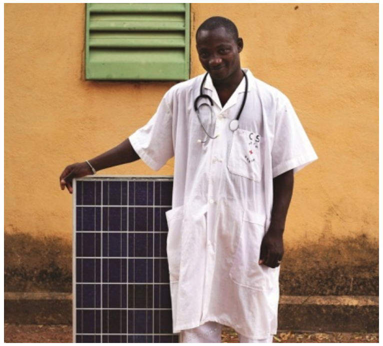
ESMAP
Energy Sector Management Assistance Program

TRACE
Tool for Rapid Assessment of City Energy

Realizing Energy Efficiency Opportunities in Rio de Janeiro





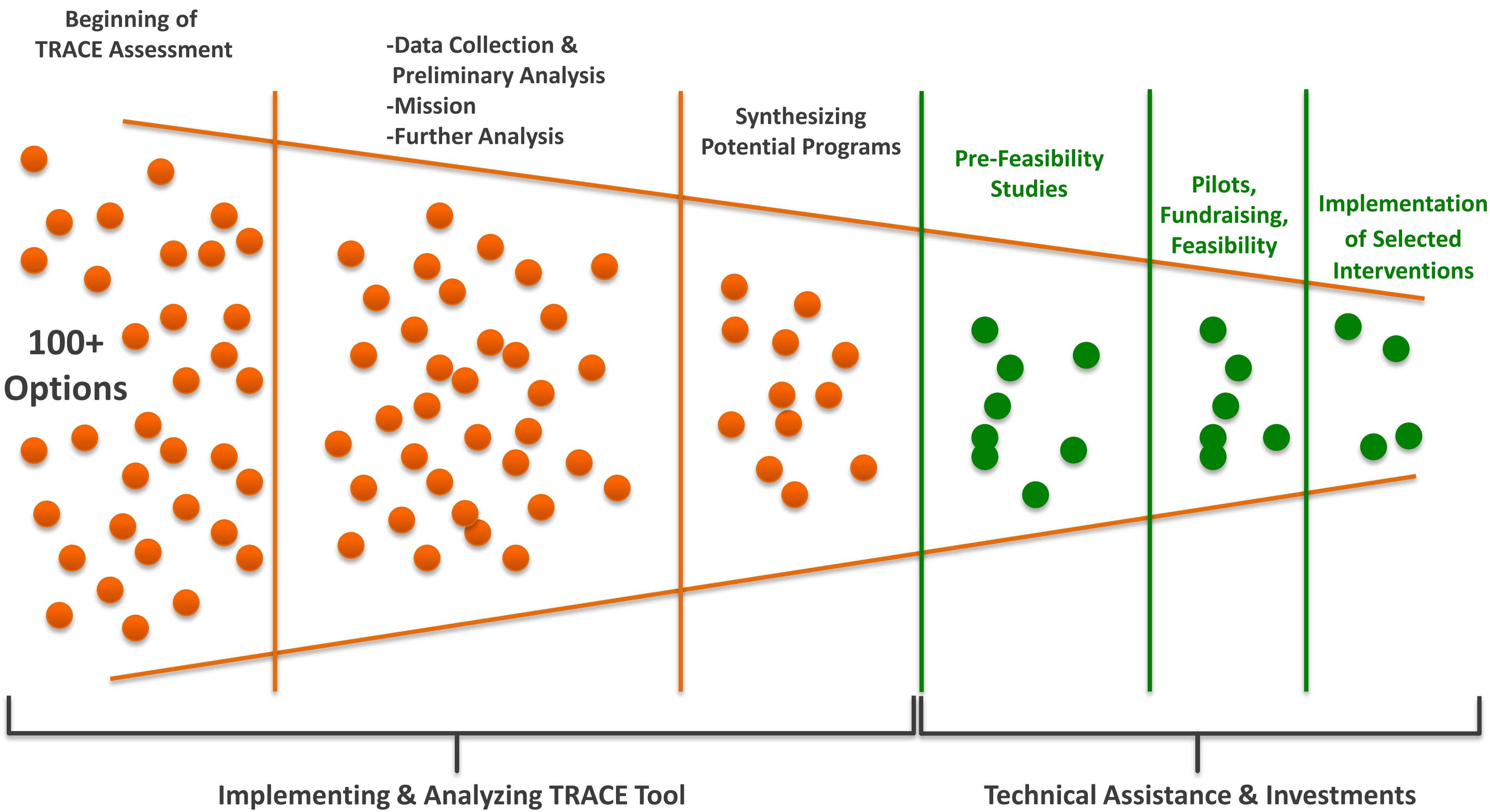
Agenda

- Overview
- Findings by Sector
    1. Public Lighting
    2. Public Buildings
    3. Solid Waste
    4. Water and Wastewater
    5. Transport
    6. Power
- Conclusion and Next Steps
- Annexes

This is an interim presentation showing the completion of the TRACE 1 phase of the partnership between the World Bank and the Municipality of Rio de Janeiro. The presentation summarizes findings from the assessment of energy efficiency in Rio de Janeiro , and suggests the next steps.

OVERVIEW

Overview of the World Bank's Technical Assistance Program to Rio de Janeiro



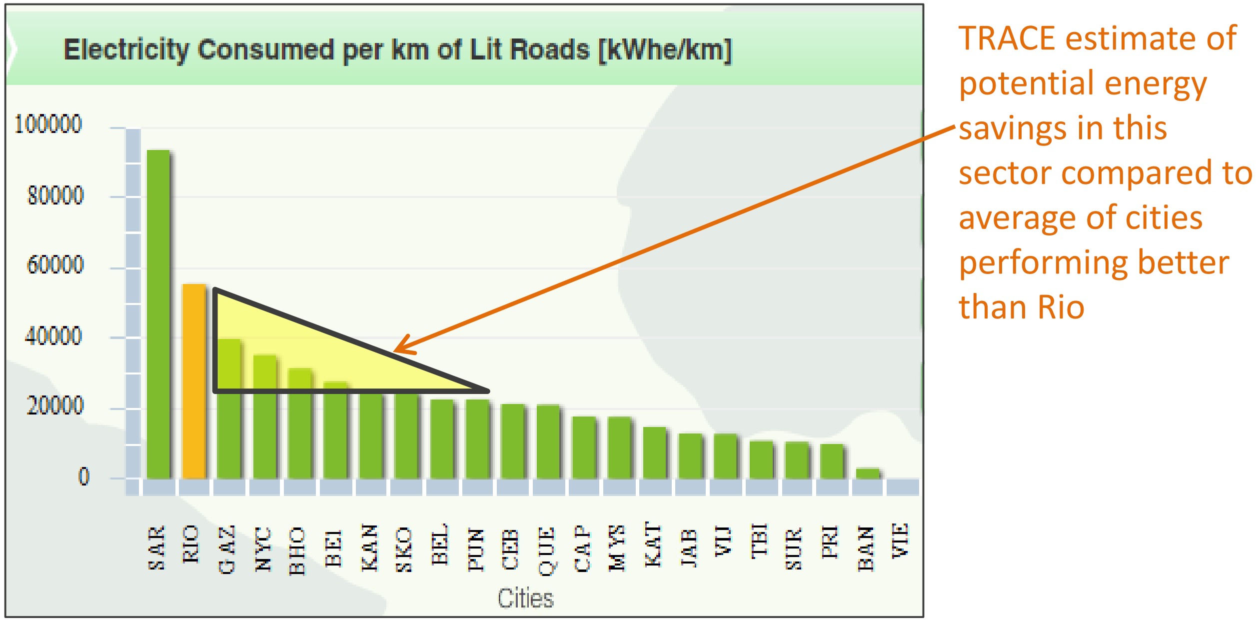
The initial phase of the program is guided by Tool for Rapid Assessment of City Energy (TRACE), and feedback from the municipality enabled the team to finalize energy efficiency (EE) activities applicable to Rio de Janeiro

Level of Activity Progress	☑ Done	☑ Done	☑ Done

How the TRACE tool identifies opportunities for energy savings

1. Data is collected across multiple sectors in Rio
2. Rio's energy use in those sectors is compared ("benchmarked") to other cities in TRACE database
3. Savings potential estimated by assuming Rio can achieve the same level of energy efficiency as the <u>average</u> of all better performing cities in database

- After TRACE analysis is conducted and priority sectors are identified, a "bottom-up" analysis can be done to develop more precise estimate of savings potential in relevant sectors in Rio.



See Annex I for list of city names.

Prioritization Summary

EE OPPORTUNITIES ARE MOST SIGNIFICANT FOR THE MUNICIPALITY AND WHOLE CITY IN PUBLIC LIGHTING, MUNICIPAL BUILDINGS, TRANSPORTATION, AND POWER

Sector	Overall Potential for Improvement	Current Energy Spending (US$/Year)	City Authority Level of Influence		Prioritization Score (Savings Potential*)
City Authority Potential Savings					
Street Lighting	40%	52,301,592	Budgetary Control	**[1.0]**	20,920,636.80
Municipal Buildings	40%	46,680,308	Budgetary Control	**[1.0]**	18,672,123.32
Solid Waste	18%	15,466,467	Budgetary Control	**[1.0]**	2,706,631.73
Citywide Potential Savings					
Private Vehicles	15%	1,729,000,000	Multi-Agency (controls one part)	**[0.4]**	103,740,000.00
Power	18%	2,907,900,130	Local Stakeholder	**[0.1]**	51,469,832.30
Public Transportation	10%	593,036,780	Policy Formulator/Regulator	**[0.8]**	45,070,795.28
Potable Water	20%	63,892,260	Local Stakeholder	**[0.2]**	2,555,690.39
Wastewater	24%	6,647,438	Local Stakeholder	**[0.2]**	319,077.07

*Potential Improvement X Current Spending X Level of Influence = Prioritization Score
Source: TRACE Sector Prioritization

Financial Highlights

- Potential US$35 to US$45 million fiscal space from energy efficiency programs for the municipality per year
- Potential US$180 to US$220 million in city-wide energy efficiency potential per year. Savings from citywide programs are distributed amongst many stakeholders.

Sector Priority Highlights

- Municipality opportunity is greatest in the public lighting and municipal buildings sectors
- City-wide opportunities are greatest in the private vehicle transportation sector, as well as the power and public transportation sectors

Recommendations Summary

Summary of Energy Efficiency Opportunities for Rio de Janeiro

1 Public Lighting
- Public spaces lighting audit and retrofit program
- Street lighting audit and retrofit program
- Installation of light emitting diode (LED) technology
- Installation of dimmers where appropriate
- Finishing the installation of LED traffic lights
- Finishing the replacement of mercury with HPS lamps

2 Public Buildings
- Creation of a permanent energy efficiency task force
- Institutionalization of EE PAMPE Incentives for the secretaries
- Conducting buildings audit and benchmarking
- Implementation of technical measures (lighting controls, appliances, sectional lighting, timers, motion sensors, etc.)
- Implementation of lifecycle cost procurement

3 Solid Waste
- Optimization of the waste collection routes.
- Vehicle tire replacement, and preventative maintenance
- Retrofitting plants at Jacarepaguá, Caju, Irajá - as needed. Some are being closed or used only as transfer stations for recyclable waste. Caju is used for composting organic waste

4 Water and Wastewater
- Investment in a pressure monitoring system
- Installation of water efficient fixtures
- Individual household metering in the remaining parts of the city

5 Transportation
- Influencing private transportation policy within the city where possible
- Using municipal vehicle tax incentives to improve efficiency in private transportation
- Traffic restraint measures
- Car parking management – variable charging for parking spaces
- Park and ride infrastructure

6 Power
- Continued collaboration with the State on favela pacification in order to allow investments in a secured grid
- Creating an official program with a partnership among the municipality, Comlurb, and Light in order to offer a comprehensive package to the favelas after pacification
- Supporting sustainability educational campaigns in the favelas
- Public awareness campaign and complaints clearing house for technical loss reductions

Each sector is covered in detail in the following slides in the indicated order.

