TOOL FOR RAPID ASSESSMENT OF CITY ENERGY – BOGOTÁ, COLOMBIA

Table of Contents

(Disclaimer)

TRACE (Tool for Rapid Assessment of City Energy) was developed by ESMAP (Energy Sector Management Assistance Program), a unit of the World Bank, and is available for download and free use at: http://esmap.org/TRACE.

ESMAP
Energy Sector Management Assistance Program

Executive Summary

This report, supported by the Energy Sector Management Assistance Program (ESMAP), utilizes the Tool for the Rapid Assessment of City Energy (TRACE) to examine urban energy use in Bogotá, Colombia. This study is one of three that were requested by the cities, and undertaken in 2013 by the World Bank's Latin America and the Caribbean (LAC) Energy Unit (the others being León and Puebla in Mexico), with the intention of beginning a dialogue on energy efficiency potential in municipalities in the Region. The implementation of TRACE in Puebla and León contributed to the development of the urban energy efficiency strategy by the Mexican Secretary of Energy (SENER).

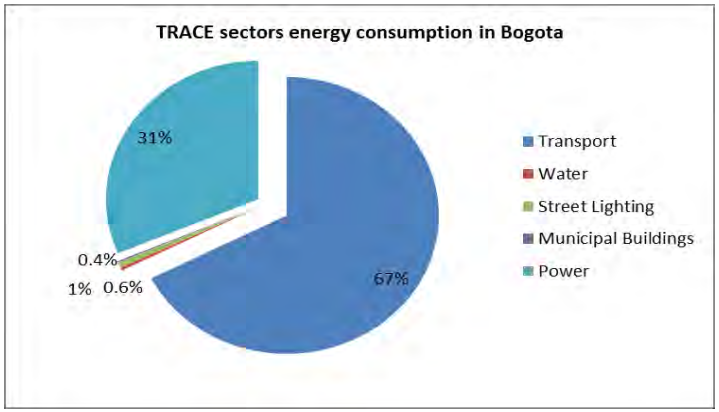
The Tool for Rapid Assessment of City Energy (TRACE) is a simple and practical tool for conducting rapid assessments of energy use in cities. The tool helps prioritize sectors with significant energy savings potential, and identifies appropriate energy efficiency (EE) interventions across six sectors - transport, municipal buildings, water and wastewater, street lighting, solid waste, and power & heat. In many cities around the world, these six sectors are often managed by the city government, and as such local authorities have a large degree of influence over public utility services. TRACE is a low-cost, user-friendly, and practical tool that can be applied in any socioeconomic setting. It allows local authorities to get a rapid assessment of their city's energy performance, and to identify areas where a more in-depth analysis is warranted. The TRACE tool includes approximately 65 specific energy efficiency interventions, based on case studies and best practices around the world. The TRACE tool is targeted primarily at local authorities and local public utility service companies, but it could also be useful for state or federal authorities in order to increase their knowledge on how to make municipalities more energy efficient by developing EE strategies.

Because the TRACE assessment is rapid, there are limitations in the depth of the analysis. Recommendations made by TRACE should therefore be viewed as an indication of what could be done to improve the city's energy performance and reduce their energy expenditures. The tool does not currently assess the residential, industrial, or commercial sectors. In many cities around the world, the six TRACE sectors are under municipal jurisdiction, however, in LAC, city authorities sometimes have only a limited degree of influence over sectors such as transport, electricity, water, and sanitation.

In consultation with local authorities in Bogotá and based on sector analyses carried out by local consultants, a number of recommendations were generated through the TRACE analysis to help the municipality improve the efficiency of energy use in the provision of urban services. The three sectors identified in Bogta with the highest savings potential and where the local administration has a significant degree of control are: public transport, street lighting, and potable water. A summary of all six sectors that were evaluated are discussed below along with the principal recommendations.

Overview of energy use in Bogotá

Two-thirds of the overall energy consumption related to TRACE areas is used by public and private transport, while almost one third by the power sector. The rest of two percent is divided between street lighting (one percent), water sector and municipal buildings. Since the Municipality of Bogotá did not provide the fuel consumption related to waste collection and management, the energy analysis pertaining to public utility services under the city government did not include solid waste sector. As elsewhere in the world, the transport sector requires a large amount of energy to fuel private vehicles and buses operating in the city. Assuming the data on water sector energy consumption is accurate, the relatively low level can be explained by the fact that water delivery is largely gravitational from elevated reservoirs, and the fact that only 25 percent of the wastewater in Bogotá receives primary treatment. More than a third of the electricity consumption in Bogotá is used by the residential sector, while industry accounts for 32 percent and commercial sector for 26 percent. The street lighting and municipal buildings sectors require about 5 percent of overall electricity consumption.



TRANSPORT - A pioneer in sustainable transport initiatives in Latin America, Bogotá developed a Bus Rapid System in 2000, which has become a model for the country, region, and world. In addition to the BRT system known as TransMilenio, the public transport network includes the integrated public transport system (SITP) and traditional buses. 43 percent of the daily commutes in Bogotá are made by public transport. However, in recent years, the quality of public transport service has declined due in large part to traffic congestion. Currently, city managers are stepping up efforts to expand the BRT network and modernize the SITP fleet, and integrate TransMilenio with SITP buses. There are over 1,500,000 cars in Bogotá, which makes private transport energy intensive, thereby contributing to traffic congestion and pollution in the city. Although the city has undertaken some initiatives meant to reduce the use of cars, such as *pico e plata* (restricting both private and public vehicles based on the last digits of the license plate), private transport has continued to increase. The city has a good non-motorized transport (NMT) network, including 376 kilometers of bike lanes. However, not all of them are in good shape, and some are not interconnected. The city is currently expanding its NMT network by building bike lanes and bike stations where people can rent or park their bicycles. City managers are also planning to further integrate NMT with the broader public transport system. Some of the energy efficiency initiatives that could be considered by the local authorities include:

Public Transport Development - Continue expanding the BRT network and the integration of BRT buses with SITP and traditional buses.
Non-motorized Transport Modes - Expand the cycling lanes and pedestrian network in order to encourage NMT as both feeder systems for public transport and as options for short trips.

STREET LIGHTING – In the last year, local authorities in Bogotá have been working on an initiative to improve street lighting in the city by replacing old mercury bulbs with more energy efficient sodium vapor and LED lamps. Overall, there are approximately 330,000 street lamps in Bogotá, with 100 percent coverage, including in low-income neighborhoods. Despite good street lighting coverage, the quality of service is not always good. Although the energy consumption per kilometer of lit streets is low (11,672 kWh), public lighting requires a large amount of electricity, which translates into high costs to the city. A large project replacing 33,000 sodium vapor bulbs with LEDs is expected in the near future, an initiative that is expected to reduce energy consumption by 30 percent and enhance the quality of street lighting in the city. The tender for the first LED lamps is under way and the first batch of 11,000 highly energy efficient bulbs should be implemented by 2015. In the short- to medium-term, there are several interventions that can be done to improve the efficiency of public lighting:

- *Procurement Guide for New Street Lights* - Produce a specific procurement guide for public lighting and choose an efficient solution based on modern, efficient technology when replacing the lights.
- *Street Lighting Timing Program* - A light dimming program allows street lights to be adjusted for specific needs in a particular area, according to varying weather and/or activity levels (more light is needed in the evenings when people are out than in the early morning hours when there is less activity on the streets).
- *Street Lighting Audit* - Conduct an audit of all street lamps in the city.
- *Street Lighting Retrofit* - Undertake the renovation of street lamps with more efficient technology that can deliver the same lighting levels with lower energy consumption, reducing associated carbon emissions and operational expenditures. The cost of LED technology has fallen to the point that it is the optimal choice today for street lighting, but the financial savings depends on the vintage and efficiency of existing lighting.

WATER SECTOR - The water and sanitation is managed by a public company under the local government. The water comes through a gravitational system from the rivers in the mountains, thus requiring small energy for pumping and treatment activities. With 100% water coverage in the city, Bogotá has a total of 1.8 million water connections, of which 1.6 million in the residential sector. Annually, more than 477 million cubic meters is produced, of which only 273 million cubic meters is actually sold to the customers (the rest being lost or not billed). On average, the city uses 93.98 liters per capita per day. The water sector in Bogotá is one of the most efficient in the TRACE database, recording 0.23 kWh/ cubic meter, one of the lowest energy consumptions for treating potable. The TRACE analysis did not consider the energy used for irrigation and stormwater management, as it took into account only electricity consumed for municipal water and wastewater. In the future, the local government and the water utility company should join efforts to reduce some of the 35 percent losses in the system, which occur mainly due to old, poorly insulated pipes. The high-income communities subsidize the water tariffs for low income groups. Only 25 percent of the wastewater is treated, while the rest is discharged into the rivers, thus increasing water pollution. The city is addressing this issue through the construction of new wastewater treatment capacity that will provide 100 percent treatment by 2018. The energy consumption for treating wastewater should also increase, from the existing 0.05 kWh/cubic meter related to the 25 percent of the wastewater treated, to approximately 0.3 kWh/cubic meter in the future. The energy efficiency measures recommended by TRACE to improve the water sector include:

Active Leak Detection Program - Implement a program to identify and repair leaks in the water system.

Pressure Management - Enforce a program that could help reduce the treatment and pumping costs by minimizing the required delivery pressure and leakages in the water pipes.

POWER SECTOR – The power sector in Bogotá is managed by the local electricity provider, Codensa, a joint venture between the public and private sectors. Electricity is produced by a network of hydropower plants located outside the city with an overall installed capacity of 2,575 MW. There are nearly 1.8 million households with power connection in Bogotá. With a primary electricity consumption of 1,217 kWh of electricity per capita, Bogotá compares favorably to other cities in the TRACE database with similar climate. The city is also performing well in terms of overall losses in the system. Similar to water and solid waste, the power service is stratified according to the location of the customer's residence and income, with rich communities subsidizing the electricity bills of lower-income consumers.

SOLID WASTE - The solid waste sector in Bogotá is managed by both private and public companies. Bogotá generates 6,732 tons of waste daily, which represents 322 kg of solid waste per capita, a figure that places Bogotá in the middle of the TRACE database compared with cities with a similar Human Development Index. Like many cities in the region, Bogotá does not have a selective collection system, and only 5.5 percent of solid waste in the city is recycled. As in the water sector, higher-income groups subsidize the waste collection tariffs for low-income communities. Recently, the city replaced some of the waste trucks with more efficient vehicles. Today, 30 percent of the new waste fleet runs on natural gas, and some comply with Euro 4 emission standards. The landfill, located 20 kilometers from the city, is one of the largest of its kind in Latin America, and is equipped with a leachate treatment plant and biogas collection facilities managed by third parties. Under the *Basura Cero* program (Zero Waste), the city is undertaking an ambitious initiative to reduce the amount of waste dumped at the landfill by 2025 with a major increase in recycling.

MUNICIPAL BUILDINGS - The municipal buildings stock comprises 1,664 buildings, including 734 educational units, 91 public offices, and 172 healthcare facilities, in addition to a number of sports and cultural offices. The municipal facilities are managed by each of the 20 sub-districts in the city, under the coordination of the Municipality of Bogotá. However, as in many cases worldwide, the city does not have reliable data on the overall floor space and energy consumption of municipal buildings. Due to mild climate, the buildings do not require heating or cooling. According to the TRACE analysis performed on a sample of six public offices, the energy consumption of 98 kWh of electricity per square meter is higher than some of the cities in the TRACE database. The city could improve the efficiency of the municipal buildings sector by employing a few easy,

accessible measures, such as a benchmarking program, in addition to some retrofits.

The matrix below presents the public utility sectors identified by TRACE with the highest energy saving potential and the interventions local authorities should consider undertaking in order to reduce consumption and improve overall efficiency of the city. These interventions can be implemented over one or two years, and would require upfront investments between US$100,000 and US$1 million.

Matrix with energy efficiency priorities and proposed programs

PRIORITY 1 Public Transport	**Energy spending in the sector**		**Potential savings**	
	$917,935,197		$165,000,000	
	Responsible Institution	**Cost**	**Energy savings potential**	**Time of implementation**
1. Public Transport Development	Department of Transportation	$$$	***	> 2 years
PRIORITY 2 Private Transport	**Energy spending in the sector**		**Potential savings**	
	$1,390,516,286		$295,000,000	
	Responsible Institution	**Cost**	**Energy savings potential**	**Time of implementation**
2. Non-Motorized Transport Modes	City	$$$	**	> 2 years
PRIORITY 4 Street Lighting	**Energy spending in the sector**		**Potential savings**	
	$32,850,000		$6,800,000	
	Responsible Institution	**Cost**	**Energy savings potential**	**Time of implementation**
3. Street Lighting Audit and Retrofit	City/Codensa	$$	***	1-2 years
4. Procurement Guide for New Street Lights	City/Codensa	$	***	< 1 year
5. Street Lighting Timing Program	City/Codensa	$	***	< 1 year
PRIORITY 5 Potable Water	**Energy spending in the sector**		**Potential savings**	
	$12,415,011		$1,390,000	
	Responsible Institution	**Cost**	**Energy savings potential**	**Time of implementation**
6. Active Leak Detection & Pressure Management	Acueducto	$$$	***	> 2 years
PRIORITY 5 City Authority	**Energy spending in the sector**		**Potential savings**	
	N/A			
	Responsible Institution	**Cost**	**Energy savings potential**	**Time of implementation**
7. Awareness Raising Campaign	City	$	**	1-2 years

Methodology

The Tool for Rapid Assessment of City Energy (TRACE) helps prioritize sectors with significant energy savings potential, and identifies appropriate energy efficiency (EE) interventions across six sectors - transport, municipal buildings, water and wastewater, street lighting, solid waste, and power & heat. It consists of three principal components: (i) an **energy benchmarking** module which compares key performance indicators (KPIs) among peer cities (ii) a **sector prioritization** module which identifies sectors that offer the greatest potential with respect to energy-cost savings, and (iii) an **intervention selection** module which functions like a "playbook" of tried-and-tested energy efficiency measures. These three components are woven into a user-friendly software application that takes the city through a series of sequential steps: from initial data gathering to a report containing a matrix of first-order energy efficiency recommendations tailored to the municipality's individual context, with implementation and financing options. The steps in the TRACE analysis are as follows:

1. Collection of Candidate City Energy Use Data

TRACE contains a database of 28 key performance indicators (KPIs) collected from 80 cities. Each of the data points that make up these KPIs is collected for the municipality prior to the application of the tool and, as TRACE is launched, this collection of information will grow with current and reliable data.

2. Analysis of City Energy Use Against Peer Cities

The performance of a city is compared with a range of peer cities—selected by the city based on population, climate, and human development—to determine their performance in each of the six sectors (3-6 KPIs per sector). The benchmarking process provides an overview of energy performance so that the city can assess its relative rankings against peer cities in each sector. The Relative Energy Intensity (REI), or in simpler terms the percentage by which energy use in a particular sector could be reduced, is calculated using a simple formula. The formula looks at all of the cities that are performing better on certain KPIs (e.g., energy use per street light), and estimates the average improvement potential. The higher the number of cities in the database, the more reliable and representative the final results will be.

3. Assessment and Ranking of Individual Sectors

During the initial city visit, a number of meetings and interviews are conducted to collect additional data across city departments and agencies, augmenting benchmarking results with contextual information. At the end of the first phase, a prioritization process takes place to identify sectors with the greatest technical energy savings potential. Energy costs are also weighed, as is the ability of city authorities to control or influence the outcome. Priority sectors are reviewed in detail in the second phase.

The main frame of TRACE

4. Ranking of Energy Efficiency Recommendations

TRACE contains a playbook of over 60 tried and tested energy efficiency recommendations in each of the sectors. Some examples include:

- Buildings | Lighting Retrofit Program
- Organizational Management | Energy Efficiency Task Force, Energy Efficient Procurement
- Power & Heat | Solar Hot Water Program on Buildings
- Public Lighting | LED Replacement Program for Traffic Lights
- Transport | Traffic Restraint in Congested Urban Areas, City Bus Fleet Maintenance
- Waste | Waste Management Hauling Efficiency Program
- Water & Wastewater | Pump Replacement Program

The TRACE Benchmarking Module

Recommendations are then assessed based on five different factors: *finance; human resources; data* and *information; policy, regulation* and *enforcement;* and *assets and infrastructure*. This step helps cities better assess potential measures that are within its capacity to implement effectively. TRACE then allows recommendations to be plotted on the basis of two attributes in a 3x3 matrix (energy savings potential and first cost), with an additional filter that enables the user to sort recommendations based on the speed of implementation.

Recommendations in each priority sector are quantitatively and qualitatively evaluated based on key data, including institutional requirements, energy savings potential, and co-benefits. The recommendations are supported by implementation options, case studies, and references to tools and best practices.

5. Report Preparation and Submission

A Final City Report incorporates the various sections outlined above along with the review of the findings and recommendations by city authorities. The intention of the TRACE report is to identify, together with the city, high-priority and near-term actions to improve the energy efficiency and overall management of municipal services.

The report includes:

- City background information, such as city contextual data, key city development priorities, energy efficiency drivers, and barriers.
- An analysis of the six sectors, including a summary of the benchmarking results.
- A summary of sector prioritization based on the city's objectives.
- A draft summary of recommendations provided in the City Action Plan.
- An Annex including more in-depth information on energy efficiency options and best-practice case studies.

The limitations of TRACE

The fact that TRACE is simple and easy to implement, also means that there are limitations with respect to the depth of analysis. For example, the tool may identify Street Lighting as the a priority sector in terms of potential energy savings, but it does not go into city specific details on the required costs to undertake street lighting rehabilitation projects. Thus, even if the energy savings potential is assessed to be high, the costs may be even higher, and an investment in the sector may not be warranted. Similarly, although TRACE specifically focuses on the service areas that fall within the purview of local authorities, the tool cannot factor in the institutional and legislative mechanisms that may be needed to implement specific energy efficiency specific recommendations.

