

ENERGY EFFICIENCY IN SUB-SAHARAN AFRICAN CITIES

OCTOBER 27, 2015

RUTU DAVE

THE WORLD BANK



# ESMAP Energy Efficient Cities Program and Tool for Rapid Assessment of City Energy (TRACE)



# Cities are important....



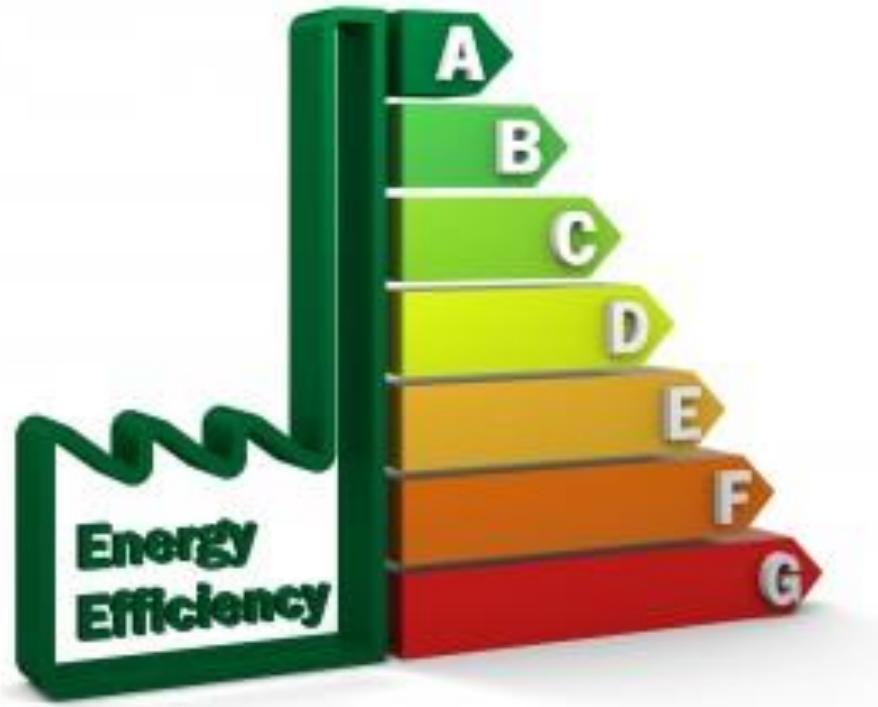
# Constrained services



# Limited resources



# Doing more with less



# Prioritization



??  
or



# TRACE Why TRACE?

## Strong Demand from Cities

- Strong desire to reduce energy costs through EE improvements
- A lack of decision-support tool to identify major EE interventions across urban sectors
- Desire to learn from peer cities' and international best practices

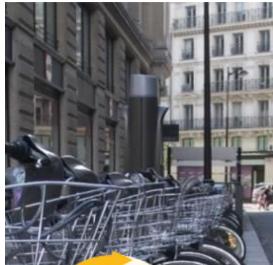
## Key Advantages of TRACE

- Cross-sectoral
- Focuses on areas under the control of the city authority
- Relatively low data requirements, low cost, intuitive and quick to implement
- Strong ownership of cities

