watts
IBGE - *Instituto Brasileiro de Geografia e Estatística* – Brazilian Institute of Geography and Statistics
IGAM - *Instituto Mineiro de Gestão da Águas*- Institute of Water Management of Minas Gerais
INMETRO - *Instituto Nacional de Metrologia, Qualidade e Tecnologia* - National Institute of Metrology, Quality and Technology
IPEA - *Instituto de Pesquisa Econômica Aplicada* – Research Institute of Applied Economics
IPTU - *Imposto Predial e Territorial Urbano* - Urban Land Tax
kWh – Kilo Watt Hour
MW – Mega Watts
MWh – Mega Watt Hours
ONS – *Operador Nacional do Sistema Elétrico* - National Eletrical System Operator
PAC - *Programa de Aceleração do Crescimento* - Growth Acceleration Program
PBE – *Programa Brasileiro de Etiquetagem* - Brazilian Appliance Labeling Program .
PEE - *Programa de Eficiência Energétia*- Energy Efficiency Program
PNE - *Plano Nacional de Energia* - National Energy Plan 2030
PNEf - *Plano Nacional de Eficiência Energética* - National Energy Efficiency Plan
PROCEL - *Programa Nacional de Conservação de Energia Elétrica* - National Electricity Conservation Program
RBM – *BH Metas e Resultados* - Results Based Management
RELUZ - *Programa Nacional de Iluminação Pública e Sinalização Semafórica Eficiente*- National Program forEfficient Public Lighting and Traffic Light Signal
SEDRU - *Secretaria de Desenvolvimento Regional e Políticas Urbanas* - State Department of Regional Development and Urban Policy
SETOP –*Secretaria de Estado de Transportes e Obras Públicas* - State Department of Transportation and Construction
SIN - *Sistema Interligado Nacional* - National Interconnected System
SLU - *Superintendência de Limpeza Urbana* - Urban Cleaning Superintendence
SUDECAP - *Superintendência de Desenvolvimento da Capital* - Superintendence for the Development of the Capital
SUPRAM - *Superintendência Regional de Regularização Ambiental* -Regional Superintendence of Environment and Sustainable Development
TRACE - Tool for Rapid Assessment of City Energy
UGEM - *Unidade de Gestão Energética Municipal* - The Municipal Energy Management Unit

World Bank

The World Bank Group is an international organization that provides financial and technical assistance to developing countries. It includes the International Bank for Reconstruction and Development (IBRD), which aims to reduce poverty in middle-income and creditworthy poorer countries by promoting sustainable development through loans, guarantees, risk management products, and analytical and advisory services. Established in 1944 as the original institution of the World Bank Group, IBRD is structured like a cooperative that is owned and operated for the benefit of its 188 member countries. The WBG also includes the International Development Association (IDA), which provides interest-free loans—called credits— and grants to governments of the poorest countries and the International Finance Corporation (IFC), which provides loans, equity and technical assistance to stimulate private sector investment in developing countries. A fourth body is the Multilateral Investment Guarantee Agency (MIGA), which provides guarantees against losses caused by non-commercial risks to investors in developing countries. The Bank Group also includes the International Centre for the Settlement of Investment Disputes (ICSID), which provides international facilities for conciliation and arbitration of investment disputes.

Energy Sector Management Assistance Program (ESMAP)

The Energy Sector Management Assistance Program (ESMAP) is a global knowledge and technical assistance program administered by the World Bank. It provides analytical and advisory services to low- and middle-income countries to increase their know-how and institutional capacity to achieve environmentally sustainable energy solutions for poverty reduction and economic growth. ESMAP is funded by Australia, Austria, Denmark, Finland, France, Germany, Iceland, Lithuania, the Netherlands, Norway, Sweden, and the United Kingdom, as well as the World Bank.

Tool for Rapid Assessment of City Energy (TRACE)

TRACE is a decision-support tool designed to help cities quickly identify energy efficiency (EE) opportunities. The tool was developed by the Energy Sector Management Assistance Program (ESMAP). It includes an energy benchmarking module that compares a city with peer cities, a sector prioritization module that ranks the sectors with the greatest energy efficiency potential, and a recommendations module which provides specific energy efficiency interventions. It has been used (or is being used) in cities in 20 countries in Europe, Asia, Latin America and Africa.

Executive Summary

Belo Horizonte is one of the largest cities in Brazil. Its economy has been growing rapidly over the last decade, and preparations for hosting the 2014 FIFA World Cup have resulted in several infrastructure projects. As the economy has grown, so has the demand for energy; and Belo Horizonte has demonstrated a commitment to sustainable development in meeting its needs. As part of this commitment, Belo Horizonte partnered with the World Bank to identify underperforming sectors, evaluate improvement and cost-saving potential, and prioritize sectors and actions for energy efficiency intervention using the Tool for Rapid Assessment of City Energy (TRACE). TRACE is a strategic tool designed by ESMAP to help cities quickly identify energy efficiency opportunities. It covers six sectors: transportation, public lighting, buildings, power and heat, waste, and water and wastewater. In Belo Horizonte, TRACE facilitated a discussion across service sectors, highlighted potential budget and energy savings, and provided expected results of key actions for the City. Belo Horizonte is the first city in Latin America to implement TRACE.

TRACE first benchmarked Belo Horizonte's energy use against 60 peer cities on 28 key performance indicators. This allowed city authorities to know where they were doing well compared to peer cities and where they could improve. After the benchmarking, TRACE prioritized sectors according to their potential to save energy and financial resources through energy efficiency. Sectors that are largely controlled by the municipality have the potential to realize up to US$10 million in annual savings. The municipal buildings sector has the most significant potential followed by street lighting and solid waste. In the remaining sectors, the city as a whole has the potential to realize up to US$250 million in annual savings through energy efficiency. Private transportation has the most potential; followed by the public transportation, power sector, potable water and solid waste sectors.

In consultation with leaders of each sector, TRACE generated a number of important energy efficiency recommendations, which Belo Horizonte could implement to realize its energy efficiency potential. Key recommendations for each sector are described below:

TRANSPORT – The City is investing nearly one billion dollars in urban mobility infrastructure. While the investments make sense individually, they are not well interconnected. Interconnecting the different plans and projects to facilitate better use of different transport modes and infrastructure would result in substantial financial and energy savings. For example, providing a park and ride infrastructure, and/or parking at the right places would allow people to use more public transportation which reduces energy costs. Fare integration with electronic tickets which allow users to use different modes within a time frame, would also save energy and money. Traffic congestion in the central business district needs immediate action; measures such as traffic flow optimization around Praça Raul Soares would greatly improve mobility and save time, energy and financial resources. The optimization would save over 200,000kWh/annum, and take between 1 to 2 years to implement.

BUILDINGS – The administration of municipal buildings is highly decentralized, resulting in limited strategic coordination and understanding of this sector. The voluntary Internal Commission for Energy Conservation (*Comissão Interna de Conservação de Energia* – CICE) program has resulted in a few organizations implementing energy efficiency measures, but a more authoritative organizational structure for energy efficiency is needed. Thus, establishing a centralized organizational unit with statutory authority and a mandate which *includes* energy efficiency, is critical in order to take advantage of the substantial energy and financial savings potential. Given the organizational structure of Belo Horizonte, this unit could be created as part of SUDECAP. The unit would have economies of scale and critical mass to provide energy efficient repair and maintenance services. Installing more efficient, sectional and/or motion-sensored lighting in buildings is critical as well given their absence in public buildings.

PUBLIC LIGHTING – There are several options for realizing energy efficiency opportunities in the public lighting sector that engaging an Energy Services Company (ESCO) will help the city to find the optimal solution. The ESCO would need to consider the desire for higher luminosity and safety while exploring consumption-based billing, selective public lights dimming, light emitting diodes and several other options for reducing unnecessary energy consumption in the sector. Done well, this would help the city save around

US$4 million per year. This effort would build upon the switch to more efficient sodium vapor lamps that the City recently completed.

WATER AND WASTEWATER – Belo Horizonte is geographically located away from local sources of water and on elevated ground. Therefore, water is expensive as it has to be pumped over long distances and over hills in order to reach consumers. Thirty-three percent of the water that gets to the city is lost through leakages or theft. Installing an active leak detection system would result in significant energy and financial savings. The City currently relies on citizens' willingness to report water leakage. While an active leakage detection system is expensive, it is typically implemented to the point where the marginal benefit of the system is equal to the marginal cost of the system. The payback period of such a system can be as low as 3 months but often longer depending on the local circumstances.

SOLID WASTE –The municipality spends a significant amount of resources collecting and transporting solid waste to landfills. As a result, it is necessary to optimize the route of garbage trucks as that would result in significant financial and energy savings. The first cost of such a program can be lower than US$100,00 while the energy savings can be more than 200,000 kWh/annum. Since 95 percent of the garbage trucks are operated by private operators under concession, potential improvements can be negotiated into the contracts which are renewed biannually. The resultant savings will build upon the Biogas Energy Use Center (at the landfill in the Jardim Filadélfia) in improving the financial position of the solid waste utility.

POWER AND HEAT – Belo Horizonte's power sector has low technical and commercial losses compared to cities in the TRACE database. The local utility has won several national and international awards for reducing technical and commercial losses, and implementing energy efficiency programs. Additionally, heating is not required in Belo Horizonte, hence this report does not have recommendations for the power and heat sector.

NEXT STEPS: ACTION PLAN - TRACE does not produce an energy efficiency action plan, hence the next step is to produce an action plan for the city. The first step in creating the action plan is to identify the organization or entity responsible for leading the creation of the plan. Based on international experience, successful plans are often created by organizations that have political support from the Mayor, represent key sectors identified in the report, have the prerequisite resources, and are likely to lead the implementation of the plan. There is often a need to maintain the energy efficiency momentum in the city; hence the city could implement some low hanging fruit initiatives - such as improving traffic flow around Praça Raul Soares - so that people can start seeing some of the results of energy efficiency initiatives.

There are several ways to develop action plans. Prioritizing the recommendations starting with low cost but high impact recommendations might be optimal. For instance, *creating a centralized unit with statutory authority and a mandate including implementing EE measures (B1*[1]*)* is initially a question of realigning the reporting structure in the municipality, and providing statutory authority and resources to the new organization. While implementing this recommendation, the City could be conducting analytical work such as the *Public Space Lighting Program Audit Program (PL2)*. These measures could be combined with recommendations which are politically visible because they can create momentum behind the EE programs. Table ES 1 lists recommendations which can be considered in this category as they can be done in less than a year.

Table ES 1: List of Interventions which can be Done in Less than a Year[2]

EE municipal task force **(B1b)**
EE strategy and action plan **(B2 – See Annex 1)**
Traffic flow optimization **(T1-See Annex 5)**
Purchasing and servicing contracts **(GEN2)**
Energy performance contracting **(GEN3)**
Awareness raising campaign **(GEN4)**
Educational measures **(PW4)**

[1] Note that the code (B1) refers to Buildings recommendation 1, and additional details are provided for each recommendation in the recommendation section of the report

[2] The code in bold (e.g. B1b) identifies the recommendations as it is described in more detailed in the recommendations section

Street lights audit program **(PL4)**
Public spaces lighting audit program **(PL2)**
Computer power-save project **(B8)**
Installing efficient lighting **(B6)**
Green building guidelines for new buildings **(B9)**

Medium term (implementation in 1 to 2 years) recommendations would result in significant savings as well, and their implementation is less challenging once resources have been identified. For instance, *Sectoral and motion-sensored lighting **(B7)*** in buildings results in significant energy savings and yet does not require extensive politically-charged stakeholder consultations inorder to begin the implementation process. The implementation could begin once the technical studies are done. Table ES 2 lists some of the recommendations which can be considered in this category.

Table ES 2: List of Interventions which can be done in One to Two Years

Improve performance of water system networks **(PW1)**
Municipal buildings EE task force **(B1a)**
Waste composting program **(SLW4)**
Sectoral and motion-sensored lighting **(B7)**
Waste collection vehicle fleet maintenance audit and retrofit program **(SLW2)**
Water-efficient pumps and fixtures **(PW3)**
Capital investment planning **(GEN1)**
Parking restraint measures **(T3-See Annex 7)**
Buildings benchmarking program **(B5)**
Fuel-efficient waste-vehicle operations **(SLW1 – See Annex 4)**

Long-term (begin implementation in more than 24 months) recommendations are slightly more expensive but result in significant improvement in EE. They require significant preparatory analytical studies before implementation can begin. For example, Belo Horizonte would need to hire an ESCO to conduct a *Public Spaces Lighting Audit Program* (PL2) before implementing the *Public Lighting Dimming Program* (PL1). In the water sector, active leak detection and pressure management program is quite expensive hence it would be good to analyze the point at which the marginal cost of installing the system is equal to the marginal benefit from the water no longer lost. Table ES 3 lists recommendations which can be considered in this category.

Table ES 3: List of Recommendations which can be done in Over 2 Years

Municipal offices audit and retrofit program **(B3 – See Annex 2)**
Active leak detection and pressure management program **(PW2-Annex 8)**
Public light dimming program **(PL1 – See Annex 3)**
Consumption-based billing in public lighting **(PL3)**
Waste infrastructure planning **(SLW3)**
Enforcement of vehicle emission standards **(T4)**
Municipal schools audit and retrofit program **(B4-See Annex 2)**
Non-motorized transportation modes **(T2-See Annex 6)**
Interconnecting Different Modes of Transportation, Plans and Projects **(T5)**
Mandatory building EE codes for new buildings **(B10)**

ESCO Alternative - In the case of resource constraints, Belo Horizonte might find it helpful to engage an Energy Services Company (ESCO). An ESCO typically invests in implementing energy efficiency measures, and gets paid from the energy savings. Given the report findings, an ESCO would be particularly suited for the public lighting and public buildings sectors. The ESCO could study different technologies such as LED lighting technologies and/or timed dimming alternatives which can help the city to reduce electricity consumption while maintaining the desired amount of lighting.

Background

Brazil is the largest country in Latin America with a population of 191 million people.[3] As one of the fast-growing developing countries, Brazil's economy recently became the sixth largest in the world, just behind France and ahead of the United Kingdom. Belo Horizonte is the capital of Minas Gerais State and the sixth largest city in Brazil, with a population of 2.4 million living in 331 km^2. It represents 1.24 percent of the national population and 1.3 percent of the economically active population of the country. The City currently contributes 15.5 percent of the Gross Domestic Product (GDP) of the State of Minas Gerais and is ninth among municipalities that contribute the most to the national GDP.

Belo Horizonte is located about 364km northwest of Rio de Janeiro (Figure 1). As one of the cities hosting the 2014 FIFA World Cup, Belo Horizonte has several infrastructure projects underway. These have contributed to its economy in a significant way.

Table 1: Belo Horizonte's Key Statistics

Population	*2,375,151 inhabitants*
GDP	*US$24Billion*
Climate	*Tropical*
Total Area	*331.4 km^2*
Density	*7,167.02 inhab/km^2*
Religion(s)	*Catholic, evangelical, spirit*
Main Industries & Services	*Commerce, financial services, public administration services*
HDI	*0.839*

Source: World Bank

Belo Horizonte has taken a number of steps to demonstrate its commitment to sustainability and efficient energy use. In 2009, it launched the 2030 Strategic Plan (*Planejamento Estratégico* 2030). The plan includes environmentally sustainable development and a 20 percent reduction in GHG emissions from the business as usual scenario by 2030 as key objectives. Its Results Based Management (*BH Metas e Resultados* - RBM) program has one of the twelve components focused on being a Sustainable City. Law no. 9415, which established incentives for building owners to use solar energy, liquefied petroleum gas (LPG) or natural gas for water heating, was passed in 2007. Proposed improvements to this law aim to raise the contribution of solar water heating to 51 percent of the total annual water heating energy demand. The improvement would require that the solar water heating equipment have National Institute of Metrology, Quality and Technology (*Instituto Nacional de Metrologia, Qualidade e Tecnologia* – INMETRO) certification.

Figure 1: Map of Belo Horizonte

Source: Belo Horizonte Municipality

The City invested funds from the National Program for Public Lighting and Traffic Light Signal (*Programa Nacional de Iluminação Pública e Sinalização Semafórica Eficiente* - RELUZ) to replace mercury vapor lamps with sodium vapor lamps. The investment is saving the city 4,442.64 MWh each year. Belo Horizonte Transportation and Transit Company (*Empresa de Transportes e Transito de Belo Horizonte* - BHTRANS) replaced 22,000

[3] Census 2010 - Brazilian Institute of Geography and Statistics *(Instituto Brasileira de Geografia e Estatística)*

traffic light incandescent lamps at 853 intersections in the city with more efficient LED (Light Emitting Diode) lamps. BHTRANS estimates that the City is saving US$1.2 million / per year from the investment. The Urban Cleaning Superintendence (*Superintendência de Limpeza Urbana* – SLU) generates up to 4.3 MW of electricity from its landfill in Jardim Filadélfia, and the Sanitary Company of Minas Gerais *(Companhia de Saneamento de Minas Gerais* - COPASA) generates 2.4 MW from its wastewater treatment facility at ETE Arrudas. Minas Gerais Energy Company *(Companhia Energética de Minas Gerais* – CEMIG*)*, the electric utility serving Belo Horizonte, invests an average of US$28 million in EE each year.

Belo Horizonte has several more initiatives aimed at improving sustainability: (a) Operation Oxygen - allows the city to monitor emissions from diesel-powered vehicles. Four mobile monitoring units carry out random emissions tests and vehicles exceeding state-issued limits are penalized; (b) Energy Conservation Program by the Municipal Public Administration – The Municipal Energy Management Unit (*Unidade de Gestão Energética Municipal,* UGEM) assesses all high-voltage units in the municipality and proposes energy conservation measures; (c) and the Banning of Plastic Bags. In 2008, Belo Horizonte became the first state capital in Brazil to ban the use of plastic bags.