The TRACE assessments have been very relevant in cities in Eastern Europe and CIS countries, where most of public utility services are under the city government and thus the local public administration has a high-degree of control over the TRACE sectors. In other parts of the world, such as in Latin America, there is less municipal control over the TRACE sectors, either because they are managed at a state or federal level, or because the service is provided under contract by a concessionaire. In 2013, TRACE was implemented in seven largest cities in Romania where important utility services, such as public transport, district heating, street lighting but also municipal buildings are under the local government. In some cases, even if operation and maintenance of a certain sector is outsourced to a private concessionaire (as it is the case of street lighting), the municipality owns the related infrastructure and can make decisions over the sector. In Romania, the TRACE studies helped the local authorities and national government prepare local energy efficiency measures to be implemented with support from funds from the European Union, with the scope of reducing greenhouse gas emissions (GHG) and energy related costs, as part of Europe 2020 Strategy with the objective of reducing GHG emissions by 20 percent over the next few years.

Background

A middle income country and the third largest economy in Latin America, Colombia is located on the northwestern coast of South America, bordering Panama in the northwest, Venezuela and Brazil in the east, Ecuador and Peru in the south, the Pacific Ocean in the west, and the Caribbean Sea in the north. One of the 17 mega bio-diverse countries in the world (it ranks first in bird species), Colombia is spread over 1.1 million square kilometers, and is home to 47 million people (2014 estimate). It is the third most populous country in Latin America (after Mexico and Brazil), and home to the second largest number of Spanish speakers in the world (after Mexico).

The country has a diverse geography that comprises six natural regions, including mountains, plains, sea & ocean, islands, and coastal areas. Colombia has a tropical climate along the coastlines and eastern plains, and cooler weather in the east. Most urban centers are located in the highlands of the Andes Mountains, the Amazon rainforest, tropical grasslands as well as on the Pacific and Caribbean coasts.

A constitutional republic comprising 32 departments and the capital district of Bogotá, Colombia has experienced armed conflict since the mid-1960s involving the government, paramilitary, crime-syndicates, and left-wing guerilla groups who are fighting to increase their influence over the country's territory. The conflict reached its peak in the 1990s, and has decreased considerably since the year 2000.

In 2012, Colombia's Human Development Index was 0.719. According to the World Bank GINI index, the income inequality ratio in Colombia in 2010 was 55.6 (where 0 is perfect equality and 100 is perfect inequality). The country's economy relies heavily on natural resources (oil, gas, coal, minerals, agriculture, forestry), in addition to chemicals, food processing, health related products, textiles, and electronics, as well as military and metal products. Colombia is the world's fourth largest coal exporter and the fourth largest oil producer in Latin America. Real GDP has increased by 4 percent annually in the past several years, continuing a decade of strong economic performance. Today, 56 percent of the country's GDP is contributed by services, 37.8 percent by industry, while agriculture accounts for only 6.6 percent. Colombia has been struggling to overcome poverty, with almost one-third of the population living below the poverty line. The country is part of the CIVETS group of six leading emerging markets that includes Indonesia, Turkey, Egypt, Vietnam, and South Africa. Colombia has a Free Trade Agreement with the United States, and has signed or is negotiating similar accords with a number of European and Asian states.

According to official estimates, the most populous cities in Colombia are the following:

City	2010
Bogotá	7,776,845
Medellín	2,441,123
Cali	2,344,734
Barranquilla	1,212,943
Cartagena	990,179
Cúcuta	643,666
Soledad	599,012
Ibague	548,209
Bucaramanga	527,451
Soacha	500,097

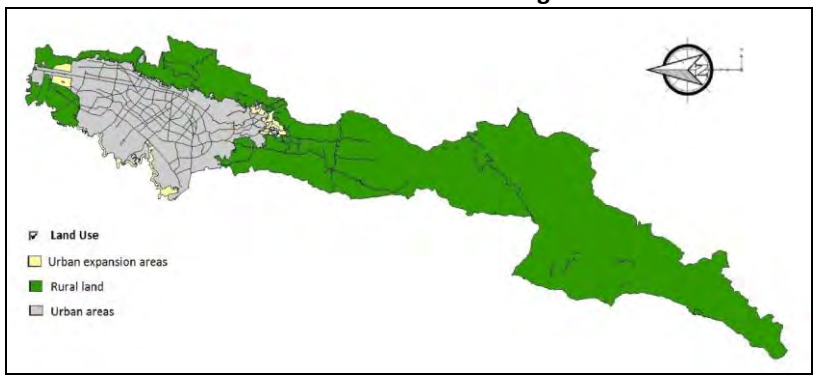
Located in the central part of Colombia on the Bogotá River, at 2,640 meters above sea level, Bogotá is the capital of the country and also the capital of the department of Cundinamarca. One of the largest cities in Latin America and the 30th biggest in the world, Bogotá has a population of around 7.6 million (according to official figures in 2012), an increase of 10 percent compared to the 2005 census. The city is spread across roughly 1,600 square kilometers, with a density of approximately 4,800 inhabitants per square kilometer. The metropolitan area comprises several localities with a total population of 10.7 million. Bogotá has several airports, including the El Dorado International Airport, which is the principal hub for domestic and international flights.

The city has a subtropical highland climate, with an average temperature of 14.5°C. The driest months are December, January, July,

and August while the rainiest months are April and May, and from September through December. The warmest month is usually March, when the temperature can reach 20°C. While temperatures are fairly consistent throughout the year, weather conditions are unpredictable and can change radically during the course of a single day, due to the El Niño and La Niña phenomena.

The city comprises some 20 localities or districts which form an extensive network of neighborhoods, including: Usaquén, Chapinero, Santa Fe, San Cristóbal, Usme, Tunjuelito, Bosa, Kennedy, Fontibón, Engativá, Suba, Barrios Unidos, Teusaquillo, Los Mártires, Antonio Nariño, Puente Aranda, La Candelaria, Rafael Uribe, Ciudad Bolívar, and Sumapaz. One-quarter of the municipal area is rural. Most of the high-income communities are located in the northern and northeastern parts of the city, close to the foothills of the Eastern Cordilliera. Most of the rural communities are based in the south, home to some of the poorest districts.

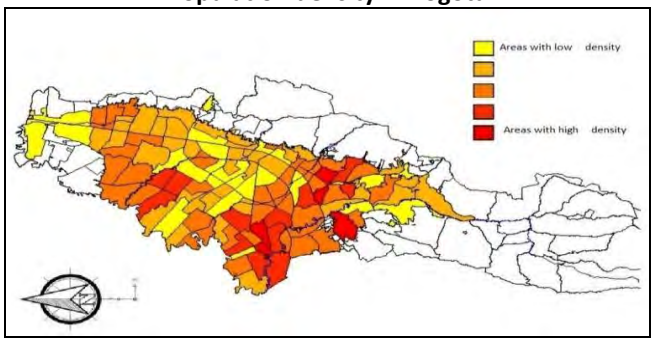
Rural and urban areas in Bogotá



The highest population density is in the south and southwest, where most low-income communities live. Conversely, the northern area, which is the home to the wealthiest groups, has the lowest density. The industrial and commercial areas, as well as the financial district, are located in the northern and downtown areas.

Bogotá is the key economic and industrial center of Colombia, and one of the major destinations of the imports of capital goods, accounting for 26 percent of the national GDP. The local economy relies predominantly on the service sector and real estate activities (15 percent), followed by commerce (13 percent), and industry (12 percent). Other important sectors are financial services, healthcare, construction, and telecommunications. The unemployment rate is 9.5 percent.

Population density in Bogotá



Often referred at as the Athens of South America, Bogotá is home to a large number of universities and libraries, and has an extensive educational system of primary and secondary schools and colleges.

National Legislative Framework on Energy Efficiency

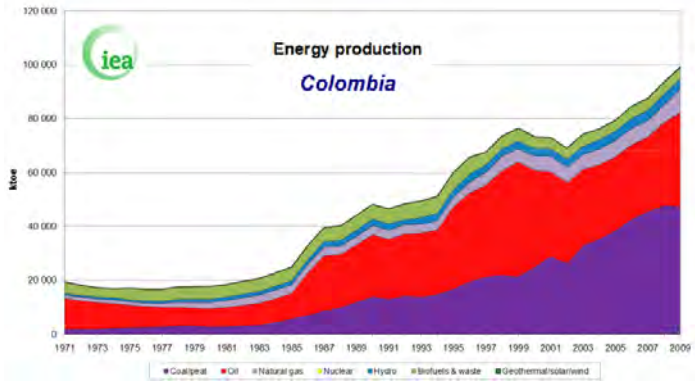
The electricity sector in Colombia was liberalized in 1994, and is divided into four branches: power generation, transmission, distribution, and retail/trade. The Public Service Law (L-142, 1994) liberalized the sector and opened it to competition in the four branches. The Ministry of Energy and Mines (MEM) is responsible for sector planning and policy. The Regulatory Commission for Energy and Gas (CREG) is responsible for setting electricity and gas tariffs and regulating the respective markets. The electric system is operated by an independent agency that is responsible for managing the electricity grid and power plants. All power producers must sell energy on the market.

The country's National Development Plan for the period 2010-2014 requires the government to prepare an action plan to implement the Rational and Efficient Use of Energy Program (PROURE) aimed at reducing energy consumption by 3 percent and promoting the use of renewable energy.[1] The action plan includes a number of measures, such as development of energy projects from non-conventional sources, reduction of energy losses, incentives for employing clean technologies, and the efficient use of energy in various sectors (e.g., commercial, residential and transport).

The country has received support from international organizations to develop and improve energy efficiency legislation, such as the low carbon strategy (supported by USAID, UNDP, and the World Bank) and sustainable building codes (with support from the IFC).

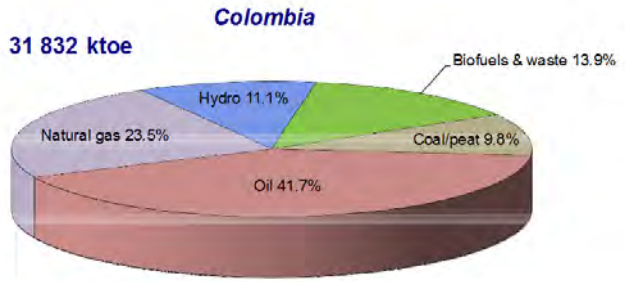
Energy production in Colombia has increased over that last two decades, especially for oil and coal. Oil production increased from 60,000 to 80,000 ktoe between the late 1990s and 2005, while coal production doubled during the same period of time. The country imports refined oil products, since internal refining capacity is insufficient to cover domestic demand. Oil accounts for the largest share of total energy supply, followed by natural gas and hydropower. The transport sector is the largest energy consuming sector, and largest consumer of petroleum products (gasoline and diesel).

Energy production in Colombia from 1970s to 2000s



Natural gas is used mostly by the residential sector (for cooking water heating), in addition to power generation and transport.

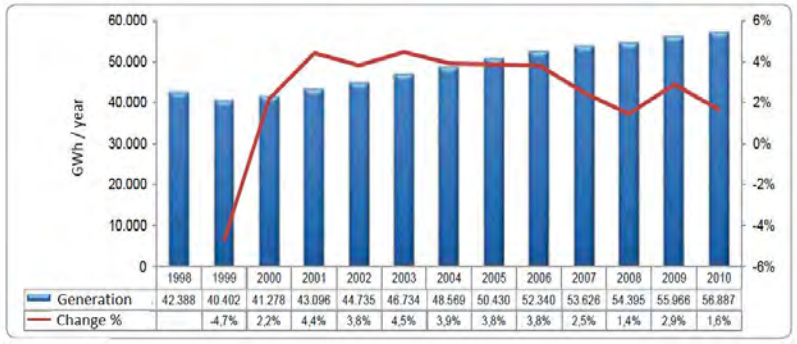
Share of total primary energy supply in 2009



Electricity generation expanded in the past decade from 41,278 GWh in 2000 to almost 57,000 GWh in 2010.

[1] National Development Plan 2010-2014

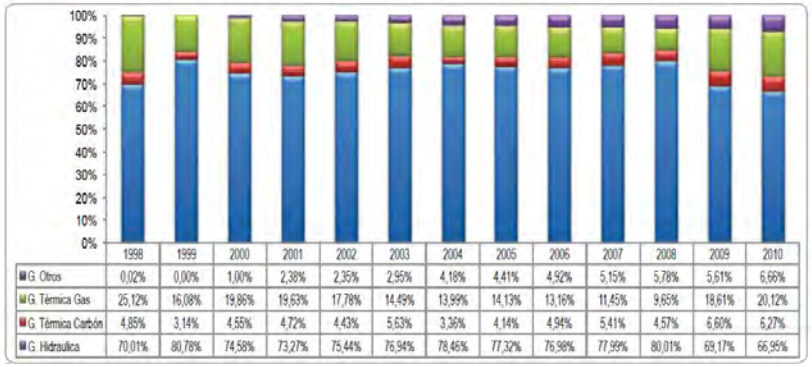
Electricity generation in Colombia between 1998 and 2010



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Generation	42.388	40.402	41.278	43.096	44.735	46.734	48.569	50.430	52.340	53.626	54.395	55.966	56.887
Change %		-4,7%	2,2%	4,4%	3,8%	4,5%	3,9%	3,8%	3,8%	2,5%	1,4%	2,9%	1,6%

Almost two-thirds of the country's installed power capacity is based on hydro, 31.5 percent on fossil fuel (natural gas, coal, oil), and 4.4 percent on small power plants consuming a range of fuels. 65 percent of electricity generation is from hydropower plants and 20 percent from natural gas plants. Natural gas for electricity production has gone up over the past two decades following several dry years that severely impacted hydropower production. The government has been encouraging power generation "firm" energy sources that are less affected by the weather, including fossil fuels, and renewables (geothermal and biomass). A degasification terminal for Liquefied Natural Gas is currently being built in Colombia so as to increase the consumption of natural gas in the country to meet growing energy demand.

Electricity generation by source between 1998 and 2010



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
G. Otros	0,02%	0,00%	1,00%	2,38%	2,35%	2,95%	4,18%	4,41%	4,92%	5,15%	5,78%	5,61%	6,66%
G. Térmica Gas	25,12%	16,08%	19,86%	19,63%	17,78%	14,49%	13,99%	14,13%	13,16%	11,45%	9,65%	18,61%	20,12%
G. Térmica Carbón	4,85%	3,14%	4,56%	4,72%	4,43%	5,63%	3,36%	4,14%	4,94%	5,41%	4,57%	6,60%	6,27%
G. Hidraulica	70,01%	80,78%	74,58%	73,27%	75,44%	76,94%	78,46%	77,32%	76,98%	77,99%	80,01%	69,17%	66,95%

Transmission and distribution losses amounted to 18.5 percent in 2009, a decrease from the 2005 peak of 21.2 percent.

Percentage of losses in the electrical system

YEAR	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
LDS - RTS	15,5%	15,5%	12,9%	18,3%	20,1%	19,3%	17,6%	19,9%	19,7%	19,7%	17,0%	16,9%
STN	1,8%	1,4%	1,6%	1,5%	1,7%	2,0%	2,0%	1,9%	2,0%	1,8%	1,8%	1,7%
TOTAL	17,3%	16,9%	14,5%	19,8%	21,8%	21,2%	19,6%	21,8%	21,6%	21,5%	18,8%	18,5%

LOCAL DISTRIBUTION SYSTEM - LDS
REGIONAL TRANSMISION SYSTEM - RTS
NATIONAL TRANSMISION SYSTEM - NTS
TOTAL LOSS

Local Initiative Regarding Energy Efficiency in Bogotá

The Bogotá Development Plan "Bogotá Humana" aims to improve human development in the city, giving priority to the children and adolescents. The plan focuses on three objectives: reducing segregation and discrimination; responding to climate changes and securing water; and defending and strengthening the public sector.

The strategy related to climate change emphasizes the promotion of public transport, expanding non-motorized transport modes, and increasing the use of renewable energy. Additionally, the Plan includes a series of actions to promote the efficient use of natural resources, including the reduction in the generation of solid waste generation and the increase in recycling, and increasing the efficiency of urban services.

The Level of Authority of Federal Government and Local Authorities regarding Public Utility Services

Public services in Bogotá are managed by a combination of Federal and Municipal oversight.

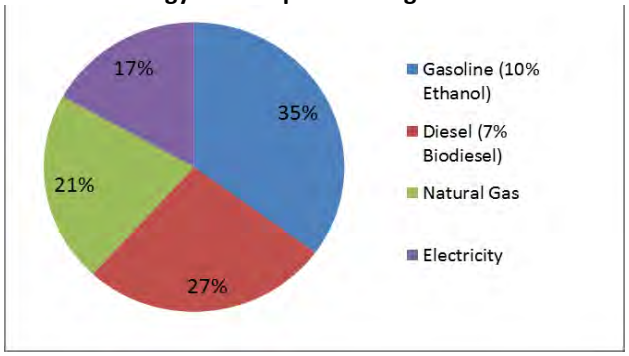
Transport - This sector is managed by the city government through the Department of Transportation. Some of the large projects require financial support from the national government.
Waste - The local government coordinates solid waste collection and management activities. The national government is responsible for hazardous and biological wastes.
Water - The water sector is managed by a company under the city government. However, water policies and tariffs are established at the local and national level.
Power – The power sector is managed by the local electricity provider, Codensa, a public-private entity. Electricity tariffs are set at the national level by the Regulatory Commission for Energy and Gas (CREG).
Street Lighting - The street lighting system in Bogotá is operated by Codensa, the electricity company, with supervision from the local government. Codensa also owns the street lighting infrastructure.
Municipal Buildings - Municipal buildings in Bogotá are managed by the 20 local districts authorities.