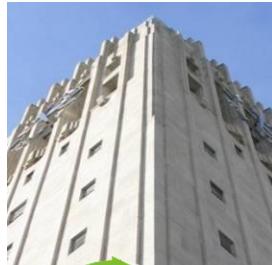




## Evaluating Energy Efficiency Opportunities in 6 Municipal Sectors



TRANSPORT



BUILDINGS



PUBLIC  
LIGHTING



WATER &  
WASTEWATER



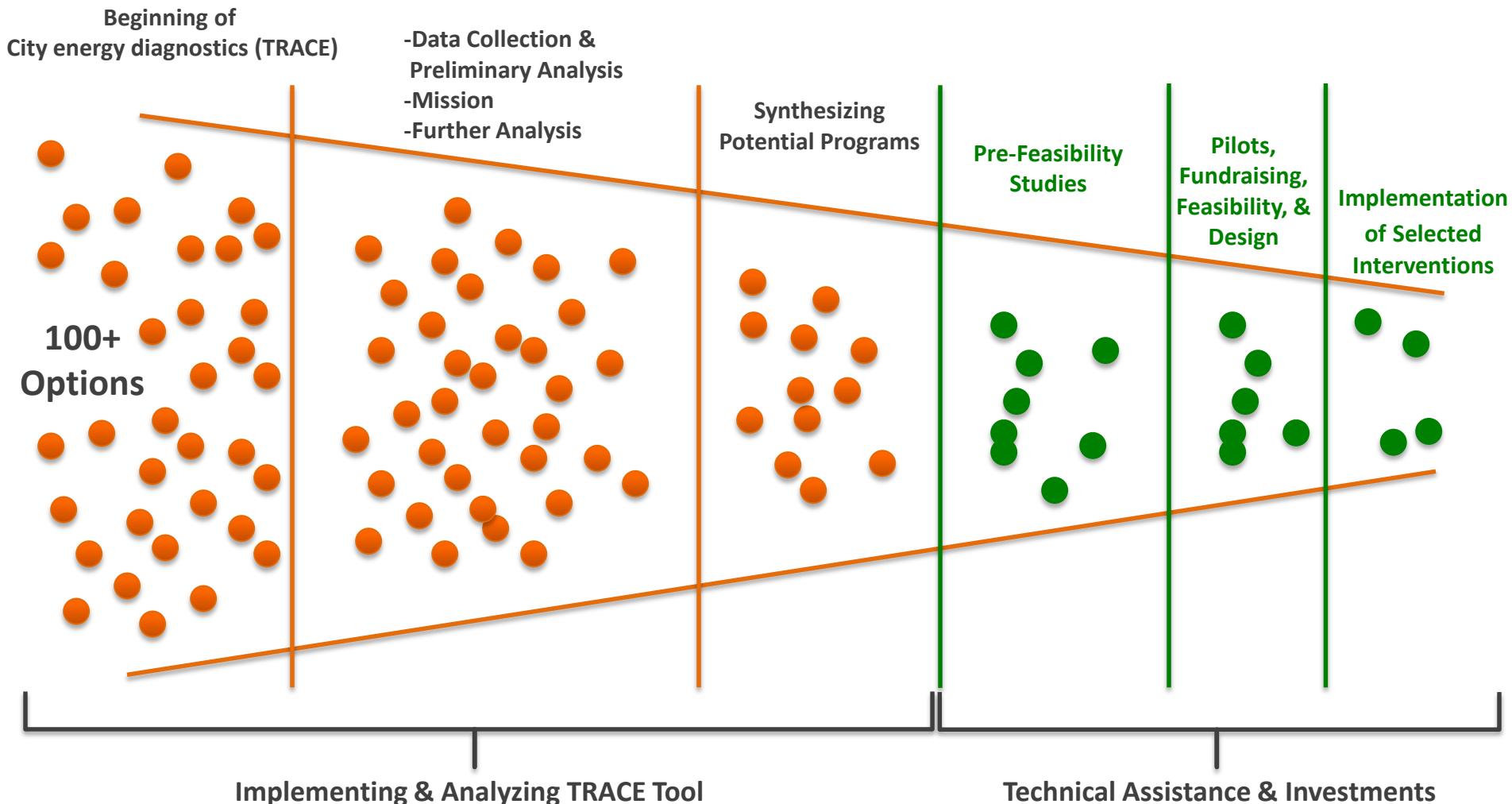
POWER &  
HEATING



SOLID  
WASTE



# Overview of the World Bank's urban energy efficiency Technical Assistance Program



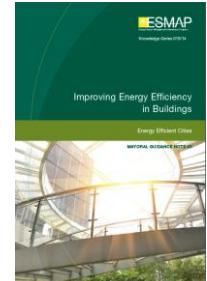
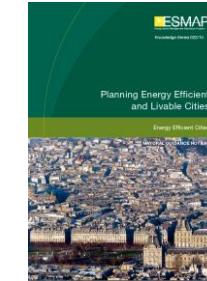
# City Energy Efficiency Transformation Initiative

## ENHANCING KNOWLEDGE & BUILDING CAPACITY – RESOURCES TO SUPPORT EE IN BUILDINGS



Knowledge Products

- What can local governments do to improve energy efficiency in their cities? (Mayoral Guidance Notes - <http://www.esmap.org/node/3155>)



- How to measure the performance of energy efficiency projects? (*underway - focus on street lighting & buildings*)



Capacity Building

- Bring urban and energy practitioners together
- Extend reach of CEETI program
  - **Energy Efficiency Project Resource Center Resource Center EEPHC** –in cooperation with the open wiki-platform Energypedia