FINDINGS BY SECTOR

Structure of Each Sector Presentation

Each slide describes the benchmarking results , Rio's innovative activities, and provides actions for consideration.

Benchmarking — **Green** histogram for benchmarking

Innovative Activities Underway — **Black** descriptive text, pictures, graphs

RECOMMENDATIONS

- Savings potential based on TRACE Benchmarking estimates
- Savings potential based on refined "bottom-up" model
- Savings potential based on rough/coarse data estimates from Rio

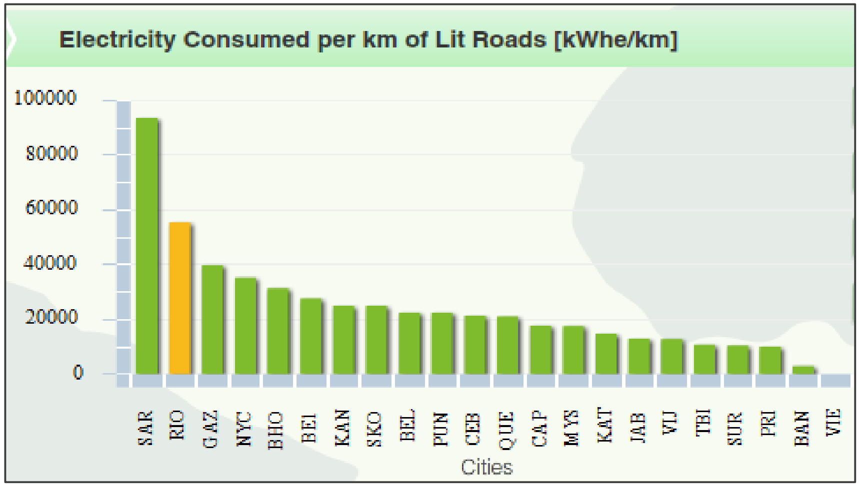
Blue, **Green**, or **Orange** tables summarize the opportunity based on data availability for the preliminary analysis

1

REALIZING THE ENERGY EFFICIENCY OPPORTUNITIES IN THE

PUBLIC LIGHTING SECTOR

Rio's public lighting electricity consumption is quite high compared with peer cities



Benchmarking results:

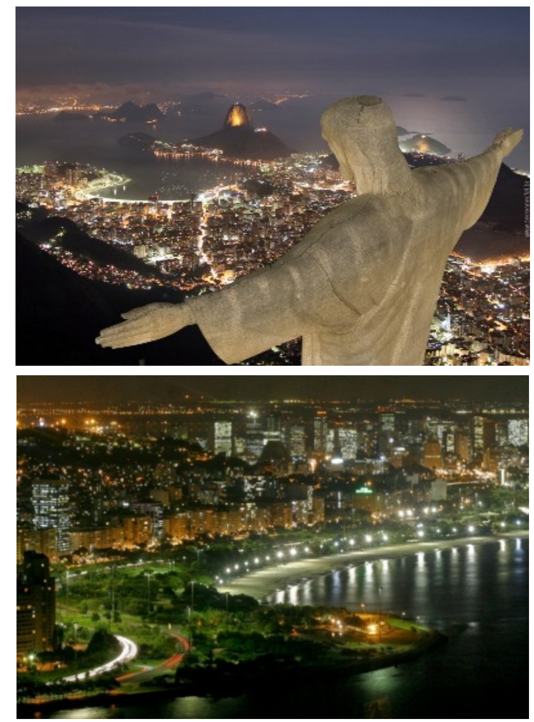
- Among the highest in the list of cities in the TRACE database
- It is about 2.5 times the consumption of the average city
- 60% higher than New York City
- 80% higher than Belo Horizonte

Likely reasons:

- Luminosity standards which are higher than the national standards (ABNT5101). According to RioLuz, the standard is also 100% higher than in Europe. As a result consumption per km of lit road or light pole is high, despite penetration of high pressure sodium lamps.
- Underestimation of roads in some areas (some favela streets are not counted as roads by Policy Pacifying Units (UPP)).
- Substantial lighting of public spaces (beaches, parks, monuments) beyond roads

Additional information:

- Public lighting expenditure accounts for two thirds of the municipal government power consumption.



High luminosity at night. Guanabara Bay / Flamengo Beach.

RioLuz is actively promoting more efficient public lighting technologies

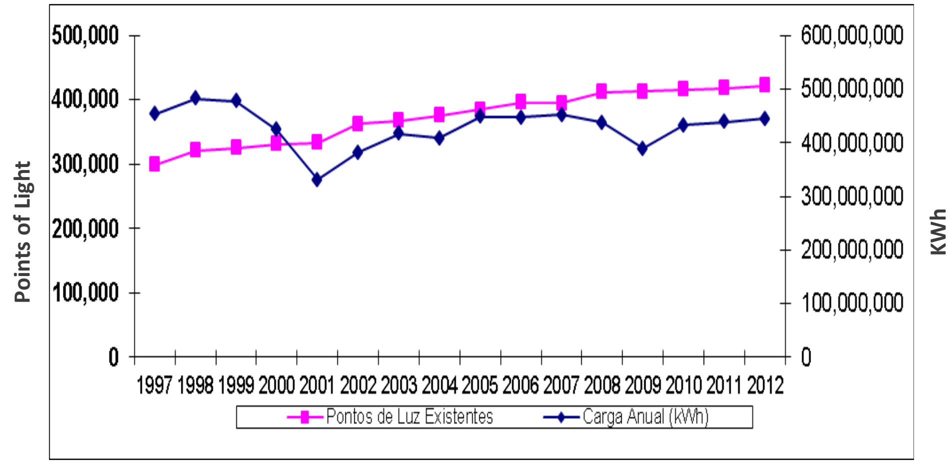
Increased coverage and cost reduction

- Cost reduced despite significant increase in lighting points
- Reduction of the out-of-service rate (19% in 2009 to about 1% in 2012)
- High penetration of High Pressure Sodium (HPS) (68%+) lamps replacing mercury

Continued innovation

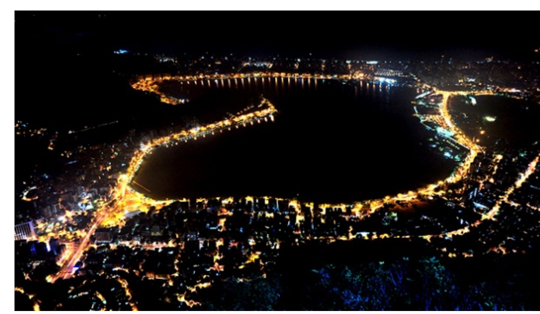
- LED pilots underway for public lighting
- Solar PV power under study
- Lamp recycling program -> resource efficiency and cost reduction
- LED for traffic signaling (currently at 60%)

Increase in Points of Light as Electricity Consumption Decreases



RioLuz' Lamp recycling center

LED utilization for traffic signaling



LEDs around Lagoa Rodrigo de Freitas

Using LED technology in appropriate areas would enable the city to realize energy, financial, and GHG emission savings

Description

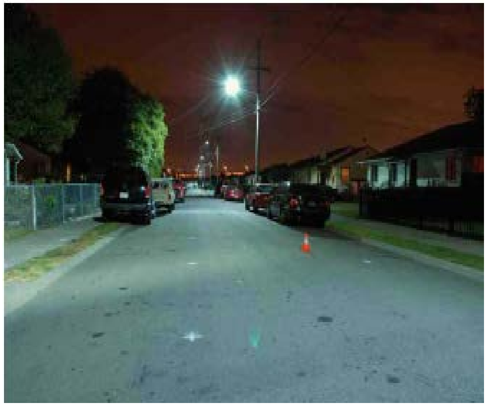
- Light Emitting Diode (LED) technology consumes less electricity compared to many other forms of public lighting technology.
- LED technology is being tested by companies such as GE in Rio.
  - Four companies have been approved for bidding.
  - Given the World Cup and Olympics, LED lighting might be useful in certain parts of the city.
- Cities testing LED public lighting include Oakland, California, and Boston.

Estimated Benefits Based on Refined LED Model

Indicator	Annual Savings once Implemented	Cumulative Savings after 10 Years
Energy Savings (GWh)	470 GWh	3,126 GWh (1,100,000 Rio homes powered for 1 yr)
Financial Savings (US$ million)	US$72 million	US$390 million
CO_2 Emissions Savings (tCO_2e)	110,000 tCO_2	937,000 tCO_2 (24,000,000 coniferous trees planted and grown for 10 yrs)

HPS Lighting

LED Lighting



Sources: City of Oakland LED Technology Demonstration

Key Figures

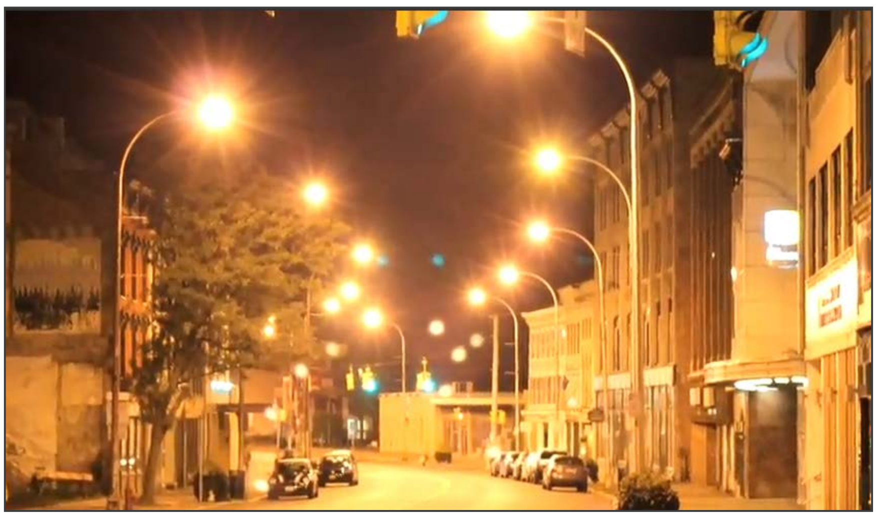
Investment: Replacing all 421,451 lamps would cost US$ 200 million (spread over 4 yrs)
Implementation: 3-5 yrs
Payback: about 3 yrs

Replacing remaining mercury vapor lamps with high pressure sodium vapor lamps would result in additional savings

Description

- Replacing mercury vapor lamps with high pressure sodium vapor lamps is good for the environment and results in financial savings.
- This retrofit is fairly common around the world and Rio de Janeiro has already replaced a significant number of lamps. The lamps are more compact, and longer-lasting

Street lit with Sodium Lamps



Source: General Electric

Est. Benefits based on Coarse/Rough Projections

Indicator	Annual Savings once Implemented	Cumulative Savings after 10 years
*Electricity Savings (GWh)	22 GWh	220 GWh (79,000 Rio homes powered for 1 year)
Financial Savings (US$ million)	US$2.5 million	US$25million
CO_2 Emissions Savings (tCO2e)	6,600 tCO_2	1,700,000 (coniferous trees planted and grown for 10 years)