Bogotá Sector Diagnostics

Power Sector The electricity provider in Bogotá is Codensa, a public-private company whose major stakeholder is Edensa, a public entity with shares held by the municipal government. The other important stakeholder is the Italian power group, Enel.

As of 2012, there were 1,769,398 households with power connections. The amount of electricity consumed in Bogotá accounts for approximately 15 percent of the total electricity produced in Colombia.

Energy consumption in Bogotá 2012



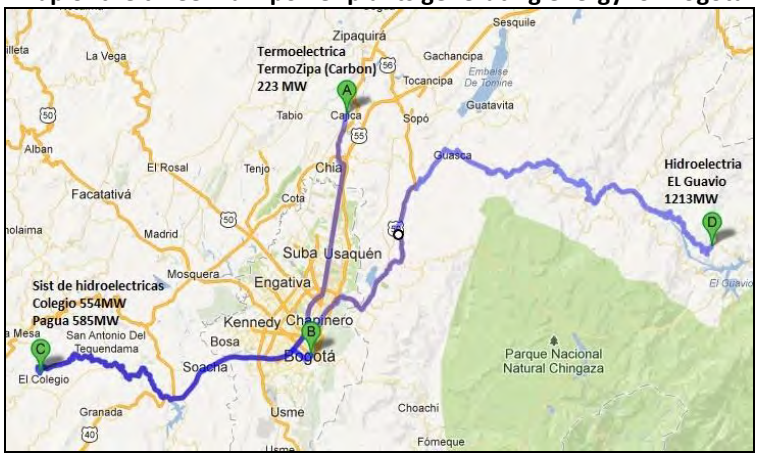
Sources: UPME and SIU

In 2012 the total electricity in the city amounted to 9,194 GWh. Overall, electricity accounts for up to 17 percent of the total energy used in the city. [2]

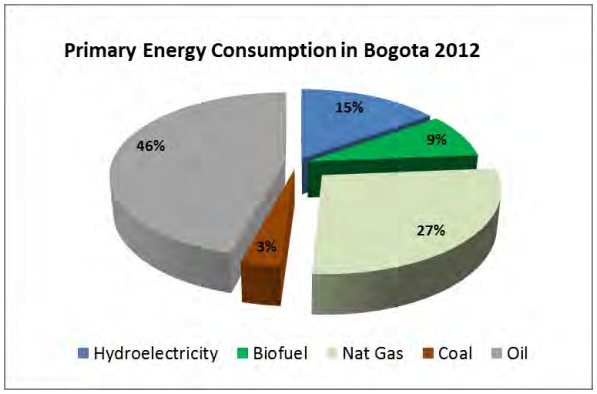
[2] Cuadernos de Fedesarrollo, #45 - July 2013

Electricity is produced by a network of three power plants located outside the city with an overall installed capacity of 2,575 MW. One of the facilities comprises two hydro-plants, Colegio and Pagua, respectively, located along the Bogotá River, with an installed capacity of 1,139 MW. Termozipa is a coal power plant located in municipality of Cajica, about 40 kilometers far from Bogotá, and has an installed capacity of 223 MW. Finally, the Guavio hydropower plant is 180 km northeast of Bogotá, and has an installed capacity of 1,213 MW. During El Nino events, which reduce rainfall, the city is susceptible to power shortages because of the high dependence on hydropower plants. Such situations have prompted the country to establish a premium payment system for "firm" energy producers, which largely benefits fossil fuel plants.

Map of the three main power plants generating energy for Bogotá

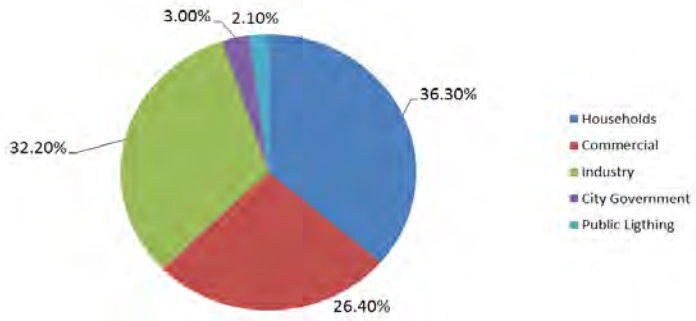


The largest amount of electricity goes to residential sector (40.2 percent), followed by commercial (31.6 percent), industry (22.2 percent), public offices (3.4 percent), and street lighting (2.3 percent).



Electricity consumption in the city has gradually increased over the past decade, rising from 6,751 GWh in 2002, to 8,455 GWh in 2008, reaching 9,081 GWh in 2011. Consumption in the industrial sector dropped slightly from 2008 and 2009, as some factories moved out of the city to take advantage of lower land and operational costs. Consumption in the commercial sector went up as a result of an increase in the number of supermarkets and shopping malls in the city.

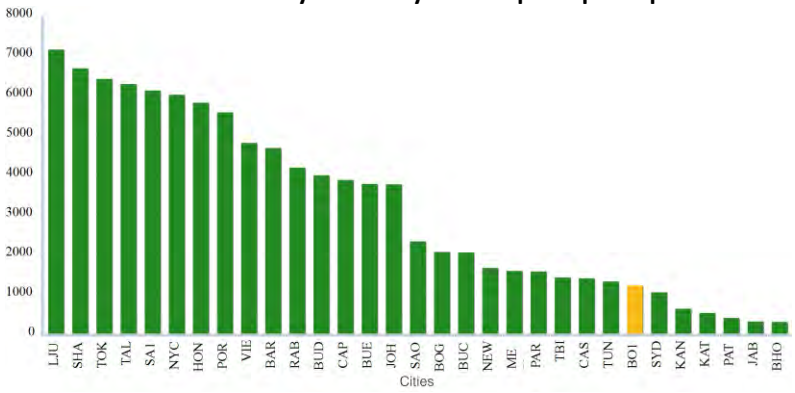
Electricity consumption in Bogotá in 2012



The largest share of electricity in Bogotá is consumed by the residential sector (36.3 percent), followed by industry (32.2 percent) and commerce (26.4 percent).[3] The municipal government consumes 5.1 percent of the electricity in the city.

With a primary electricity consumption of 1,217 kWh per capita, Bogotá compares favorably to other cities in the TRACE database with a similar climate. For example, Bogotá ranks similarly on the indicator with Tunis and Sydney; it has a primary electricity consumption level almost half that of Sao Paulo, and three times less than Cape Town or Budapest.

Primary electricity consumption per capita



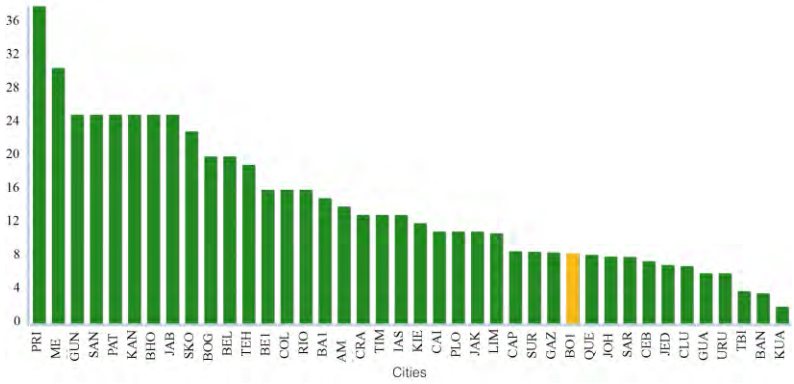
During the hot season between November and February, the city requires more energy for cooling. Conversely, when the weather is colder, some heating is required. In addition, more electricity is used during Christmas and summer holidays. The main explanation for the relative low energy consumption per capita in Bogotá is the temperate climate. Also, the altitude of Bogotá at 2,640 meters above sea level reduces the need for air conditioning.

The technical losses in the transmission and distribution network are 8.39 percent, a figure that places Bogotá in the lower half of the TRACE database compared to cities with a similar Human Development

[3] Análisis de la situación energética de Bogotá y Cundinamarca Estudio Fedesarrollo EEB

Index (HDI). The losses are half those of some Eastern European cities, such as Iasi, Timisoara, and Craiova in Romania or Banja Luka in Bosnia and Herzegovina, and almost four times lower than in Mexico City. With respect to commercial losses, Bogotá has the third lowest level among city in the TRACE database with a similar HDI, with 1.31 percent, after Tbilisi and Bangkok.

Percent Total T& D Loss



Electricity tariffs in Bogotá are differentiated according to the type of user. In 2012, the commercial sector paid 286 pesos (US$0.15) per kWh of electricity, almost same price as industry (298 pesos/kWh). Public offices pay more, i.e., 336 pesos (US$018) per kWh. For the residential sector, electricity and water services are stratified based on the location of the household and income. Thus, wealthy communities subsidize the energy and water bills of low-income communities. Bogotá is divided into six socio-economic *"estratos"* (strata). People living in the highest, high and medium-high strata bear the subsidies for the other three groups, i.e., lowest, low, and medium-low.

People in the lowest strata receive a 60 percent subsidy, while those in the low group receive 40 percent. People in medium-low income group receive a 15 percent subsidy. The subsidies come with some consumption limits. Once people exceed the limit, they must pay the full rate. For instance, subsidies for households located at 1,000+ meters in altitude have a maximum monthly electricity consumption of 130 kWh before reaching the subsidy limit. Those living below 1,000 meters (who presumably need more air conditioning) have a limit of 170 kWh per month. People in the medium-high income group pay the tariff in full. The high and highest socio-economic strata pay 20 percent more in their tariffs to compensate for the subsidies to poor communities. 78 percent of the users belong to the medium-low to lowest income groups. The average monthly consumption for the residential sector is approximately 207 kWh, which varies by income group. For example, high income consumers use about twice as much electricity on average as low-income consumers (kWh 337 kWh vs. 152 kWh).

Urban Transport

According to official data, 38 percent of the 9,169 Gg of CO2-equivalent in greenhouse gas emissions in the city in 2008 were produced by the transport sector.[4] Other largest polluters in the city are solid waste sector and construction industry (ceramic and cement).

The public transport system in Bogotá is managed by the Secretary of Mobility, the local transport authority of the city. The urban transport system in Bogotá is composed of three main networks: TransMilenio, which operates the Bus Rapid Transit system (BRT), the integrated public transport system (SITP), and traditional bus service. In addition, there are nearly 50,000 taxis in Bogotá operated by private companies.

Between 2003 and 2011, about 25 percent of the total public transport fleet was taken off the road in an attempt to reduce the number of older and polluting vehicles. While the number of buses was reduced from nearly 20,000 to 14,694, the BRT fleet has almost tripled.

TransMilenio is based on a BRT network with high-capacity buses operating on dedicated bus lanes. The buses are managed by private

[4] Regional Inventory of GHG Cundinamarca y Bogotá - PRICC 2008

concessionaires under the supervision of the local transport authority. According to the city managers, currently there are 1,600 BRT buses that can carry between 160 and 260 passengers each. TransMilenio was the first BRT project in Colombia, and has been developed in three stages. The system in Bogotá was launched in December 2000, initially with 41 kilometers of dedicated bus lanes, covering Avenida Caracas and Calle 80. The second stage was completed in December 2012, expanding the network by 36 kilometers, from Avenida 26 to Calle 10. With 12 lines totaling 112 km on dedicated bus lanes and 115 stops, the BRT system in Bogotá has become the largest such system in the world. Meanwhile, more lanes were built on Avenida 26 covering 14 kilometers of network from the airport to the city center, and an additional 7.7 kilometers on Avenida 10 crossing the city from south to north. In addition to buses, the system includes a number of pedestrian bridges, walkways, bike lanes, and docking stations. Electronic bulletin boards in the main bus stations provide real time information on bus schedules and routes. The occupancy ratio of BRT buses is 40 percent during off-peak hours and consistently reaches 100 percent during peak hours.

The development of the BRT system was a large, ambitious project whose total costs amounted to 2,528,501 million pesos (approximately US$ 1.4 billion). The World Bank is financing integrated mass transit systems that include BRT in selected medium-sized and large cities in Colombia, building on the experiences of TranMilenio. The goal is to improve mobility along the most strategic mass transit corridors, provide better access by the poor through feeder services and fare integration, and build greater institutional capacity at the national and local levels to improve urban transport policies, urban planning and traffic management.[5]

Under the BRT system in Bogotá (and other cities in Colombia where it is being developed), concessionaires purchase the buses and take care of operational and maintenance aspects, while the government is responsible for the maintenance of roads and infrastructure. Passengers pay for trips using electronic cards. If the money collected by BRT concessionaires cannot cover the operational expenses, the Municipality of Bogotá finances the difference from the local budget.

BRT system in Bogotá

Source: www.sibrtonline.org

In addition to BRT, the TransMilenio network includes the "feeders", buses that connect residential areas to BRT bus stops. Currently, there are approximately 500 feeders operating on 90 routes connected to BRTs. Overall, the TransMilenio network covers 663 kilometers.

Feeders operating in Bogotá

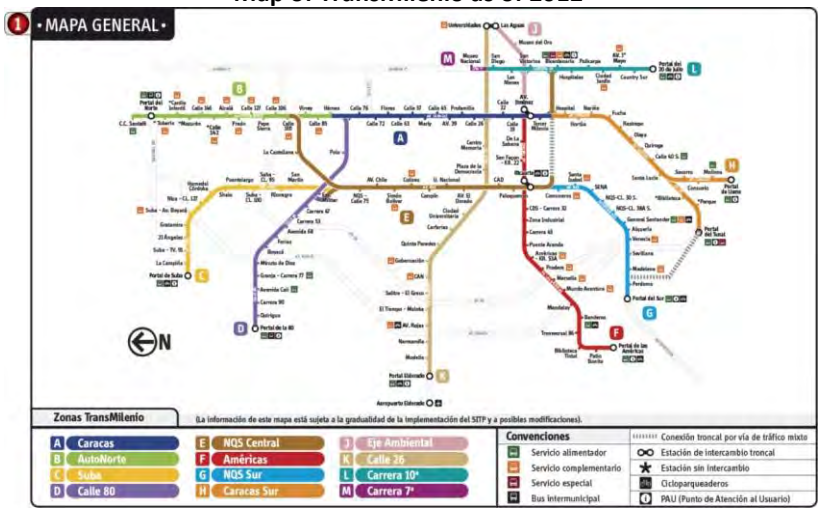
Source: www.sibrtonline.org

The second public transport network in Bogotá, the SITP, is operated by private companies. The SITP fleet comprises of regular buses of different capacities, from 19 to 80 people. People pay for the trip by an e-ticket, and SITP operators are paid per passenger. The revenues are managed by the city authorities to cover operational costs (including bus and e-ticketing operators). Similarly to the BRT system, if ridership revenues are

[5] Source: http://documents.worldbank.org/curated/en/docsearch/report/60813

not sufficient to cover operational costs, the difference is made up by the city. In addition, the City is considering providing subsidies to SITP users as a way of boosting ridership.

Map of TransMilenio as of 2012



The traditional public transportation system is an old network that has been operating in Bogotá for decades. It is made of nearly 15,000 buses owned and operated by 66 private companies. Traditional buses cover 508 routes in the city. There are generally no designated bus stops, thus vehicles can stop whenever passengers request. Trips are paid by cash on the bus. This system is quite inefficient, as buses often are old, require a large amount of fuel, and operate at low average speeds. However, in the future the city plans to replace the traditional bus system with the SITP, which would remove old and highly-polluting buses from the roads.

There are almost 50,000 taxis in the city operated by private companies. Most of the cars are seven years or older. The City issues the taxi authorization and sets the tariffs. Since 2003, the number of taxis in Bogotá has been limited to 50,890. Currently, a pilot project of 50 electric taxis operated by private companies is under way. Codensa, the electricity company, is providing the energy charging infrastructure. Some tax exemptions are offered to taxi companies that use electric vehicles. However, the project has not proven to be very successful so far. Taxi companies complain that people cannot recognize the electric vehicles because they are painted in a different color (blue) than regular cabs (yellow). Also, there are only a few charging facilities available to taxi drivers.

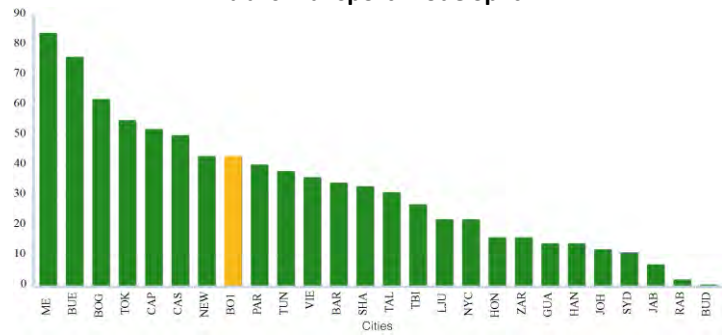
Electric Vehicle in Bogotá

The trip by BRT bus is 1,400 pesos (US$0.73) during off peak hours and 1,700 pesos (US$0.95) in peak hours. Passengers who use traditional buses pay around 1,400 pesos per trip. Taxis charge a minimum of 3,500 pesos (US$1.84) per trip.

According to the TRACE analysis, 43 percent of the commuters use public transport for their daily commutes. This percentage places Bogotá in the high end of the TRACE database with comparable cities. Thus, more people use buses in Bogotá than in Tallinn, Ljubljana, or Shanghai, but fewer than in Casablanca, Cape Town, or Mexico City.