Federal, State and Municipal Responsibilities in Energy Efficiency

The relationships between federal, state and municipal responsibilities in EE are fairly complex. In summary, the federal government passes laws and regulations and creates programs which have had a strong influence on the sector. The federal government also provides financial resources for energy efficiency projects. The state often acts as a conduit of resources from the national government, administers services such as urban metro rail transportation, and controls power and water utilities - CEMIG and COPASA respectively. The municipality legislates on matters of local interest to protect the environment; provides in-city public transportation infrastructure; provides waste collection and treatment services; and owns offices, schools and one hospital.

Most recently, Belo Horizonte has been developing the Municipal Greenhouse Emission Reduction Plan using findings from its GHG inventory, which was conducted in 2009 and updated in 2012. The City also created the Sustainable Buildings Certification Program in 2012. The program awards certificates to buildings that have implemented programs that reduce water and energy consumption. It also successfully competed against 35 other cities to host the 2012 World Congress of the ICLEI (Local Governments for Sustainability) conference in May-June 2012.

Within this context, the City's objective with TRACE implementation is to bring all existing energy efficiency activities under a single strategic framework, improve competitiveness and conserve financial resources. This will allow the City to strategically prioritize its energy efficiency activities. TRACE also suggests tried and tested energy efficiency measures based on international experience, their potential to save energy, and their potential to save financial resources. These will allow the city to improve its energy efficiency following international best practices.

Energy Trends in Brazil

There are three major trends in Brazil which make EE a critical part of the country's energy strategy:

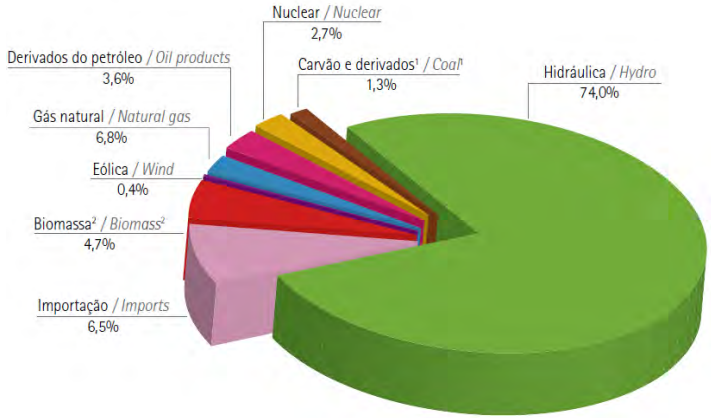
1. Growth in energy demand necessitating energy infrastructure investments – Brazil experienced (and continues to experience) significant economic growth. According to the Applied Economic Research Institute of Brazil (IPEA), the Brazilian economy grew by 23 percent over the last five years, and by 45 percent over the last 10 years. Between 1970 and 2005, energy demand grew by 215 percent and energy supply grew by 213 percent according to the Energy Research Company *(Empresa de Pesquisa Energetica)*. EE is critical because it mitigates energy demand in the short term and delays the need for higher-cost investments in new energy infrastructure. Planning, licensing, and constructing new generation capacity often takes more time and resources than EE investments.

2. Less carbon intensive energy mix - According to the National Energy Balance (*Balanço Energético Nacional – BEN*), Brazil's electricity generation mix is dominated by renewable energy sources. Large

hydropower corresponds to more than 74 percent of total domestic supply (Figure 2).This is a favorable trend that the government wants to maintain. It reduces the production of GHG emissions and local pollutants as well as associated economic and healthcare costs.

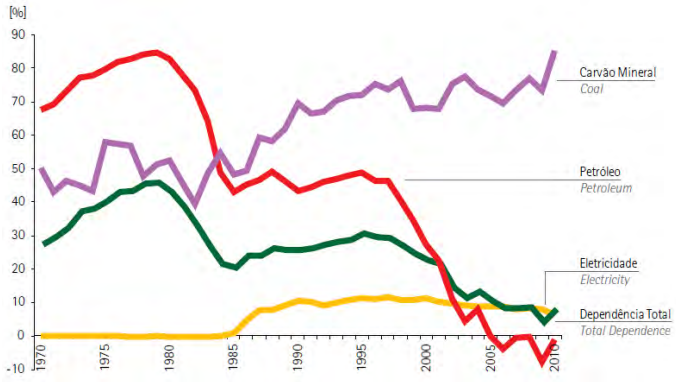
3. Falling external energy dependence and the goal of becoming a net energy exporter - As can be seen in Figure 3, Brazil's external dependence on energy has decreased with the exception of energy from coal. In 2006, the country became self-sufficient in petroleum and is developing alternative energy sources with the goal of becoming a net-energy exporter. EE lowers energy consumption, and hence supports the government's goal. It also improves the competitiveness of Brazilian exports.

Figure 2: Domestic Electricity Supply by Source – 2010



Source: 2011 National Energy Balance

Figure 3- Brazil's External dependence on energy



Source: National Energy Balance, 2011

Energy Efficiency in Brazil

The Ministry of Mines and Energy published the National Energy Plan 2030 (*Plano Nacional de Energia* - PNE) in 2007. At the strategic level, the plan provides an integrated approach to the development of the energy sector. At the tactical level, it provides subsidies for expansion in the electricity, oil, natural gas and biomass energy sectors. Among these sources of energy, the plan prioritizes the expansion of hydro electricity generation, petroleum and natural gas production and the development of biofuels. PNE also outlines the need to employ more renewable sources of energy and sets energy consumption reduction targets based on EE measures. The plan projects lower energy supply growth rates of 3.7 percent and 3.5 percent per year in the periods between 2010-2020 and 2020-2030 respectively due to greater EE on both demand and supply sides.

In the oil and gas sector, the Brazilian government established the National Program for the Rational Use of Oil and Natural Gas (CONPET) and the Brazilian Labeling Program (PBE). CONPET boosts efficiency in energy use in various industries, with an emphasis on the housing and transportation industries, and develops environmental education. The program seeks to mobilize the Brazilian society to rationalize petroleum and natural gas consumption, reduce greenhouse gas emissions, promote research and

technological development, and provide technical support to increase EE at the point of final energy usage. PBE provides information about product performance considering EE, noise and other factors that may influenceconsumers' choice. PBE also aims to boost industry competitiveness through continuous improvement induced by consumers' choice, encourage product innovation and technological improvements, and reduce energy consumption.

In order to further promote EE, the Ministry of Mines and Energy published the National Energy Efficiency Plan (*Plano Nacional de Eficiência Energética* - PNEf) at the end of 2011. The plan identifies instruments for EE fund raising, and promotes improvement in the EE legal and regulatory framework in order to enable an EE market. More specifically, PNEf established a set of actions to be implemented in industrial buildings, public buildings, street lighting and sanitation in order to achieve energy saving targets. It was built off the 20-year-old National Electricity Conservation Program (*Programa Nacional de Conservação de Energia Elétrica*-PROCEL) which emphasized electricity conservation.

The National Electric Energy Agency (*Agência Nacional de Energia Elétrica* - ANEEL) has been a pillar behind the country's EE programs. Its obligations, including improving EE, were outlined in Decree 9427, which was passed in 1997. ANEEL's Normative Resolution 300 of 2008 established the requirement that each public utility must invest at least 0.5 percent of its net operating income in actions aimed at combating electricity wastage. This program has been instrumental in encouraging utilities to invest in EE. As a result, many have Energy Efficiency Programs (*Programa de Eficiência Energética* - PEE). CEMIG (the power utility serving Belo Horizonte), has invested approximately US$278 million in 159 EE projects since 1998. Between 2008 and 2010 CEMIG invested US$144 million in EE, expecting to reduce demand by 133 MW.

ANEEL also plays an important role of establishing regulatory mechanisms such as Law no. 10295/01, which empowers states to define minimum levels of efficiency or maximum levels of electricity consumed by equipment produced or commercialized in the state. Since the State of Minas Generais controls CEMIG, it has several EE programs through the company. These are described in the Power and Heat section of this report.

TRACE City Energy Efficiency Assessment Report - Brazil

Sector Diagnostics

Sector Diagnostics

With the help of the World Bank, Belo Horizonte implemented the Tool for Rapid Assessment of City Energy Use (TRACE) in order to assess EE opportunities in the city. TRACE assesses potential energy and cost savings across six municipal service areas: urban transport, municipal buildings, water and wastewater, power and heat, street lighting, and solid waste. As a result, TRACE allows authorities and policy makers to think of a city in a sustainable holistic way.

TRACE assesses energy and cost savings potential using a relatively simple process. Detailed description of the TRACE process is provide in Annex B. In a nutschel, 28 key performance indicators selected for Belo Horizonte are compared with similar indicators from other cities included in the TRACE database. For example, the amount of electricity consumed per light pole in Belo Horizonte is compared with the amount of electricity consumed per light pole in several other cities. For a more refined comparison, cities can be sub-selected based on level of development (Human Development Index), climate, or population. Cities that perform better than Belo Horizonte on a particular performance indicator serve as a proxy for the level of improvement that Belo Horizonte can potentially achieve. For example, if several cities have a lower energy consumption per street light pole, it is an indicator that local authorities in Belo Horizonte could achieve energy savings in the 'Street Lighting' sector (e.g. by installing dimmers on public lighting poles for use when the streets are relatively vacant). TRACE indicators are both energy related (e.g. the fuel consumption of the public transport fleet) and not (e.g. urban transport modal split). The energy related indicators help assess energy and cost savings potential in each service area. The non-energy indicators help give a more rounded picture of these service areas, and thus help fine-tune the recommendations.

TRACE then calculates the energy and cost savings potential for each of the six service areas. Based on where the biggest cost and energy savings could be achieved, and the level of influence that the city authority has over the sector, a prioritized list of sectors is drawn. The prioritized list is split into sectors which in which the city authority pays the energy bill, and those in which both the city authority and individual residents pay the energy bill.

The priority list then feeds into a list of recommendations which are likely to have the biggest impact for resources invested. Appropriate recommendations are selected by establishing a match between the city's capabilities in terms of *finance, data and information, human resources, policy, regulation and enforcement, and assets and infrasctructure*; and capabilities needed to impliment the recommendations based on international experience. On-site interviews and field visits help to select the appropriate recommendations, and provide a more rounded picture of sustainability challenges and opportunities in Belo Horizonte.

TRACE focuses on areas under the municipality control hence does not

Table 2: Primary enterprises that provide services in the sectors covered in this report

	Transport	Buildings	Public Lighting	Water and Wastewater	Power and Heat	Solid Waste
Federal Government	Metro rail through **CBTU**					
State Government	Intercity / Inter-municipality transportation		**CEMIG** provides lighting under contract from the city	**COPASA** provides potable water and wastewater treatment services	**CEMIG** provides lighting under contract from the city	
Municipality	In-city transportation through **BHTRANS**	Schools, municipal offices and one hospital	**SUDECAP** supervises CEMIG			Waste collection and treatment through **SLU**

Source: World Bank

include the industrial and residential sectors. Additionally, the typical implementation of TRACE does not provide detailed cost and benefit analysis for each recommendations though resources are provided to allow such analysis as part of the ”next steps” after implementing TRACE.

The following sections include a quick analysis of each of the six sectors analyzed with TRACE, along with some key findings. The sectors are covered in the following order: transport, solid waste, water and wastewater, power and heat, public lighting and buildings. Table 2 gives a high-level view of the key enterprises that provide services in each sector covered in the report.

Transport

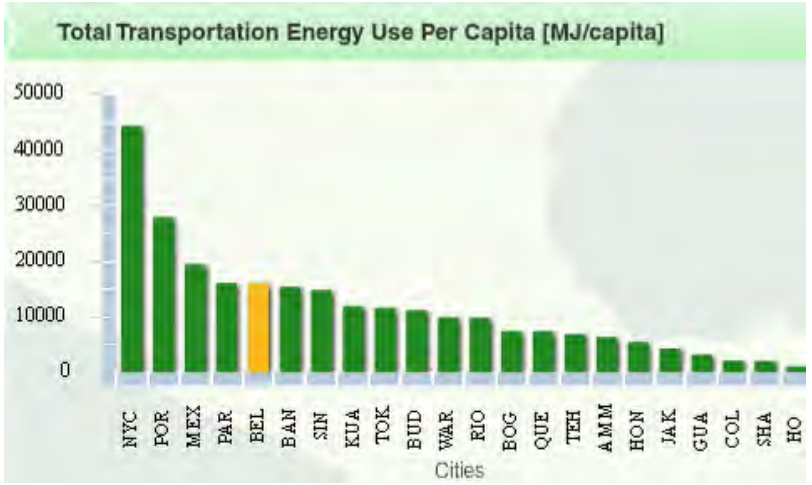
The Federal Government is responsible for the metro rail system in Belo Horizonte through the Brazilian Company of Urban Trains (CBTU). The federal government is also responsible for the administration of the National Traffic System, and it is represented by the Traffic Department of Minas Gerais[4] (*Departamento de Trânsito de Minas Gerais* DETRAN-MG) in the State. As an executive organ, DETRAN-MG is responsible for planning, coordinating, supervising and implementing transit activities, such as vehicle licensing and issuing the driver’s licenses. The State controls the inter-municipal transportation system through the State Department of Transportation and Construction (SETOP). At the municipal level, BHTRANS[5] is responsible for the transportation system in Belo Horizonte. BHTRANS was created in 1991 by Municipal Law No. 5953. It plans, organizes, directs, coordinates, executes, delegates and controls the provision of public services related to collective transportation of passengers, and the municipal road system. The company is mostly owned by the municipality of Belo Horizonte (98 percent), subsidized by the Urban Transport Fund (*Fundo de Transporte Urbano* – FTU) and administered by the Municipal Urban Services Secretariat.

Transport diagnostics results

Transportation diagonostic data was very robust. TRACE benchmarking results of transportation energy use per capita show that the energy consumption per capita in Belo Horizonte is higher than the average city in the database. The benchmarking results comparing Belo Horizonte (BEL) against similar cities is shown in Figure 4.

When the transportation energy use per capita is disagregated into public and private transportation energy use per passenger kilometer, TRACE benchmarking reveals a similar pattern of high energy consumption per passenger-kilometer in Belo Horizonte. According to Figure 4, Rio de Janeiro has a lower transport energy use per capita. This is partly because Rio de Janeiro has a more developed metro system.

Figure 4: Transportation energy use per capita



Key: NYC=New York City; POR=Porto; MEX=Mexico City; PAR=Paris; BAN=Bangkok; SIN=Singapore; KUA=Kuala Lumpur; TOK=Tokyo; BUD=Budapest; WAR=Warsaw; RIO=Rio de Janeiro; BOG=Bogota; QUE=Quezon City; TEH=Tehran; AMM=Amman; HON=Hong Kong; JAK=Jakarta; GUA=Guangzhou; COL=Colombo; SHA=Shanghai; HO=Ho Chi Minh City.

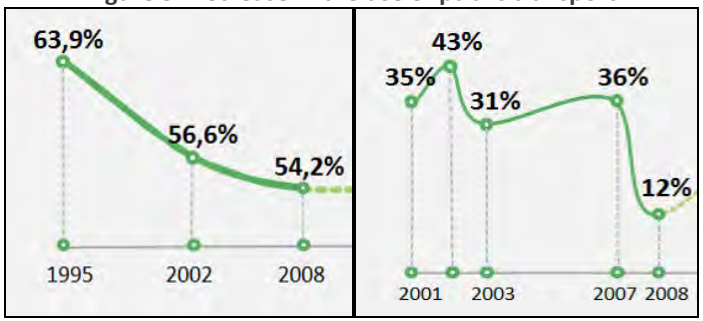
Source: TRACE, World Bank

The topography in Belo Horizonte also increases fuel consumption by an additional 5 percent according to one study. However, there are other reasons behind this high energy consumption per capita in the transport sector. First, there is a significant decrease in public transportation usage as shown in Figure 5a. Many local citizens attribute this decrease to the quality of public transportation as shown in Figure 5b.

[4] www.detrannet.mg.gov.br
[5] http://www.bhtrans.pbh.gov.br

Additionally, public transportation in Belo Horizonte is dominated by buses since the metro rail system is fairly limited. Buses generally consume more energy than the metro; and buses in Belo Horizonte have been getting slower due to congestion (Figure 6).

Figure 5: Decrease in the use of public transport

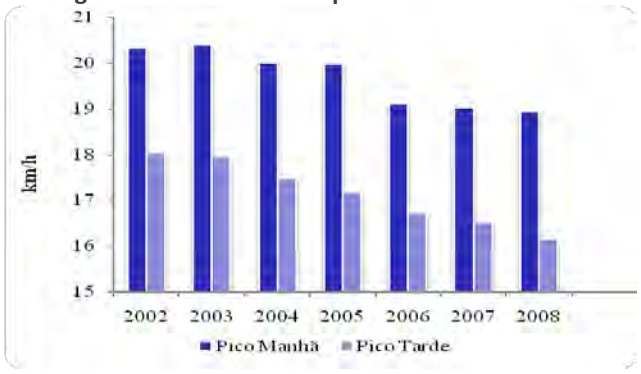


(a) Decrease in the use of public transport (b) Quality perception of public transport

Source : BHTRANS

The afternoon peak speed has dropped from 18km/h in 2002 to about 16 km/h while the morning peak hour speed has dropped to just under 19 km/h. This has the compound effect of favoring private transportation over public transportation as people find it faster to commute using private cars.