*Assumes 20% savings based on numbers provided by Rioluz on already-replaced lamps. The efficiency gains may not be that high because the auxiliary equipment consumes energy stepping up the voltage down.
*10 year coarse/rough projections are based on a static baseline by multiplying the annual savings by 10

Key Figures

Investment: US$30 million according to RioLuz
Implementation: 1 yr

Implementing selective dimming would improve overall lighting efficiency of the city

Description

- Selective dimming could be applied to selected parts of the City during specific hours (e.g., 2-6am **where there are no security or tourism concerns)**. These areas include churches, and parks that people do not use frequently during those hours. **The dimming is rarely noticeable to the human eye when done properly**
- It is important to note that this option would not work in all parts of the city, but in specific areas. The city would need to conduct a public spaces lighting and retrofit program.
- Melbourne in Australia conducted a park and waterfront lights retrofit and reduced energy consumption by 80%

Lamp with a sensor for dimming. Source: Kirklees UK

Est. Benefits Based on Coarse/Rough Projections

Indicator	Annual Savings once Implemented	Cumulative Savings after 10 years
*Electricity Savings	13 GWh	46,000 (Rio homes powered for 1 year)
Financial Savings	US$1.5 million	US$15 million
CO_2 Emissions Savings	3,900 tCO_2	1 million (coniferous trees planted and grown for 10 years)

*Assumes can only be applied to 10% of the city lighting for 3 hours per night

Key Figures

Investment: about US$2,000,000
Implementation: 1 year
Payback: < 1 year

Engaging an ESCO is the best course of action in public lighting sector

- There are opportunities for significant savings and the Energy Service Company (ESCO) would need to investigate solutions
- **Advantages of ESCOs**
  - No upfront investments by the municipality
  - Municipality pays for the service, hence mitigates the technology risk
  - Large, well-resourced ESCOs tend to do well
- **The ESCO would need to include the following in its tasks:**
  - Public lighting audit and retrofit program
  - Investigation of LED, dimmers, HPS as alternative efficient lighting technology (among other opportunities)

2

Realizing the Energy Efficiency Opportunities in the

PUBLIC BUILDINGS SECTOR

It is often difficult to get a comprehensive picture of the EE opportunities in public buildings due to diffuse responsibilities and limited data

City Hall Main Building

Buildings Sector Relevant Observations:

Some practices negatively affect energy efficiency:

- Limited data to help with the analysis of energy consumption
- No agency is in charge of consolidation and analysis of energy consumption data across public buildings, though there is centralized monitoring in education
- Energy management is fragmented between the different departments or even buildings of the municipality
- Limited incentives for secretariats to be more energy efficient

Buildings Relevant Observations

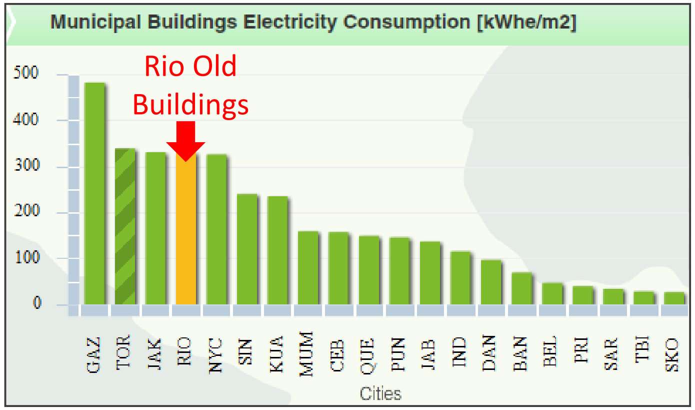
- Newer buildings such as the New Education Center are fairly energy efficient – utilize natural light, efficient fans and air-conditioning, PROCEL-labeled equipment, efficient lighting
- Older buildings do not appear as energy efficient
- The City has been implementing some successful energy efficiency programs which can be scaled up and strengthened

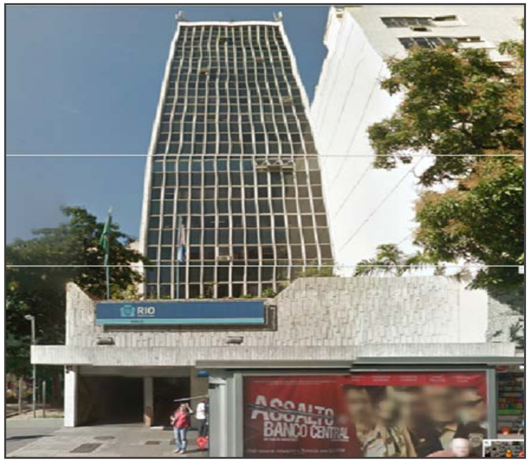
Examples of EE Projects Done by the Municipality

2011 - PCRJ - EFFICIENCY	DESCRIPTION	KWH SAVED IN 2011 (ESTIMATE)	GJ	KWH SAVED PER YEAR (ESTIMATE)	GJ	R$ INVESTED (2011)
CASS 1	Illumination	Concluded in 2012	Concluded in 2012	296,700	1068.12	378,948.93
CASS 2	Illumination	Concluded in 2012	Concluded in 2012	251,800	906.48	310,097.19
State School Units	Illumination 36 municipal schools 20,000 illumination points more efficient (lamps, ballasts and lighting).	1,333,600	4800.96	1,333,600	4800.96	2,252,766.51
Jesus Mun. Hospital	Illumination and acclimatization Modernize illumination and air-conditioning.	534,500	1924.2	534,500	1924.2	372,776.08
SMTR II (CET Rio)	Replacement of a lot of the lighting system for traffic signal with LED lights, which consume less energy and have a longer life.	Concluded in 2012	Concluded in 2012	5,170.66	18.61	3,806,519.57
Miguel Couto Hospital	Illumination and acclimatization Modernize illumination and air-conditioning.	1,653,400	5952.24	1,653,400	5952.24	664,446.56
TOTAL		3,521,500.00	12,677.40	4,075,170.66	14,670.61	372,776.08

Benchmarking shows there is substantial EE opportunity in older public buildings

Older Buildings Benchmarking: RioLuz Building

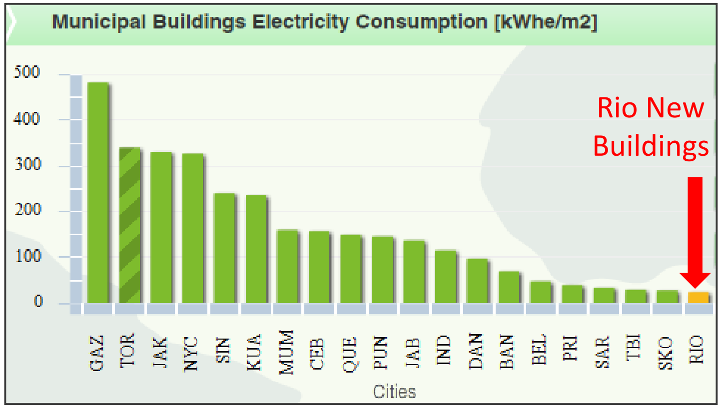




Older Building Benchmarking Highlights

Electricity consumption of older buildings, which represent the majority of buildings, is among the highest of all cities in the TRACE database

Newer Buildings Benchmarking: Educational Center



New Building Benchmarking Highlights

New buildings tend to be very efficient consuming very little electricity per unit area. They have the best results of all cities in the TRACE database

Rio de Janeiro is implementing some good EE practices in building energy efficiency, and these can be strengthened

Examples of Good Practices

- Creation of the Qualiverde program which sets standards for efficient buildings and awards tax credits and urban benefits for buildings that meet the standards
- Procurement requiring PROCEL efficiency seal
- Energy efficiency audits and retrofitting (lighting, refrigerators) as part of the Light program
- Use of natural lighting as much as possible in the newer educational centers

PROCEL Labeling

Qualiverde Tax Credits

	Territorial Property Tax During Construction	Territorial Property Tax After Construction	Real Estate Transfer Tax	Services Tax During Construction
QUALIVERDE	50%	10%	50%	1,5%
TOTAL QV	EXEMPT	20%	EXEMPT	0,5%
Obs.	During 2 years	All units Review every 3 years		The regular tax rate is 3,0%

Qualiverde Program Sample Measures:

1. **Water management**
- Saving devices: flow valves/toilets with dual drive mechanism
- Reuse wastewater system

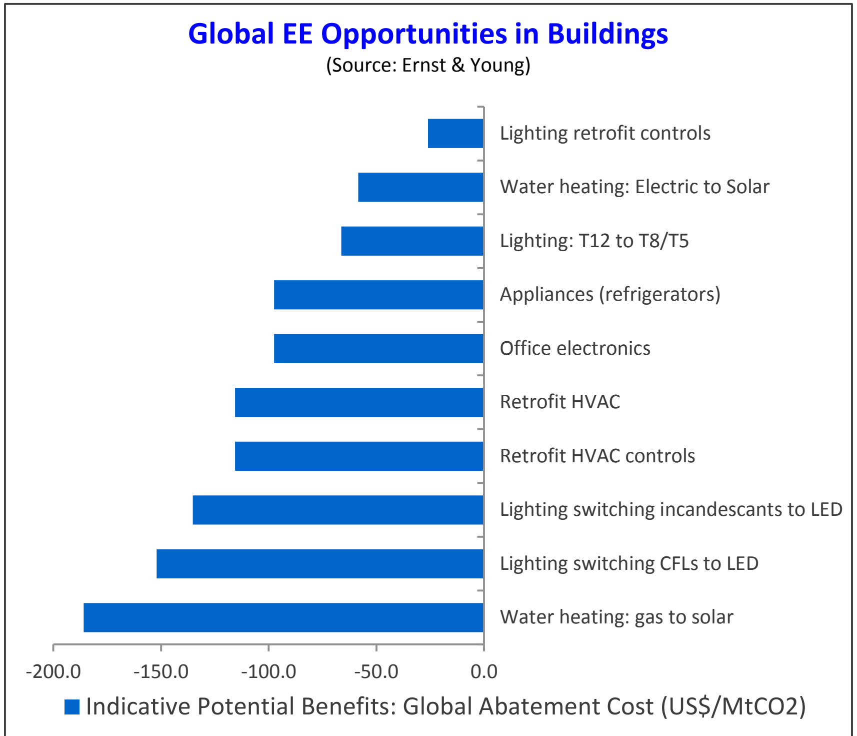
2. **Energy Efficiency**
- Solar water heating
- Efficient artificial lighting/LED
- Efficient day lighting
- Alternative Energy Sources: photovoltaic solar panels

3. **Design**
- Green Roof
- Solar and wind orientation
- Façade system: weather protection & shading systems

Several low-cost interventions can be implemented to realize the EE opportunity in municipal buildings

Description

- Based on walk–through audits of mostly offices and schools, there are several interventions which could be implemented in order to realize the EE potential in Rio's public buildings.
- Examples include more efficient lighting, sectional lighting, timed or sensored lighting, programmable thermostats, HVAC retrofits, etc.



Est. Benefits Based on TRACE Benchmarking

Indicator	Annual	10 Years
Electricity Savings (MWh)	90 - 120 (GWh)	900-1200 GWh (equivalent to 350,000 to 440,000 Rio households powered for 1 yr)
Financial Savings (US$ million)	US$19-23 million	US$190-230 million
Carbon Emissions Savings (tCO_2e)	30,000-37,000 (tCO_2)	300,000 - 370,000 (equivalent to 7.6 - 9.5 million coniferous trees planted and tended for 10 yrs)

*Benefits based on performing up to the average of cities performing better than Rio
*Assumes 40 to 50% savings if the city is committed to a variety of necessary investments
*Uses a static baseline for the projection

Key Figures:

Investment: Benefits are based on international comparison. Due to lack of data the team could not calculate specific investment costs. The AC example overleaf provides estimates for investments in improved air conditioning.