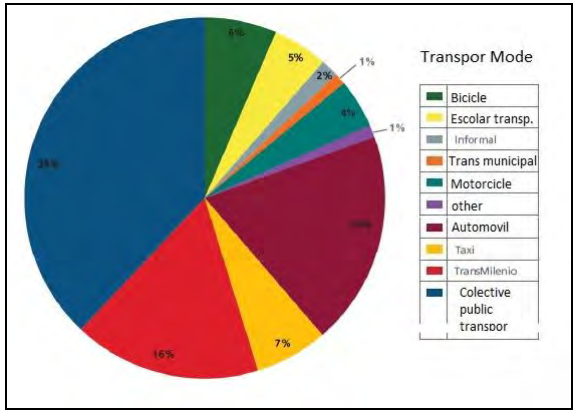
There are approximately 7.7 million trips taken by all means of transportation in Bogotá each day. Roughly 38 percent of the population in Bogotá and surrounding districts rely on traditional buses; 19 percent use private cars, 16 percent use TransMilenio, 7 percent rely on taxis; 6 percent on bicycle; and 4 percent on motorcycles.

Public Transport Mode Split



Nearly 1.6 million daily trips are taken on BRT buses. The BRT capacity has increased steadily, from 700,000 passengers per day in 2003, to 1,672,000 passengers by 2011.[6] Since it became operational in December 2000, more than 4 billion people have used the BRT system, with an average of nearly 200,000 passengers during rush hour.

Transport modes in Bogotá and surrounding districts



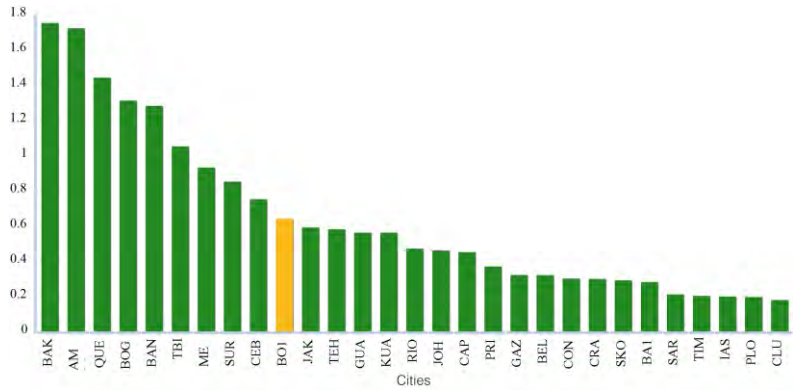
BRT buses are equipped with GPS systems. TransMilenio monitors the buses from a control center through 600 cameras installed across the city. The cameras are connected to the police system, for security purposes. Operators sitting in the control room can communicate with drivers in real time, monitor the bus speed, and instruct drivers to speed up or slowdown in order to improve traffic flow.

Transport monitoring center

With an energy consumption of 0.64 MJ/passenger-kilometer, the public transport system in Bogotá is quite energy intensive compared to cities with similar Human Development Index. Bogotá ranks at the higher end of the TRACE database, with energy consumption comparable to Jakarta and Tehran. The city requires twice as much energy per passenger-kilometer as Belgrade and fifty percent more than Johannesburg, but is more energy efficient than Cebu, Mexico City, or Tbilisi.

Energy consumption public transport - MJ/passenger-km

[6] Técnica de Transmilenio. http://www.sibrtonline.org/es/fichas-tecnicas/transmilenio/6



For the indicator of meters of road of high capacity transit, Bogotá performs well, thanks to the lengthy BRT network. With 118.4 meters per 1,000 people, Bogotá ranks fourth in the TRACE database among cities with a comparable Human Development Index, behind three cities in Romania.

During the 2000s, people were very satisfied with the BRT service. However, in recent years the quality of the services has declined. As traffic has increased, especially in the evening, people must spend long hours on the bus to get home. Traffic congestion in the city has resulted in the average travel speed dropping from 27 km/hour to 19.3/hour for public transport, and from 31 km/hour to 23 km/hour for private cars. The average travel time has also increased, from 51 minutes per trip in 2002 to 65 minutes in 2011. BRT buses operate with an average speed of 26 km/hour, higher than other buses. Local studies reveal that public transport is more utilized by low income communities, while taxis and private cars are more prevalent among high income communities. For example, more than 65 percent of the highest socio-economic group and more than half of high income communities rely on private cars. Conversely, 60 percent of the lowest socio-economic stratum, more than 55 percent of the low income group, and over 40 percent of the mid-low income communities rely on public transport. More than 12 percent of the wealthiest communities in Bogotá travel by taxis, as opposed to only a few percent among poor communities. In addition, people who ride buses must spend twice as much time in transit as those who drive private cars (77 minutes vs. 40 minutes).

Currently, city authorities in Bogotá are in the process of integrating TransMilenio and the SITP systems. This should reduce the number of public transport vehicles in Bogotá, with high capacity buses replacing some of the most highly-polluting traditional buses. With the goal of improving traffic flow in the city, the local administration is considering adjusting the work schedule for public offices and schools to reduce traffic during rush hour. City managers are also contemplating offering discounts to those who travel during off-peak hours.

TransMilenio lines - phases I, II & III

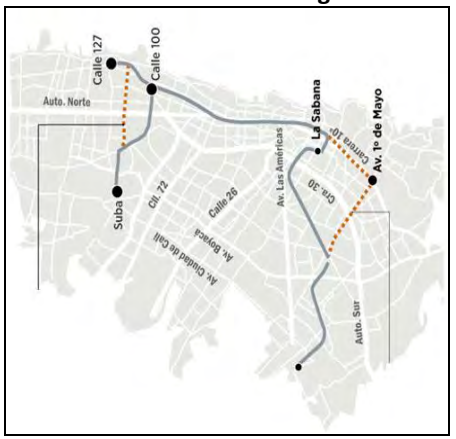
The BRT system in Bogotá has provided the foundation for the country's sustainable transport framework (National Policy on Urban Mass Transportation Systems). The country's national development plan for the period 2010-2014 seeks to promote public transport and simultaneously discourage the use of private automobiles. The Inter-American Developing Bank (IDB) is providing support to the implementation of the Strategic Public Transportation Systems (SETP) aimed at enhancing efficiency, affordability, quality, safety, and environmental sustainability of public

transport, and helped replicating the BRT in Cali.[7] Similar BRT transport systems were developed in Bucaramanga, Medellin, Barranguilla, Cartegena, and Pereira with financial support from the World Bank. A special unit within the ministry of transport, the Urban Mobility and Sustainability, was created in 2012 to monitor the implementation of the SETP program across the country. The national government has joined efforts with local authorities to promote Integrated Mass Transport Systems in cities with 600,000+ inhabitants, and Strategic Public Transport Systems in cities with a population between 250,000 to 600,000 people. [8] Currently, the World Bank is providing US$350 million financial support to Colombia for the National Urban Transport Program (NUTP) that provides support to a new efficient transport system in seven cities, including Bogotá.

Currently, the city is focusing on a new BRT line, which should cover 35 kilometers on Avenida Boyacá crossing the city from south to north. The estimated value of the project is 1,563,488 million pesos (approximately US$860 million). The new routes will bring the total BRT related investments to 4,091,989 million pesos (around US$2.2 billion).[9] In addition to dedicated road infrastructure, the upcoming BRT project will include new bus stops, pedestrian crossing bridges, and a number of bus stations. Once the new lanes are complete, the system will be able to serve nearly 2 million passengers per day.

Both the 2006 Mobility Plan and the TransMilenio development plan outline several forward-thinking initiatives to enhance public transport in the city, including a new metro, cable cars, and light rail connecting Bogotá to surrounding districts.[10, 11] The city is preparing to develop its first light rail network (ligeros) to operate in the northern, western, and southern neighborhoods. The total cost of the project is estimated at US$2.2 billion; 70 percent of the money is to come from the national budget. The engineering design is estimated at US$27.8 million, with US$16.67 million in loans from the World Bank. Construction is expected to start in 2015, and the first network to operate in Suba, a neighborhood of one million people in northern Bogotá, beginning in 2018. Three private companies have submitted proposals to build and operate the future light rail system under a concession contract.[12] So far, two of the proposals have received the green light from the city authorities to move forward with the feasibility study.

First metro line in Bogotá



A feasibility study is under way to assess the development of 2.8 kilometers of cable car system in Cuidad Bolivar, a 700,000 neighborhood in the hilly area, that will connect it to TransMilenio in the Tunal area. The overall cost of the project is estimated at 250 billion pesos (US$125 million).

Currently, the city is testing electric buses on feeder routes. A pilot project of 200 hybrid buses with a capacity of 80 people has recently

[7] http://www.iadb.org/es/proyectos/project-information-page,1303.html?id=CO-L1091

[8] National Development Plan 2010-2014 “Prosperidad Para Todos”, Sector Transporte

[9] National Development Plan - Documento CONPES 3737 - Política Nacional de Transporte Urbano Masivo

[10] Transmilenio S.A & Alcaldia de Bogotá, Junio de 2011 - Plan marco 2010

[11] Plan maestro de movilidad para Bogotá, Secretaria de Transito y Transporte, 2006

[12] http://www.metroenBogotá.com/documentos-oficiales/se-destraba-la-construccion-de-la-primera-linea-del-metro-para-Bogotá

started operating (April, 2014). Some of the feeder operators plan to approach city managers about switching to electric trolleybuses beginning in 2015.

Electric bus test drive in Bogotá

Private Transport

As in many cities around the world, traffic in Bogotá has deteriorated due to the large increase in the number of private vehicles. As a result of economic growth and a rise in individual income, an increasing number of city residents have been able to purchase low-cost used vehicles, many of them imported.

According to official statistics, in 2011 there were a total of 1,572,700 vehicles in Bogotá. 92 percent were private, 7 percent were buses, and one percent municipal vehicles.[13] As of 2011, there were 1,455,061 private vehicles registered in the city, of which 58 percent were automobiles and 19 percent were motorcycles.

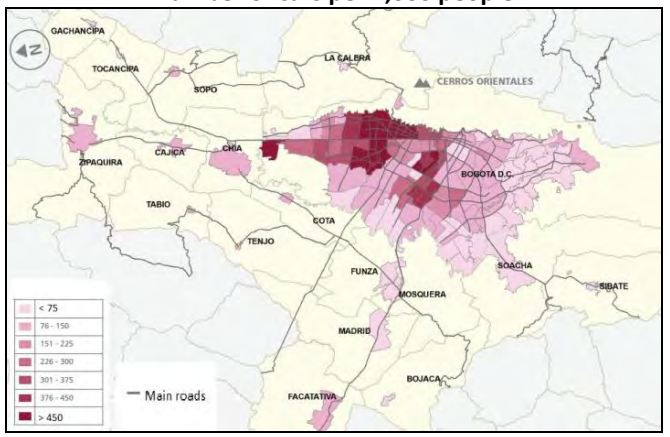
[13] SDM - Movilidad en Cifras 2011

Private vehicle split in 2011

Type of Private Vehicle	Quantity	%
Automobile	839,799	58%
Motorcycle	269,452	19%
Jeep	161,860	11%
Small Trucks	160,855	11%
Other	23,095	2%
Total	**1,455,061**	**100%**

The number of automobiles more than doubled from 2002 to 2011, from 350,000 to almost 840,000 units. At the same time, the number of motorcycles increased from 16,397 to nearly 270,000 units. A survey conducted in Bogotá and surrounding districts in 2012 showed that in the northern part of the city every other person owns a car, i.e., the "motorization rate" is more than 450 vehicles per 1,000 people. The motorization rate is lower in the southern and western neighborhoods at around 150 cars per 1,000 people.

Number of cars per 1,000 people



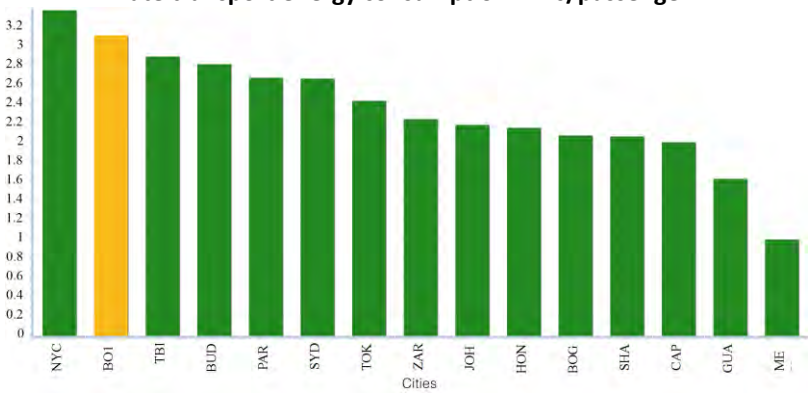
Local authorities in Bogotá have adopted several policies aimed at reducing traffic and greenhouse gas emissions. Since 1998, the *Pico y Placa* system (peak and license plate) restricts both private and public cars

based on the last digit of the license plate number from operating on the streets during peak times of the day. According to this rule, four numbers are restricted every day for private vehicles and two digits for buses from 6 AM to 8 PM. For example, the license numbers ending in digits 5,6,7 and 8 are restricted on Monday, cars with plates ending in 9,0,1 and 2 on Tuesday, and so forth. The restrictions apply only during week days. However, despite the policy, the amount of private transport has continued to increase at the expense of public transport. As has occurred in other cities that have implemented a similar system, people often purchase a cheap second car to get around the restriction, which not only diminishes the impact of the policy, but also adds older and more polluting vehicles to the road.

A park-and-ride facility is located in the northern Bogotá where people can leave their private cars and then take a bus to the BRT/feeder stop. The parking charge is 3,000 pesos (US$1.50) per day. The local transport authority is planning to develop more park-and-ride facilities in the future. In addition, Bogotá has several pedestrian bridges that help people cross large streets and high-ways in the city, as well as get to the elevated BRT bus stations.

With an energy consumption of 3.12 MJ per private passenger kilometer, Bogotá has the second highest energy intensity in the TRACE database after New York City.

Private transport energy consumption – MJ/passenger-km



In 2012, public and private transport required 215 million gallons of diesel and nearly 284 million gallons of gasoline. Overall fuel consumption has gone up by about 7 percent since 2003.

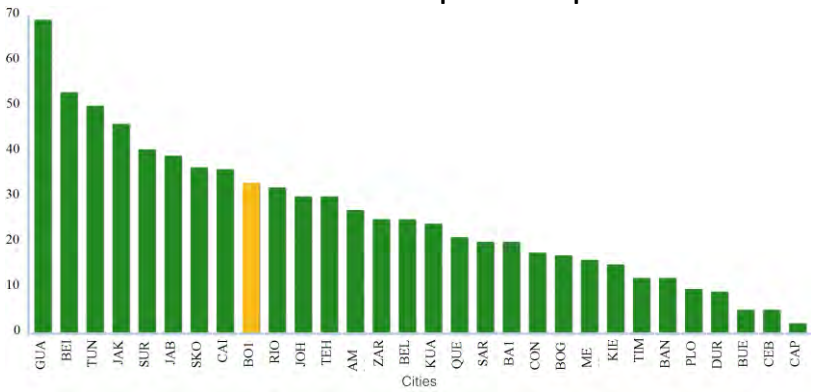
Fuel consumption in Bogotá between 2003 and 2012

Year	Diesel (Gal/year)	Gasoline (Gal/year)
2003	164.381.533	301.473.367
2004	181.141.593	290.848.606
2005	191.758.075	273.207.565
2006	194.013.326	269.143.203
2007	200.180.258	262.382.108
2008	201.852.789	257.148.418
2009	200.581.560	255.894.433
2010	204.053.568	269.499.756
2011	214.356.201	278.186.536
2012	215.968.446	283.393.265

While diesel consumption went up by almost 25 percent, the amount of gasoline went down by 6 percent. The slight decrease in gasoline consumption is most likely due to the higher efficiency of new vehicles, restrictions on private vehicle usage, and the rise in BRT ridership. The transport system also consumes about 11,230,000 cubic meters of natural gas.

According to the TRACE analysis, 33 percent of the city residents rely on non-motorized transport. This figure puts Bogotá at the higher end of the database compared to similar cities. More people walk and bike in Bogotá then in Mexico City, Belgrade or Quezon City, but fewer than in Skopje, Jakarta, and Beijing.

Non-motorized transport mode split



Bogotá has an extensive and growing bike and pedestrian network. There are 376 kilometers of bike lanes in Bogotá, however, not all of them are in good shape or complete. Some of the bike lanes are connected to the BRT system, with a number of bike parking facilities where people can leave their bicycles before getting on the bus. There are a few bike-sharing stations in Chapinero and Kennedy neighborhoods, where people can rent around 400 bikes. In the future, the local transport company is planning to develop more bike share docking stations at the main bus stations in the city. Currently, there is an ongoing tender for new bike parking facilities with a total capacity of 1,400 bikes.

The number of daily trips by bicycle increased 37 percent between 2005 and 2011, from 285,000 to 450,000 trips. Although most bikers belong to lower-income groups, biking has also become more popular among middle and upper income communities for short trips. With more people turning to biking, local estimates are that there was a reduction in CO_2 of around 3,800 tons between 2000 and 2007.

Bike lanes in Bogotá

City managers plan to expand the current bike network by 145 kilometers and connect them to the public transport system. In this way, people could combine public transport with biking, which would contribute to less fuel consumption and pollution.

Bike parking

Most of the pedestrian network in Bogotá is located in the city center. Bogotá has the largest pedestrian corridor in Latin America. Alamida El Porvenir is an 18-kilometer corridor of pedestrian and bicycle paths connecting low-income neighborhoods outside the city to public services, jobs, and shops. The network connects the neighboring municipality of Soacha to the Fontibon, Kennedy, and Bosa areas in Bogotá, covering around one million people.

Alamida El Porvenir pedestrian corridor

One of the most popular pedestrian areas in the city is La Plaza de Bolivar (Bolivar Square), in the heart of the historical center, where the Bogotá City Hall is located. A number of pedestrian malls are located in the most attractive touristic spots in the city, La Candelaria.