Figure 6: Peak hour bus speed in Belo Horizonte



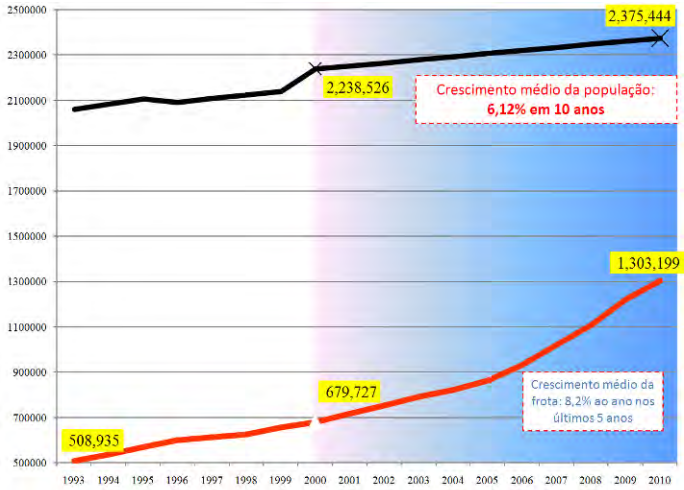
Pico Manhã = morning peak hour, pico tarde = evening peak hour

Source: BHTRANS

Private Vehicles

In private transportation, the city is faced with a rapid increase in motorization. As observed around the world, the rate of motorization increases when the GDP per capita reaches US$ 10,000. Belo Horizonte's GDP per capita is US$ 10,430. Between 2000 and 2010, the population in Belo Horizonte increased by 6 percent as the number of vehicles in the city increased by 92 percent over the same 10 years (Figure 7). BHTRANS expects this trend to continue to the extent that 52 percent of the passengers will use private cars by 2020 up from the current 46 percent.

Figure 7: The increase in Belo Horizonte's vehicle fleet



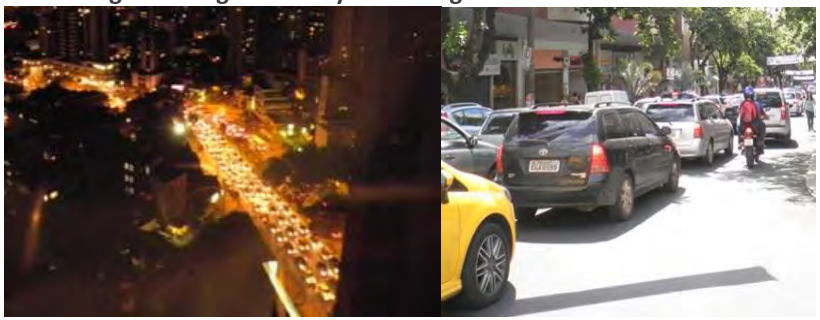
Cresciment médio da população: 6,12% em 10 anos = Average population growth 6.12% in 10 yearsCresciment médio da frota: 8,2% ao ano anos ultimos 5 anos = Average fleet growth: 8.2% per year in the last 5 years.

Source: BHTRANS

The increase in motorization by itself would not necessarily have resulted in Belo Horizonte consuming significantly more energy on transportation than its peer cities. The increased motorization accompanied by low share of non-motorized transportation of 27.3 percent does result in higher energy use. The resultant traffic congestion - as the transportation infrastructure tries to cope with the influx of vehicles - further increases

energy consumption when compared to cities with similar human development index but less traffic congestion (Figure 8).

Figure 8: Night and day time congestion in Belo Horizonte



(a)Night time congestion (b)Day time congestion

Source: TRACE Team, World Bank

Energy consumption in the transport sector is also increased by the limited amount of high capacity roads. With 37 meters of high capacity transit roads per 1000 people, high transit is quite limited in Belo Horizonte (Figure 9).

Figure 9: High capacity transit benchmarking

BUD=Budapest; WAR=Warsaw; PAR=Paris; NYC=New York City; TOK=Tokyo; BUC=Bucharest; TAL=Tallinn; KUA=Kuala Lumpur; RIO=Rio de Janeiro; SIN=Singapore; HON=Hong Kong; BAN=Bangkok; AMM=Amman; MEX=Mexico City; JAK=Jakarta; QUE=Quezon City; TEH=Tehran; BOG=Bogota; SHA=Shanghai

Source: TRACE , World Bank

Limited parking infrastructure also increases energy consumption as parked cars end up clogging city streets and slowing traffic flow (Figure 10).

Figure 10: Limited parking infrastructure in many parts of the City

Parked cars in new part of the city

Parked cars in older parts of the city

Source: TRACE Team, World Bank

Finally, the different modes of transportation in the city are interconnected in a limited way. The infrastructure for buses to feed the metro rail system is limited; there is no park and ride infrastructure which would enable more residents to use public transportation. Such limitations favor increased energy consumption.

Current transportation development programs

The City is working hard to improve its transportation system. At the strategic level, there are three major instruments that it is using to guide development in the transportation sector: The 2030 Strategic Plan (*Planejamento Estratégico de Belo Horizonte – 2030)* which guides citywide development; the 2020 BHTRANS Strategic Plan *(Plano Estratégico BHTRANS 2020),* which focuses on the city's transportation plans; and the Sustainable Urban Transportation Plan *(Plano de Mobilidade Urbana Sustentável - Plan MobBH),* which focuses on sustainable transport in the city. The Results-Based Management program*(Programa BH Metas e Resultados)* helps track progress from the Mayor's Office.

In implementing the plans, Belo Horizonte has several large transportation projects under way. The biggest of these is the BRT construction project. The city plans to have 73.7 km of BRT constructed by 2014 (Figure 11) More than half of the BRT route is being constructed along Antônio Carlos and Cristiano Machado Avenues. The main stations are planned along Antonio Carlos Avenue at Station Pampulha and Station São José. The integration of the BRT and metro is planned along São Gabriel and José Cândido. About US$800 million has been secured from the Federal Government through the Growth Acceleration Program (*Programa de Aceleração do Crescimento*-PAC) targeted at creating infrastructure for the 2014 FIFA World Cup.

Figure 11: BRT construction in Belo Horizonte

(left image) Belo Horizonte's BRT construction plans
(right image) One of many BRT construction sites in Belo Horizonte
Source: TRACE Team, World Bank

The City also plans to expand its metro rail system by 31.6 km into two new lines. This would allow the integration of the metro rail and BRT transportation systems in the city. As part of its sustainable mobility plan, the City plans to develop pedestrian pathways. Additionally it plans to have 360 km of bike paths developed by 2020 (Figure 12).

Based on the EE diagnostics and current city plans above, Belo Horizonte has a lot of good plans. TRACE recommendations described in this document would help Belo Horizonte move along in some of its plans.

Figure 12: Planned biking paths in the City

(a) Mayor Lacerda (in Khaki shirt) promoting biking in the City

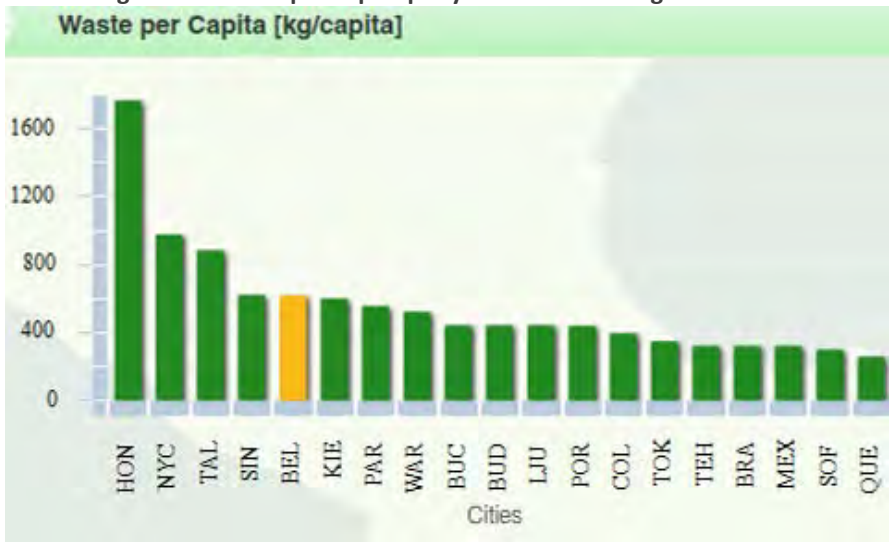
b) Existing bike paths (red), planned paths (white), paths being implemented (blue)

Source: TRACE Team, World Bank

Solid Waste

The Urban Cleaning Superintendence (*Superintendência de Limpeza Urbana* – SLU), created in 1973, is the public local authority responsible for collecting and disposing of solid waste in Belo Horizonte as stipulated in the City's Solid Waste Master Plan (*Plano Diretor de Resíduos Sólidos*). It develops cleanup projects, manages the cleaning and maintenance of public roads, develops technical standards for the solid waste master plan, and associated investment plans. SLU collects 95 percent of generated solid waste, which is relattively high compared to many cities around the world. The high capture rate is partly because SLU has increased its efforts to collect solid waste from the slums (*favelas*).

Figure 13: Waste per capita per year benchmarking result



Key: HON=Hong Kong; NYC=New York City; TAL=Tallinn; SIN=Singapore; KIE=Kiev; PAR=Paris; WAR=Warsaw; BUC=Bucharest; BUD=Budapest; LJU=Ljubljana; POR=Porto; COL=Colombo; TOK=Tokyo; TEH=Tehran; BRA=Bratislava; MEX=Mexico City; SOF=Sofia; QUE=Quezon City;

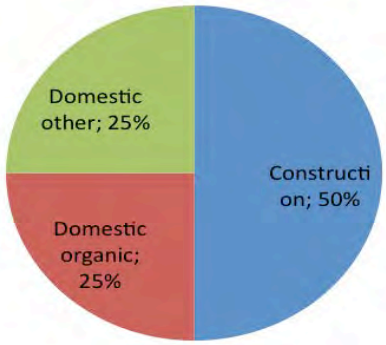
Source: TRACE , World Bank

SLU's financial needs are met by resources from the Federal Government through the municipality, the National Bank of Socio and Economic Development (*Banco Nacional de Desenvolvimento Econômico e Social* - BNDES), the Ministry of Cities, and the Growth Acceleration Program (Programa de Aceleração do Crescimento-PAC). Additionally SLU charges prolific waste generators individual rates, and residents a waste collection fee through property tax *Imposto Predial e Territorial Urbano (IPTU)*.

Solid waste diagnostic results

The quality of the solid waste data was high. Belo Horizonte had the data and no proxies were used for this diagnostic. Visiting the facilities helped to provide a holistic understanding of the sector. The amount of waste per capita in Belo Horizonte is high compared to cities with a similar Human Development Index (Figure 13). The above-average amount of waste can be explained by the large amount of construction projects in Belo Horizonte. Four thousand tons of domestic waste is collected each day and construction constitutes 50 percent of the waste (Figure 14)

Figure 14: Solid Waste Composition in Belo Horizonte



Source: SLU

A limited amount of the construction waste is recycled at three recycling centers owned by SLU. The federal government passed Law 12305 - the National Solid Residue Policy (*Politica Nacional de Residuos Solidos)*--in 2010, which describes the responsibilities of waste generators, including disposal of the waste. As a result, SLU is expecting demand at its construction waste recycling centers to increase. The recycled material is

used to produce construction materials such as bricks which are often sold at a discount of 30 percent (Figure 15).

Figure 15: Bricks made from recycled construction material

Source: SLU

The percentage of recycled solid waste in Belo Horizonte is relatively low as shown in Figure 16.

Figure 16:Percentage of recycled waste in Belo Horizonte

Key: HON=Hong Kong; NYC=New York City; TAL=Tallinn; SIN=Singapore; KIE=Kiev; PAR=Paris; WAR=Warsaw; BUC=Bucharest; BUD=Budapest; LJU=Ljubljana; POR=Porto; COL=Colombo; TOK=Tokyo; TEH=Tehran; BRA=Bratislava; MEX=Mexico City; SOF=Sofia; QUE=Quezon City;

Source: TRACE Team, World Bank

The City has the opportunity to improve its recycling given that 25 percent of the domestic waste is organic. The need for recycling is further evidenced by non-decomposable waste in some rivers and streams.

Recycling is currently done through associations of 'waste pickers' who process recyclable waste at warehouses owned by SLU. SLU collects and brings most of the recyclable waste to recycling centers, though 'waste pickers' are often seen around the city collecting paper, plastic, bottles and cans for recycling. After collection, the scavengers sort and process the waste before selling to local manufacturers. There are 60 such associations of 'waste pickers' working in 80 warehouses. However, their ability to meet the recycling needs of Belo Horizonte is limited because the recycling infrastructure and SLU's ability to increase the number of warehouses is limited. Currently, only two percent of the solid waste is selectively collected. Improving this number would require educating the citizens, providing the right trash cans, providing better infrastructure, and getting a good understanding of the market of recycled waste.

Figure 17: SLU's Biogas Electricity Generating Plant

Source: TRACE Team, World Bank

In addition to the limited recycling, the City also composts organic waste from supermarkets and restaurants--a total of about 50 establishments--

and conducts pyrolysis of hospital waste. The compost is used in public schools and public parks.

With respect to energy use and production, SLU has a 4 MW biogas power generation plant at the landfill which is connected to the local grid (Figure 17). The plant was developed by a partnership between a Brazilian company (51 percent) and an Italian company (49 percent). The companies paid about US$9 million to the City in order to explore the opportunities. They also awarded 30 percent of the carbon credits from the project to the City, and 5 percent of revenues generated from excess electricity sold to CEMIG.

Figure 18: Waste transfer center

Source: SLU

On the energy expenditure side, the collection of solid waste and transportation to the landfill consumes about US$5 million compared to about US$0.5 million consumed by the rest of SLU's facilities. Solid waste transportation planning could be improved as described in the fortcoming recommendations section. SLU owns 45 trucks (about 5 percent of the entire fleet); the rest are owned by private companies under contract from SLU. Forty percent of this waste goes directly to the main Sabara landfill and 60 percent goes to a transfer center (Figure 18) where it is loaded into larger $60m^3$ trucks before transportation to Sabara.

Water and Wastewater

The National Water Authority (*Agência Nacional de Águas*-ANA) is an independent federal entity, linked to the Ministry of the Environment, which is responsible for managing Brazil's water resource at the national level.[6] ANA creates technical standards for implementing the Water Law. Through ANA, the federal government manages rivers and lakes bordered by more than one state as well as those between Brazil and neighboring countries. The state owns groundwater and surface water that have source and mouth within the state territory. Among the state agencies, the Institute of Water Management of Minas Gerais[7] (*Instituto Mineiro de Gestão da Águas* -IGAM) is responsible for planning, administrating and allocating the water resources through water-use concessions. The funds raised from the concessions are transferred to IGAM and later to the agencies which manage the water resources.

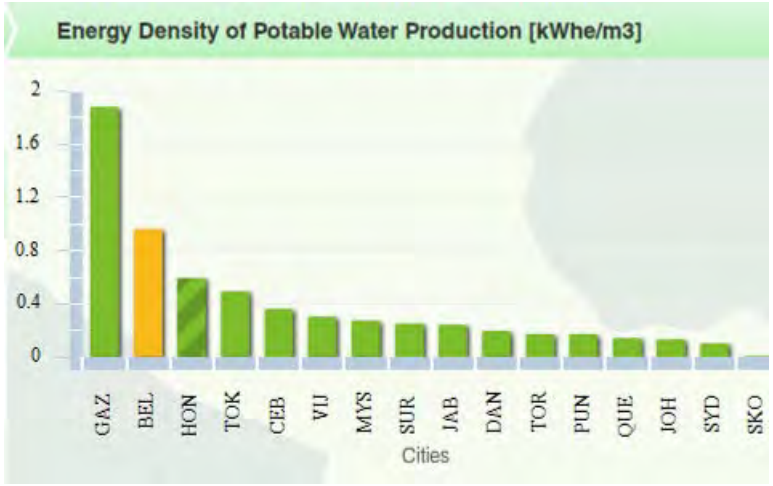
In Belo Horizonte, Sanitary Company of Minas Gerais (*Companhia de Saneamento de Minas Gerais* - COPASA) provides water and wastewater treatment services under a license issued by the Regional Superintendence of Environment and Sustainable Development (*Superintendência Regional de Regularização Ambiental* – SUPRAM). COPASA is a mixed capital company listed on the stock exchange. SUPRAM is the state agency responsible for environmental licensing, planning, supervising, protecting and managing waterresources in Minas Gerais. In addition to SUPRAM, COPASA is also regulated by the Sanitation and Water Supply Service Regulating Authority (*Agência Reguladora de Serviços de Abastecimento de Água e de Esgotamento Sanitário do Estado de Minas Gerais* – ARSAE - MG), which was created as a special local authority to regulate and provide financial and technical administration in the water and wastewater sector. ARSAE is connected to the State Department of Regional Development and Urban Policy (*Secretaria de Desenvolvimento Regional e Políticas Urbanas* - SEDRU).

ANA is in charge of water quality at the national level and IGAM, through the Water of Minas Gerais Project, is responsible for monitoring the quality of surface and groundwater at the state level. At the municipality level, water quality is controlled by the Secretary of Health in Belo Horizonte. However, COPASA performs its own water quality analysis before, during and after the water treatment process to detect any harmful tastes, odors, chemicals or microorganisms. COPASA's water quality checking process is quite high - they have 1000 check points and they measure about 600 critical points every month.