Implementation: 2 to 3 years

Low-cost A/C interventions offer quick savings for municipal government

Description

- Air-conditioning typically accounts for 45% of all electricity consumed in buildings such as those in Rio de Janeiro.
- Based on walk-through audits, there are substantial opportunities to improve the efficiency of A/C systems in Rio. These include:
  - Using programmable thermostats for central A/C
  - Using timers for on the window units
  - Replacing old A/C units with newer, more efficient units
  - Maintenance (cleaning filters, monitoring coolant levels, etc.)

Est. Benefits Based on Installing A/C Timers in Schools & Municipal Office Buildings

Metric	Annual	5 Years
Electricity Savings (MWh)	13 – 20 MWh	67 – 101 MWh (equivalent to cooling all Rio's schools for 1.5 yrs)
Financial Savings (US$ million)	US$ 1.1 - 1.7 million	US$ 5.6 - 8.6 million
Emissions Savings (tCO_2e)	0.71 – 1.45 $MtCO_2e$	20.0 – 30.3 $MtCO_2e$ (equivalent to planting 913 million coniferous trees)

Assumptions: (1) window units are primary tool for A/C in schools & municipal office buildings; (2) hospitals not included in analysis; (3) timers reduce # hours used by 15-25%.

Central AC Unit

Window A/C Units

Programmable Thermostat

A/C Timers

Key Figures:

Upfront Investment: ~$500,000
Implementation: 1 to 2 years
Payback: 1-2 years
Summary: Cost of equipment is fairly minimum, and depending on the chosen technology, payback period is short. An ESCO is best positioned to study, evaluate, and implement different options.

Realizing EE opportunities in the public buildings sector would benefit from a comprehensive approach

ACTIVITY	PURPOSE
Creation of a Permanent **Energy Efficiency Task Force**	Improves the energy use data collection, manages the implementation of EE measures, reports to senior leadership, has mayor's support
Institutionalization of **EE PAMPE Incentives** for the Secretaries	Rewards secretaries who implement energy efficiency measures in their departments along with other metrics in the system
Conducting Buildings Audit and Benchmarking Programs	Performs detailed measurements of energy performance of buildings and benchmarks buildings against peer buildings
Implementation of Technical Measures	Physically installs sectional lighting, timed air-conditioning, motion-sensored lighting, sectional lighting and so on
Implementation of Lifecycle Cost Procurement	Emphasizes lifecycle cost when procuring office equipment, lighting, refrigeration, etc., instead of one time cost at the moment of purchase

ESCO or Private Company (for Conducting Buildings Audit and Benchmarking Programs; Implementation of Technical Measures)

3

REALIZING THE ENERGY EFFICIENCY OPPORTUNITIES IN THE

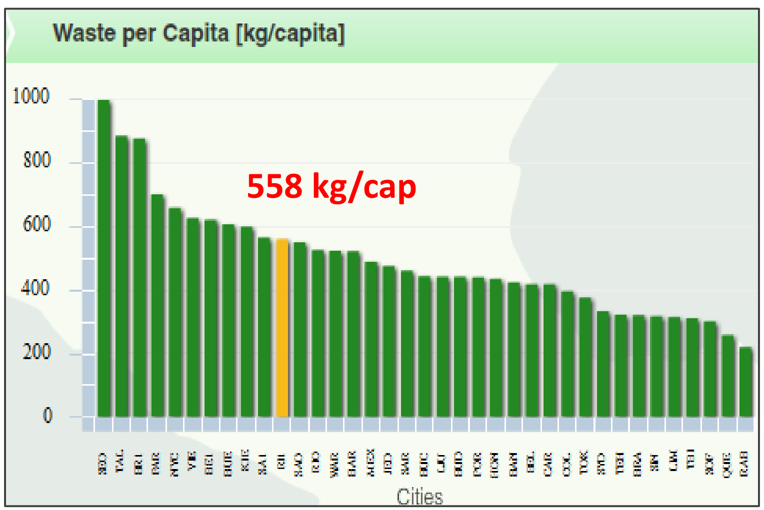
SOLID WASTE SECTOR

Though slightly high, waste per capita in Rio is comparable with other Latin American Cities

Waste Collection Truck
Source: Comlurb

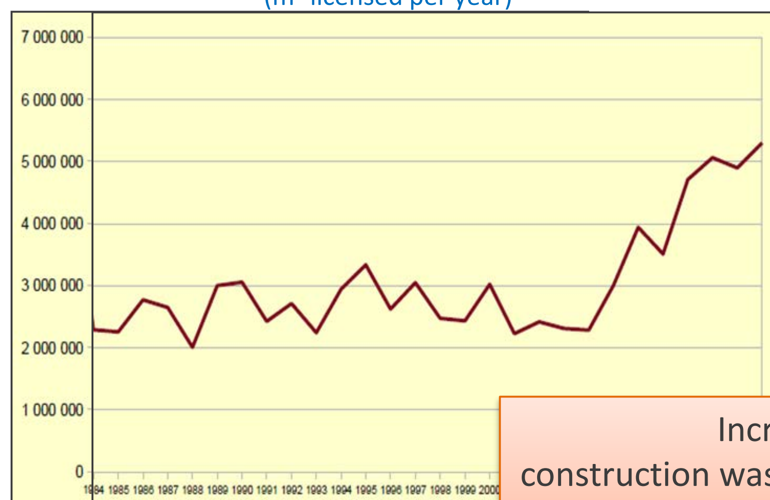
Benchmarking Highlights

- Higher than 70% of TRACE cities with similar human development index (within the same HDI range.
- Comparable to other Latin American Cities (within 10% range of Belo Horizonte, Sao Paulo, Buenos Aires, Santiago, Mexico City)
- Lima and Bogota are significantly lower



Source: TRACE: World Bank

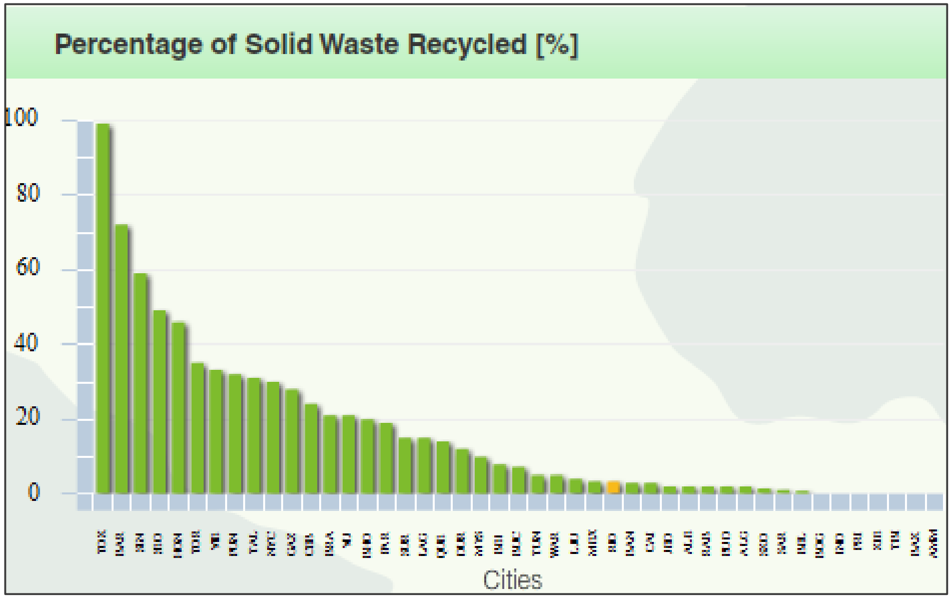
Increase in Construction Licensing Since 1984
(m^2 licensed per year)



Source: Comlurb

Increase in construction waste may partially explain the high waste per capita

Recycling in Rio is comparatively low; there are opportunities to improve



Source: TRACE: World Bank

Key Observations:

- Residential selective collection by Comlurb is still limited at 0.45% of residential waste and 0.23% of total waste
- Most recycling is done by informal waste pickers (120+ associations)
- Additional recycling/composting done by Comlurb at Caju, Iraja, Gericino stations

Benchmarking Highlights:

- Recycling in Rio de Janeiro is fairly limited at 3.3%
- Recycling percentage is similar to Mexico City, and its about half of the percentage in Belo Horizonte
- It is substantially lower than New York City with 30% recycling, and Barcelona with 72% recycling

Opportunities under Planning/Consideration:

- Increasing recycling is a requirement of the 2012 Solid Waste Management Law
- Expansion of selective residential recycling to 4,600 ton/month, by increasing coverage of this program from 41 to 119 neighborhoods (Comlurb / BNDES financing)
- Composting production (currently used by the City for forestry applications) could be increased four-fold -> limited public financing in the short term

There is need to optimize waste collection routes last optimized in 1973

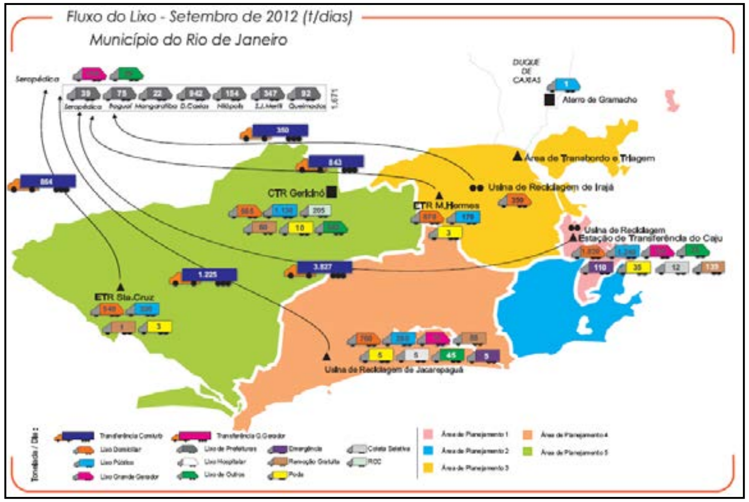
Rio has changed significantly since 1973

	1970	2012	% Change
Population (million)	4.25	6.4	51%
Vehicle fleet (million)	0.2	2.6	1089%
Vehicle ownership (vehicles/1000 habitants)	52	410	690%
Residential Waste Generation (kg/inhabitant/day)	0.7	0.85	20%
Total Residential Waste Production (tons/day)	3000	5400	80%

Traffic flow was recently optimized with lanes changing directions during peak hour, some lanes reserved for buses, etc.

Bus Rapid System Exclusive Lane
Source: Rio de Janeiro Municipality

The Flow of Waste in Rio de Janeiro City
Source: Comlurb



Schematic representation of the flow of waste in Rio de Janeiro

Optimizing waste collection routes would result in substantial energy efficiency savings

Description

- Garbage collection routes can be optimized so that the fuel consumed is minimized. This would include specifying the shortest routes for the trucks, and training the drivers. Additionally, vehicle maintenance can be improved to reduce fuel consumption.
- Though most waste collection is done by public and some private companies under concession from the city, optimizing their garbage collection routes would enable the city to negotiate cheaper contracts.
- C40/Clinton Foundation has already studied this intervention. In addition to route optimization, they also studied driver training (5-20% savings), and improved maintenance (1-5% savings).