Plaza de Bolivar

Source: www.skyscraperlife.com

A large number of people from neighboring localities, such as Soacha, Madrid, Cajica or Sopo, work in Bogotá and commute daily by car. Conversely, many Bogotá residents travel to the western and northern areas outside the city, where some industrial enterprises are based. This is leading to significant car flow to and from Bogotá, adding to the traffic congestion, especially during the morning and evening rush.

As transport is the main source of pollution in Bogotá, over time the local government has taken efforts to reduce fuel consumption from transport. Some initiatives have been designed to promote alternative means of transportation, such as walking and biking, and for residents to leave their cars at home. To this end, the city established "car free day," which has become quite popular and a model for other cities. Air quality measurements during each car free day have shown a significant decrease in air pollution. Bogotá is credited with holding the largest weekday car free day in the world. The first free car day was held in February 2000. The day has become institutionalized through a referendum that was passed in the fall of 2000 after 63 percent of the voters approved a permanent car free day. During car free day, it is believed that around 600,000 vehicles are left at home. In 2014, Bogotá expanded the car free day initiative, by expanding it from one day to an entire week (February 6 through February 13).

Car Free Day in Bogotá

Source: imaginacolima.blogspot.com

While some of the proposals were welcome by people (such as the car free days), other initiatives have been less popular with the city residents, such as the initiative to restrict access to the city center for cars with only

one passenger. National government authorities are currently discussing the possibility of instituting congestion pricing in cities with more than 400,000 people.

Although local statistics indicate that air quality in Bogotá has improved slightly over the past decade, poor air quality remains a concern. Recently, the city approved a plan requiring cars to undergo periodic inspection and maintenance to control emissions. The plan also requires SITP buses to be equipped with catalytic converters. In the future, the municipality is seeking to employ a number of measures to further reduce air pollution. Some proposals target the transport sector, such as employing oxidation catalysts for freight vehicles that drive in the city, introducing secondary air injection for motorcycles with engines smaller than 250 cubic centimeters, and equipping buses and minibuses with emission filters.

Street Lighting

The street lighting in Bogotá is operated by the electricity provider Codensa, with supervision by the local government through the Special Unit for Public Services (UAESP) within the Municipality of Bogotá. The street lighting infrastructure belongs to Codensa.[14] The municipality pays for electricity, operation & maintenance costs, and the use of light poles to Codensa. The electricity provider outsources the maintenance of the street lighting infrastructure to two contractors. UAESP audits the street light service through an independent company in order to make sure that it meets the standards. Inspections conducted during nighttime identify lamps that are our or do not work properly. The flaws detected in the system are discounted from the electricity bill.

There are approximately 330,000 lamps in Bogotá. In the 2000s the local authorities replaced the energy-intensive mercury bulbs with more energy efficient, modern sodium vapor lamps. Today, 99 percent of the lamps are sodium vapor lamps, with a very small share of halide and mercury lamps, and a few LEDs. About 20 percent of street lighting in Bogotá is metered, mostly the light points located along highways. The rest has no metering. Codensa estimates the consumption of the unmetered light points based on a formula considering the hours of operation (assuming a 12-hour daily consumption per light pole) and the average consumption per light bulb (approximately 25 years). Most of the lighting is located on the main roads (79 percent), while the rest is located on sidewalks, parking lots, sport and recreational facilities, and parks.

Light poles in Bogotá

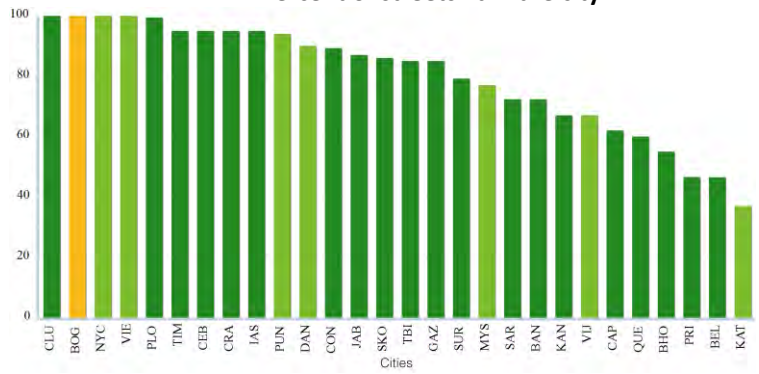
Source: www.comteq-ltda.com

National regulations require the lighting systems to meet standards. For instance, depending on the type of lamps, the lifespan of fluorescent bulbs should be between 3,000 and 8,000 hours.

All streets in the city are lit, including low income neighborhoods. This places Bogotá among the few cities in the TRACE database with 100 percent street lighting coverage.

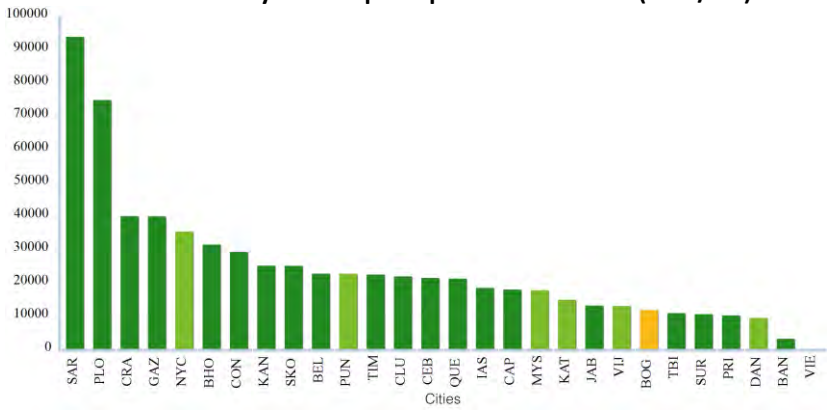
[14] There are ongoing discussions and judiciary processes between the Municipality of Bogotá and CODENSA regarding the ownership of the street lights assets, in particular those built after the creation of CODENSA.

Percent of streets lit in the city



The total energy consumption necessary to operate the street lighting system in Bogotá amounts to 168 GWh. Bogotá is among the most efficient cities when it comes to electricity used per kilometer of lit roads, i.e., 11,672 kWh.

Electricity consumption per km of lit roads (kWh/km)



The system is performing better than most of the Eastern European cities in the TRACE database, such as the seven largest cities in Romania, Gaziantep in Turkey, and Sarajevo in Bosnia and Herzegovina, although it uses slightly more electricity than Tbilisi in Georgia and Pristina in Kosovo.

The city pays 48 billion pesos (approximately US$25 million) to cover the electricity bill, at an average tariff of 290 pesos (US$0.15) per kWh. Operational and maintenance expenditures for street lighting amounted to 131 billion pesos in 2012 (US$73 million. In many cities in Colombia the cost of street lighting is borne directly by citizens under a levy included in their electricity bill. In Bogotá, street lighting is covered from the local budget, with service charges for lighting paid by property owners. The final tariff includes the cost of energy and distribution services, as well as a fee the City has to pay to Codensa for using the light poles. The final electricity tariff includes the cost of energy consumed (assuming a 12 hour daily consumption per light pole) and distribution services, as well as a 'leasing' fee the City has to pay to Codensa for the use of the light poles. This fee is calculated based on the lifespan of bulbs (approximately 25 years). The city is considering changing the payment method to include the street lighting service in the energy bills of those with electricity connections.

Local studies indicate that the amount of energy necessary to operate the street lighting systems in Colombia amounts to around 4 percent total electricity consumption in the country.[15] The street lighting network in Bogotá requires 2.1 percent of the total municipal electricity used, or about 42 percent of total municipal government usage. Following the replacement of mercury bulbs with sodium vapor lamps, electricity consumption by street lighting was reduced by about 12 percent. However, from 2008 to 2012 it went up by 3.7 percent.

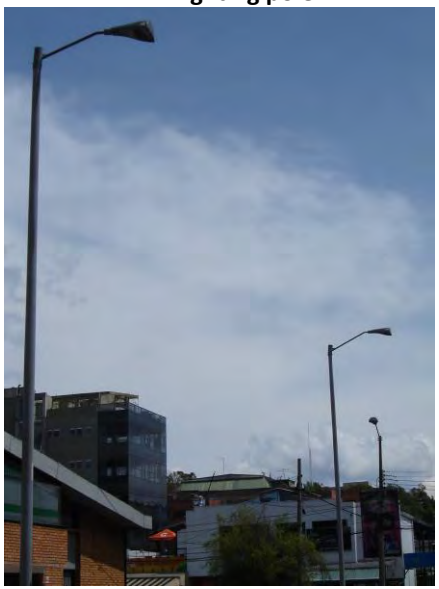
In recent years, the local public administration stepped up its efforts to modernize the street lighting system in the city and reduce energy consumption. For example, under a pilot project the light poles at the National University of Colombia were equipped with devices to allow lamps to be monitored by a remote-controlled system. The city upgraded the poles on the main roads to include meters and enhance their

[15] Afanador, E. Estudio sobre el alumbrado público. Asocodis & Andesco

efficiency. A new lighting system has also been implemented in Plaza de Bolivar in the historical center.

Codensa has implemented a 400 million pesos (US$20,000) street lighting retrofit pilot project of 33 LED lamps near the company's headquarters on Carrera 13. The pilot included the replacement of the entire infrastructure, including new light poles, LED bulbs, and underground cabling. In the immediate future, the company plans on installing 100 more LED lamps at the National Museum. In the next few months, Bogotá will undertake an ambitious project of replacing approximately 33,000 sodium vapor bulbs with LED lamps. The total value of the project is estimated at US$32.8 million. The first batch of 11,000 lamps should be replaced by 2015, and is expected to cost US$9.5 million. First LED bulbs will be installed on the pedestrian networks in the historical center (La Candelaria). This project is expected to help reduce electricity consumption in the units replaced by 30 percent, and improve the quality of public lighting in the city.

LED lighting pole



Codensa will organize a tender to purchase the LED bulbs based on pre-agreed specifications, and the most competitive price. Currently, negotiations between the city managers and Codensa are taking places in order to reduce implementation-related costs. The local government plans to develop regulations regarding LEDs bulbs, but is uncertain if LEDs will be feasible in low-income districts of the city. However, the city managers believe that the system could be further improved if they could organize a tender to choose a new operator.

Water Sector

Potable Water

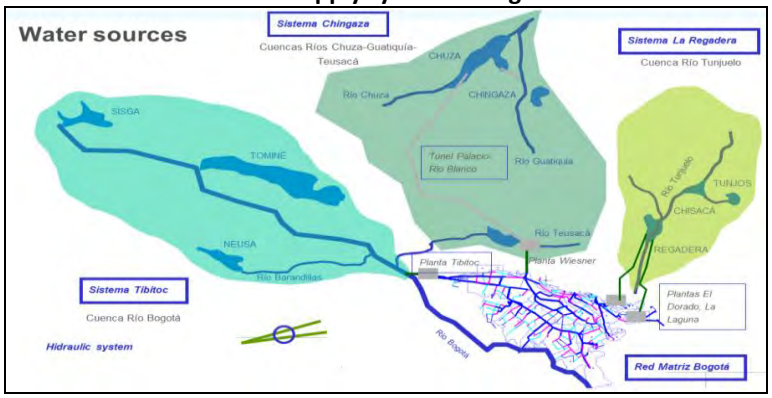
The water sector in Bogotá is managed by *Empresa de Acueducto Y Alcantarillado de Bogotá,* known as Acueducto, a public utility company under the city government. The company is in charge of production, treatment, and distribution of water, and wastewater services. The water supply system includes water reservoirs, pumps, distribution networks, treatment and storage facilities. The company is outsourcing maintenance services to third parties. Currently, Acueducto supplies nearly 100 percent of Bogotá with potable drinking water on a continuous basis to over 1.8 million water connections in residential, industrial and commercial areas. The company provides sewerage services to 99.2 percent of the city, covering nearly 1.8 million clients.

Most of the water supplied to Bogotá comes from above-ground sources from the Rio Bogotá and Chingaza system located at high altitudes. In 1972, Acueducto initiated an inter-basin transfer project from the Chingaza basin to Bogotá to meet Bogotá's rapidly growing population. The program was completed in 1997 and consists of two reservoirs (Chuza and San Rafael), the Francisco Wiesner treatment plant, and a series of tunnels to transport raw and treated water. Today, the system is one of the great water engineering projects of Latin America.

To provide power to its different facilities, Acueducto has developed three small hydro power plants with a total installed capacity of 20MW. A new plant of 20MW is in the pipeline. In general, energy consumption for pumping is relatively low, as much of the water moves through a gravitational system to the pumping facilities.

The water system in Bogotá operates with 57 water tanks with a total storage capacity of 572,000 cubic meters, and 33 pumps with an overall capacity of 30 GWh per year. There are also 34 kilometers of transmission pipes, and 477 kilometers of distribution network. In addition, the system has several water tunnels that carry water from the rivers to the treatment plants. There are eight reservoirs, with a total capacity of 1,238 million cubic meters. The largest network of three reservoirs belongs to Tibitoc River basin, north of Bogotá, with a total of 894 million cubic meters. The Chingaza water system includes two reservoirs that can store up to 332 million of cubic meters of water. Finally, the smallest network is La Regadera, south of Bogotá, with a capacity of 12.4 million of cubic meters.

Water supply system in Bogotá



Source: Acueducto

Acueducto is managing four treatment plants with a total capacity of 26 cubic meters per second. The largest facility is Wiesner, part of Chingaza system. The plant can supply 70 percent of the water required in Bogotá at 14 cubic meters per second. Usually, the facility supplies the city for nine months a year. However, when the water transmission tunnel is undergoing maintenance work (about three months a year), the plant pumps water from the San Rafael dam. The second largest facility with a treatment capacity of 10.5 cubic meters per second, Tibitoc is responsible for 28 percent of water supply in the city. Tibitoc was constructed upstream of the city on the Rio Bogotá in 1959 with a capacity of 3.5 m3/s, and later underwent an upgrade to 5 cubic meters per second. Finally, La Regadera is a small and isolated water network, comprising two treatment plants, Eldorado and Laguna. The Tibitoc and El Dorado water treatment plants use conventional treatment processes, while the Wiesner facility has a direct filtration system.

Acueducto is tackling the water scarcity during dry seasons by promoting efficient water consumption and setting a ceiling for water usage. The Municipality of Bogotá is exploring alternative water sources, such as ground and rain water. Moreover, the city's sustainable building code is promoting the collection of rain water by residential consumers.

The Chingaza water system near Bogotá

Source: torrescamara.com

The water company serves 1,812,228 customers in Bogotá, of which 1,623,621 are residential customers. The largest pool of customers

belongs to the middle-income group (sector 2 and 3), with 69 percent of the water connections. The lowest-income groups (sector 1 and 2) account for 39 percent of water connections, while the highest-income households (sector 5 and 6) account for 9 percent of water connections. Like electricity, the water tariffs are stratified based on the location of the residence and household income. The water service has a cross subsidy whereby sectors 5 and 6 subsidize sectors 1, 2 and 3.

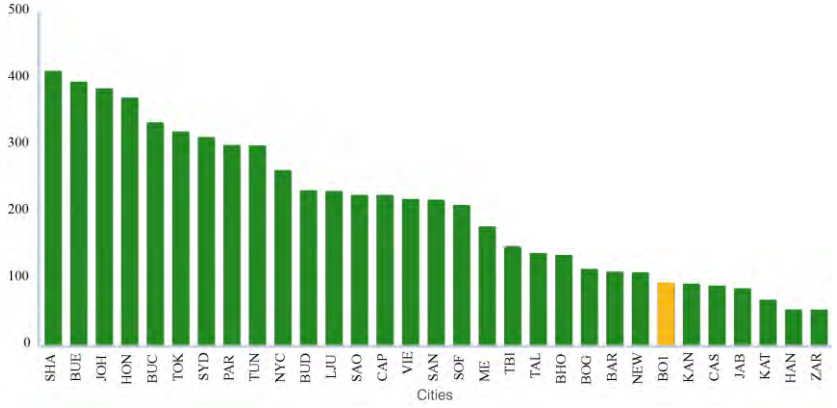
Number of customers connected to water & sewage network in Bogotá

Residential Use / Socio Economical Sector	Bogotá	
	Water service	Sewage service
Sector 1	103.949	91.311
Sector 2	537.526	527.580
Sector 3	581.792	580.994
Sector 4	251.671	251.490
Sector 5	81.098	79.915
Sector 6	67.585	67.064
Residential	**1.623.621**	**1.598.354**
Multiple user	**63.168**	**62.466**
Industry	7.333	7.306
Commercial	114.251	113.637
Official / Public instit	2.913	2.872
Special	952	941
No Residential	**188.617**	**187.222**
Total	**1.812.238**	**1.785.576**

In 2012, the total amount of water produced in Bogotá amounted to 477 million cubic meters. The water actually sold amounted to 272.7 million cubic meters. Of this, 203.6 million cubic meters went to residential customers. According to the TRACE analysis, the city uses 93.98 liters per capita per day. This figure places Bogotá in the lower side of the database comparable with cities with similar climate. The city needs less water than Barcelona or New Delhi, and half as much as Santiago de Chile or Vienna.

Average consumption in the residential sector is even lower, of only 78.2 liters/day. Consumption varies depending on socio-economic group. For example, the richest households use 233 liters per day. The highest income group, sector 6, required a total of approximately 11 million cubic meters, against 69 million cubic meters that went to sectors 2 and 3. Overall, 75 percent of the water in Bogotá is consumed by sectors 1, 2, and 3.

Water consumption per capita/day - cubic meter/capita/day



The construction of the Chingaza system effectively secured Bogotá's long-term water supply. While the city's water sources were expanding, the actual per capita water use in Bogotá fell due to the increase in tariffs mandated by the *Comision Reguladora del Agua* (CRA). Bogotá residents now pay some of the highest water tariffs in Latin America.