Potable Water Diagnostics Results

The data for potable water diagonostic was fairly reliable as well. Facility tours only enhanced the diagonostics. The energy density of potable water production in Belo Horizonte is high as shown in the benchmarking results (Figure 19)

Figure 19: Benchmarking energy density of potable water production



Key: GAZ=Gaziantep; HON=Hong Kong; TOK=Tokyo; CEB=Cebu; VIJ=Vijaywada; MYS=Mysore; SUR=Surabaya; JAB=Jabulpur; DAN=Danang; TOR=Toronto; PUN=Pune; QUE=Quezon City; JOH=Johannesburg; SYD=Sydney; SKO=Skopje

Source: TRACE, World Bank

The high energy density is caused by two natural reasons: First, Belo Horizonte does not have its own water sources. Hence, the water has to be pumped from long distances (Table 3).

[6] www.ana.gov.br
[7] www.igam.mg.gov.br

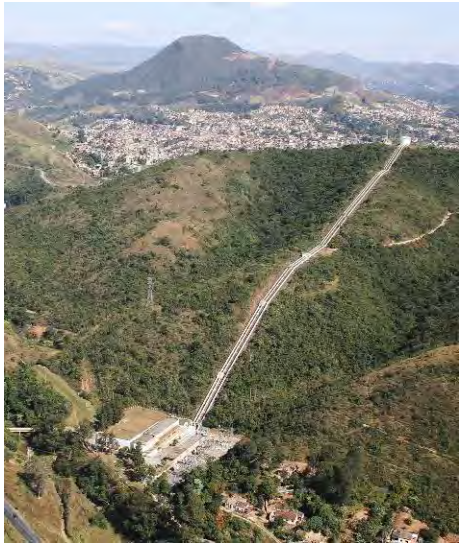
Table 3: Belo Horizonte Water System

Water Source	Distance from Belo Horizonte (km)	% of Consumed Water
Sistema Rio das Velhas	10	63%
Sistemas da Bacia do Paraopeba	34	24%
Sistema Morro Redondo	6	9%

Source: COPASA

Secondly, water has to be pumped over several hills before it flows to the final customers in Belo Horizonte under gravity. Figure 20, Sistema Rio das Velhas, is an example. The city has tried to keep the energy consumption low. It uses relatively new pumps, which are appropriately sized for the water volume, and there are plans to expand the Rio das Velhas System to 8m^3/s from the current 6m^3/s.

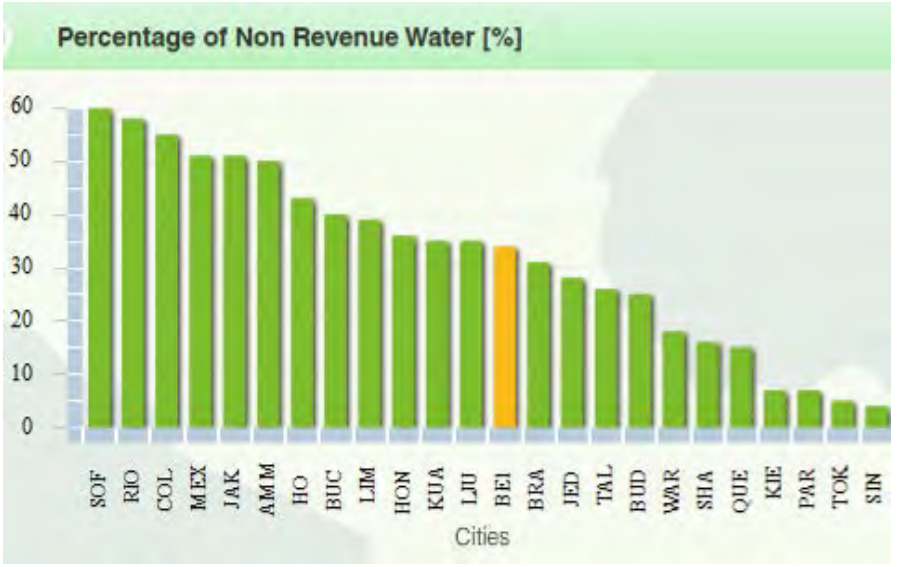
Figure 20: Rio das Velhas System pumping station



Source: Belo Horizonte Municipality

The percentage of non-revenue water in Belo Horizonte is 34 percent, which is better than Rio de Janeiro and Mexico City but still quite high when compared with peer cities (Figure 21)

Figure 21: Benchmarking of non revenue water



Key: SOF=Sofia; RIO=Rio de Janeiro; COL=Colombo; MEX=Mexico City; JAK=Jakarta; AMM=Amman; HO=Ho Chi Minh City; BUC=Bucharest; LIM=Lima; HON=Hong Kong; KUA= Kuala Lampur; LJU=Ljubljana; BRA=Bratislava; JED=Jeddah; TAL=Tallinn; BUD=Budapest; WAR=Warsaw; SHA=Shanghai; QUE=Quezon City; KIE=Kiev; PAR=Paris; TOK=Tokyo; SIN=Singapore

Source: TRACE, World Bank

The high non-revenue water percentage can partially be attributed to slums in the city (Figure 22) Some *favela* residents illegally pipe water from the COPASA system. Some wealthier residents seek to illegally pipe water for gardens and swimming pools as well. Since Belo Horizonte is large, it is difficult for COPASA to monitor the entire city with the current infrastructure. Water is also lost due to leakages which can go undetected for periods of time. The City does not have an active water leakage detection system; hence, someone has to report a leakage to COPASA before any remedies are implemented.

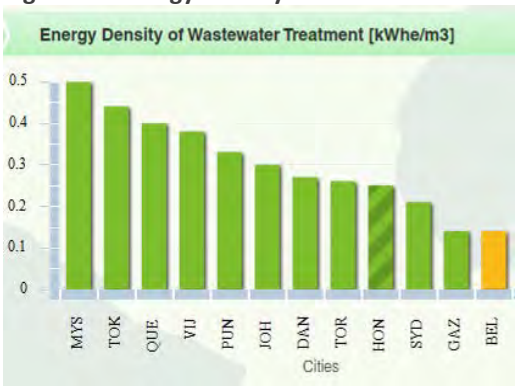
Figure 22: One of the *favelas* in Belo Horizonte

Source: TRACE Team, World Bank

Wastewater Diagnostics Results

Wastewater treatment in Belo Horizonte consumes the lowest amount of energy from the list of cities in the TRACE tool database (Figure 23).

Figure 23: Energy Density of Water Treatment



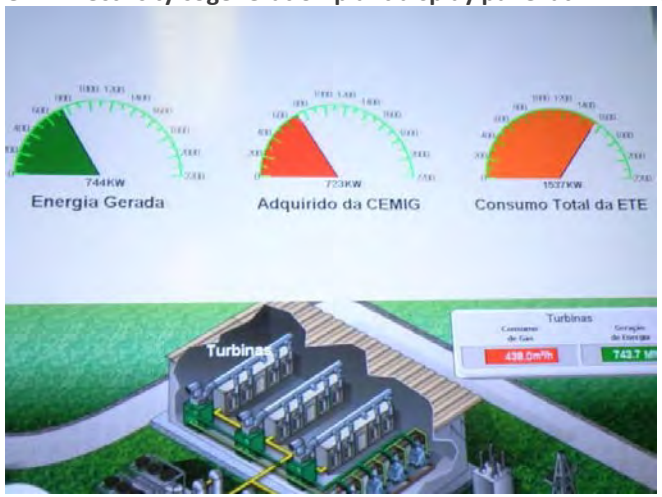
Key: MYS=Mysore; TOK=Tokyo; QUE=Quezon City; VIJ=Vijaywada; PUN=Pune; JOH=Johannesburg; DAN=Danang; TOR=Toronto; HON=Hong Kong; SYD=Sydney; GAZ=Gaziantep;

Source: TRACE, World Bank

The low energy density of wastewater treatment is largely because the wastewater treatment facilities are located downhill. Hence wastewater flows to the facilities under gravity. About 70 percent of the water flows to the facilities through the proper channels, and there is a 'wastewater hunting' program to increase this percentage. The limited amount of energy consumed at the facility is used to recycle the wastewater being treated and to pump oxygen into the aerobic treatment system.

At Wastewater Treatment Plant (*Estação de Tratamento de Esgoto*) ETE Arrudas, COPASA has a 2.4 MW cogeneration plant (Figure 24)

Figure 24: Electricity cogeneration plant display panel at ETE Arrudas



Energia Gerada – Generated Energy; Adquirido da CEMIG – acquired from CEMIG; Consumo Total da ETE – Total energy consumed at the treatment facility

Source: TRACE Team, World Bank

The methane-based plant currently generates 30 percent of ETE Arrudas' energy needs, and COPASA has plans and resources in place to increase the self-generation to 90 percent. The expansion is funded by the World Bank, the federal government's PAC program and COPASA's own resources for a total investment of US$100 million.

Power and Heat

CEMIG, a mixed capital company, is responsible for electricity production, transmission and distribution in Belo Horizonte. The city is connected to

the National Interconnected System (*Sistema Interligado Nacional* - SIN) which transmits 98 percent of all electricity consumed in the country. The National System Operator (ONS) administrates the SIN. ONS has five operation centers around the country, which coordinate, supervise, and control the generation mix on the SIN.

Figure 25: Belo Horizonte transmission and distribution losses

MEX=Mexico City; BOG=Bogota; TEH=Teheran; COL=Colombo; RIO=Rio de Janeiro; AMM=Amman; HON=Hong Kong; KIE=Kiev; JAK=Jakarta; TAL=Tallinn; LIM=LIMA; BUD=Budapest; WAR=Warsaw; QUE=Quezon City; JED=Jeddah; BUD=Budapest; POR=Porto; HO=Ho Chi Minh City; SHA=Shanghai; URU=Urumqi; PAR=Paris; LJU=Ljubljana; TOK=Tokyo; SIN=Singapore; BAN=Bangkok; KUA=Kuala Lumpur; BRA=Bratislava

Source: TRACE Team, World Bank

All electricity distribution concessionaires on the National Interconnected System, such as CEMIG, are part of the Regulated Market or Regulated Contract Market (*Ambiente de Contratação Regulada* – ACR). Those with consumption over 500 GWh/year are required to participate in the electricity auctions. Smaller distributors are not required since they can obtain electricity from local suppliers. The auctions are regulated by the National Electric Energy Agency (ANEEL) and are organized by the Electric Energy Commercialization Chamber (CCEE). These auctions seek to provide the lowest possible price of electricity to be passed on to the consuming public.

Power and heat diagnostics results

The data for the power sector was very reliable as well. CEMIG in Belo Horizonte has very good results for transmission and distribution losses among cities with similar HDI in the TRACE database as shown in Figure 25. The company recently invested US$2.8 billion in upgrading its equipment in order to reduce the frequency and amounts of technical losses.

In terms of non-technical losses, CEMIG has very good results compared to cities in the TRACE benchmark as well (Figure 26)

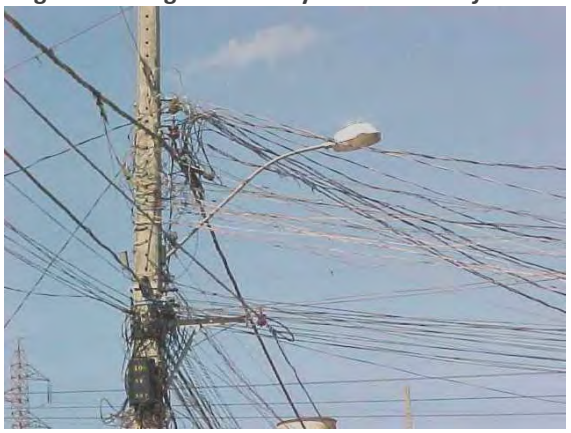
Figure 26: Percent of non-technical losses in Belo Horizonte

MUM=Mumbai, SKO=Skopje; RIO=Rio de Janeiro; BOG=Bogota; CAP=Cape Town; JOH=Johannesburg; GUA=Guangzhou; HON=Hong Kong; SHA=Shanghai; URU=Urumqi; JAK=Jakarta; QUE=Quezon City; GAZ=Gaziantep; AMM=Amman; CEB=Cebu; NYC=New York City; SYD=Sydney=BAN=Bangkok

Source: TRACE Team, World Bank

CEMIG estimates that they lose 2.5 percent of electricity to fraud where people tamper with the measuring equipment in order to save money; the other 2.5 percent is the result of illegal connections to the electricity network (Figure 27). About 20,000 families in the *favelas* use illegal connections.

Figure 27: Illegal electricity connection in *favelas*



Source: CEMIG

Fifteen thousand customers (hotels, industries and schools) out of 7 million are responsible for 50 percent of the total electricity consumption. In order to reduce loss through fraud, CEMIG closely monitors these 15,000 customers. They have systems which send SMSs to CEMIG reporting electricity usage; conduct inspections and "make examples" of high profile consumers found stealing by taking them to court.

For the other 2.5 percent, CEMIG has a number of innovative programs which have minimized the non-technical losses. The programs are also a response to national programs and legislation. The most important of these are PROCEL, ANEEL's Normative Resolution 300 of 2008 and PNEf. PROCEL is the oldest electricity conservation program which was started in the 1990s, ANEEL requires that local utilities invest 0.5 percent of their operating revenues in EE projects, and 1 percent in research and development; and PNEf identifies instruments for EE fund raising, and promotes improvement in the EE legal and regulatory framework. The government was motivated to implement these programs partly because 18 percent of Brazil's electricity is wasted through inefficient usage.

In order to comply with the legislation, CEMIG invests about US$28 million/year in EE. About 60 percent of the investment is dedicated to the low income population through the Living Together program *(Conviver*); 20 percent to non-profit organizations, hospitals, and old people's homes through the Energy for the Good *(Energia do Bem*) program; 15 percent to industrial customers, and 5 percent to education through the CEMIG at Schools Program.

Conviver educates low income families on the efficient, safe andregular use of electricity (Figure 28). The program also identifies low income families consuming the most energy and replaces their old appliances. They have replaced fridges in 10 percent of the households with the highest energy consumption, and replaced electric showers in 10 percent of households with the largest number of family members. Since electricity tariffs in Brazil are tiered by energy usage, families who reduce their energy consumption significantly end up paying less because their tariffs decrease when they enter a lower consumption tier. Thus, the families are less likely to illegally connect to the electricity distribution system (Figure 27). CEMIG also replaces old hospital equipment through the *Energia do Bem* program (Figure 29). Appliance replacement allows CEMIG to educate other families and hospitals about the benefits of being energy efficient.

Figure 28: Educating low income households on how the worn-out rubber seal wastes electricity

Source: CEMIG

Figure 29: Newly replaced hospital equipment

Source CEMIG

Electric shower water heaters constitute a significant proportion of a typical family's energy consumption in a given month. As a result, CEMIG has another program called *Conviver Solar.* Similar to the programs for replacing old fridges and hospital equipment, the company also installs solar water heaters as a way to educate families about the benefits of solar water heating (Figure 30).

Figure 30: Solar water heater

Source: CEMIG

CEMIG also has a program where they educate municipalities on EE practices as well as another where they use an Energy Services Company (ESCO) model to help industrial customers reduce energy consumption.

These programs have been fairly successful. CEMIG was featured on Dow Jones' Sustainability Index 13 times in a row – the only elecctricity company in Latin Ameria to achieve such feat. The company won 6 other sustainability awards including the Environmental Management Leader presented by the Business Leaders Group in partnership with the Brazil Economic Newspaper.

Heating

Because heating is not required for Belo Horizonte's climate, it was not analyzed in this report.

Belo Horizonte Solar

Belo Horizonte is known as the solar capital of Brazil. Five years ago, solar activity in Belo Horizonte accounted for 60 percent of all activities in Brazil. There are currently 1.98 million square meters of solar panel in Minas Gerais, and Belo Horizonte accounts for approximately 50 percent – 800,000 square meters. The City also has the second largest pool solar heating system in Latin America. BH Solar is an association of solar companies in the Belo Horizonte metropolitan area. These five smallto medium companies account for 35 percent of all solar equipment production in Brazil. The companies have mainstreamed solar water heating to the extent that customers demand solar water heating when buying new apartments in the City, and there are 2,600 buildings in the city with solar water heating systems. It only takes two years for the system to pay for itself.

Public lighting

Public lighting in Belo Horizonte is managed by the Superintendence for the Development of the Capital (*Superintendência de Desenvolvimento da Capital* – SUDECAP), which is a department of the municipality. The national government has an indirect role in public lighting in Belo Horizonte as Article 20 of the Constitution states that municipalities should be responsible for public lighting. For instance, the federal government regulates tariffs through ANEEL Resolution no. 4143 and sets the national lighting standard (ABNT5101), which states the minimal amount of light per given area. The national government also has influence through national programs such as PROCEL, for public lighting and buildings, and PNEf.

Figure 31: Percentage of lit roads benchmarking

Key: NYC=New York City; CEB=Cebu; PUN=Pune; JAB=Jabalpur; SKO=Skopje; GAZ=Gaziantep; SUR=Surabaya; MYS=Mysore; KAN=Kanpur; VIJ=Vijaywada; CAP=Captown; QUE=Quezon City; BHO=Bhopal; KAT=Kathmandu; POK=Pokhara.

Source: TRACE, World Bank

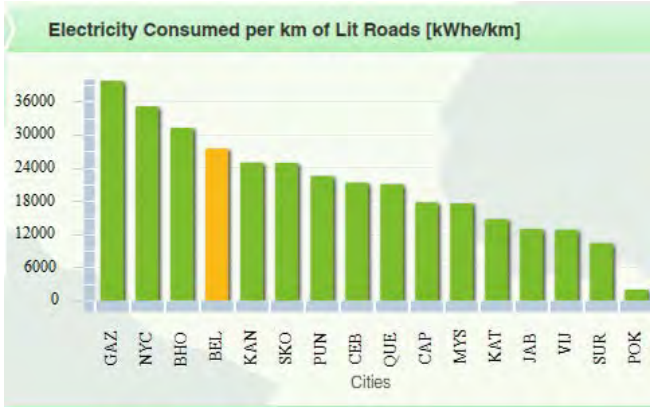
In Belo Horizonte, CEMIG supplies, maintains and operates the public lighting service under contract from SUDECAP. SUDECAP pays CEMIG from "Contribution for Public Lighting" fees charged to the residents of Belo Horizonte as part of their electricity bills. In the current contract, CEMIG gets 13.33c/kWh without maintenance and 14.44c/kWh with maintenance. The city currently pays about US$ 206,000 per month to CEMIG for material, equipment and workforce. Citizens without electricity pay their contribution for public lighting through the Urban Land Tax (*Imposto Territorial Urbano* – IPTU).