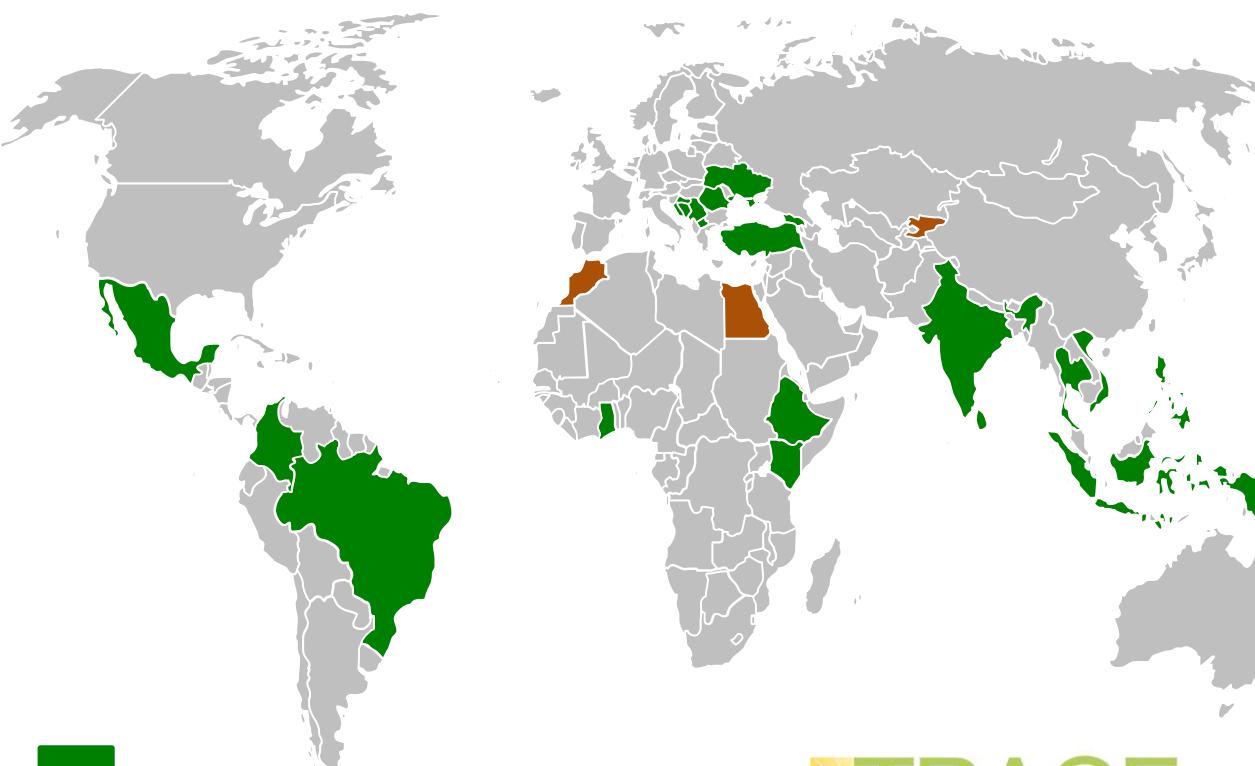
[https://energypedia.info/wiki/Energy\\_Efficiency\\_Project\\_Resource\\_Center](https://energypedia.info/wiki/Energy_Efficiency_Project_Resource_Center)

- Development of **e-learning program** on energy efficiency in cities (incl. course on EE public buildings)  
<http://einsteinstitute.worldbank.org/ei/course/energy-efficiency-public-buildings>

# TRACE – Contributing to Genesis of EE Programs in 67 Cities

TOOL GOING THROUGH TARGETED DISSEMINATION AND MAJOR TECHNICAL IMPROVEMENT

35 Countries Reached & Targeted Dissemination Planned



 Completed deployment  
 Upcoming deployment

  
TRACE  
Tool for Rapid Assessment of City Energy

## Major Enhancement to TRACE 2.0

- Adding industry, commercial buildings and residential buildings sectors
- Updating the recommendations to include the latest technologies
- Adding new benchmarking data
- Improving usability of the tool
- Converting the tool to Excel for improved transparency and flexibility



Tools

# City Energy Diagnostics – Tool for Rapid Assessment of City Energy (TRACE)

A DECISION SUPPORT TOOL FOR EVALUATING ENERGY EFFICIENCY OPPORTUNITIES IN CITIES

## TRACE:

“ ...a practical tool for conducting rapid assessment of energy use in cities, that identifies and prioritizes sectors, and suggests specific energy efficiency interventions... ”  
*(public lighting; transport; buildings; water and waste water; solid waste; power and heat)*

Energy Efficient Cities Initiative  
Tool for Rapid Assessment of City Energy Save