The residential sector and public offices pay a monthly charge of 7,136 pesos (US$3.56) for O&M and administration costs, in addition to 2,423 (US$1.21) pesos per cubic meter of water. Sectors 1, 2, and 3 receive 15 to 70 percent in subsidies which are borne by the customers in sectors 5 and 6. These higher-income customers pay a full cost recovery tariff plus a percentage to cross-subsidize sectors 1, 2 and 3, which can increase tariffs up to 70 percent. The commercial sector pays a monthly fee of 10,704 pesos (US$5.35), in addition to 3,635 pesos (US$1.81) per each cubic meter of water.

Total water consumption by sector (cubic meter/year)

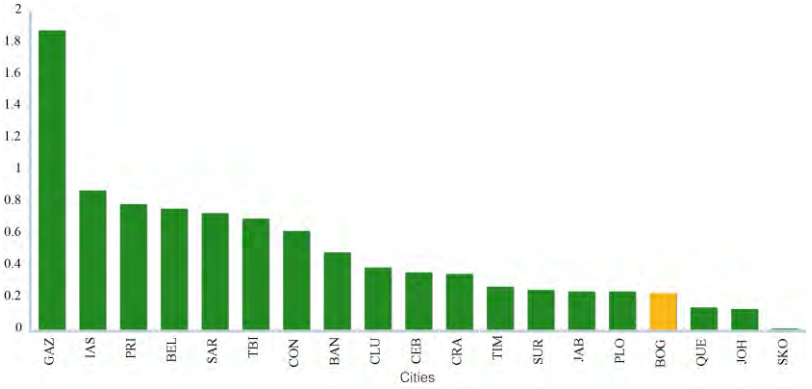
2012	Bogotá		
Socio Economcial Sector	Water Service	%	Sewage
# 1	14.293.828	7,02%	12.590.052
# 2	67.451.321	33,11%	65.859.796
# 3	69.556.524	34,15%	69.410.301
# 4	29.728.357	14,59%	29.707.798
# 5	11.451.867	5,62%	11.158.410
# 6	11.215.577	5,51%	11.084.203
Average Residential	203.697.474	100%	199.810.560
Multiple user	12.476.501	18,06%	12.334.731
Industry	14.045.363	20,33%	16.572.397
Commercial	27.983.397	40,50%	27.504.559
Official / Public ins	11.824.508	17,11%	11.381.046
Special	2.770.929	4,01%	2.749.758
No Residential	69.100.698	100%	70.542.491
Total	272.798.172		270.353.051

The water distribution system is split into five geographical regions, called "commercial areas." There is one contractor in each area responsible for operation and maintenance services. The water distribution network is divided into five regions according to the hydraulic activity and distribution of the main water pipes. Some 90 meters installed on the main pipes and 721 meters across the distribution network measure the water activity, including losses.

Water commercial areas and service areas in Bogotá

Energy consumption for the overall process of catchment, treatment, and water supply is low, requiring 0.23 kWh of electricity per cubic meter. This is the fourth lowest figure in the TRACE database of comparable cities, after Skopje, Johannesburg, and Quezon City.

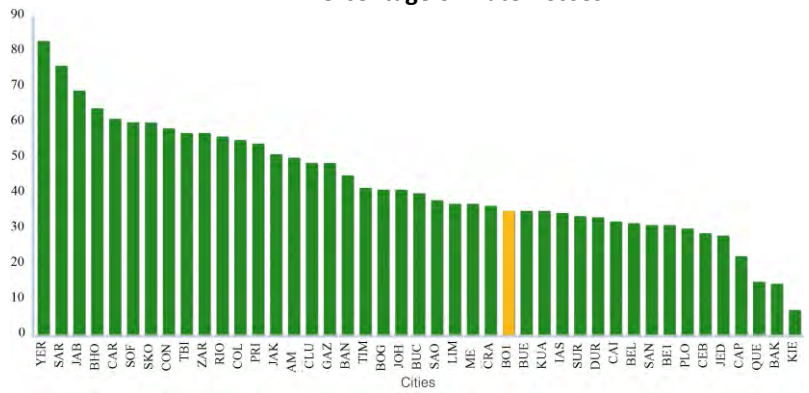
Energy consumption to produce potable water - kWh/cubic meter



Acueducto needs almost 100 million kWh of electricity annually to treat the potable water produced. The electricity used for potable water treatment accounts for 5 percent of the total energy consumption of the company.

With overall 35 percent water losses in the water system, the capital of Colombia is in the middle of the TRACE database of comparable cities. Water losses are similar to Buenos Aires, Kuala Lumpur, but are higher than Belo Horizonte, Cape Town, or Belgrade, and lower than Johannesburg, Bucharest, Jakarta, and Rio de Janeiro.

Percentage of water losses



According to national regulations, a maximum of 30 percent losses can be charged to the clients. Hence, the 5 percent difference between the accepted losses and actual figure is borne by Acueducto. Technical losses account for 48 percent. There are severe leakages in the network, as most of the water pipes are old and poorly insulated. Most commercial losses occur due to metering issues and water theft from the network. Collection of revenues is good, i.e., 97 percent of all clients pay their water bills on time.

Acueducto has been undertaking a program aimed at reducing water losses and promoting efficient consumption. The city plans to improve the efficiency of water pumps through replacement and maintenance. Most of the high, energy intensive pumps are used to supply water to the hilly areas of the city. Between 2011 and 2013, the city was able to reduce electricity for pumping by 9 percent.

Acueducto is planning on expanding the network and gradually increase the maximum capacity of water production, from 26 cubic meters per second to 38 cubic meters per second by 2047.[16]

[16] EAAB Master plan available at www.acueducto.com.co/wpsv61/wps/html/resources/empresa/PPLANMAESTRO300409.pps

Wastewater

The wastewater sector is also operated by Acueducto. Currently, there is only one wastewater plant in the city, though some local industries have their own sewage treatment networks. Only 25 percent of the wastewater in the city is treated; the rest is discharged into the Bogotá River through a network of canals and wetlands.

Acueducto has carried out a number of initiatives to prevent rainwater from getting mixed with wastewater. Bogotá has had a network of rainwater and wastewater pipes that drain into the Bogotá River. The wastewater would be discharged into a few small rivers, namely the Fucha River, the Tunjuelo River, and the Salitre (or Juan Amarillo River), all highly polluted, and from there would drain into the Bogotá River. The Bogotá River has become highly polluted, posing environmental and health risks.

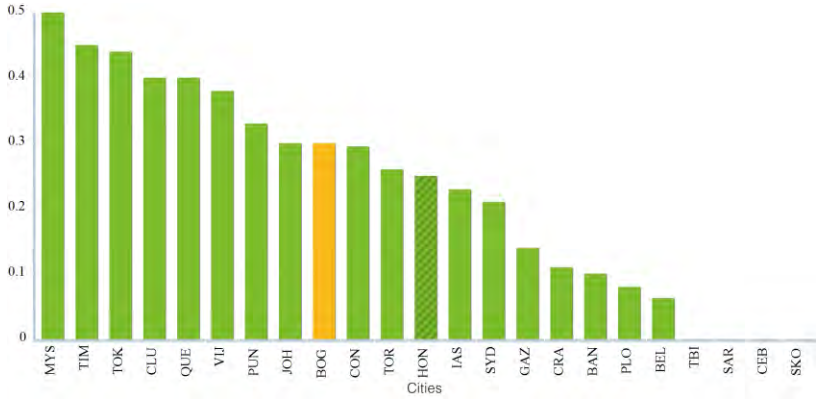
The first section of the Salitre wastewater treatment plant was built in 2000, and has a capacity for primary treatment of wastewater of 4 cubic meters per second. The plant serves 2 million people living in northern Bogotá. There are a total of 1,785,576 sewage connections in the city, of which nearly 1,600,000 are in the residential sector.

The sludge collected by the sewage treatment plant is used to produce 350,000 cubic meters of biogas per month. Most of the biogas is used to heat water and operate the anaerobic digesters at the plant. The bio-solids dehydration process can generate 165 tons/day of organic materials that are transported to the *El Corzo* landfill.

The four small rivers crossing Bogotá

In 2012, the wastewater treated in Bogotá amounted to 167.9 million cubic meters, and required 13.9 million kWh of electricity. Considering the limited amount of wastewater that is treated in the city (25 percent), the information on electricity consumption may not accurately reflect per capita energy consumption per cubic meter (currently it provides a low estimate of 0.052 kWh per cubic meter which would be the most efficient in the TRACE database). When the new wastewater treatment facility is completed in 2018, the city will be able to expand the capacity of wastewater treated, and would require more energy. Estimates indicate that in the coming years, Bogotá would need approximately 0.3 kWh to treat one cubic meter of wastewater, comparable to cities in Eastern Europe or Johannesburg in South Africa. In 2012, the overall energy expenditure for potable and wastewater amounted to approximately 26 billion pesos (US$14.5 million).

Expected energy consumption for wastewater treatment – kWh/cubic meter



The residential sector and public offices pay a monthly charge of 3,636 pesos (US$1.81), in addition to 1,559 pesos (77 US cents) per cubic meter of water. The wastewater sector uses the same cross-subsidy as the water sector.. Industrial customers pay a flat fee of 4,763 pesos (US$2.38) in addition to 2,229 pesos (US$1.11) per cubic meter of wastewater. Commercial clients pay 5,452 pesos (US$2.72) as monthly charge and 2,338 pesos (US$1.16) per cubic meter.

Since 2004, the local authorities have undertaken a process of reducing the amount of pollution flowing into the Bogotá River under a plan to the year 2020.[17] The plan is being carried out by Municipality of Bogotá together with the Environmental Agency and other relevant stakeholders.

[17] National Development Plan COMPES 3177 – July 15, 2002

Only 25 percent of wastewater is treated in Bogotá

Under the plan by the national environment ministry (MADS), sanitation companies are to prepare wastewater management for all municipalities along the Bogotá River. A special fund for the Bogotá River Basin receives 7.5 percent of the property taxes collected. With loans from international/multilateral banks and money from the local budget, Bogotá has expanded the wastewater system by developing underground collection pipes, building a new section of the Salitre plant, and new pumping stations.

Acueducto and the regional environmental agency (Corporacion Autonoma Regional, CAR) are undertaking an ambitious mega-program of approximately US$1.5 billion to improve environmental conditions in the Bogotá River. The water company is building large wastewater interceptors to convey wastewater to Canoas and has initiated detailed design for a primary treatment plant. CAR has embarked on the US$487 million Rio Bogotá Environmental Recuperation and Flood Control Project with co-financing from the World Bank of US$250 million. The project's objective is to transform 68-km of the Bogotá River into an environmental asset for the Bogotá metropolitan region by improving water quality, reducing flood risk, restoring riparian habitats, and creating multifunctional areas along the river that provide an ecological habitat, as well as opportunities for public use.

Wastewater treatment facility in Bogotá

The expansion of the Salitre wastewater treatment plant should be finalized in 2018, at a cost of US$390 million. Upon completion, the treatment capacity would go from 4 cubic meters per second to 8 cubic meters per second. The treatment will be also upgraded, from primary treatment to secondary treatment with activated sludge, which will require higher energy consumption. The construction of a new facility, Canoas PTAR, is expected to begin in 2015. Upon completion of these projects, the amount of wastewater treated should expand from 25-30 percent to 100 percent and the quality of wastewater is expected to improve. Salitre will treat about one-third of the raw wastewater, while the new Canoas facility based on activated sludge will treat the other two-thirds.

Solid Waste

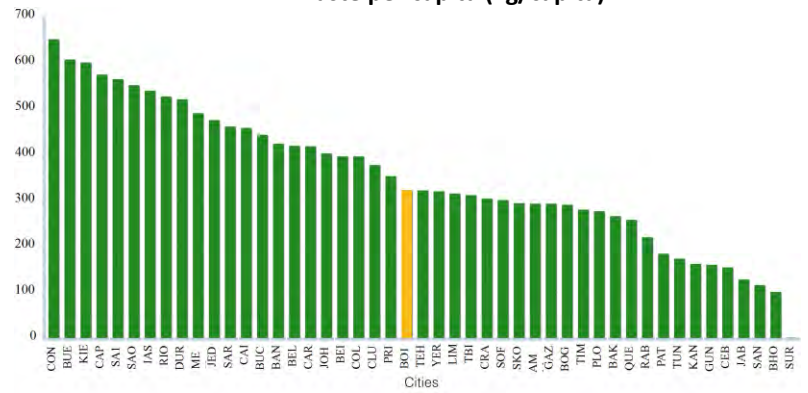
Because city authorities were not able to provide fuel consumption data for the solid waste collection and management sector in Bogotá, the analysis is based on limited information on waste generation and recycling in the city. Consequently, the potential energy savings are based on estimates from other similar cities in the region and globally.

The solid waste sector in Bogotá is operated by both private and public concessionaires, and it is overseen by the city through UAESP (define), a special unit within the municipal government in charge of public services. More than 53 percent of the solid waste collection is operated by Agua, a public company, while 47 percent is handled by private operators. The landfill is owned by the City, and is operated by a private concessionaire.

The waste fleet comprises of 420 trucks and 220 compactors. None of the trucks is equipped with a GPS system. Recently, most of the old waste trucks were replaced with more efficient vehicles. About 30 percent of the new solid waste fleet runs on natural gas, and comply with Euro 4 emissions standards.

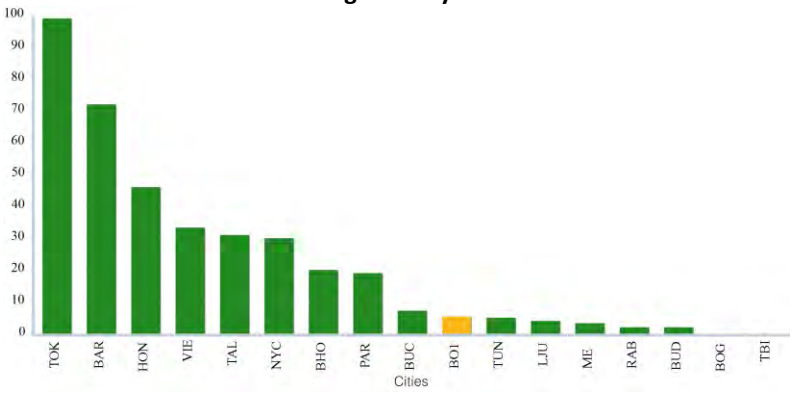
Bogotá generates 6,732 tons of waste daily, which represents about 322 kg of solid waste per capita, a figure that places Bogotá in the middle of the TRACE database compared to cities with similar a Human Development Index. The amount of solid waste per capita is comparable to the cities of Tehran and Yerevan; it is lower than Kiev, Santiago de Chile or Sao Paulo, but higher than Sofia, Amman, or Gaziantep.

Waste per capita (kg/capita)



Reportedly, nearly 100 percent of the solid waste in Bogotá is collected, with 96 percent going to the landfill. The city is performing poorly when it comes to recycling. Only about 5 percent of solid waste is recycled. This figure is quite low compared to cities with a similar climate. For example, Paris recycles almost four times more solid waste than Bogotá, Tallinn almost six times more, while in Barcelona the amount is thirteen times higher. According to city authorities, Bogotá recycles around 357 tons per day.

Percentage of recycled waste



Bogotá does not have a formal separated collection system. Recycling is done informally by scavengers which get paid by the City according to the amount of solid waste sorted, at a rate of approximately 90,000 pesos (US$47) per ton. The majority of recycled items are aluminum, paper, and cardboard, some of which is sold abroad. According to the Japanese International Cooperation Agency (JICA) and the Colombian Department of Taxes and Customs (DIAN), exports of recycled wastes in Colombia increased 35 percent between 2000 and 2011.

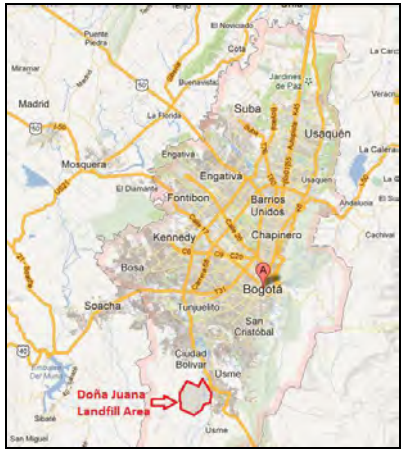
The amount of industrial waste has declined in recent years due to the movement of some factories out of the city. A few collection companies deal exclusively with hazardous and construction waste. Some construction and demolition waste is dumped at mining facilities. Recently, the City of Bogotá launched a program called *Basura Cero* (Zero Waste), with an ambitious target of reducing the amount of landfilled solid waste by 2025.[18] The program provides an overarching framework for encouraging people and private entities to increase selective collection and recycling activities in the city. The smaller the quantity of solid waste that is taken to the landfill should result in lower expenditures on solid waste collection, transport, and management, which would ultimately save money for the city.

People with high incomes subsidize the waste collection tariffs for poor communities in Bogotá. For example, in 2012, people living in upper income neighborhoods paid up to 32,484 pesos (US$18) per month, while low-income communities paid around 12,687 pesos (US$7). The money from solid waste fees is collected by UAESP to cover solid waste collection and management.

Solid waste truck operating in Bogotá

Located in Usme, around 20 kilometers south of Bogotá, the Doña Juana landfill is one of the largest of its kind in Latin America. Owned by the city government, but operated by a private concessionaire, the facility is spread over 315 hectares. It includes a leachate treatment plant and a number of biogas collection facilities managed by private companies under concession agreements.