There are several public lighting EE programs in Belo Horizonte already. All public lighting lamps were recently changed from mercury to sodium vapor. The program started in 2003 and was completed in 2009. However, the total electricity cost remained the same because more street lights were added as the city grew, increasing the percentage of lit roads. The idea was to have more lamps while keeping costs low.

Public lighting diagnostics results

The data for public lighting diagonostic was very robust. The team did not use any proxies as the city provided sound data. At 100 percent, the percentage of lit roads in Belo Horizonte is high - comparable to cities such as New York City (Figure 31). However, the electricity consumed per kilometer of lit road remains high at 27,583 kWhe/pole, despite having recently changed all lamps from mercury to sodium vapor (Figure 32)

Figure 32: Electricity consumed per km of lit road benchmarking



Key: GAZ=Gaziantep; NYC=New York City; BHO=Bhopal; KAN=Kanpur; SKO=Skopje; PUN=Pune; CEB=Cebu; QUE=Quezon City; CAP=Capetown; MYS=Mysore; KAT=Kathmandu; JAB=Jabulpur; VIJ=Vijaywada; SUR=Surabaya; POK=Pokhara

Source: TRACE, World Bank

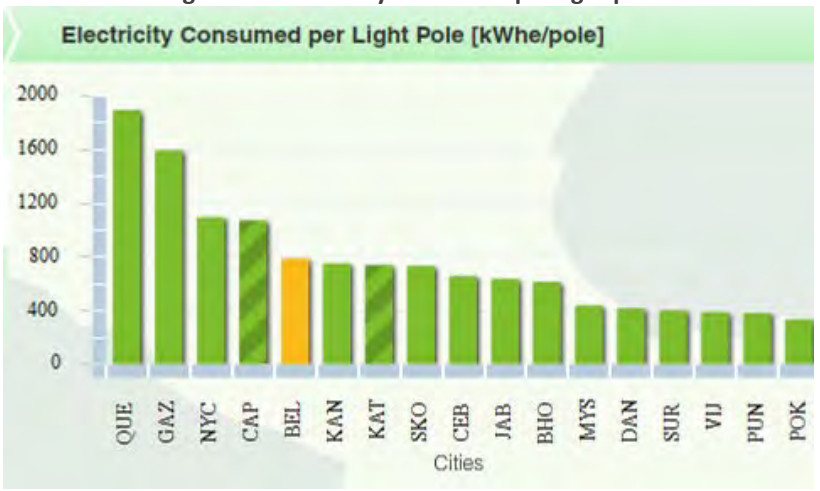
This high electricity consumed per kilometer of lit road is partially explained by the high number of light poles per kilometer of road in Brazil as part of the national lighting standard ABNT5101 (Figure 33)

Figure 33: High number of light poles per km of road

Source: TRACE Team, World Bank

As shown in Figure 34, the electricity consumption per light pole in Belo Horizonte is quite high as well.

Figure 34: Electricity consumed per light pole



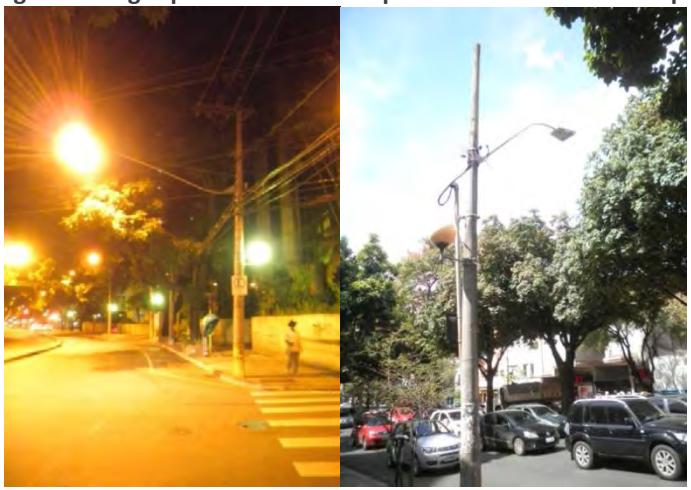
Key: QUE=Quezon City; GAZ=Gaziantep; NYC=New York City; CAP=Capetown; KAN=Kanpur; KAT=Kathmandu; SKO=Skopje; CEB=Cebu; JAB=Jabulpur; BHO=Bhopal; MYS=Mysore; DAN=Danang; SUR=Surabaya; VIJ=Vijaywada; PUN=Pune; POK=Pokhara

Source: TRACE, World Bank

According to the head of SUDECAP, the electricity consumed per light pole in Belo Horizonte is high because light poles along major streets have two lamps: one for the road and the other for the sidewalk (Figure 35).

During the diagnostics mission in Belo Horizonte, the team also came across lamps which were not turned on at night and some which remained on during the day. SUDECAP estimates that 4 percent of the street lights will not be on at night, and another 4 percent will stay on during the day. Since CEMIG is paid based on the product of the number of light poles, a *standard estimate* of the number of hours that the lights are on, and the number of days in a month, there is an opportunity for improvement.

Figure 35: Light poles with two lamps: road and sidewalk lamps



(a) Two-lamp light pole at night time (b) Two-lamp light pole during daytime

Source: TRACE Team, World Bank

Buildings

There are three major groups of buildings under control of the municipality of Belo Horizonte: schools, hospitals, and municipality offices. The municipality owns 255 schools in the City of Belo Horizonte. It also owns Municipal Odilon Behrens Hospital, which is a 487-bed teaching hospital founded in 1944. For offices, the municipality owns and rents several buildings around the city. SUDECAP has just started a buildings reporting program. This program is meant to shed light on energy consumption in municipal buildings.

Figure 36: Belo Horizonte Municipality Hospital

Source: Belo Horizonte Municipality

Building energy efficiency diagnostics

Since it was difficult to obtain data on buildings, the benchmarking data in TRACE was not very applicable to the Belo Horizonte context. As a result the team conducted technical walk-throughs as part of the assessment.

From this assessment, three key findings emerge which have strong implications for energy consumption in municipal buildings:

1. Building operations in the city are extremely decentralized with no single department in charge. As shown in Annex A, there are 65 municipality units, each with its own staff in charge of its buildings. These units have different inclinations towards EE. As a result, energy efficient practices are not widespread. When it comes to procurement, many simply purchase the cheapest option without considering the lifecycle costs. Only a handful of the building offices have adopted some energy efficient practices as part of the Internal Commission for Energy Conservation (*Comissão Interna de Conservação de Energia* - CICES*)* program.
2. The team also noticed that, with the exception of the Mayor's Office, most city buildings had inefficient lights. In addition, there is limited sectional lighting, implying that switching the lights on in one corner of a floor lights up a significant portion of the entire floor even if the rest of the floor is vacated.
3. An analysis of the electricity expense revealed that the municipality's public buildings electricity bill--predominantly for lighting--was comparable with the citywide public lighting bill. Clearly, there is an opportunity for improvement in municipal building energy expenditure.

TRACE City Energy Efficiency Assessment Report - Brazil

Energy Efficiency Recommendations

Energy Efficiency Recommendations

After the diagnosis, TRACE prioritizes sectors according to their EE potential. The results for Belo Horizonte are shown in Table 4:

Table 4: Prioritization of Sectors According to EE Potential

Sector	Energy Expenditure (US$)	Relative Energy Intensity	*Level of Local Control	Ranking Score
City Authority Sector Ranking				
Municipal Buildings	10,409,407	40%	1.00	4,163,763
Street Lighting	17,634,494	39%	0.52	3,535,034
Solid Waste	5,736,690	40%	1.00	2,294,784
City Wide Sector Ranking				
Private Vehicles	1,588,710,432	28%	0.40	179,746,525
Public Transportation	150,154,906	36%	0.80	42,892,501
Potable Water	55,808,519	13%	0.38	2,693,319
Wastewater	4,605,567	5%	0.38	84,005

* (from 0-no control, to 1-full control)

Source: TRACE, World Bank

The ranking is divided into City Authority Sector Ranking and City Wide Sector Ranking. The former roughly corresponds to sectors where the municipality pays the energy bill, and the later roughly refers to sectors where both residents and the city authority pay the energy bill. Energy expenditure in the sector is a sum of money spent on energy. In the case of Belo Horizonte, this is mostly electricity and fuel. The Relative Energy Intensity is the potential improvement in the given sector for Belo Horizonte. It is calculated using the average of cities performing better than Belo Horizonte. For example, if the average expenditure on public lighting for cities performing better than Belo Horizonte is 61 units, and Belo Horizonte spends 100 units, then its relative energy intensity is (100-61)/100 = 39 percent. The level of local control ranges from zero - where the city authority has very limited control - to one - where the municipality has full control, as in the municipal buildings sector. The ranking score is a product of energy expenditure, relative energy intensity and level of local control.

Three technical issues deserve clarification in order to better understand this sector ranking. Since the energy consumption data came from the city departments, the values are relatively steady. The relative energy intensity partly depends on the number of cities doing better than Belo Horizonte. The largest number of cities comparable to Belo Horizonte in each benchmark was used in order to be consistent. The level of control is a guided estimate from the city departments. Thus, the ranking is a good mix of technical analysis and consultations with city officials.

The prioritization feeds into recommendation prioritization, which has two main components: the recommendations themselves, and the city authority's capabilities. There are close to 60 energy efficiency recommendations in TRACE based on internationally tried and tested energy efficiency practices. Each of these recommendations comes with a scoring of low, medium or high on a *Finance, Human Resources, Data and Information, Policy Regulation and Enforcement, and Assets and Infrastructure* scale. The scoring is based on expert assessment of what it would take to implement each recommendation on each dimension of the scale. For instance, large infrastructure projects would have a high score on *Finance*, as the projects require significant financial resources. During the onsite visits, city capabilities in each subsector are assessed through discussions with subsector leaders using the same methodology. For instance, in the public transportation subsector a city would be assessed on its Policy, Regulation and Enforcement capability using the low, medium or high scoring as clearly defined in TRACE. A low score in the subsector on this dimension means that the city has limited capability to regulate traffic, and its enforcement capability is weak as well. Appropriate recommendation are then based on matching what it would take to implement a recommendation, and the city capabilities in each subsector. These recommendation go through an additional selection process based on local political considerations. Thus city authorities can easily drop recommendations that are political challenging from additional analysis.

Recommendations for Belo Horizonte are shown in Table 5. The recommendations are categorized using three characteristics: The colors

indicate the approximate time it would take to implement each recommendation. Recommendations **in blue** could be implemented in less than a year, those **in black** between one and two years and those **in orange** in three years. Vertically, the recommendations are grouped into three cells based on the approximate energy savings. Recommendations with minimum energy savings are located in the cell at the bottom of the table, and those with higher energy savings are in the cell at the top. Horizontally, recommendations with the lowest first cost are located in the cell to the right, and those with higher first cost in the cell to the left. The alphanumeric code allows the reader to find the recommendation in the text. For example, **(B1)** is **B**uildings recommendation **1**. The implementation plan will not necessarily follow this order; but, we discuss one possible way of organizing the recommendations as part of an implementation plan at the end.

Municipal Buildings Energy Efficiency Recommendations

There is substantial EE potential in municipal buildings in Belo Horizonte. The team's TRACE recommendations can be grouped into three major groups: creating a centralized organizational unit with statutory power and an EE mandate, audit and retrofit programs, and citywide EE programs.

Creating a centralized organizational unit with statutory power and an energy efficiency mandate

Efforts to clearly understand municipal buildings sector are at an early stage as each municipal department is in charge of its own buildings and there is little coordination among the units. *Creating a centralized unit with statutory authority, and a mandate including implementing EE measures***(B1)** is the key TRACE recommendation for this sector. The unit could be part of SUDECAP or a new task force. Task forces tend to be transitory; hence being part of SUDECAP would bring stability to the new organizational unit. Whichever mode of organization the city chooses, it is critical that the organization has statutory power since the current voluntary programs under the CICES have had limited impact.

The energy efficiency organization would need to create an *EE strategy and action plan* **(B2 - see Annex 1)**,which is critical for putting the current programs under one influential umbrella and mapping the way forward. As discussed with the Mayor's Office, the strategic EE plan would be part of the city's 2030 plan, and results can be monitored as part of the city's results-based management program. This would enable the city to monitor its progress towards its EE goals, and publicize the importance of EE to municipal departments.

The organization would be allocated a budget to go with mandate for EE upgrades in municipal buildings. Combining upgrades with natural building renovations tends to be the best use of limited resources. For example, replacing a leaking roof could be combined with adding insulation and a white roof; or if new windows are being installed, they could be upgraded to highly insulated windows using resources allocated to the organization.

Municipal audit and retrofit programs (see Annex 2)

Audit and retrofit programs need to be conducted in order to have a good understanding of the current EE status within municipal buildings. The following programs are proposed:

- *Municipal offices audit and retrofit programs* **(B3)**
- *Municipal schools audit and retrofit programs* **(B4)**

SUDECAP has started developing a database of municipal buildings and their energy consumptions. This effort can be expanded into a *municipal buildings benchmarking program* **(B5)** which will enable the municipality to compare buildings and focus resources on buildings that need it the most.

Since there is only one municipal hospital, the benchmarking program applies to the 255 schools in the city and approximately 50 municipal office buildings.

Audit and retrofit programs would extend beyond the benchmarking by identifying immediate savings opportunities, and implementing rapid payback programs across all buildings owned or rented by the municipality. Examples of easily implemented tasks identified by the team involve:

- *installing efficient lighting as in the Mayor's offices across municipal buildings* **(B6)**
- *Sectional and motion-sensored lighting* **(B7)**
- *computer powersave programs where computers are set to go into the powersave mode when not used for a long period of time* **(B8)**

The programs could be implemented by a hired official or by an ESCO which will be paid from energy savings. CEMIG is using the same ESCO business model in its EE work in the industrial sector.

Table 5: TRACE Recommendations for Belo Horizonte

Blue=<1year; Black 1-2 years; Orange – >2 years

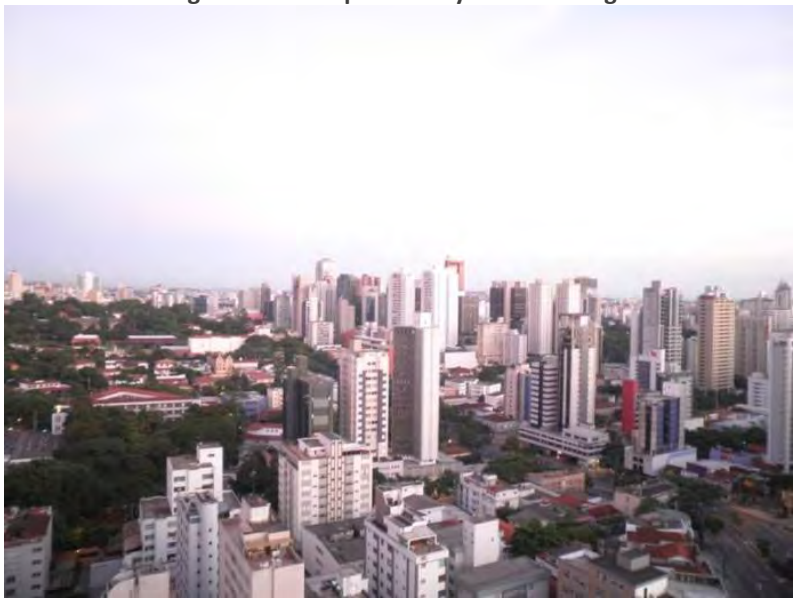
		First Cost (US$)		
		>1,000,000	100,000 - 1,000,000	<100,000
Energy Saving Potential	>200,000 kWh/annum	Active leak detection and pressure management program **(PW2-Annex 8)**	Municipal offices audit and retrofit program **(B3 – See Annex 2)**	Mandatory building EE codes for new buildings **(B10)**
		Public light dimming program **(PL1 – See Annex 3)**	Traffic flow optimization**(T1-See Annex 5)**	Green building guidelines for new buildings **(B9)**
		Measuring electricity consumed in public lighting **(PL3)**	Improve performance of water system networks **(PW1)**	Fuel-efficient waste-vehicle operations **(SLW1 – See Annex 4)**
		Interconnecting Different Modes of Transportation, Plans and Projects **(T5)**	Enforcement of vehicle emission standards **(T4)**	Sectoral and motion-sensored lighting **(B7)**
	100,000 - 200,000 kWh/annum	Municipal schools audit and retrofit program **(B4-See Annex 2)**	Municipal buildings EE task force **(B1a)**	Buildings benchmarking program**(B5)**
		Non-motorized transportation modes **(T2-See Annex 6)**	Waste infrastructure planning **(SLW3)**	
			Waste composting program **(SLW4)**	
			EE municipal task force **(B1b)**	Installing efficient lighting**(B6)**
			EE strategy and action plan **(B2 – See Annex 1)**	Parking restraint measures**(T3-See Annex 7)**
			Capital investment planning **(GEN1)**	
			Purchasing and servicing contracts **(GEN2)**	
			Energy performance contracting **(GEN3)**	
			Awareness raising campaign **(GEN4)**	
	<100,000 kWh/annum		Educational measures **(PW4)**	Computer power-save project **(B8)**
				Waste collection vehicle fleet maintenance audit and retrofit program **(SLW2)**
				Water-efficient pumps and fixtures **(PW3)** Street lights audit program**(PL4)** Public spaces lighting audit program**(PL2)**

KEY: **B**=Buildings; **GEN**=General;**PL**=Public Lighting; **PW**=Portable Water; **T**=Transport; **SLW**=Solid Waste

Citywide building programs

Beyond municipal buildings, the building EE programs can be extended to all city buildings (Figure 37)

Figure 37: Examples of Citywide Buildings



Source: TRACE Team, World Bank

The City has recently launched the Sustainable Buildings Certification Program as part of the Brazil 2014 FIFA World Cup sustainable programs. The program is four-dimensional, focusing on measures that reduce water and energy consumption, air emissions, and solid waste generation. Medals are awarded to organizations that perform well in these dimensions (Figure 38). With increased support, this program will encourage sustainable construction in the City, reduce GHG emissions and improve air quality.