Est. Benefits Based on Refined Traffic Flow Model

INDICATOR	ANNUAL	10 YEARS
Fuel Savings (million liters)	1.3 – 2.5 million liters of diesel/yr	11 to 24 million liters of diesel
Financial Savings	US$ 82,000 - 250,000	US$575,000 - 1,500,000
CO2 Emissions Savings ($MtCO_2e$)	1.3-2.5 $MtCO_2e$	11.3 – 22.5 $MtCO_2e$ (equivalent to 580 million coniferous trees planted and tended for 10 yrs)

*Assumes 10 - 20 % potential fuel savings improvement based on Clinton Foundation Study
*IPCC Diesel emission factor of 19.9 tC/TJ of diesel

Key Figures
Investment: US$ 275,000
Implementation: < 1 year

TRACE ESMAP

Replacing the recycling equipment at Jacarepaguá, Caju, Irajá would result in minimal savings, but potentially improve recycling capacity, and help the Rio de Janeiro "brand"

Description

- Replacing 20-year old electromechanical equipment with more efficient equipment would result in lower energy consumption and lower operation and maintenance costs.
- The three plants have up to 80 motors ranging in size from 8 to 150 HP, which are 20 years old on average, and the retrofit would reduce Comlurb's electricity consumption

Additional Information

- There is need to perform detailed study of the potential savings. Savings seem fairly minimal, though the renovation would boost recycling capacity in the city.

Est. Benefits Based on Coarse/Rough Projections

Indicator	Annual	10 Years
Electricity Savings* (MWh)	430 to 600 MWh	4,300 - 6,000 MWh (1,500 - 2,000 equiv. to powering Rio households for 1 yr)
Financial Savings	US$ 100,000 - $150,000	US$1,000,000 - $1,500,000
CO2 Emissions Savings (tCO_2e)	130 – 170 tCO_2	1,300 - 1,700 tCO_2e (equiv. 30,000-40,000 coniferous trees planted and tended for 10 yrs)

*Assumes a 30 - 40% reduction in electricity consumption at the facilities due to the use of more efficient equipment

Key Figures

Investment: US$250,000 to 500,000

Implementation: 1 year

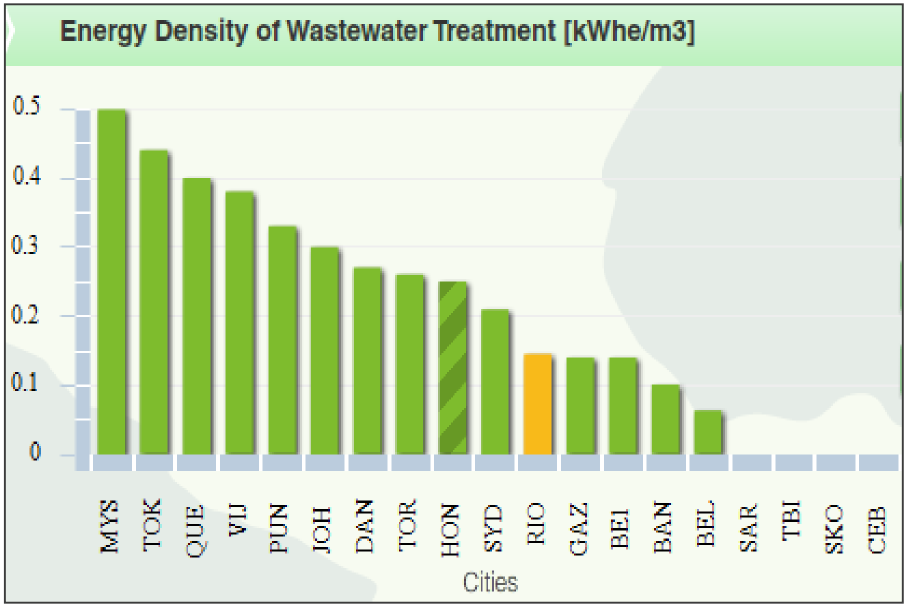
Payback: 2 to 4 years

4

Realizing the Energy Efficiency Opportunities in the

WATER AND WASTEWATER SECTOR

Wastewater treatment system is quite efficient with an overall low energy density



Source: TRACE: World Bank

Benchmarking highlights

- Rio de Janeiro ranks higher than Toronto, Sydney, Tokyo, Hong Kong, and many other cities
- Limited need for wastewater pumping because of gravity-led discharge
- Self-generation reduces power required from the grid by 30% (ETE Alegria)

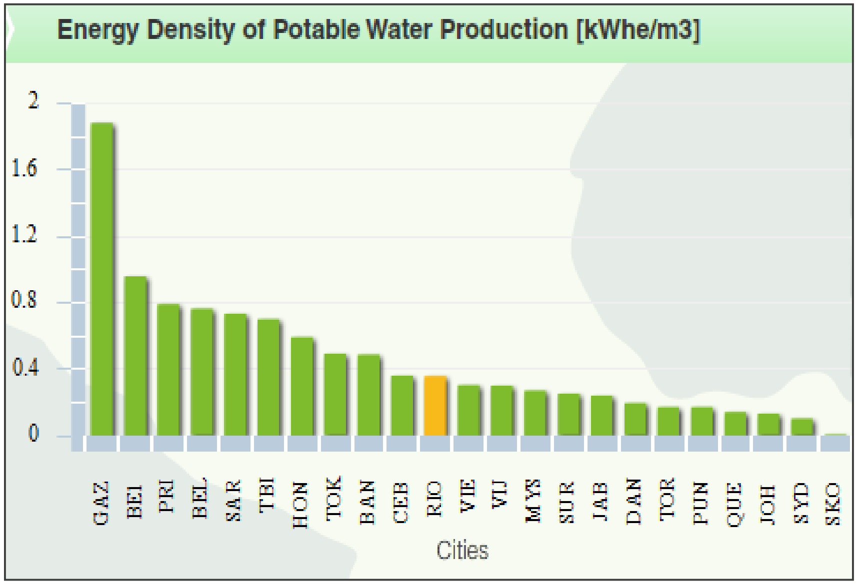
ETE Alegria

Image Sources: TRACE Team

CEDAE has some resource efficiency measures:

- Production of biogas, biofuel, biocarbon, and compost
- Reutilization of effluent treated at the Penha station for street cleaning, among other services
- Under study: Reutilization of treated water for industrial use in a petrochemical facility 49km away

Amount of energy needed to produce potable water could be reduced but the result is fairly good given the city's geography



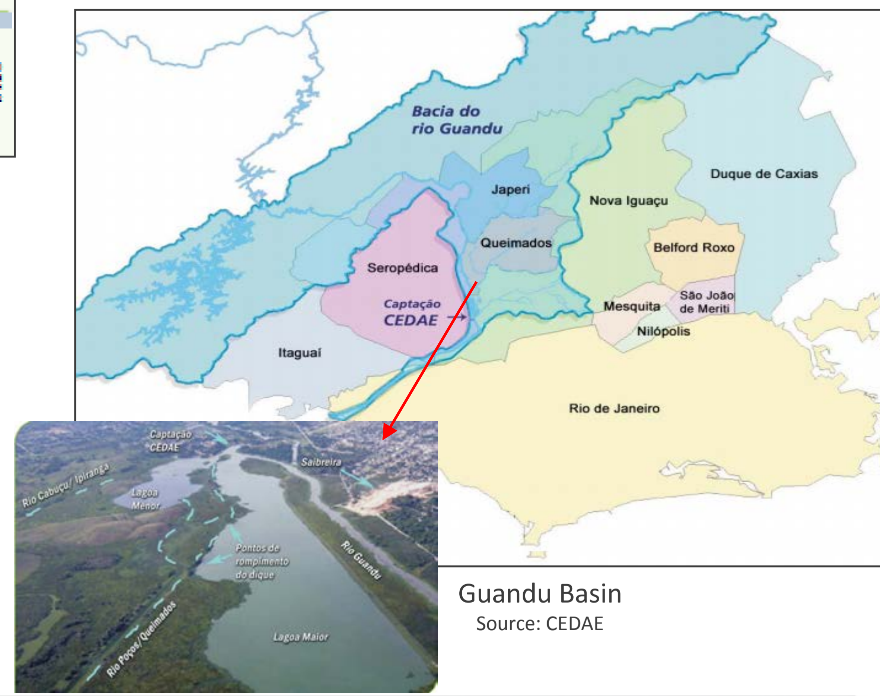
Source: TRACE: World Bank

Benchmarking Highlights

- The amount of energy needed to produce a unit of water in Rio is less than in cities such as Belo Horizonte, Tokyo, Hong Kong, Tbilisi, and many others
- Cities, such as Toronto, Sydney, and Johannesburg, use slightly less energy per unit of potable water

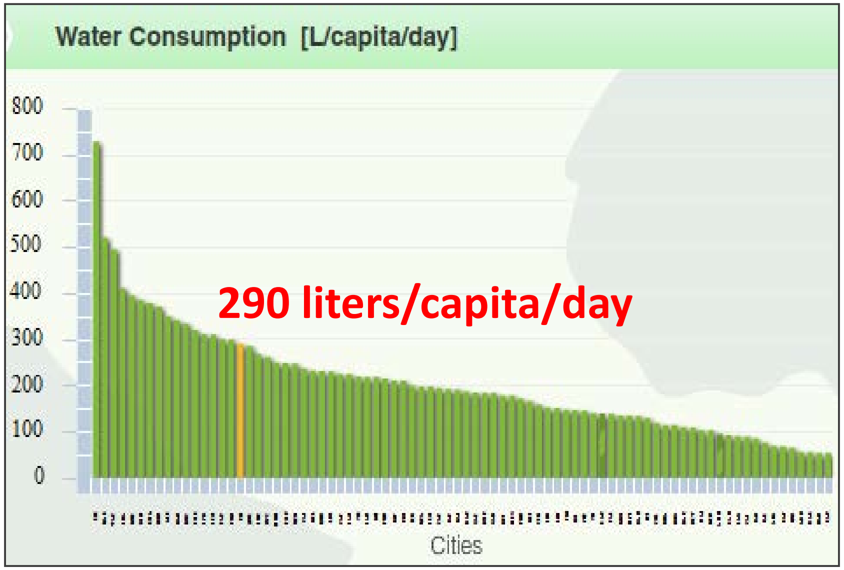
Key Observations

- Energy consumption is relatively low given the long distance (~60km) between main source/treatment station and population center
- Recent investments in EE (replacement of pumps, valves, frequency inverters – US$12M) yielded significant efficiencies:
  - o 27,000 MWh/year saved
  - o 3.4MW of peak demand suppressed



Guandu Basin
Source: CEDAE

Water consumption per capita per day is quite high and represents energy efficiency opportunities



Source: TRACE: World Bank

Benchmarking Highlights

- Rio's water consumption per capita per day is higher than 80% of all TRACE cities
- It is 30% higher than the average city for cities with the same level of development (similar HDI range)
- High by Brazilian and Latin American standards
  - 1.3x Sao Paulo and Santiago
  - 1.6x Brasilia and Mexico City
  - 1.8x Belo Horizonte
- Lower than Buenos Aires