Location of the Doña Juana landfill near Bogotá

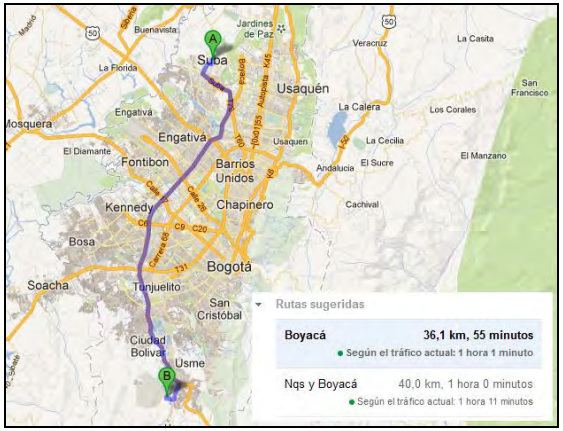


[18] http://www.Bogotábasuracero.com/plan-desarrollo

Some of the trucks serving communities in the northern part of the city must travel 35 kilometers to get to the landfill. According to UAESP, the amount of waste dumped at the landfill between 1998 and 2012 amounted to more than 28 million tons, and it has increased every year. It is estimated that the amount of solid waste entering the landfill went from 1.8 million in 2002, to 2.23 tons in 2010, and increase of 20 percent. In 2012, 2.28 million tons of solid waste entered the facility, approximately 190,000 tons per month, or 6,300 tons per day.

The landfill has a methane gas collection and recovery system that is managed by the private operator, ESP. The company is developing a project to capture methane gas and use it for local industry (e.g., brick factories). The City has submitted a proposal to capture methane gas to the UN Framework Convention for Climate Change, that would reduce more than 18 million tons of CO_2-equivalent for the period 2009-2030.[19] However, due to low price of carbon credits on the international market, the methane capture project is facing financial difficulties.

Distance travelled to the landfill



The City pays a flat charge for each ton of waste deposited at the facility. Over the past decade, the collection activities were managed by private operators, which increased their solid waste collection and management fees. New agreements for solid waste operators are expected to lower the fees.

Although the city authorities could not provide with the information on fuel consumption for solid waste collection and management related activities, the TRACE team identified potential savings for the sector. Bogotá could save some money by enforcing new routes for solid waste trucks, which would result in lower fuel use per ton of waste collected and transported.

The city authorities plan to review the current solid waste collection system. Three options are being considered: (1) keep the status-quo (with public and private operators); (2) organize the collection system under a public company, or (3) open the process to competition between private and public entities. The city wants to formalize the selective collection system within the existing framework with informal scavengers. City managers are assessing the options for making selective collection mandatory for households. They are also thinking of developing a pilot project to establish a composting facility together with the farmers' market.

Municipal Buildings

The municipal buildings in Bogotá are managed by each of the 20 sub-districts in the city, with some oversight from the Municipality of Bogotá. The municipal building stock comprises of 1,664 buildings, including 734 educational units, 91 public offices, and 172 healthcare facilities, in addition to a number of sports and cultural offices. Although the Municipality has certainty on the number of the buildings, the city managers do not know the overall floor area of such facilities.

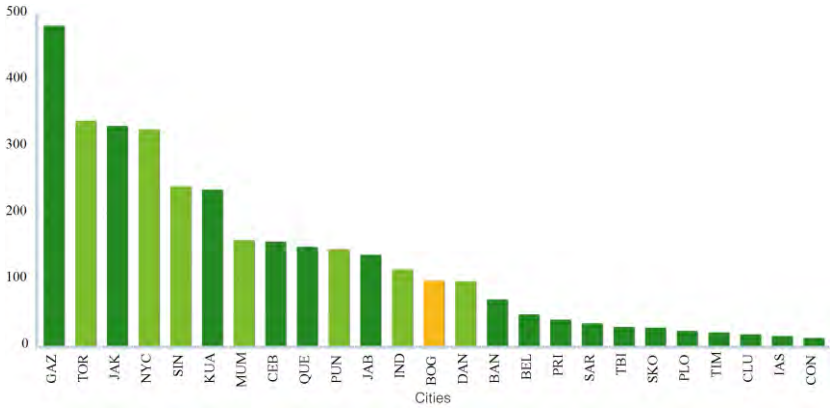
Due to a mild climate, the buildings do not require much heating or cooling. However, if temperatures fall below 5 Celsius degree, people may turn on the heaters. More people use air conditioners (A/C) in recent years, due to rise of temperatures in the afternoon (20+ Celsius degree).

[19] UNFCCC - Project Design Document - Doña Juana Landfill gas to energy project

Some of the facilities may require some A/C, especially glass buildings that allow for little air circulation. Some of the new buildings are equipped with central air conditioning systems.

Since the local government could not provide with the overall floor space, the TRACE analysis was based on only six governmental buildings. According to the analysis, the electricity consumption comes to 98 kWh per square meter, a figure that places Bogotá in the middle of the TRACE database. Hence, the city is performing better than Mumbai or Quezon City but is lagging behind other peers, such as Belgrade or Tbilisi.

Electricity consumption per square meter (kWh/square meter)



According to the most recent figures (2011), the overall electricity consumption of municipal buildings in Bogotá amount to 101,938 MWh. The largest consumption, 51 percent, is by municipal companies (such as water, telecommunications, energy), followed by healthcare facilities (17 percent), and public offices (9 percent). Some hospitals are very energy-intensive with an annual electricity consumption of nearly 2,000 MWh. According to local authorities, annual energy expenditures (including electricity and natural gas) amount to 13.4 billion pesos (US$6.7 million). At an average tariff of 334.5 pesos (US$0.17) per kWh, the analysis assumed that the city pays approximately 11.7 billion pesos (US$5.9 million) per year for electricity bills in municipal buildings.

In recent years, with support from the UNDP, the Colombian government has undertaken steps to improve energy efficiency in municipal buildings.[20] A guide was developed by the National University of Colombia to optimize lighting energy use in different parts of public buildings such as offices, restrooms, and kitchens. A national energy efficiency agency has been established to implement energy efficiency projects. An assessment of energy usage in non-residential buildings is underway in four cities, including Bogotá. Finally, a pilot study to audit energy consumption in healthcare facilities has developed software to measure and reduce energy consumption in hospitals.

The Bogotá City Hall

Based on national energy efficiency studies, there is potential to reduce energy consumption in commercial and public sector buildings by 4.4 percent, with a 2.5 percent target by 2015. Authorities have initiated programs to replace incandescent bulbs with more efficient lamps, and public institutions are required to comply.[21]

[20] U.N & UPME - Determinación del consumo final de energía en los sectores residencial urbano y commercial, 2006

[21] MME - Resolucióin 18-0609 de 2006. Subprogramas del PROURE

Currently, the local government of Bogotá is updating the 1995 Construction Code that establishes regulations for water, electricity, and natural gas systems. With support from the IFC, the municipality of Bogotá is drafting the guidelines targeting an efficient use of electricity, natural gas, and solid waste management in buildings. Finally, the local environment agency is developing a social housing program to incorporate a number of eco-urban measures.

Meanwhile, the city could consider developing an energy database, where all energy-related information can be tracked and monitored. The database could include some basic information regarding the surface area of the buildings, the annual electricity and heating consumption. Such energy efficiency database could be used to further prepare an efficient analysis on the energy saving potential of the municipal buildings. After the database is prepared, the local government could take into consideration an audit and retrofit process. This could enable cost savings in municipal buildings, while also reducing the carbon footprint of the city.

After the saving potential for each indicator was calculated, a sector prioritization was done in TRACE, based on the amount of energy that could be saved. The most promising three sectors in Bogotá where the local government has an important degree of authority are ”Public Transport,” “Street Lighting,” and “Potable Water.” All priorities identified by TRACE were presented and discussed with local public administration officials in Bogotá. Six recommendations have been chosen together with the city managers, and these are discussed in more detail in the sections below.

Sector prioritization

City Authority Sector Ranking

Rank	Sector	REI%	Spending (US $)	CA Control	Score
1	Public Transportation	20.0	917,925,197	0.90	165,226,535
2	Street Lighting	30.0	32,850,000	0.70	6,898,500
3	Potable Water	15.0	12,415,011	0.75	1,396,688
4	Municipal Buildings	20.0	7,461,300	0.50	746,130
5	Wastewater	10.0	1,859,068	0.75	139,430
6	Solid Waste	31.5	0	0.75	0

City Wide Sector Ranking

Rank	Sector	REI%	Spending (US $)	CA Control	Score
1	Private Vehicles	25.0	1,390,516,286	0.85	295,484,710
2	Power	10.0	1,797,937,778	0.18	32,362,880
3	District Heating	0.0	0	0.01	0

These recommendations should be viewed by local authorities as an indication of what could be done to improve their city’s energy performance and reduce the city’s energy bill. The decision to actually implement a recommendation or not should be done only after a comprehensive feasibility study is completed. At the same time, energy efficiency interventions should not be viewed or conceived in a vacuum. Often, energy efficiency interventions have benefits that cross sectors. For example, interventions that aim to improve the energy efficiency of a municipal building could be done together with other retrofits to improve structural integrity, or to make these buildings more resilient to disasters.

Street Lighting

Street Lighting Audit and Retrofit

Street lighting is the sector with the second largest energy saving potential in Bogotá. The city has already replaced the mercury public lights with more efficient sodium vapor lamps. However, the city has begun a program to replace 10 percent of the sodium vapor lamps (approximately 33,000 lamps) with efficient, environmental friendly LED lamps.

Codensa is the owner of most of the street light infrastructure and together with the city of Bogotá, are retrofitting the system. Codensa has financial resources to implement the replacement program. If they wished to extend retrofits beyond 10 percent, they could explore other financial alternatives, such as the use of energy service company (ESCOs). It is expected that the change in technology replacement will not be a cost to the municipality which pays for using the infrastructure owned by Codensa, since the higher infrastructure costs are balanced out by energy savings.

An important aspect to be addressed to improve the efficiency in public lighting is metering. Measuring public lighting consumption in Bogotá can be challenging, because some areas of the city do not have an independent network and both residential buildings and light poles share the same electricity distribution cables. Thus, street lighting billing may not be based on real consumption, but rather on 12-hour daily average consumption estimates per light pole. The Municipality could benefit from having metered consumption in terms of energy savings; however, this issues needs to be further analyzed.

Procurement Guide for New Street Lights

Bogotá could produce a specific procurement guide for the upcoming LED retrofit program that could ensure compliance with technical standards. The guidelines associated with a new lighting technology can help deliver the same lighting levels for lower energy consumption, reduce related carbon emissions, as well as operational costs. A life cycle approach in the procurement guide could lower maintenance requirements and costs, and decreases interruptions to service. It is estimated that developing a green procurement guide could have the potential of achieving 200,000 kWh in energy savings annually with a modest investment of less than US$100,000.

This recommendation builds on the city's current plans to replace 10 percent of the existing sodium vapor bulbs with more efficient LED lamps. Thus, the city managers may consider the preparation of guidelines that could establish clear rules for new infrastructure.

10 percent of the street lamps will be replaced with LED bulbs

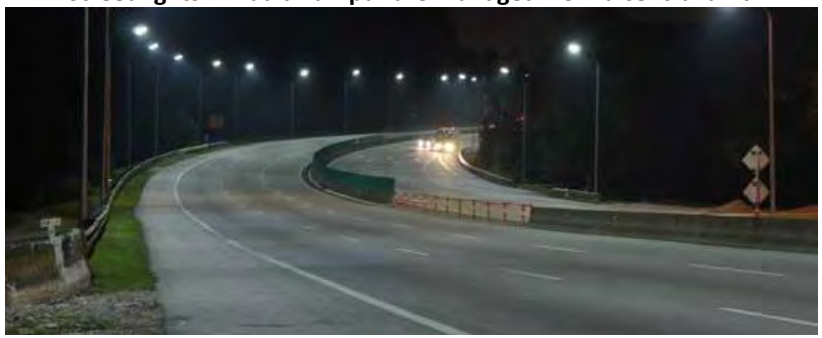
City authorities could consider updating the current street lighting manual and use international guidelines, such as those of IESNA (Illuminating Engineering Society of North America), which define best practices for visibility and safety guidelines. The procurement guide needs to establish clear parameters regarding illumination, pole spacing and lamp type, as well as dimming or illumination operations during nighttime for all types the streets and other public spaces in the city.

Street Lighting Timing and Dimming Program

Street lighting timing and diming programs could be a simple and inexpensive method of reducing electricity consumption in Bogotá. TRACE estimates that an initial capital investment of US$100,000 over a year could prompt between 100,000 and 200,000 kWh in energy savings, for each program.

The public light dimming program can reduce energy consumption without affecting safety in the city. By dimming the lights gradually, eyes are able to adjust to lower lighting levels, and the dimming is barely noticeable. This requires the installation of retrofit systems on each existing light pole and uses wireless technology to monitor and dim the street lights. The retrofitting process simply requires the addition of a small antenna to the lamp heads that can be plugged into the electronic ballast with no need for additional wiring. Light timing and dimming programs are very efficient because they save both energy and money, reduce the brightness of bulbs at times of low road or street usage, and vary bulb brightness at different times. For instance, Kuala Lumpur employed a timing system on a 66 km highway. This investment resulted in 45 percent energy savings. The individual light point (bulb) in the system is controlled through an electronic management system from a central unit. It enables dimming profiles adjusted to suit conditions on the road for different lamps, lamp failures, and can create a database for future reference.

Street lights in Kuala Lumpur are managed from a central unit



Source: www.kslights.com550

Active Water Leakage Detection Program

Losses in the water sector in Bogotá could be tackled through interventions aimed at diminishing the water leakages in the network and improving the efficiency of the system. In the short- and medium-term, with an initial investment of up to US$1 million, the local authorities may consider implementing an active leak detection and pressure management program that would result not only in reducing water losses but in energy savings. The water detection program could use modern techniques, such as ground microphones and digital leak correlators, as well as demand management valves and meters. Leak detections can also significantly reduce the risk of ground contamination in sewage systems.

Water leakage in Bogotá is considered severe as a result of the age and condition of the pipe network, and for the longer term, it will be necessary to undertake a comprehensive rehabilitation process of the water network and replace obsolete and leaking pipes.

Before embarking on an ambitious rehabilitation project that will need to take place over many years and require large amounts of investment, the water operator, Acueducto and the City should consider short- to medium-term solutions to reduce water losses. The local administration should consider developing a leak detection and water pressure management program that could minimize the losses in the system, such as in extraction works and pipelines, long distance water transmission mains, and distribution networks. Excess water pressure could be reduced by installing flow modulation valves on gravity networks and/or pump controls and pressure sensors to moderate pump performance to suit daily variations in flow demand, thus sustaining maximum efficiency and minimizing energy use. A complementary pressure management program could help reduce treatment and pumping related costs by minimizing the required delivery pressure and leakage. Such a program is most suitable for large networks with several small leaks that would be difficult and expensive to locate and repair. The local public administration of Bogotá could partner with various organizations and/or coalitions of local non-profit entities to gain access to their experience and expertise in order to implement the most appropriate changes in the city's pipe or pumping infrastructure. In addition to the technical intervention, a public outreach campaign can encourage the city residents to take part in water conservation efforts.

The City of Iasi in Romania is a good example where the local authorities managed to minimize water losses in the network and improve overall efficiency of the system. The local water company partnered with a US-based environmental provider to develop a US$120,000 pilot leak detection and water conservation program, as a pre-requisite for implementation of a much larger infrastructure rehabilitation program.

Digital water leak monitor

Source: halmapr.com

Eventually, the program helped reduce water losses by 8 million cubic meters, and saving up to US$3 million per year.

Awareness Raising Campaign

Another TRACE recommendation for Bogotá is related to helping citizens become more aware of the benefits of energy efficiency. This program is aimed at encouraging the city government to use public education and training campaigns to increase awareness and understanding of energy conservation, but also to change people's attitude towards energy efficiency. The city government can provide citizens with easy, accessible information related to energy efficiency so as to influence behavior.

Awareness campaigns could target public utility services, such as water and solid waste, and following the extensive information campaigns that have been used for TransMilenio. Energy efficiency programs can be promoted in various ways. The City could employ advertising campaigns, public events and features in the local media, use dedicated websites, training programs in schools and community centers, and even an energy efficiency champion program. In addition to changing the behavior of the city residents, the indirect payback of such interventions would be translated into less pressure on energy infrastructure, smaller amount of greenhouse gas emissions, better air quality, and financial savings.

One way of increasing public awareness can be done through training programs. For instance, in partnership with an education provider, the local authorities could develop a training program for efficient use of water that could be rolled out in schools and offices. Although the city water consumption per capita is fairly good (less than 100 liters per capita per day), there is room for improvement. The program should primarily target large energy users, such as public and private offices, manufacturing plants, industrial facilities, schools and hospitals, but also residential sector. Other stakeholders, such as non-profit organizations, utility companies, and businesses, would also be welcome to join the program.

Promoting water efficiency in Miami

Source: miamidade.gov

Energy efficiency could be promoted by public education campaigns that could help spread the word about the benefits related to less energy consumption. The city of Bogotá could join efforts with an advertising and marketing company to work out a strategy for providing information on energy efficiency issues. Such campaigns can rely on a number of

communication tools, such as posters, billboards, leaflets spread throughout the city, in addition to articles and ads in the local media.

One of the sectors where such initiatives could apply to in Bogotá is solid waste. The City and solid waste operators should actively engage citizens in waste recycling. The city and the solid waste operators should join efforts to organize public campaigns to teach people through leaflets and information displayed on posters about selective collection. Moreover, such public campaigns could also help promote the city's ambitious program "Basura Cero," aimed at reducing to zero the amount of solid waste dumped at the landfill by 2025.