Figure 38: Medals for the Sustainable Buildings Initiative

Source: Belo Horizonte Municipality

In addition to the medals, Belo Horizonte could also provide *Green Guidelines for Energy Efficient Buildings* **(B9)** to all new construction in the city as an extension of the sustainable buildings initiative. The guidelines could be voluntary, involve minimal standards or offer incentives to building developers. This program would advance the quality of building design and construction; promote EE for all buildings to save money, water and energy. If the sociopolitical environment allows, the program can be strengthened into a *Mandatory Building Energy Efficiency Codes for New Buildings* **(B10)**. This would apply to all entities applying for permission to build in the city.

Public Lighting

Public lighting has the second largest EE potential of all areas under control of the municipality. Belo Horizonte has already replaced all mercury public lights with sodium vapor lamps, replaced traffic lights with LED lights, and tested the effectiveness of LED street lights in the city. To harness the diagnosed opportunity, the team recommends using an open ESCO tender to investigate innovative ways to reduce public lighting energy consumption. The ESCO would explore the implementation of a light dimming program, and measurement of the electricity consumed in public lighting among other options. ESCOs can ben an effective way of promoting EE investments in public lighting. They can provide a “one stop window” solution to the city so that the city can effectively outsource the project from energy audit to development through implementation and monitoring. In some cases the ESCO are also able to arrange or facilitate financing for the project.

Public lighting dimming program (PL1 - see Annex 3)

Belo Horizonte already has fairly efficient public lighting lamps. However, the lights are on all night at the same level of intensity. Demand for street lighting varies significantly during the night; hence, there are opportunities to strategically dim the lights when demand is minimal--as was done in Oslo in Norway, and Kirklees in the UK. Implementing this recommendation would be preceded by a *Public Spaces Lighting Audit Program***(PL2)** which will assess the effectiveness of the program in different public spaces in light of the local conditions. For example, public lighting provides a sense of safety and security. Dimming would be done strategically:

- The public lights would be dimmed to the national standard (ABNT5101) since the current light levels in Belo Horizonte are above the national standard.
- The change in the amount of light will barely be visible to the naked eye as the dimming is done gradually at specific hours.

The public lighting dimming program would reduce energy consumption without affecting the perception of safety in the city. To make the program more effective, the municipality could explore the applicability of the program in different parts of the city. The lights in selected parts would be dimmed when there are few people on the streets (e.g. between 3am and 6am).

Measuring electricity consumed in public lighting (PL3)

There currently is no consumption-based billing in public lighting in Belo Horizonte. Measuring electricity consumed in public lighting in Belo Horizonte is inherently challenging because both buildings and public lights share the same electricity distribution cables. As a result, a *Street Lights Audit Program (PL4)* would be necessary to assess the costs and benefits of the program in the context of the current infrastructure. Measuring the amount of electricity consumed in public lighting would better align the incentives in the sector. Since the current contract pays CEMIG based on the number of hours that the lights are *supposedly* on, knowing the actual consumption would benefit the City of Belo Horizonte. The TRACE team observed variation in the time that street lights were on, and having that reflected in payments would benefit the City.

Solid Waste

Optimization of waste collection trucks flow and operations

The amount of money spent on energy in SLU's facilities is limited. However, the municipality spends 10 times more on energy used to transport solid waste to landfills than on energy consumed around therest of SLU facilities. Thus *Fuel Efficient Waste Vehicle Operations* **(SLW1 - see Annex 4)** would save the city a significant amount of resources. Operational improvements such as work practices of waste collection vehicles and their crews, and better management and planning can reduce fuel use per ton of waste collected and transported. Additional benefits include better productivity leading to increased vehicle payloads and reduced number of heavy commercial vehicles in residential areas, and release of resources to collect more waste from *favelas.* The benefits would immediately apply to the 45 trucks owned by SLU. Since the remaining trucks are privately owned and operated under concession, SLU could include the expected improvements into the next round of contract negotiations. The contracts are renewed every two years; therefore improvements can spread through the vehicle fleet fairly quickly.

Improving vehicle operations can be combined with *Waste Vehicle Fleet Maintenance Audit and Retrofit Program* **(SLW2).** Given the concession structure of the current fleet, SLU could implement this program by setting targets for improved fuel efficiency as some of the conditions for contract renewal. A well-maintained fleet is directly linked to better fuel economy of waste collection vehicles.

Waste Infrastructure planning (SLW3)

Belo Horizonte could also implement *Waste Infrastructure Planning*. While the infrastructure for regular solid waste treatment is sound, the recycling infrastructure can be improved since the cooperatives have limited capacity. To implement this recommendation, the city would need to assess current waste infrastructure energy use in detail, and then identify opportunities in waste treatment infrastructure such as building additional warehouses. The auditing program for monitoring and collection of data would enable the city to be more efficient and effective, which can enable the city to treat more waste and more waste types. Thus, the city could improve the percentage of recycled waste from the current 7 percent.

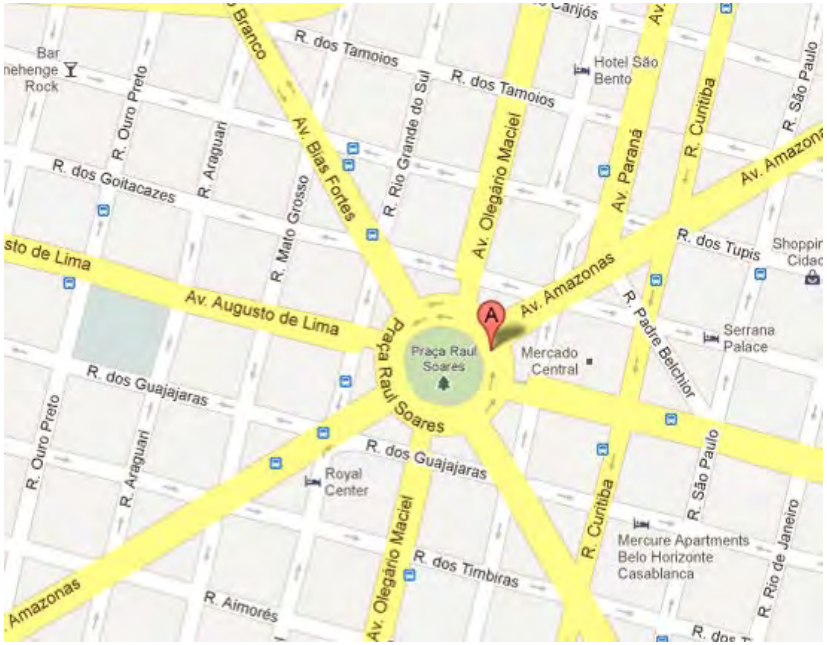
Improved composting

*A Waste Composting Program***(SLW4**) would reduce energy consumption as the organic waste does not have to be taken to the central processing center in Sabara. Composting can be done with minimal infrastructure; hence, energy savings could be accomplished using limited resources. Additionally, the waste composting program would reduce pressure on the Sabara landfill, and has the potential to generate revenues if the compost is sold to farmers.

Transport - Private Cars

Traffic Flow Optimization **(T1-see Annex 5)** would greatly improve the flow of traffic through the city, particularly around Praça Raul Soares (Figure 40).

Figure 39: Praca Raul Soares - the intersection of 8 roads at the city center

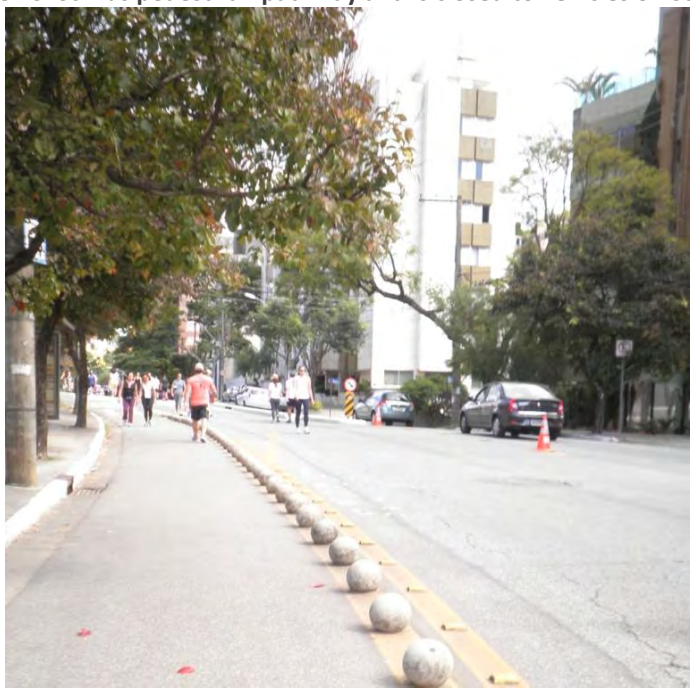


Source: Google Maps

With a GDP per capita around US$ 10,000, motorization in Belo Horizonte is only going to increase as people get wealthier, and the culture favorably views car ownership. The optimization would reduce journey length, time and fuel consumption. For instance, TECTRAN Group conducted traffic optimization studies for Belo Horizonte and found that fuel consumption could be decreased by 23 percent and CO_2 emissions by 41 percent if the traffic flow around Praça Raul Soares was optimized. The optimization could be accomplished by optimizing traffic signals, changing the direction of traffic flow in some streets or providing real time information (about traffic jams, accidents, parking etc) to drivers through AM radio channels and billboards.

*Improving Non-motorized Transportation***(T2 - see Annex 6)** is another recommendation which could result in energy savings for the City. Belo Horizonte could increase pedestrian pathways in the streets as exemplified by Bandeirantes Avenue (**Figure 41**) and Prudente de Morais Avenue, both in the southern part of the city.

Figure 40: St. has pedestrian pathway and is closed to vehicles on Sunday



Source: TRACE Team, World Bank

The City has been promoting biking, and has plans to further develop bike pathways. This development program could be complimented by bike rental programs, as many cities around the world have done. Such programs are inexpensive and they tend to reduce energy consumption and traffic congestion. They also improve the health of the users, reduce noise pollution and improve air quality.

Improving parking or creating parking restraint measures **(T3 - see Annex 7)** is fundamental to sustainable transportation in Belo Horizonte. Proper parking planning would remove vehicles clogging some streets, especially in newly developed areas, and thus improve the traffic flow. Parking fees could be planned such that it is more expensive to park in the city center, and it gets cheaper as one drives towards the outskirts of the city. Additionally, it would be critical to create park and ride infrastructure which feeds into the extensive BRT system that the City is developing. The City of Oxford in the UK provides a very good example of a good park and ride system. People drive from far outside the city, and park their private cars outside the main ring road, and take the public buses into the city.

Enforcing Vehicle Emission Standards **(T4)** would improve vehicle efficiency which reduces fuel consumption, air pollutants, and cases of lung disease. This can most easily be done by requiring annual checks of vehicles and could save the city significant energy per year. The program would compliment Operation Oxygen which is focused on diesel vehicles. The Inspection Program in Mexico provides a case study for Latin America. Drivers are required to display a sticker indicating that their vehicle passes inspection or incur a fine.

Transport - Public Transportation

The city has substantial plans and investments underway in the transport sector as discussed in the diagnostics section. However, the investments are not fully integrated and traffic jams have been increasing in size and duration. The key TRACE recommendation is to *Interconnect the Different Modes of Transportation, Plans and Projects***(T5).**

Figure 41: Planned Station Pampulha

Source: BHTRANS

Deeper analysis is required to find the best ways to integrate the different modes of transportation. For instance, there is minimal public parking, and where the parking is available, more could be done to support multi-modal transportation. While there are plans to build a station which combines BRTs along Antônio Carlos and Pedro I Avenues at Pampulha Station (**Figure 42**) *(Estação Pampulha),* plans to integrate private car passengers through measures such as park-and-rides are not clear. In addition, the subway could be better integrated.

Potable Water

As mentioned in the diagnostics section, Belo Horizonte is located on high ground and does not have native sources of drinking water. Thus, potable water is pumped from long distances, and has to be pumped up several hills before it reaches the final consumers. COPASA could initiate an *Improve Performance of System Networks program***(PW1).** This general program seeks to indentify improvement opportunities in the entire system. Studies might recommend improving sections of the network in order to reduce the risk of burst pipes and leakages.

Given that pumping consumes a significant amount of energy, and that COPASA has a 33 percent non-revenue water, the City could save a significant amount of energy and resources by instituting *Active Leak Detection and Pressure Management Program* **(PW2 - see Annex 8)**. The system could help quickly detect leakages or points of water theft unlike the current system which relies on human reporting of water leakages. The system could be achieved using ground microphones, digital leak noise correlators or other technologies available on the market. Pressure management has the added benefit of reducing treatment and pumping costs. However, it is more appropriate where the network is passive while active leak detection is more universal. Depending on the preference of the municipality, the system could be financed from the city budget or through a build-own-operate-transfer mechanism.

The city could also promote the use of *Water Efficient Fixtures and Fittings* **(PW3)** through *Educational Measures* **(PW4).** For instance, residents could be encouraged to use low flow taps and showers. Low flow showers would also reduce the energy consumed without significantly impacting the showering experience. Alternatively, low flow fittings could be required as part of the construction permitting process as was done in India, or the municipality could provide incentives for people to switch to low flow showers.

The educational measures could be in the form of more informative bills, promotional leaflets sent with monthly bills, advertisements, and information on company websites etc.

General Recommendations

There are general TRACE recommendations which apply to all sectors in addition to the sector-specific recommendations discussed above. The *Capital Investment Planning***(GEN1)** recommendation encourages the City to incorporate EE considerations at the planning stage of developing infrastructure projects. This avoids having to go back to the drawing board in order to retrofit EE measures. Additionally, big EE infrastructure projects should be mainstreamed in City development plans.

Procurement offers a significant opportunity to improve EE across all sectors of the City. *Energy Efficient Purchasing and Servicing Contracts* **(GEN2)**encourages the city to procure energy efficient products, and to use EE as one of the criteria for awarding contracts. This promotes economic growth by reducing the amount of wasted energy, reducing energy costs, and allowing the municipality to influence areas where it would not otherwise have influence. For example, contractors to the City would need to consider their own efficiency as part of the bidding process.

Energy Performance Contracting **(GEN3)** allows the city to get into performance contracts with Energy Service Companies (ESCOs) as a way of financing some EE measures. Belo Horizonte would need to provide the baseline energy performance figures, and contractors would determine the energy savings that they can guarantee. Under a Guaranteed Savings Contract, the city would bear the initial cost of implementing the measures, and the cost is repaid from the energy savings. Under a Shared Savings Contract, the ESCO bears the initial costs of implementing the project, and the ESCO would receive a share of the savings.

Finally, an *Awareness Raising Campaign* **(GEN4)** for the citizens generally helps to improve EE citywide. This can help change attitudes towards EE.

Public EE awareness can be raised through advertizing campaigns, public events, articles in local periodicals, websites, EE champion programs, and/or training programs in schools, community centers and businesses.

Action Plan

The next step in the process is to develop an action plan for implementing these EE recommendations. There are several ways to develop action plans. Given that Belo Horizonte has included some of these recommendations in its 2030 plan, and that it is going through strong economic growth, one might find prioritizing the recommendations starting with low cost but high impact recommendations as prudent. For instance, *creating a centralized unit with statutory authority and a mandate including implementing EE measures (B1)* is initially a question of realigning the reporting structure in the municipality, and providing statutory authority and resources to the new organization. While implementing this recommendation, the City could be conducting analytical work such as the *Public Space Lighting Program Audit Program (PL2)*. These measures could be combined with recommendations which are politically visible because they can create momentum behind the EE programs. For instance, *Traffic Flow Optimization (T1)* is relatively low in cost, and would be highly visible as traffic around Praça Raul Soares improves. Table 6 lists recommendations which can be considered in this category as they can be done in less than a year.

Table 6: List of Recommendations which can be Done in Less than a Year

EE municipal task force **(B1b)**
EE strategy and action plan **(B2 – See Annex 1)**
Traffic flow optimization **(T1-See Annex 5)**
Purchasing and servicing contracts **(GEN2)**
Energy performance contracting **(GEN3)**
Awareness raising campaign **(GEN4)**
Educational measures **(PW4)**
Street lights audit program **(PL4)**
Public spaces lighting audit program **(PL2)**
Computer power-save project **(B8)**
Installing efficient lighting **(B6)**
Green building guidelines for new buildings **(B9)**

Medium term (implementation in 1 to 2 years) recommendations would result in significant servings as well, and their implementation is less convoluted once resources have been identified. For instance, *Sectoral and motion-sensored lighting **(B7)***results in significant energy savings and yet does not require extensive politically-charged stakeholder consultations to begin implementation. The implementation could begin once the technical studies are done. Table 7 lists some of the recommendations which can be considered in this category.