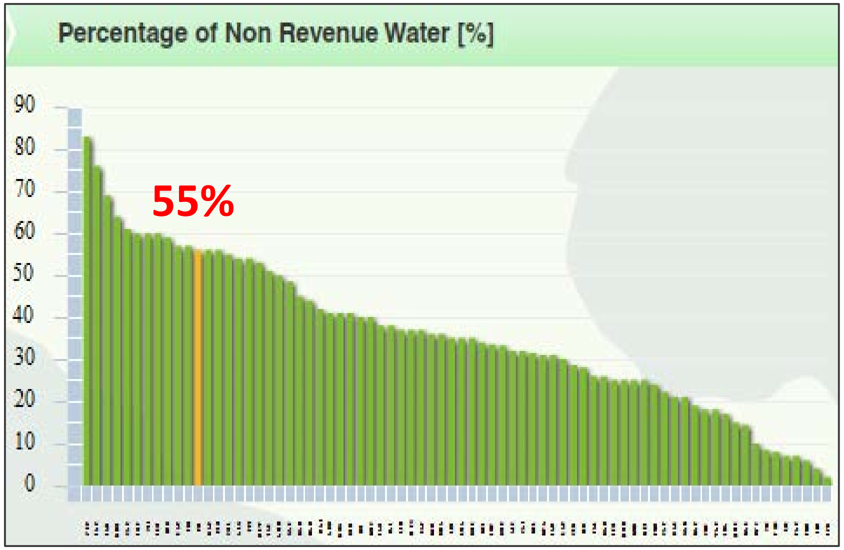
Key Observations

There are reduced incentives for rational use given:

- Illegal connections to the water distribution system
- Limited coverage of individual family metering
  - Limited metering in the favelas
  - Estimates of individual family connection coverage range from 65%-84%

Pictures Legend: Clockwise:
(1) Water Leakage in Vieira Souto Avenue in Rio de Janeiro City; (Marinho, Isabela , globo.com)
(2) Water Leakage in Manguinhos Favela; (Rocha, Fabiano (2012), globo.com)
(3) CEDAE Workers Repairing Clandestine Water Connection (Rio State)

Amount of non-revenue water is substantially high and this represents energy efficiency opportunities



Source: TRACE: World Bank

Likely Reasons

- High technical losses (leakages) at 34%
- High commercial losses:
    - 22% relative to water production
    - 33% relative to consumption
    - Illegal connections
    - Limited coverage of micro-metering

Benchmarking Highlights

- Higher than 85% of cities in the TRACE database
- 50% higher than average
- High by Brazilian & Latin American standards (highest of Latin American cities within database)

Practical Impact

- For every 1,000 liters produced:
    - 340 liters are not used due to leaks
    - 550 liters (including the 340 liters which leak) is not paid for directly
- About 34% of the energy used to produce the water is wasted
- Paying consumers (incl. City Hall) pay close to double the direct costs of producing the water

Investment in pressure monitoring system for the water distribution network and replacement of valves results in substantial savings

Description

Installing a pressure monitoring system, replacing old valves in the South Zone and automating when valves are open or closed would:

- reduce the amount of leakages in the water distribution system,
- improve overall system performance as the water pressure is optimized, and
- Reduce bursts and leakages which in turn reduces the amount of energy needed to pump the water

Key Agencies

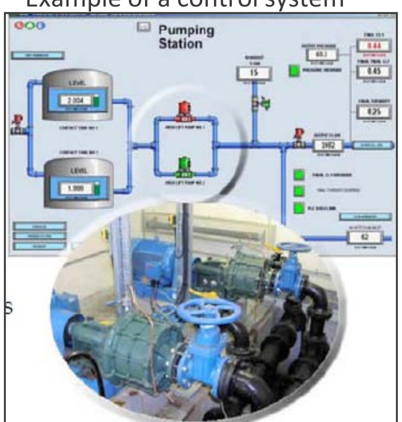
CEDAE already has a proposal for the project, and is eager to make the investments in order to realize the EE opportunity

Est. Benefits Based on Coarse/Rough Projections

Indicator	Annual	10 Years
Electricity Savings	130 GWh	1,300 GWh (equivalent to 48,000 Rio households powered for 1 yr)
Financial Savings (US$ million)	US$13 million	US$130 million
CO_2 Emissions Savings	40,000 tCO_2	400 ,000 tCO_2 (equivalent to 10 million coniferous trees planted and tended for 10 yrs)

*CEDAE has done the study and assumes 20% reduction in electricity consumption

Example of a control system



Burst water pipe at high/low pressures

Source: Mide Kent Water (left); Ronie McKenzie, WRP, Ltd. (right)

Key Figures

Investment: US$10 million

Implementation: 1.5 years

Payback: 1 year

Potable water individual metering and installation of water-efficient fixtures would result in substantial savings

Description

- Individually metering households, where there is group metering, would reduce water consumption, and efficient fixtures would reduce water consumption including in cases where people are not paying for the water.
- COPASA from Minas Gerais has a very successful program which has resulted in reduced water consumption. The company replaced fixtures for families in the favelas that consumed the most amount of water.

Additional Information

- The City passed a law requiring individual metering for all new buildings
- INMETRO issued regulation on efficient faucets, but the market of this type of efficient appliances doesn't seem to be well developed in Brazil yet

Water Meter, and Water Efficient Shower Head and Faucet

Est. Benefits Based on Coarse/Rough Projections

Indicator	Annual	10 Years
Electricity Savings	13 - 33 GWh	130 - 330 GWh (equivalent to powering 5,000-12,000 Rio households for 1 yr)
Financial Savings	US$3 - 6 million	US$ 26 – 64 million
CO_2 Emissions Savings	4,000-10,000 (tCO_2)	40,000 - 100,000 tCO_2 (equivalent to 1 - 2.6 million coniferous trees planted and tended for 10 yrs)

*Savings would vary from 10 – 25% , depending on whether both fixtures & meters
*At least 65% of households already have individual household meters
*Assumes intervention could be applied to 20% of Rio households

Key Figures

Investment: US$ 2 to 4 million
Implementation: 1 year
Payback: 1 to 2 years

Waste Water Treatment Facility Pump Replacement

Description

- Pumps consume 90% of the energy used by the waste water treatment facilities
- Replacing the five 800 HP pumps with new pumps would result in significant savings
- Trash ends up in the waste water treatment facilities. Removing this trash through supporting Comlurb/Light/UPP partnership would improve the efficiency of the pumps

Wastewater treatment facility pumps

Removed trash, which reduces pump efficiency at treatment facility pumps

Image Source: TRACE TEAM

Est. Benefits Based on Coarse/Rough Projections

Indicator	Annual	10 Years
Electricity Savings	14 - 18 (GWh)	140 - 184 GWh (5,000 - 7,000 Rio households powered for I yr)
Financial Savings	US$4 - 6 million	US$40 - 60 million
CO_2 Emissions Savings	4,000 - 6,000 (tCO_2)	41,000 - 55,000 tCO_2 (1.1 - 1.4 million coniferous trees planted and tended for 10 yrs)

*Assumes savings around 30% to 40% with newer more efficient pumps and improved trash removal

Key Figures

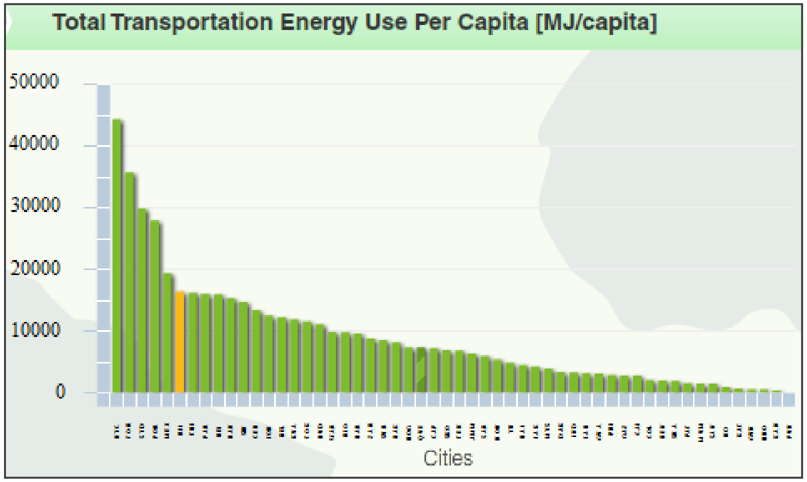
Investment: 1 to 2 million
Implementation: < 1 year
Payback: < 1 year

5

REALIZING THE ENERGY EFFICIENCY OPPORTUNITIES IN THE

TRANSPORT SECTOR

Rio has high transportation energy consumption per capita



Benchmarking Highlights

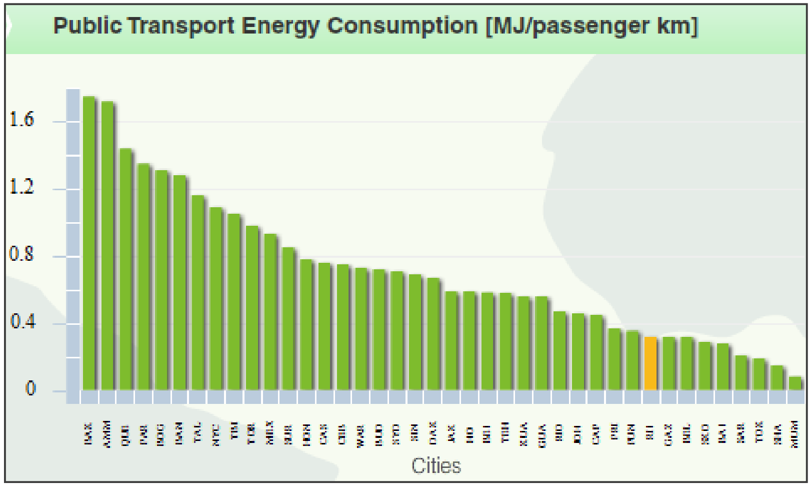
- Total transportation energy use per capita is among the highest 10% of all cites in the TRACE database
- Slightly higher than **Belo Horizonte** which does not have a Metro System, more than double **Bogota**, and slightly less than **Mexico City**
- Globally less than **New York**, but much higher than **Shanghai**

Key Observations

- On first look, it is unclear why the transportation energy use per capita is substantially higher than average.

Further investigation of public transportation and private transportation is needed.

Public transportation energy consumption in Rio is highly efficient with little energy consumption per passenger kilometer



Benchmarking Results

- Among the lowest 20% of all TRACE cities
- About half of the average value
- **About half of Belo Horizonte's** public transportation energy consumption
- **Better than Bogota, New York, Mexico City, Sydney,** and many other cities

Key Observations

- Public transportation seems highly efficient in terms of energy use
- Enhanced efficiency of bus system—modernized bus fleet, and Bus Rapid System
- Expansion and modernization of the metro system
- Optimized traffic flow

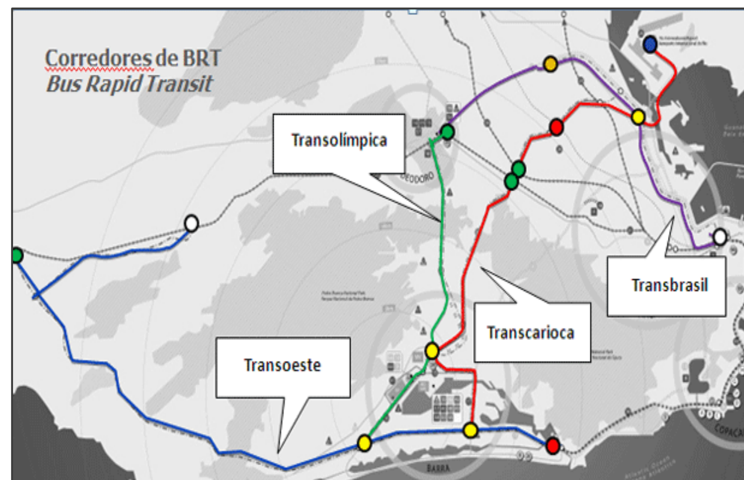
Rio is implementing a comprehensive array of measures to rationalize and increase capacity / efficiency of its public transportation system