Promoting Zero Waste in Bogotá

Source: Bogotá.gov.co

Promoting public transport

Source: www.keepcalm.o-matic.co.uk; www.bangalore.citizenmatters.in

Another method of raising awareness is through the use of local energy efficient champions, who teach people about the importance and benefits of energy efficiency. The City could recruit and train, on a voluntary basis, a few well-known or famous individuals, including local authority figures (e.g., government, businesses, or health) or music or film stars, to spread the word about the benefits of reducing energy consumption. The City could provide knowledge and logistical support to the energy efficiency champions, and monitor their progress. The local government can also monitor the number of people participating in training programs, hits on energy efficiency websites, relevant articles in the media, and the number of energy efficiency champions.

Urban Transport By virtue of being the largest energy consumer in the city, Public Transport has the largest energy efficiency potential in Bogotá. According to the TRACE analysis, the sector can reduce its energy consumption by 20 percent, largely through modal shift from private vehicles to public transport and non-motorized transport (NMT). The city has been actively improving the efficiency of the transport system through the SITP initiative, expansion of TransMilenio, developing the first metro line, and expanding NMT networks. In addition to the expansion of the public transport networks, there is a need to better manage and control the use of private and public vehicles which can negatively impact traffic congestion, energy consumption, and air quality. In parallel, city managers must continue to pay attention to improving the quality of public transport service, especially for the popular and well-used BRT system. Bogotá is expanding the BRT with 35 kilometers of new routes, and is also pursuing, with private investors, a light rail system that would connect the northern, western, and southern neighborhoods.

Another key area for the city is non-motorized transport, which includes the improvement and expansion of pedestrian routes and the nearly 400 kilometers of existing bike lanes. In addition to completing and connecting some of the cycling lanes, municipal authorities are hoping to interconnect them with the public transport systems, to serve as alternative feeder systems to the TransMilenio and SITP systems. This might include locating bike parking areas near bus and other transit stops to facilitate transfer between the modes. Other mechanisms for promoting BRT include providing tariff incentives for people who do part of their journey by bike or on foot. The city has experimented with bike share programs, which have proven popular in other cities, and would be an added incentive to encourage bicycle use in the city.

ANNEX TRACE BOGOTÁ RECOMMENDATIONS

Detailed Recommendations from TRACE

Improving Energy Efficiency in Bogotá, México

ANNEX 1: STREET LIGHTING AUDIT AND RETROFIT

DESCRIPTION

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

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

ATTRIBUTES

Energy Savings Potential
> 200,000 kWh/annum

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

Speed of Implementation
1-2 years

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

IMPLEMENTATION OPTIONS

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

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

MONITORING

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

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

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

CASE STUDIES

ESCO street light retrofit, Akola, India

Source: Energy Sector Management Assistance Program (ESMAP) (2009). "Good Practices in City Energy Efficiency: Akola Municipal

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

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

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

Lighting Retrofit, City of Oslo
Clinton Climate Initiative, Climate Leadership Group, C40 Cities http://www.c40cities.org/bestpractices/lighting/oslo_streetlight.jsp
The City of Oslo formed a joint-venture with Hafslund ASA, the largest electricity distribution company in Norway. Old fixtures containing PCB and mercury were replaced with high performance high pressure sodium lights and an advanced data communication system using

powerline transmission that reduces the need for maintenance. Intelligent communication systems can dim lights when climatic conditions and usage patterns permit. This reduces energy use and increases the life of the bulbs, reducing maintenance requirements.
The system is now fully equipped with all its components and is being calibrated to sort out some minor problems related to production failure in communication units. Overall the system has performed well under normal operating conditions.

TOOLS & GUIDANCE

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

ANNEX 2: PROCUREMENT GUIDE FOR NEW STREET LIGHTS

DESCRIPTION

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

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

ATTRIBUTES

Energy Savings Potential
> 200,000 kWh/annum

First Cost
< US$100,000

Speed of Implementation
< 1 year

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

IMPLEMENTATION OPTIONS

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

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

MONITORING

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

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

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

CASE STUDIES

Midlands Highway Alliance (MHA), UK http://www.emcbe.com/Highways-general/idea%20case%20study.pdf Working under the East Midlands Improvement and Efficiency Partnership (EMIEP), the Midlands Highways Alliance (MHA) will save the region GBP11 million across highways maintenance and improvements by 2011. Supported by Constructing Excellence, the nine councils in the region and the Highways Agency have been making efficiency savings through a best practice procurement framework for major and medium sized highways schemes and professional civil engineering services, sharing best practice in maintenance contracts and by the joint procurement of new technologies such as street lighting and signage. The document outlines the minimum and desired specifications for street lighting technologies in order to achieve the carbon emissions and cost reductions required.
"Lighting the Way" Project, Australia http://www.iclei.org/fileadmin/user_upload/documents/ANZ/CCP/CCP-AU/EnergyToolbox/lightingtheway.pdf

Australia is committed to reducing its growth in greenhouse emissions. Currently initiatives are underway at all levels of government to improve the efficiency of public lighting, including State and local government trials of more efficient public lighting. Public lighting of minor roads is a major source of greenhouse gas emissions for local government. There are many opportunities to improve the quality of the lighting while reducing both the costs and greenhouse emissions.
The various stakeholders have produced a procurement guide, "Lighting the Way", which provides information to assist local governments in improving the public lighting of minor roads in their communities while reducing their greenhouse emissions, lowering their costs and decreasing their liability and risk. These outcomes can be achieved through use of energy efficient solutions that provide better service in street lighting and comply with Australian Standards (AS/NZS 1158).
It outlines technical and other issues related to energy efficient lighting. It also provides some guidance for councils on techniques to improve their ability to negotiate public lighting issues with distribution businesses. A number of lamp types offer considerable advantages over the standard 80 watt mercury vapor lamps in terms of power consumption, lumen depreciation, light output, maintenance, life span, aesthetics and performance in various temperatures.

TOOLS & GUIDANCE

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

ANNEX 3: STREET LIGHTING TIMING PROGRAM

DESCRIPTION

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

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

ATTRIBUTES

Energy Savings Potential
> 200,000 kWh/annum

First Cost
< US$100,000

Speed of Implementation
< 1 year

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

IMPLEMENTATION OPTIONS

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

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

MONITORING

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

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

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

CASE STUDIES

Control system for public lighting, Kirklees, UK

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

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

lights, Kirklees CA estimates savings of approx. US$ 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 center 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. US$ 12 million. Currently the program saves approx US$ 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: ACTIVE WATER LEAK DETECTION & PRESSURE MANAGEMENT

DESCRIPTION

Develop a leak detection and pressure management program to minimize 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

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

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

IMPLEMENTATION OPTIONS

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

(BOOT)	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 organization 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 maximized 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 organizations 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 organizations 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 organizations 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 kilometer of water main per day: Measures the average volume of water leakage per kilometer 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, Iași, Romania

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

With an EcoLinks Challenge Grant of $46,820, Regia Autonomă Județeană Apa-Canal Iași (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 than 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, Galați, 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

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-liters 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)

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 water main 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 center to respond to in-house training needs. PPWSA renewed old pipes using state-of-the-art materials and labor from PPWSA staff. PPWSA also institutionalized performance monitoring, coming up with progress reports and performance indicators on a regular basis and annually subjecting its accounts and procedures to an independent audit. The project advocated the transfer of more managerial autonomy to PPWSA to enable it to use its own funds on maintenance and rehabilitation programs. The result of the project was that PPWSA became financially and operationally autonomous, achieved full cost recovery, and transformed into an outstanding public utility in the region.

ANNEX 5: AWARENESS RAISING CAMPAIGNS

DESCRIPTION

Public education and training campaigns will increase the public's awareness and understanding of the benefits of energy efficiency and can help change attitudes towards energy efficiency. Providing information on easy ways to be more energy efficient can help modify citizen behavior and contribute to overall energy-savings. This can be achieved through:

- Advertising campaigns
- Public events
- Articles in the local press
- User-friendly website providing information about energy efficiency
- Training programs in schools, community centers and businesses
- An 'energy efficiency champion' program

Key benefits are more efficient energy behaviors by residents leading to reduced energy consumption within the city. Indirect benefits include reduced pressure on energy infrastructure, reduced carbon emissions and better air quality.

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
Financial savings
Security of supply

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Targeted training programs	Working with an experienced education/training provider, the city authority develops training programs which can be rolled out in schools and offices. These programs should target big energy users, for example, offices. These programs can also be implemented through a partnership with other organizations, such as utility companies, businesses and NGOs.
Public education campaigns	Working with an advertising and marketing company experienced in public education campaigns, the city authority develops a strategy for providing information on energy efficiency to all residents. This can include posters, billboards and leaflets, as well as public media announcements and advertisements. A partnership can be created with a business or utility company to help finance this.

Energy efficiency champions	The city authority recruits local energy efficiency champions and trains them to teach people about the importance and benefits of energy efficiency. Champions can be anyone interested in spreading the message about energy efficiency, for example, local authorities, businesses, local community groups, NGOs, health trusts, school children and other individuals. This implementation activity can be carried out in a number of ways: • Ask champions to come to a 'train the trainer' course and provide them with support to run sessions within their own community. • Teach champions about simple ways to save energy, and then give them leaflets to distribute in their community. Ensure that champions inform people that they are the local contact for any energy efficiency questions. Since energy efficiency champions are often volunteers, an officer should be appointed to provide support and encouragement, conduct regular follow ups and monitor progress of each energy efficiency champion program.

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:

- Number of people participating in training programs annually
- Number of hits to city energy efficiency website monthly (if developed) or number of requests for energy efficiency measures
- Number of articles in the press about energy efficiency

- Number of energy efficiency champions trained (if this option is chosen)

CASE STUDIES

PlaNYC, New York
www.nyc.gov/html/planyc2030/html/plan/energy.shtml ;
www.nyc.gov/html/planyc2030/downloads/pdf/planyc_energy_progress_2010.pdf.
PlaNYC is a comprehensive sustainability plan for the city's future. The plan puts forth a strategy to reduce the city's greenhouse gas footprint, while also accommodating a population growth of nearly one million, and improving infrastructure and environment. Recognizing the importance to reduce global carbon emissions, and the value of leading by example, New York has set the goal of reducing its citywide carbon emissions by 30% below 2005 levels. Within the Energy sector of the plan, the city has an initiative to undertake extensive education, training, and quality control programs to promote energy efficiency. By 2010, the city launched an energy awareness campaign, and set up training, certification, and monitoring programs. The plan proposes that these measures will be delivered through a series of partnerships until an Energy Efficiency Authority is established.

Energy Efficiency Office, Toronto, Canada
City of Toronto http://www.toronto.ca/energy/saving_tips.htm
The Energy Efficiency Office in Toronto provides energy saving tips for households, businesses and developers on the city's website. As an example, the Energy Efficiency Office conducts the Employee Energy Efficiency at Work (E3@Work), an awareness program designed to save money and promote energy efficiency practices by managing office equipment power loads. Developed and implemented by the City of Toronto in 2002, the program is being promoted to business establishments and offices across the city. The goal is to reduce energy consumption and building operating costs, improve energy security and reliability and help preserve the environment.

Low Carbon Singapore, Singapore
Low Carbon Singapore http://www.lowcarbonsg.com
"Low Carbon Singapore" is an online community dedicated to help Singapore reduce its carbon emissions and move towards the goal of a low carbon economy. The project aims to educate individuals, communities, businesses and organizations on issues relating to climate change, global warming and clean energy, providing information, news, tips and resources on various ways to reduce carbon, including adoption of clean energy and energy efficient behaviors and technologies. Low Carbon Singapore is published by Green Future Solutions, a Singapore-based business that promotes environmental awareness and action for a green future through a network of green websites, events, presentations, publications and consultancy.

Carbon Management Energy Efficiency (CMEE) Programme, Walsall Council, UK
Walsall Council http://www.walsall.gov.uk/index/energy_awareness_staff_presentations.htm
Walsall Council has been rolling out energy awareness training by the Carbon Trust under their funded Carbon Management Energy Efficiency (CMEE) program, including:

- Energy surveys of the council's least energy efficient buildings
- Evaluating feasibility of combined heat and power (CHP) generation at the council's leisure centers
- Raising staff awareness through a number of energy presentations to senior managers, building managers, school caretakers and a number of the council's general staff. A total of 226 staff were trained in this round using presentations developed by the Carbon Trust and adapted, with the help of some of the environmental champions, to reflect Walsall Council's needs.

The aim of the CMEE programme is to identify and achieve significant carbon savings throughout the council and as a consequence financial savings too. By reducing their energy spent, the council will also reduce the number of carbon credits it has to buy under the Carbon Reduction Commitment, which entered into force in 2010.

Siemens Energy Efficiency Academy, Brisbane, Australia

Siemens: http://aunz.siemens.com/EVENTS/ENERGYEACADEMY/Pages/IN_EnergyEfficiencyAcademy.aspx ; http://www.siemens.com/sustainability/report/09/pool/pdf/siemens_sr_2009.pdf.

The Siemens Energy Efficiency Academy brings together some of the leading international and local experts to share their insights on government policy, emerging technologies, market drivers and best practice implementation.

Apart from adopting and showcasing its own energy efficient practices, it runs regular training programs for businesses across topics such as:

- Incentive schemes: Market mechanisms, grants and funding explained
- Building winning business cases for energy efficiency
- Energy Efficiency Policy in Australian Governments
- Next generation technology - What's next?
- Best practice implementation for variable speed drives and power quality
- Energy monitoring in Industrial and Commercial facilities

Energy Awareness Week, Meath, Ireland

ManagEnergy "EU LOCAL ENERGY ACTION: Good practices 2005" http://www.managenergy.net/download/gp2005.pdf

In 2004, the Meath Energy Management Agency's (MEMA) extended its Energy Awareness Week to everyone who lived or worked in the County of Meath, Ireland, using a concentrated burst of media campaigning to raise energy awareness among consumers. Visits to schools, information displays, widespread media coverage, competitions, a 'Car Free Day' and an offer of free CFL light bulbs encouraged participation at all levels. The campaign dramatically increased requests for information from the energy agency. The competitions and promotions also improved local knowledge of energy efficiency, and encouraged people to choose sustainable energy and transport options in the future.

Energy Awareness Week activities were coordinated and carried out by MEMA with the support of the Environment Department of Meath County Council. The direct costs for the campaign were US $ 4,470. This covered printing and copying of promotional materials, prizes, and provision of reflective jackets for walking bus participants. Additional prizes and sponsorship were provided by local companies and by

Sustainable Energy Ireland (SEI).

TOOLS & GUIDANCE

Tools & Guidance
"EU LOCAL ENERGY ACTION: Good practices 2005" http://www.managenergy.net/download/gp2005.pdf

ANNEX 6: LIST OF ABBREVIATIONS FOR CITIES IN THE TRACE DATABASE

1	Addis Ababa	Ethiopia	ADD	40	Karachi	Pakistan	KAR
2	Amman	Jordan	AMM	41	Kathmandu	Nepal	KAT
3	Baku	Azerbaijan	BAK	42	Kiev	Ukraine	KIE
4	Bangkok	Thailand	BAN	43	Kuala Lumpur	Malaysia	KUA
5	Belgrade	Serbia	BE1	44	Lima	Peru	LIM
6	Belo Horizonte	Brazil	BEL	45	Ljubljana	Slovenia	LJU
7	Bengaluru	India	BEN	46	Mexico City	Mexico	MEX
8	Bogotá	Colombia	BOG/BO1	47	Mumbai	India	MUM
9	Bhopal	India	BHO	48	Mysore	India	MYS
10	Bratislava	Slovakia	BRA	49	New York	USA	NEW
11	Brasov	Romania	BR1/BRA	50	Odessa	Ukraine	ODE
12	Bucharest	Romania	BUC	51	Paris	France	PAR
13	Budapest	Hungary	BUD	52	Patna	India	PAT
14	Cairo	Egypt	CAI	53	Phnom Penh	Cambodia	PHN
15	Cape Town	South Africa	CAP	54	Ploiesti	Romania	PLO
16	Casablanca	Morocco	CAS	55	Pokhara	Nepal	POK
17	Cebu	Philippines	CEB	56	Porto	Portugal	POR
18	Cluj-Napoca	Romania	CLU	57	Pune	India	PUN
19	Colombo	Sri Lanka	COL	58	Puebla	Mexico	PUE
20	Constanta	Romania	CON	59	Quezon City	Philippines	QUE
21	Craiova	Romania	CRA	60	Rio de Janeiro	Brazil	RIO
22	Dakar	Senegal	DAK	61	Sangli	India	SAN
23	Danang	Vietnam	DAN	62	Sarajevo	Bosnia and Herzegovina	SAR
24	Dhaka	Bangladesh	DHA	63	Seoul	South Korea	SEO
25	Gaziantep	Turkey	GAZ	64	Shanghai	China	SHA

26	Guangzhou	China	GUA	65	Singapore	Singapore	SIN
27	Guntur	India	GUN	66	Sofia	Bulgaria	SOF
28	Hanoi	Vietnam	HAN	67	Surabaya	Indonesia	SUR
29	Helsinki	Finland	HEL	68	Sydney	Australia	SYD
30	Ho Chi Minh	Vietnam	HO	69	Tallinn	Estonia	TAL
31	Hong Kong	China	HON	70	Tbilisi	Georgia	TBI
32	Iasi	Romania	IAS	71	Tehran	Iran	TEH
33	Indore	India	IND	72	Timisoara	Romania	TIM
34	Jabalpur	India	JAB	73	Tokyo	Japan	TOK
35	Jakarta	Indonesia	JAK	74	Toronto	Canada	TOR
36	Jeddah	Saudi Arabia	JED	75	Urumqi	China	URU
37	Johannesburg	South Africa	JOH	76	Vijayawada	India	VIJ
38	Kanpur	India	KAN	77	Yerevan	Armenia	YER
39	Leon	Mexico	LEO				