Table 7: List of Recommendations which can be Done in One to Two Years

Improve performance of water system networks **(PW1)**
Municipal buildings EE task force **(B1a)**
Waste composting program **(SLW4)**
Sectoral and motion-sensored lighting **(B7)**
Waste collection vehicle fleet maintenance audit and retrofit program **(SLW2)**
Water-efficient pumps and fixtures **(PW3)**
Capital investment planning **(GEN1)**
Parking restraint measures **(T3-See Annex 7)**
Buildings benchmarking program **(B5)**
Fuel-efficient waste-vehicle operations **(SLW1 – See Annex 4)**

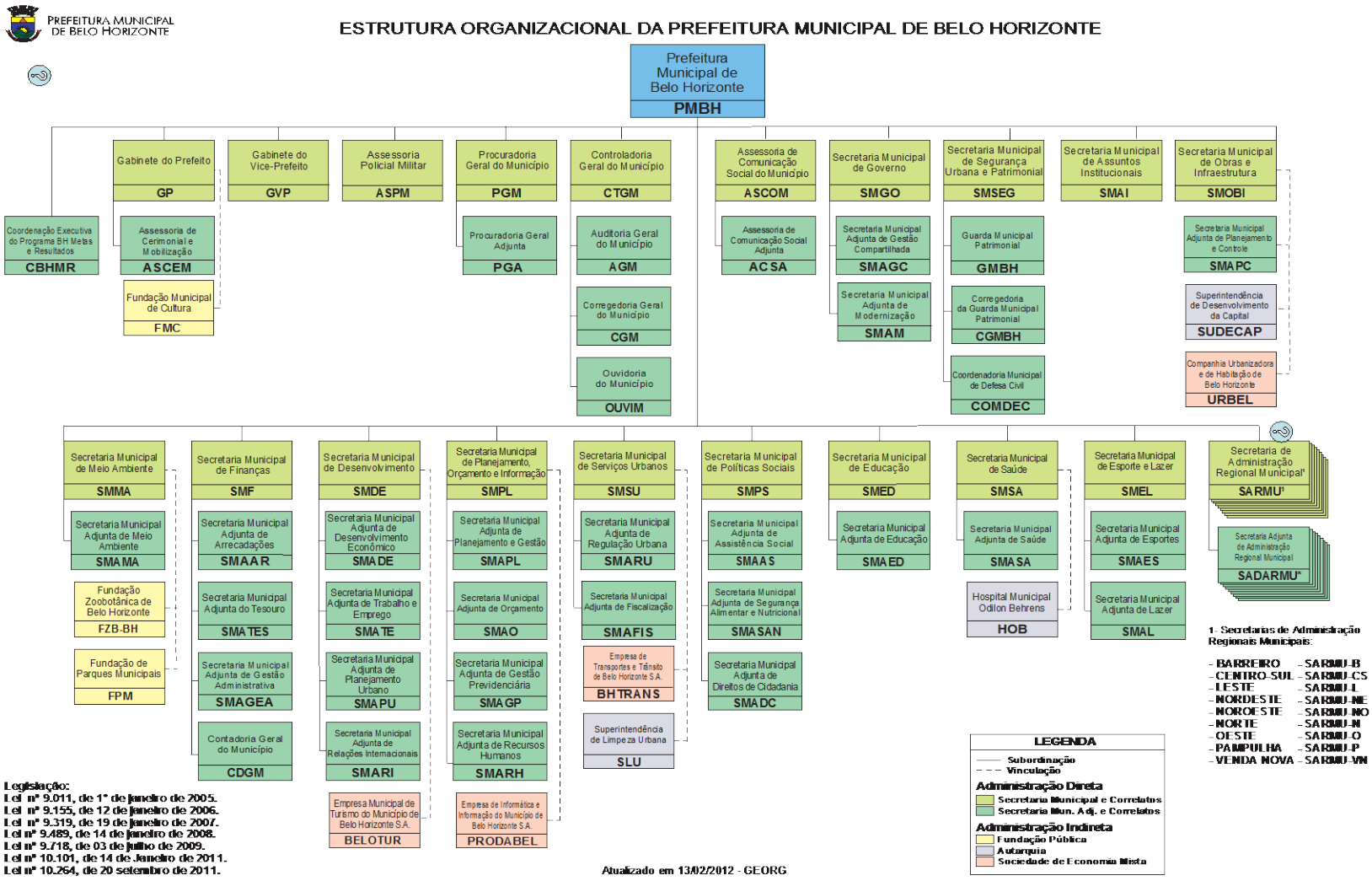
Long-term (begin implementation in more than 24 months) recommendations are slightly more expensive but result in significant improvement in EE. They require significant preparatory analytical studies before implementation can begin. For example, Belo Horizonte would need to conduct a *Public Spaces Lighting Audit Program* (PL2) before implementing the *Public Lighting Dimming Program* (PL1). Active leak detection and pressure management program is quite expensive hence it would be good to analyze the point at which the marginal cost of installing the system is equal to the marginal benefit from the water no longer lost. Table 8 lists recommendations which can be considered in this category.

Table 8 List of Recommendations which can be Done in Over 2 Years

Municipal offices audit and retrofit program **(B3 – See Annex 2)**
Active leak detection and pressure management program **(PW2-Annex 8)**
Public light dimming program **(PL1 – See Annex 3)**
Measuring electricity consumed in public lighting **(PL3)**
Waste infrastructure planning **(SLW3)**
Enforcement of vehicle emission standards **(T4)**
Municipal schools audit and retrofit program **(B4-See Annex 2)**
Non-motorized transportation modes **(T2-See Annex 6)**
Interconnecting Different Modes of Transportation, Plans and Projects **(T5)**
Mandatory building EE codes for new buildings **(B10)**

This schematic discussion is only an example. The actual action plan would need to consider resources and the socio-political context on the ground. The TRACE team highly recommends that the City identify an organization or committee to create an action plan. Successful teams often have political support from the Mayor, represent key sectors identified in the report, have the prerequisite resources and are likely to lead the implementation of the plan.

Annex A: Organizational Structure of the Municipality



Source: Municipality of Belo Horizonte

Annex B: Tool for Rapid Assessement of City Energy (TRACE)

TRACE is a decision-support tool designed to help cities quickly identify energy efficiency (EE) opportunities. The tool was developed by the Energy Sector Management Assistance Program (ESMAP). It includes an energy benchmarking module that compares a city with peer cities, a sector prioritization module that ranks the sectors with the greatest energy efficiency potential, and a recommendations module which provides specific energy efficiency interventions. It has been used (or is being used) in cities in 20 countries in Europe, Asia, Latin America and Africa.

TRACE's benchmarking module relies on 28 knowledge performance indicators (KPIs) covering six sectors: Power and Heat, Transport, Public Lighting, Water and Wastewater, and Solid Waste as shown below:

Figure 42: TRACE Key Performance Indicators

CITY WIDE KPIS

CW-1	Electricity consumption (kWhe/capita)
CW-2	Electricity consumption (kWhe/GDP)
CW-3	Primary energy consumption (MJ/capita)
CW-4	Primary energy consumption (MJ/GDP)

TRANSPORTATION KPIS

T-1	Total transport (MJ/capita)
T-2	Public transport (MJ/passenger km)
T-3	Private transport (MJ/passenger km)
T-4	Transportation Non-Motorized mode split (%)
T-5	Public Transportation mode split (%)
T-6	Kilometers of high capacity transit per 1000 people

BUILDINGS KPIS

B-1	Municipal buildings (kWhe/m2)
B-2	Municipal buildings heat consumption (kWhth/m2)
B-3	Municipal buildings energy spend as percentage of municipal budget

POWER & HEAT KPIS

PH-1	Percentage heat loss from network
PH-2	Percentage total T & D losses
PH-3	Percentage of T & D loss due to non-technical

STREET LIGHTING KPIS

SL-1	Electricity consumed per km of lit roads (kWhe/km)
SL-2	Percentage of city roads lit
SL-3	Electricity consumed per light pole (kWh/pole)

WATER & WASTEWATER KPIS

WW-1	Water consumption (L/capita/day)
WW-2	Energy density of potable water production (kWhe/m3)
WW-3	Energy density of wastewater treatment (kWhe/m3)
WW-4	Percentage of non-revenue water
WW-5	Electricity cost for water treatment (potable- and wastewater) as a percentage of the total water utility expenditures

WASTE KPIS

W-1	Waste per capita (kg/capita)
W-2	Percentage capture rate of solid waste
W-3	Percentage of solid waste recycled
W-4	Percentage of solid waste that goes to landfill

The tool contains such KPI data for 93 cities from all over the world. Such KPI data is gathered for the target city during the first stage of the TRACE process. The results are then compared against the 93 cities or a subset of the cities. The subset of cities can be chosen based on city population, human development index or climate. TRACE also allows the user to select any subset of cities which is suitable for their analyses. Typical results from the benchmarking process are shown in Figure 44.

Figure 43: Typical TRACE benchmarking result

Key: QUE=Quezon City; GAZ=Gaziantep; NYC=New York City; CAP=Capetown; KAN=Kanpur; KAT=Kathmandu; SKO=Skopje; CEB=Cebu; JAB=Jabulpur; BHO=Bhopal; MYS=Mysore; DAN=Danang; SUR=Surabaya; VIJ=Vijaywada; PUN=Pune; POK=Pokhara

After benchmarking, TRACE ranks the sectors according to their energy efficiency potential. The ranking is divided into City Authority Sector Ranking and City Wide Sector Ranking. The former roughly corresponds to sectors where the municipality pays the energy bill, and the later roughly refers to sectors where both residents and the city authority pay the energy bill. The ranking is a composite of the Energy Expenditure, Relative Energy Intensity, and Level of Local Control. The energy expenditure in the sector is a sum of money spent on energy. The Relative Energy Intensity is the potential improvement in the given sector of the target city. It is calculated using the average of cities performing better than the city. For example, if the average expenditure on public lighting for cities performing better than the city is 61 units, and the city itself spends 100 units, then its relative energy intensity is (100-61)/100 = 39 percent. The level of local control ranges from zero, where the city authority has very limited control, to one, where the municipality has full control, such as in the municipal buildings sector. Three technical issues deserve clarification in order to better understand this sector ranking. Since the energy consumption data came from the city departments, the values are relatively steady. The relative energy intensity partly depends on the number of cities performing better than the target city. The largest number of cities comparable to the city in each benchmark is typically used in order to be consistent. The level of control is a guided estimate from the city departments. Thus, the ranking is a good mix of technical analysis and consultations with city officials.

The next and final module in TRACE is the energy efficiency recommendations module. The recommendations are based on tried and tested energy efficiency recommendations. These tried and tested recommendations are filtered to be specific to the city. The filtering process has two parts: (1) the scoring of city capabilities in each subsector on ***Finance, Human Resources, Data and Information, Policy Regulation and Enforcement, Assets and Infrastructure*** scale using high, medium and low scores. This done with the help of city officials during mission and the categories are clearly defined. (2) Matching the city capabilities with the default recommendation scores on the same scale. If city capabilities exceed the recommendation scores, the city is encouraged to implement the recommendation; otherwise the city is not encouraged to implement the recommendation. Each recommendation is characterized by its energy savings, first implementation cost and implementation time based on international experience. During the meeting with heads of each of the six sectors, the cost, energy saved and implementation time assumptions are reviewed in order to make sure that they make sense in the country context.

Typical TRACE implementation does not include detailed cost and benefit analysis for each recommendation. However, resources in the form of Excel spreadsheets are provided, and these allow user to conduct detailed cost and benefit analysis. Additionally, TRACE does not cover the residential and industrial sectors of the city. This was done to focus on areas where the city authority has substantial influence.

The TRACE Process

The TRACE process is typically a three-month process as shown below.

Data Collection Phase		TRACE Implementation				City Report
Preparation for mission – gathering data	City energy use benchmarking	TRACE introduction / sector Meetings	Assess most promising sectors	Review recommendations in priority sectors	Prepare final recommendations	Prepare final city report
6 weeks		4 days	1 day	4 days	1 day	4 weeks

A TRACE team gathers KPI data for the target city during the Data Collection Phase which typically lasts for 6 weeks. During TRACE Implementation, the team will be on the ground in the target city meeting leaders of the different sectors, finalizing the data collection, finalizing the recommendations and getting client buy-in. The final stage is the report preparation phase. Writing the report typically takes 4 weeks, after which it goes through World Bank and target City quality check processes.

Improving Energy Efficiency in Belo Horizonte Brazil

Annexes

TRACE City Energy Efficiency Assessment Report


Municipal Buildings


Water and Wastewater


Solid Waste Management


Public Transport


Public Lighting


Power and Heat

THE WORLD BANK

ESMAP

TRACE

PREFEITURA BELO HORIZONTE

Annexes

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Annex 1: Energy Efficiency Strategy and Action Plan Description

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

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

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

Implementation options

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

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

Monitoring

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

validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.
Some suggested measures that relate specifically to this recommendation are as follows:

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

Municipal Initiatives to address Climate Change, Bridgeport, Connecticut, USA
Connecticut General Assembly "Municipal Initiatives to address Climate Change" http://www.cga.ct.gov/2010/rpt/2010-R-0300.htm
Regional Plan Association, Copy of Mayor's Executive Order http://www.rpa.org/bgreen/BGreen_2020_Executive_Order.pdf
Regional Plan Association "BGreen 2020: A Sustainability Plan for Bridgeport, Connecticut" http://www.rpa.org/bgreen/BGreen-2020.pdf
In 2008, the mayor issued an executive order that established a goal for the city government to reduce its annual GHG emissions from a 1990 baseline by 7% by 2012 and 20% by 2020, in accordance with the city's Plan of Conservation and Development. In order to meet this goal, the executive order required the city to obtain at least 25% of its electricity from renewable resources by 2012 and for all new major city construction and major renovation projects to earn at least a silver rating under the Leadership in Energy and Environmental Design (LEED) program, or its equivalent under similar rating systems.
The order established a Sustainability Community Advisory Committee, which is charged with:

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

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

- percentage of energy efficiency initiatives for which data is collected every year

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

Energy Efficiency Strategy, Spain

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

Energy and resource saving program, Brisbane, Australia

Good Practices in City Energy Efficiency: Eco^2 Cities: Energy and Resource Saving Program in Brisbane, available online
http://www.esmap.org/esmap/node/1225
Brisbane's population is expected to continue to grow over the next two decades. In 2007, the Brisbane City Council issued Brisbane's Plan for Action on Climate Change and Energy, which delineates the selected actions to be achieved in the short term (about 18 months) and the long term (more than five years). Brisbane has three major challenges: climate change, high peak oil demand, and greenhouse gas emissions. Analyses suggest that, if Brisbane responds intelligently to these challenges, the city may generate significant economic benefits by developing sustainable industries, while saving resources. Brisbane is actively introducing various approaches to sustainable development. In addition, in the city's "Our Shared Vision: Living in Brisbane 2026" policy document, authorities have committed to cutting greenhouse gas emissions in half, reusing all wastewater, and restoring 40 percent of the natural habitat by 2026.

Integrated resource planning and management, Stockholm, Sweden

Good Practices in City Energy Efficiency: Eco^2 Cities - Integrated Resource Management in Stockholm, available online
http://www.esmap.org/esmap/node/1228
The City of Stockholm, the capital of Sweden, has pursued integrated city planning and management to become a sustainable city. The city has a comprehensive urban vision, environmental programs, and concrete action plans to reduce greenhouse gas emissions and tackle climate change. It implements integrated urban planning approaches that consider ecological benefits and efficient resource use.
The ongoing redevelopment in the city's southern district, Hammarby Sjöstad, is a good model for understanding integrated approaches to sustainable urban planning and redevelopment. The area aims to be twice as sustainable as Swedish best practice in 1995. The area implements integrated resource management (waste, energy, water, and sewage) through systematic stakeholder collaboration and has transformed the linear urban metabolism into a cyclical one known as the Hammarby Model.
According to Grontmij AB, a private consultancy firm in Stockholm, primary assessments of the initially developed districts of Hammarby Sjöstad show that the area has achieved, for example, 28 to 42 percent reductions in nonrenewable energy use and 29 to 37 percent reductions in global warming potential.

Annex 2: Municipal Buildings Audit and Retrofit Program

Description

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

Implementation Options

Implementation Activity	Methodology
Identify Offices Program Leader	Identify a CA staff position or hire a new position to be responsible for execution and delivery of energy efficiency projects in municipal office buildings. This individual must be able to work across agencies, understand building systems and manage subcontractors.
Identify Preliminary Opportunities	Using results from the Benchmarking Program or data collected on office buildings by Office Program staff, identify preliminary opportunities for energy efficiency such as: new lighting systems, new air conditioning systems, new heating systems, new computers, server cooling opportunities, etc. Offices buildings can be more complex buildings and can have a high variety of system types, for example some may have simple window A/C (or no A/C) and others may have larger central A/C systems with chillers, cooling towers, air handlers and ductwork.
Perform Detailed Energy Audits	Walk through a variety of office buildings to identify specific energy efficiency opportunities across the following end-uses and activities: • lighting systems • air conditioning systems • heating systems • computers • server rooms and cooling of servers • appliances (water cooler, fridge, vending machines) The Municipal Offices EE Spreadsheet includes estimation methods for energy efficiency potential for offices which includes equipment retrofits, behavioural changes (turning lights off, heating set points, time of operation, etc.) and procurement guidelines.
Set Budget and	Allocate budgets for energy efficiency upgrades in municipal office buildings. Combining

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

Requirements	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
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 3: Lighting Dimming Program

Description

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

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

Implementation Options

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

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

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.