Examples of activities enhancing energy efficiency in Rio public transportation:

- Bus fleet modernization
- BRS expansion
- BRT development
- Metro expansion
- Commuter rail modernization
- Reduction of van concessions (replaced with bigger buses)
- Rio Bicycle Capital (bike sharing)
- Tariff integration
- Intermodal integration
- Intelligent traffic management

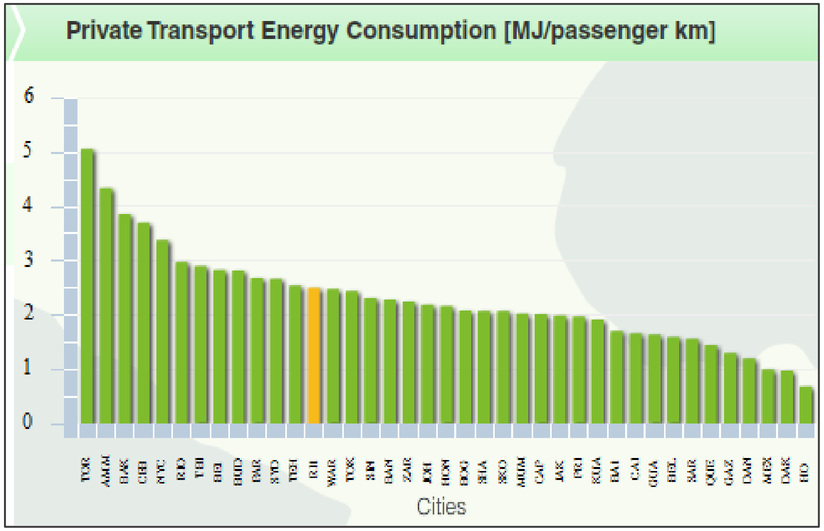
Bicycle Paths
Source: Rio de Janeiro Municipality

Articulated Bus
Source: Rio de Janeiro Municipality



Bus Rapid Transit Corridors
Source: Rio de Janeiro Municipality

There are opportunities to improve efficiency in private transportation since the energy consumption is higher than average



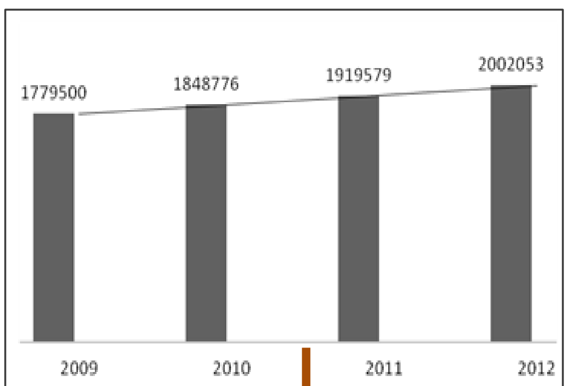
Benchmarking Highlights

- Private transport energy consumption is higher than 2/3 of all cities in the TRACE database
- It's also 15-20% higher than the average value
- It's 2.5 times higher than Bogota and Mexico City

Possible Explanations

- Increasing congestion levels (driven by significant increase in fleet) is likely an important contributor
- There is need for further research in the private sector transportation in Rio

Vehicle fleet grew by 1,089% between 1970 and 2012 or 50,000 more cars each year



increased congestion

Congestion lines in 2005

Source: Municipality of Rio de Janeiro

Forecasted congestion lines in 2025

Source: Municipality of Rio de Janeiro

Compared to benchmarked cities, the opportunity in private transportation ranges from US$160 to 260 million dollars per year

List of Possible Interventions

- Influence transport policy within the city where possible, e.g. integrating traffic impact assessment in urban development
- Using municipal vehicle taxes incentives to improve efficiency in private transportation
- Traffic restraint measures
- Car Parking Management—variable charging for parking spaces
- Park and ride infrastructure

Further research is need to assess the individual interventions which can be applied in Rio.

Est. Benefits Based on TRACE Benchmarking*

Indicator	Annual	10 Years
Fuel Savings	110 to 170 million liters	1,100 - 1,700 million liters (equivalent to 730,000 -1,100,000 cars fueled for 1 yr)
Financial Savings	US$ 170 - 260 million	US$ 1,600 - 2,600 million
CO_2 Emissions Savings	265,000 - 400,000 tCO_2	2.7 - 4.0 $MtCO_2$ (equivalent to 68 – 100 million coniferous trees planted and tended for 10 yrs)

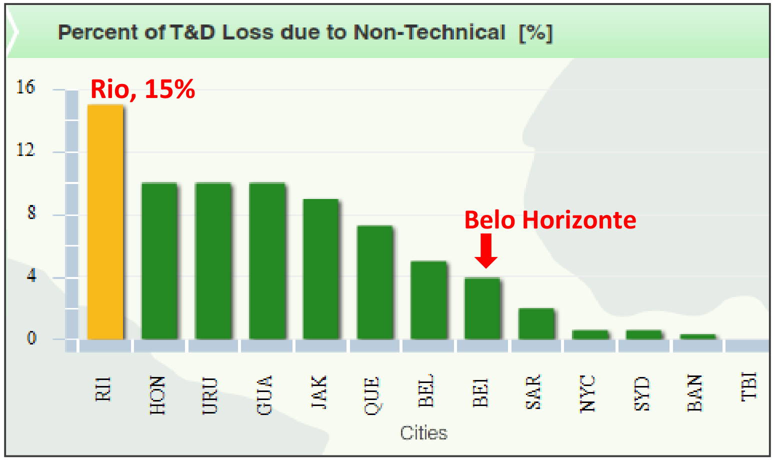
*Benefits based on performing up to the average of cities performing better than Rio
*Assumes 10 to 15% savings with the application of appropriate interventions
*Assumes that an average car in Rio consumes about 1500 liters per year

6

Realizing the Energy Efficiency Opportunities in the

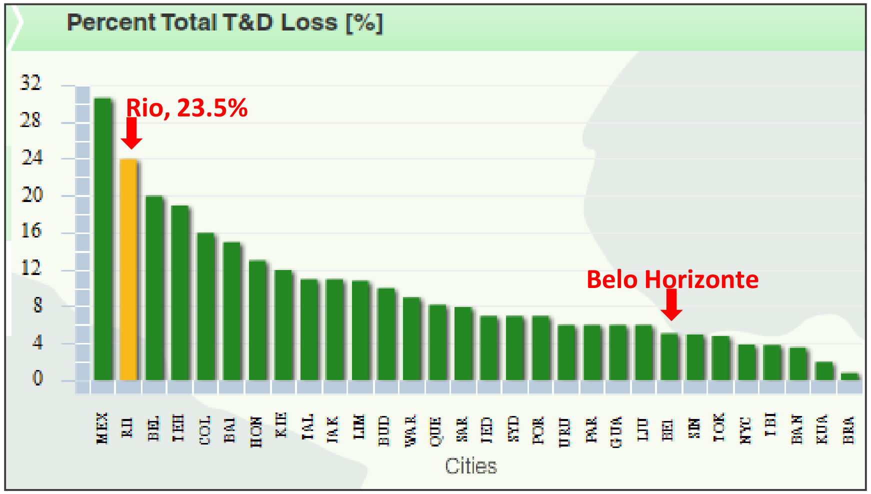
POWER SECTOR

Transmission and distribution losses in Rio are substantially high, largely due to high non-technical losses



Benchmarking Highlights

- Rio has second highest total losses for cities with same level of development (same HDI range)
- Result is three times the average value
- Results much higher than Belo Horizonte



Key Observations

- **Non-technical losses** are towards the highest end of cities in the database
- This is mostly due to very low collection in favelas and illegal connections
- Technical losses are at 8.5%; the average best practice ranges from 3-5%

TRACE ESMAP

Cooperating with the State on the pacification program is leading to significant improvements in EE in the power sector

Light's strategy after UPP Favela Pacification

1. **Grid enhancement**
   - Theft-proof (steel cover, secure boxes, telemetering, etc.)
   - Safer connections
2. **Account regularization**
   - Provide street addresses
   - Provide financial incentives to sign up *(50% discount – 2% monthly increments -> full tariff in 2 years)*
3. **Affordability enhancement**
   - Supply efficient equipment (lights, refrigerators) to targeted customers (*Efficient Community)*
   - Waste recycling-to-bill credits (*Light Recicla)*

Secured grid and telemetering reduce illegal connections and tampering to the distribution network in the favelas. If one of the metering connections is tampered with, the whole set shuts down, leading to social pressure.

The strategy has been applied in 11 of the 40 pacified favelas with great success.

Secured Grid Pole

Telemetering Box

Waste "Value Chart"

RESÍDUOS	Valor ABRIL/2012
Ferro	R$ 0,25
Garrafa VIDRO	R$ 0,10
Lata	R$ 1,70
Papel branco	R$ 0,48
Papel jornal	R$ 0,10
Papel misto	R$ 0,10
Papelão	R$ 0,18
Pet	R$ 1,00
Plástico	R$ 0,25
Plástico Filme	R$ 0,25
Tetra Pak	R$ 0,10

Community members exchange solid waste for credit towards electricity bills

Waste "Value Chart"

Refrigerator Replacement Program

Supporting Light's strategy for improving energy efficiency through UPP Social would help to reduce the non-technical losses

St. Marta Case Study

- The first police station unit in Santa Marta, was installed in December 2008, and the UPP Social Forum, which officially marked the pacification of the favela was held in October 2011.
- After the installation of the police station, Light invested in a secure grid, telemetering, more efficient equipment for targeted customers and was able to achieve significant results:
  - **Electricity savings of ~950,000 kWh/yr**
  - **Payment rates rose from 10-20% to 80-90% per month**
  - **Collections rose from $120/mo to $58,000/mo as of May 2012**

Ways that Municipality Can Help Multiply the Santa Marta Experience

1. Create an official program with a partnership among the municipality, Comlurb and Light in order to offer a comprehensive package to the favelas e.g. streamlined process of getting the permission to set up the waste-collection containers in the favelas
2. Support sustainability educational campaigns in the favelas

Est. Benefits Extrapolated from St. Marta Favela to All Households in Rio's Favelas

Indicator	Annual	10 Years
Electricity Savings	338 GWh	3380 GWh (equivalent to powering 120,000 Rio households for 1 yr)
Financial Savings	US$ 74 million	US$ 740 million
CO_2 Emissions Savings	100,000 tCO_2	1 $MtCO_2$ (equivalent 26 million coniferous trees planted and tended for 10 yrs)

*Assumes that all remaining favelas are pacified
*All benefits are calculated from extrapolating results from St. Marta favela using the data provided by Light

Santa Marta Favela

Technical losses are at 8.5%; some distribution equipment could be replaced for efficiency gains

Key Observations

- Some circuit breakers, substations and transformers are over 30 years old, and these may be renewed for improved energy efficiency.
- ANEEL Resolutions 270/2007 and 512/2012 regulate the quality of distribution equipment; hence the equipment is generally well maintained despite its age.
- However, ANEEL Resolution 024/2000 enables residents to get compensation from Light if they lose service on Light's account.

Possible interventions

- The City could have a campaign publicizing ANEEL Resolution 024/2000 so that residents can report major problems, and get them fixed, which would involve improving the distribution equipment.
- The city can also set up a "clearing agency" to help with processing the calls if allowed by law

Est. Benefits Based on Coarse/Rough Projections

Indicator	Annual	10 Years
Electricity Savings (MWh)	150 to 450 MWh	1,500 to 4,500 MWh (equivalent to powering 55,000-160,000 Rio households for 1 yr)
Financial Savings	US$ 33 - 99 million	US$ 330 - 990 million
CO_2 Emissions Savings (tCO_2e)	45,000 to 135,000 tCO_2	450,000 to 1,350,000 tCO_2 (equivalent 11 - 35 million trees planted and reared for 10 yrs)

*Assumes 1 - 3% savings city wide savings based on improvement in technical losses in transmission and distribution

30-year old circuit breakers

Key Figures

Investment: Investment costs would mostly fall on Light, and the city would need to invest in a public awareness campaign, and set up the clearing agency of the calls

Implementation: 1 year

CONCLUSIONS & NEXT STEPS

Conclusions based on consultations with the Municipality of Rio de Janeiro

- The final step of the TRACE process was the presentation of the findings to the municipality, done in May 2013
- The municipality expressed particular interest in exploring the following interventions in more detail:

1. Efficient Lighting
   - Implementation of city-wide LED program, phased in over multiple years
2. Public Buildings
   - Energy efficiency retrofits of municipal buildings, potentially focusing on a few Secretariats given that there is no single entity that manages all public buildings
3. Solid Waste
   - Optimization of waste collection routes
4. Water and Wastewater
   - Exploring opportunities for water pressure optimization with CEDAE
5. Transportation
   - Policies to encourage modal shift from private to public transportation
6. Power
   - Incentivizing investments by Light in Transmission & Distribution (T&D) upgrades
   - Creation of "clearing agency" to process calls from customers with complaints regarding service reliability and ensure proper follow up takes place

Next Steps

- Given resource constraints, the Municipality of Rio decided to take forward projects with significant mitigation potential and where the city has a higher degree of control over the management of the public service:
    - (1) efficient street lighting
    - (2) retrofits of public buildings, likely focusing on public schools and hospitals
    - Other investments can be pursued over time, or sooner if additional resources are identified
- To move things forward, the City of Rio asked the World Bank to provide more detailed implementation and financing options for efficient street lighting and public buildings.
- The next steps are:
    1. World Bank will identify and hire consultants to support the due diligence for implementation and financing options (June – August)
    2. Due diligence studies conducted and reports provided to World Bank (September – mid-November).
    3. World Bank returns to Rio to present findings of studies and request feedback from the City of Rio on which projects to support the city to implement (late November / early December)

ANNEXES

Annex I: Cities in TRACE Database

A to C	D to L	M to S	T to Z
Addis Ababa	Dakar	Mexico City	Tallinn
Alexandria	Danang	Mumbai	Tbilisi
Algiers	Dar Es Salaam	Mysore	Tehran
Amman	Dhaka	Nairobi	Tokyo
Baku	Durban	New Delhi	Toronto
Bangalore	Gaborone	New York	Tripoli
Bangkok	Gaziantep	Odessa	Tunis
Banja Luka	Guangzhou	Paris	Urumqi
Barcelona	Hanoi	Patna	Vienna
Beijing	Ho Chi Minh City	Phnom Penh	Vijawada
Belgrade	Hong Kong	Porto	Warsaw
Belo Horizonte	Indore	Pristina	Yerevan
Bhopal	Jabalpur	Pune	Zarqa
Bogota	Jakarta	Quezon City	
Brasilia	Jeddah	Rabat	
Bratislava	Johannesburg	Rio de Janeiro	
Bucharest	Kanpur	Sangli	
Budapest	Karachi	Santiago	
Buenos Aires	Kathmandu	Sao Paulo	
Cairo	Kiev	Sarajevo	
Cape town	Kuala Lumpur	Seoul	
Caracas	Lagos	Shanghai	
Casablanca	Lima	Sidney	
Cebu	Ljubljana	Singapore	
Chengdu		Skopje	
Colombo		Sofia	
		Surabaya	

NOTE: The first three letters in the name of the city serve as the abbreviation in the TRACE benchmarking graphs.

Annex II: Summary of Key Assumptions

- 10 year coarse/rough projections are based on a static baseline by multiplying the annual savings by 10
- The average of Brazil 2012 combined margin emission factors = 0.2997 tCO_2/MWh to calculate the CO_2 emissions (IGES Database)
- The average Rio de Janeiro household consumes 2799.72 kWh/yr (calculations based on data provided by Light)
- The average urban coniferous tree consumes 0.039 tCO_2 over 10 yrs (US Environmental Protection Agency)

Annex III: LED Street Lighting Model Assumptions

Assumptions for city-wide LED installation program in Rio:

Project info		
Total bulbs currently in Rio	n	418,269
Percent bulbs replaced in first year	%	25%
Percent bulbs replaced every subsequent year	%	25%
Percent current pentration of Mercury lamps	%	32%
Percent current pentration of Sodium lamps	%	68%
Percent current penetration LED lamps	%	0%
Installation cost per LED	R$	600
Cost per Mercury vapor bulb replacement	R$ / bulb	200
Cost per Sodium vapor bulb replacement	R$ / bulb	300
Cost per LED bulb replacement	R$ / bulb	400
Current electricity consumption per year	MWh / year	435,712
Current amount spent on street lighting per year	USD / year	52,301,593
Current amount spent on street lighting / MWh	USD / MWh	120.04
Current electricity consumption per lamp	MWh/lamp/year	1.04
Current % penetration of street lighting	%	80%
Annual increase in street light penetration	% year	3%
Maximum penetration of street lighting	%	95%

Bulb technical specs		
Mercury vapor wattage	watt	265
Sodium vapor wattage	watt	193
LED wattage	watt	75
Saving per bulb with Mercury	watt	190
Saving per bulb with on Sodium	watt	72
Averge life Mercury vapor bulb	hours	10,000
Averge life Sodium vapor bulb	hours	30,000
Averge life LED	hours	60,000
Average operating hours per day	hours	14.6
Operating hours per year	hours	5,338

Other Technical Data		
T&D losses	%	8.5%
Grid emission factor	tCO2e / MWh	0.2997

Financial Data		
Current Exchange Rate - $R / USD (April 9, 2013)	$R / USD	1.98
% finance by debt	%	100%
Estimated cost of capital (WACC)	%	10.0%

Summary output:

Metrics over time	**Year 1**	**Year 5**	**Year 10**
Net electricity savings (MWh)	72,356	1,088,663	2,756,790
Financial savings	(20,177,104)	12,044,082	161,575,643
Net emission reductions (tCO2e)	21,685	326,272	826,210

Financial Metrics	
Total project investment (US$)	150,513,466
Total net income (US$)	338,279,839
Return on Investment	125%
Payback period (years)	4.23
NPV	161,575,643
IRR	63%

Once fully implemented... (from year 5 onwards)	
Avg. annual electricity savings (MWh)	362,100
Avg. annual financial savings (US$)	57,806,680
Avg. annual CO2e savings	99,297

Cumulative savings	**Year 10**	**Which is equivalent* to...**		
Net electricity savings (MWh)	2,756,790	***Lighting***	984,666	***homes / year***
Net emission reductions (tCO2e)	826,210	***Planting***	21,184,870	***trees***

**Note: all figures are high-level estimates based on assumptions and are intended for indicative purposes only*

Annex IV: A/C Timers in Schools & Municipal Office Buildings Assumptions

Assumptions - installing A/C timers in schools and municipal office buildings in Rio:

Project info		
Electricity consumption of schools	kWh / year	56,507,944
Electricity consumption of municipal office buildings	kWh / year	53,371,190
Average cost of electricity for municipal buildings	R$ / kWh	0.224
% total electricity use for air conditioning	%	48%
Cost to install timer (per AC unit)	R$	100
# AC units in schools (=classrooms with AC)	n	5,080
# AC units in office buildings	n	3,599
Average operating hours per day in schools	hours	12.0
Average operating hours per day in buildings	hours	16.0
Operating hours per year in schools	hours	3,120
Operating hours per year in schools	hours	5,600
Decrease in hours used in schools	hours	(2.00)
Decrease in hours used in office blds	hours	(3.00)
% savings from EE measure in schools	%	17%
% savings from EE measure in office bldgs	%	19%

A/C unit technical specs		
Avg life of AC unit	hours	40,000
Avg. life of AC unit in school	years	13
Avg. life of AC unit in building	years	7

Other Technical Data		
T&D losses	%	8.5%
Grid emission factor	tCO2e / MWh	0.2997
tCO2e per tree planted, after 10 years	tCO2e per 10 y	0.039

Financial Data		
Current Exchange Rate - $R / USD (April 9, 2013)	$R / USD	1.98
% finance by debt	%	100%
Estimated cost of capital (WACC)	%	10.0%

Inflation		
Real Inflation Rate	%	9.60%

Summary output:

Metrics over time	Year 1	Year 5	Year 10
Net electricity savings (MWh)	19,425	66,691	74,572
Financial savings	1,599,343	5,593,423	6,058,056
Net emission reductions (tCO2e)	5,821,699	19,987,236	22,349,173

Financial Metrics	
Total project investment (US$)	438,308
Payback period (years)	1.00
NPV	6,058,056
IRR	n/a

From year 1 to year 5	
Avg. annual electricity savings (MWh)	13,338
Avg. annual financial savings (US$)	1,118,685
Avg. annual CO2e savings (tCO2e)	713,110

Cumulative savings	Year 10	Which is equivalent* to...		
Net electricity savings (MWh)	74,572	*Lighting all Rio's schools for*	1.3	*years*
Net emission reductions (tCO2e)	22,349,173	*Planting*	573	*million trees*

**Note: all figures are estimates based on assumptions and are intended for indicative purposes only*

Note: model assumes Rio would replace old A/C units with new units that already have timers, so savings stop accruing after A/C needs to be replaced

Annex V: Eco-Driving Model Assumptions

Assumptions for city-wide Ecodriving program in Rio:		
Project info		
Numer of trucks in city	n	650
Numer of trucks in project owned by Comlurb	n	50
Numer of trucks in project owned by concessiona	n	600
Current diesel consuption per month	liters / mo.	1,100,000
Current diesel consuption per year	liters / year	13,200,000
Current diesel consuption / year/ truck	liters / year	20,308
Decrease in diesel consumption / year	%	10%
% savings for municipality from concessionaire sa	%	15%
# years to roll out project	n	3
Cost of diesel fuel	R$ / liter	2.20
Training cost per truck	R$	100
Equipment cost per truck	R$	200
Start-up costs (planning routes, etc)	R$	495,000
Current maintenance costs / truck / year	R$	7,920
Reduction in maintenance costs	%	5%
Other Technical Data		
Diesel emissions per liter	tCO2 / liter diesel	0.95
tCO2e per tree planted, after 10 years	tCO2e per 10 years	0.039
Financial Data		
% finance by debt	%	100%
Estimated cost of capital (WACC)	%	10.0%
Inflation		
R$ Inflation Rate	%	9.60%

Summary output:

Metrics over time	**Year 1**	**Year 5**	**Year 10**
Net diesel savings (liters)	440,000	5,280,000	11,880,000
Financial savings ($US)	137,152	453,494	576,318
Net emission reductions (MtCO2e)	0.42	5.02	11.29

Financial Metrics	
Total project investment (US$)	273,569
NPV (US$)	576,318
Average annual financial savings (US$	82,935
Payback period (years)	1.00
IRR	n/a

Cumulative savings	**Year 10**	**Which is equivalent* to...**		
Net diesel savings (liters)	11,880,000	***Removing***	1	***truck(s) from fleet***
Net emission reductions (MtCO2e)	11	***Planting***	289	***million trees***

**Note: all figures are estimates based on assumptions and are intended for indicative purposes only*