Annex 4: Fuel Efficient Waste Vehicle Operations

Description

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

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

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

Indirect benefits include reduced accident rates and lower air emissions.

Implementation options

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

Attributes

Energy Savings Potential
>200,000 kWh/annum

First Cost
< US$100,000

Speed of Implementation
< 1 year

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

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

Monitoring

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

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

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

Measure current performance utilising data from Maintenance Department, where feasible. If this information is not readily available, it is advisable to measure current fleet performance over a reasonable period, for example, annual reviews over 5 years.
Produce monthly management targets and schedules to help identify how the program is performing and the magnitude of effort that will be required to achieve initially set KPI.

Case Studies

Energy Study on Oeiras' Municipal Fleet, Oeiras, Portugal
ManagEnergy 2010 "Good Practice Case Study: Energy Study on Oeiras' Municipal Fleet, Portugal" http://www.managenergy.net/download/nr263.pdf
The Municipality of Oeiras (CMO) worked in partnership with the Technical University of Lisbon (IST) on a project to carry out a review of the current performance of the municipal fleet, which included waste collection trucks. The objectives were to assess the fuel consumption by vehicle type, establish performance indicators (km/L), propose simple measures to improve efficiency (eco-driving training), study the potential of implementing alternative fuels (biodiesel and natural gas), and perform an environmental assessment. In the absence of complete data, the project used refuelling data and mileage records to estimate the total fuel consumption of waste collection trucks and its impact on the municipality's budget. A more advanced fleet management system was planned for the later phases, utilising technologies supported by GPS to allow for better control over fleet operations and improve the data available. The total project costs amounted to US$ 45,384, fully supported by the Municipality.
By the end of 2006, the project allowed OEINERGE (the project coordinator) to estimate that simply by processing the existing used frying oils in the County into biodiesel and using it to fuel some of the fleet's waste trucks, a reduction of approximately 10% in fossil fuel consumption could be achieved. In addition to allowing the municipality to understand the full functionality of the waste vehicle fleet and helping identify the potential problems in its management, the project has an important role for best practice dissemination, emphasising the importance of accurate data recording and monitoring to introduce fuel and cost savings.

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

MasterMap Integrated Transport Study, Daventry, United Kingdom
Ordinance Survey 2010 "Optimising waste collection using OS MasterMap Integrated Transport Network Layer Case study"

http://www.ordnancesurvey.co.uk/oswebsite/products/osmastermap/layers/Docs/DAVENTRY.pdf

Daventry local authority worked with the Northamptonshire Waste Partnership (NWP) to rationalise the number of domestic waste collection routes from nine to eight, reducing diesel costs by 12% and increasing spare capacity by 14% without increasing labour hours. The project was carried out by an external environmental advisory and management company using the OS MasterMap Integrated Transport Network (ITN) Layer with Road Routing Information (RRI) - which includes detailed road routing and drive information such as width, height and weight restrictions, taking account of delays from left and right turns and intersections. This allowed each waste vehicle route to be optimised by balancing the workload between routes on a daily or on a weekly basis.

The system enabled optimisation of existing waste collection procedures, resulting in increased spare capacity which could be retained for areas of new housing growth, in turn reducing the need for new routes. The project produced savings of over US$ 154,136 per annum for Daventry alone (not including savings by neighbouring local authorities). Since the project was funded by procuring regional public funds, the overall savings are identified to be greatly in excess of the sum of the contract value and authority time.

Eco-Driving Project, Maribor, Slovenia

Recodrive 2009 Press Release, "Eco-driving leads to fuel savings in waste management in Maribor, Slovenia" http://www.recodrive.eu/index.phtml?id=1039&study_id=2596

Maribor's public waste collection, management and transport company (Snaga) conducted a comprehensive 3 month training programme for drivers to implement and test eco-driving. Carried out as part of the EU-wide "Rewarding and Recognition schemes for Energy Conserving Driving, Vehicle procurement and maintenance" (RECODRIVE) project, the programme achieved an average 4.27% reduction in fuel consumption over 8 months. The savings in fuel costs were used to provide wage bonuses to fuel-efficient drivers. In addition, by making additional changes in their optimised routing plan, Snaga is able to collect the same amount of waste in the same area using one less vehicle.

The RECODRIVE project also constitutes information dissemination to achieve fuel savings beyond 10% in municipal fleets across Europe. Participating fleet owners further the RECODRIVE concept by inviting other fleet owners to hands-on workshops and conferences on eco-driving and fuel-efficient vehicle operations. Despite being an EU-wide scheme, RECODRIVE's knowledge hub (internet-based information dissemination) could be applied on a city-wide scale to achieve fuel efficient-operations amongst municipal waste management operators.

Garbage Collection Efficiency Project, General Santos City, Philippines

USAID "Introducing Measures To Improve Garbage Collection Efficiency" http://pdf.usaid.gov/pdf_docs/PNADB349.pdf

USAID "Moving Towards an Integrated Approach to Solid Waste Management" http://pdf.usaid.gov/pdf_docs/PNADB344.pdf

General Santos City Solid Waste Management Council organised a series of hands-on workshops to formulate ways of improving efficiency of the current collection system and management of dumpsite operations. Formerly, waste collection was concentrated only in the CBD with no regular routing or collection schedule. With the help of various stakeholders, the city formulated new collection schedules and routes and identified pre- and post-collection intervention strategies for the community. Routes were modified to reduce the number of left turns and U-turns taken by the trucks to increase speed of collection and reduce accidents. The number of staff per compactor truck was reduced from five to a maximum of three people, and waste collection trips were reduced from six trips to two-three trips per day. The enhanced collection efficiency allowed coverage of a wider area without increasing the number of trips, accelerated waste collection and provided more time for vehicle maintenance and crew rest. High levels of community representation and coordination of working groups were key to producing more efficient solutions to the current collection system.

The above improvements were complemented by simultaneous campaigns for segregation and recycling. The city government also improved management of the dumpsite while a new landfill is being prepared.

Isseane EfW and Materials Recycling Facility, Paris, France The Chartered Institution of Waste Management "Delivering key waste management infrastructure: lessons learned from Europe" http://www.wasteawareness.org/mediastore/FILES/12134.pdf The Associate Parliamentary Sustainable Research Group, "Waste Management Infrastructure: Incentivising Community Buy-in" http://www.policyconnect.org.uk In 2008, the Isseane EfW (Energy from Waste) and Materials Recycling Facility was opened on the banks of the Seine by SYCTOM (Intercommunal Syndicate for Treatment of Municipal Waste) to replace an existing incinerator that had been in operation for over 40 years. The project was approved by the municipal council of Issy-les-Moulineaux in July 2000 with a total investment cost of US$ 686 million, which will be financed over a seven year period by a type of prudential borrowing, based upon gate fee revenues from the communes. Isseane is conceived on a proximity principle so that waste travels no more than six miles to be treated. The design of the facility also takes traffic movements into careful consideration. Waste deliveries taking place below ground level to control dust, noise and odour levels. The location of the facility makes use of the river Seine, with barges taking away inert bottom ash from the incineration process for use in ancillary projects.
Local Authorities' Waste Management, Italy The Chartered Institution of Waste Management "Delivering key waste management infrastructure: lessons learned from Europe" http://www.wasteawareness.org/mediastore/FILES/12134.pdf Waste services in Italy are delivered through public bodies known as 'ATOs' which are funded directly by local authorities, responsible for defining the services required to manage local authority waste streams. New waste management infrastructure is often funded directly from the local authorities' own resources, although for large facilities there may also be some private finance, in effect through a form of prudential borrowing. In some cases waste facilities or services may be procured through a tendering process from private sector waste management companies, with contracts in place either directly with a local authority or the relevant ATO. An ATO can also fund a waste infrastructure project either in part or completely, through the use of eco-taxes. The CONAI scheme, for example, raises US$ 324million annually from an eco-tax on all packaging that sets aside funds for new waste infrastructure.

Tools & Guidance

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

Annex 5: Traffic Flow Optimization

Description

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

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

Implementation Options

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

Attributes

Energy Savings Potential
> 200,000 kWh/annum

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

Speed of Implementation
> 2 years

Co-Benefits
Reduced carbon emissions
Enhanced public health & safety

Monitoring

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

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

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

Case Studies

Arterial 'green wave' traffic flow optimisation, Portland, USA C40 Cities (2010). "Portland, USA: Optimizing traffic signal timing significantly reduces the consumption of fuel", available online from http://www.c40cities.org/bestpractices/transport/portland_traffic.jsp The City Authority optimized traffic signal timing at 135 intersections on 16 of some of Portland's most congested thoroughfares. 'Optimization' of traffic signals consists of re-timing the traffic signals to improve their synchronization across a road traffic network. The cost of an intersection synchronization varied USD 1,000-3,000. The resulting reductions in the frequency by which vehicles accelerate and decelerate, as well as the reductions in the time vehicles spend with idling engines, yielded annual fuel savings of 1,750,000 gallons of gas. This is the equivalent of removing 30,000 passenger vehicles from the road for an entire year. The city went a further step by measuring and eliminating CO2 through the purchase of carbon credits.
Variable Message Signs, Milton Keynes, UK Department for Transport (2010). "Case Study: Milton Keynes Integrated Traffic Management", available online from http://www.dft.gov.uk/itstoolkit/CaseStudies/milton-keynes-integrated-traffic-management.htm In order to achieve a more efficient usage of car parks and encourage shoppers into the central retail area of Milton Keynes, as well as reduce congestion caused by cars looking for parking, the city administration invested in Variable Message Signs which display the location and availability of parking spaces to road users. Installation costs were lowered by making use of existing ducted network in Milton Keynes used by the Police for CCTV. This created the added benefit of providing a large capacity network for future growth in data transmissions. The reduction in congestion and delays resulting from the system are estimated to save motorists and bus passengers in the central area more than GBP 3 million over a 10-year period.
High-Occupancy Vehicle lane, Madrid, Spain Monzon, A. (1999) "Managing long term congestion in HOV lanes. Effect of 2+ vs 3+ limit on the Madrid N-VI corridor", paper presented at the European Transport Conference, Cambridge, Jan 1st 1999, available online 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 6: Non-motorized Transport Modes

Description

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

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

Implementation Options

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

Attributes

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

First Cost
> US$1,000,000

Speed of Implementation
> 2 years

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

	encourage use as well as security procedures that avoid and penalise theft. Registered-user schemes require a credit card or bank details of users, but are not necessarily open to all. Non-registered user schemes are more flexible, but more open to abuse. Branding of bicycles and facilities can create revenue for local authority. See Paris case study for further details.

Monitoring

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

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

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

Case Studies

Pedestrianization with road closures, Oxford, England European Commission, Directorate General for the Environment (2004). "Reclaiming city streets for people: Chaos or quality of life?", available online from http://ec.europa.eu/environment/pubs/pdf/streets_people.pdf The main retail streets have been fully pedestrianized, while other through roads in the central area are only accessible to buses and pedestrians. The adoption of a step by step, integrated approach to the implementation of the road closure program has been seen as critical to the success of the significant road space reallocation element of the scheme. Opposition to the USD 6 million scheme was raised most notably on the basis that traffic congestion on two key routes in the city would worsen, as well as from retailers concerned about delivery access and trade levels. These concerns were attended to via an extensive consultation process and an effective publicity campaign prior to the implementation of the scheme. This included leaflets, advertisements on buses, city-wide poster boards, and a series of press releases
Dedicated cycle network, Bogota, Colombia C40 Cities (2010). "Bogota, Colombia: Bogota's CicloRuta is one of the most comprehensive cycling systems in the world", available online from http://www.c40cities.org/bestpractices/transport/bogota_cycling.jsp CicloRutas is considered a unique cycling network where design has taken the topography of the city into consideration in order to create maximum flow and function (manmade and natural features, hills, waterways, parklands, essential facilities). In a period of just 7 years, following an investment of USD 50 million, the use of bicycles on the network increased by more than 268%. CicloRutas plays an important role for lower income groups, as more than

23% of the trips made by the lowest income group in the city are by walking or by bike. The development of CicloRutas has also helped to recover public space along riverbanks and wetlands, as for many years the city's wetlands were occupied by illegal settlements.
Bicycle micro credits, Lima, Peru ICLEI (2009). "Case study 46: Assistance to purchase bicycles - Lima, Peru" in Sustainable Urban Energy Planning: A handbook for cities and towns in developing countries, available online from http://www.unhabitat.org/pmss/listItemDetails.aspx?publicationID=2839 In 1990, the Municipality of Lima set up a micro-credit programme to help low income citizens purchase bicycles. By saving on daily public transportation costs, workers can see their income effectively rise more than 12% once the loan is paid off. In order to enhance the success of the program, efforts have been made at standardizing the use of bicycles in the city. Actions to achieve this have so far consisted of the development of a manual of technical standards for the design and planning of cycle ways.
Bicycle rental, Velib, Paris, France C40 Cities (2010). "Paris, France Velib - a new Paris love affair", available from http://www.c40cities.org/bestpractices/transport/paris_cycling.jsp Paris launched a 24/7 cycle hire scheme through Velib; a public private partnership between the city of Paris and a company led by a major advertising group. Users must purchase a subscription by day, week or year, and bike rental is free for the first half hour of every individual trip, after which it costs a fixed rate. The increasing price scale ensures the bikes are kept in circulation. Notably, the City of Paris generates revenues from the project without any investment (which cost USD 108 million). The public-private partnership is the reason for this success, with the private company paying operating costs plus rights to advertising space to the City, funded by advertising revenues.

Tools & Guidance

Tools & Guidance
Sustrans (2007). "Technical guidelines for the development of cycle facilities" A series of guidance documents for professionals on the details of bicycle network design. Available online from http://www.sustrans.org.uk/resources/design-and-construction/technical-guidelines
Transport for London (2010). "London Cycling Design Standards" A guidance document for designing to reduce barriers to cycling, in order to support road safety targets. Available online from http://www.tfl.gov.uk/businessandpartners/publications/2766.aspx

Annex 7: Parking Restraint Measures Description

Restricting parking availability discourages car use and provides an incentive to use more sustainable modes of transport, including public transport.
Removing vehicles from circulation reduces fuel use and reduces congestion effects.

Implementation Options

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

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

Monitoring

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

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

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

Case Studies

Parking standards, London Plan, London, UK

London (2010). "Chapter 6: Transport" in The London Plan, available from http://www.london.gov.uk/shaping-london/london-plan/docs/chapter6.pdf pp.160-161.

The London Plan establishes maximum parking guidelines for residential development. It stipulates that all developments in areas of good public transport accessibility should aim for significantly less than 1 parking space per unit. The main challenge continues to consist of ensuring that these standards are supported other measures which reduce car dependency, both within the development and in the surrounding area, e.g. improved and increased public transportation accessibility.

SFpark curbside parking, San Francisco, USA

Institute for Transportation and Development Policy (2010) "U.S. Parking Policies: An Overview of Management Strategies", available online from http://www.itdp.org/documents/ITDP_US_Parking_Report.pdf

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

Parking fees, Aspen, US

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

The city used to suffer from high levels of congested on-street parking. In order to reduce the effects of the "ninety-minute shuffle" (where locals and

downtown commuters moved their vehicles every 90 minutes to avoid a parking ticket), the city introduced charges for on-street parking using multi-space meters. Parking fees are highest in the center and decline with distance from the core. The city had a marketing campaign to let motorists know about the meters, including distribution of one free prepaid parking meter card to each resident to help familiarize them with the system. Motorists were allowed one free parking violation, and parking control officers provide an hour of free parking to drivers confused by the meters.
Park-and-Ride, Oxford, United Kingdom Oxford City Council (2009). "Park and Ride Transfer", available online from http://www.oxford.gov.uk/PageRender/decTS/Park_and_Ride_occw.htm Oxford city has five Park-and-Ride sites serving the city's shoppers, visitors and commuters. These sites used to charge for parking to provide income to cover operational costs, but were not able to generate additional money for repairs or improvement. In order to achieve savings, the management of the Park-and-Ride sites was transferred to Oxfordshire county, resulting in efficiency savings of 250,000 GBP per year for the city administration. These savings were achieved primarily through economies of scale, and by sharing the cost of providing the service with taxpayers across the County, and not just those in the city - both of which used the facilities.

Tools & Guidance

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

Annex 8: 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 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.

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

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
Energy and Water Efficiency in Municipal Water Supply and Wastewater Treatment in Emfuleni, South Africa, available online 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.
Good Practices in City Energy Efficiency. Emfuleni Municipality, South Africa: Water Leak Management Project (Case Study), available

online http://www.esmap.org/esmap/node/663
The water supply project in South Africa's Emfuleni Municipality resulted in lower costs for water--including lower energy costs associated with water supply--and also improvements in the municipality's financial status through a new leakage management system for bulk water supply. Innovative pressure management technology was applied to the water supply system of two low-income residential areas, yielding significant savings in water and energy costs for pumping and treating water for distribution. The payback period was only 3 months and financial savings, from both reduced energy use and water losses, was estimated at US$3.8 million per year for a lifetime of 20 years. Under the performance contracting arrangement employed to finance and implement the project, the municipality retains 80% of the water and energy cost savings during the first five years and 100% of the savings thereafter. The project has been hailed as a great success for South Africa. It clearly demonstrates that the use of suitable technology under a shared savings arrangement can succeed in low-income communities. A private firm providing financing for technical innovation--at no cost to the municipality--received remuneration from sharing savings in water purchases. The contractor provided a basket of services, including financing of upfront investment capital, design, implementation, commissioning, operations and maintenance (O&M) over the contract period, as well as training municipal staff in operations prior to handover of the installation. The project resulted in substantial financial savings that led to a "win-win" situation, both for the municipality and contractor, through a successful public private partnership (PPP).

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.