**Energy Benchmarking**  
Compare the performance of your city to others

 Benchmark Data

 Benchmark Results

**Sector Prioritization**  
Identify the sectors with highest priority

 Relative Energy Intensity

 Sector Energy Spending

 City Authority Control

 Sector Priority Results

**Energy Efficiency Recommendations**  
Find ways to improve your city's energy efficiency

 Recommendations

 Initial Appraisal

 Energy Savings Assessment

 Review

 User Guide & Documents

**TRACE**  
Tool for Rapid Assessment of City Energy



ESMAP  
Energy Sector Management Assistance Program

# Energy Benchmarking

Data Collection Phase		TRACE Implementation			City Report
Gather data	Benchmark city energy use	Introduce TRACE / hold sector meetings	Assess most promising sectors	Review recommendations in priority sectors	Prepare final recommendations

## Energy Benchmarking

Compare the performance of your city to others

**Benchmark Data**

**Benchmark Results**

**Benchmark Data**

Data collated during the pre-mission phase, using the templates provided should be entered here. Go through each of the tabs on the left to access each sector. Don't forget to add the year and source of the data. If a proxy has been used (e.g. national data), check the box on the right and enter the year and source

Data Point	Year	Source	Proxy
Population Within Municipal Boundary	2010	Gaziantep	
Climate Type	2010	Gaziantep	
HDI (by Country)	2009	Human Development Index	
Primary Electricity Consumption per Capita [kWh/capita]	2010	Gaziantep	
Primary Electricity Consumption per GDP [kWh/\$GDP]	2010	Gaziantep	
Primary Energy Consumption per Capita [MJ/capita]			

**Benchmark Results**

Choose a Sector and a Key Performance Indicator from the menu to compare your city to others on the chart below. Uncheck a city in the table to remove it from the chart. Striped bars are proxy data. To generate a PDF file of a chart, click on Export.

**Select a KPI**

- Total Transportation Energy Use Per Capita
- Public Transport Energy Consumption
- Metres of High Capacity Transit per 1000 People
- Transportation Non-Motorized Mode Split
- Public Transportation Mode Split
- Private Transport Energy Consumption

**Metres of High Capacity Transit per 1000 People [m/1000 people]**

New York  
92.44:  
Source: Millennium Database of Towns and Regions (UITP)  
Year: 1995



City	Value
Sydney	225.01
Budapest	197
Warsaw	178
Paris	152

# Evaluating Energy Efficiency

Data Collection Phase		TRACE Implementation			City Report
Gather data	Benchmark city energy use	Introduce TRACE / hold sector meetings	Assess most promising sectors	Review recommendations in priority sectors	Prepare final recommendations

## Sector Prioritization

Identify the sectors with highest priority

- Relative Energy Intensity** (highlighted)
- Sector Energy Spending**
- City Authority Control**
- Sector Priority Results**

**Relative Energy Intensity**

The sliders below have been pre-set using the data provided in the Energy Benchmarking module. The TRACE City energy reduction value is calculated as the mean of the values of all chosen peer cities with better performance. The override value should only be used where the TRACE user has different sector or sub-sector using the 'Technical Energy Savings Estimation' Form.

Sector	Energy Savings Potential
District Heating	0% 10% 20%
Power	0% 10% 20%
Potable Water	0% 10% 20%
Wastewater	0% 10% 20%
Solid Waste	0% 10% 20% 30% 40%

**Municipal Buildings**

Using the Slider below, select the appropriate REI based upon site walk-throughs and visits and the guidance provided in the 'Technical Energy Savings Estimation' Form. Please provide a rationale for the change in the box below, for instance: no benchmarking data, proxies used etc.

Reason for Change: CA facilities engineering staff have been looking at boiler upgrades and fan replacement. They anticipate no less than 11% savings from these two changes alone – other system upgrades will improve efficiency by a few more percent.

Override

[Return to REI](#) [Cancel](#)

# Evaluating Energy Efficiency

Data Collection Phase		TRACE Implementation			City Report	
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**Sector Energy Spending**

Enter the amount of money spent per calendar year (\$USD) in each sector using the input boxes below. If no money is spent at the city level in a sector, leave the box blank.

Sector	Energy Spending (\$USD)	City Authority	City Wide
Public Transportation	51518994	<input type="radio"/>	<input checked="" type="radio"/>
Private Vehicles	182328446	<input type="radio"/>	<input checked="" type="radio"/>
Municipal Buildings	13836029	<input checked="" type="radio"/>	<input type="radio"/>
Street Lighting	13547485	<input type="radio"/>	<input checked="" type="radio"/>
District Heating	0	<input type="radio"/>	<input type="radio"/>



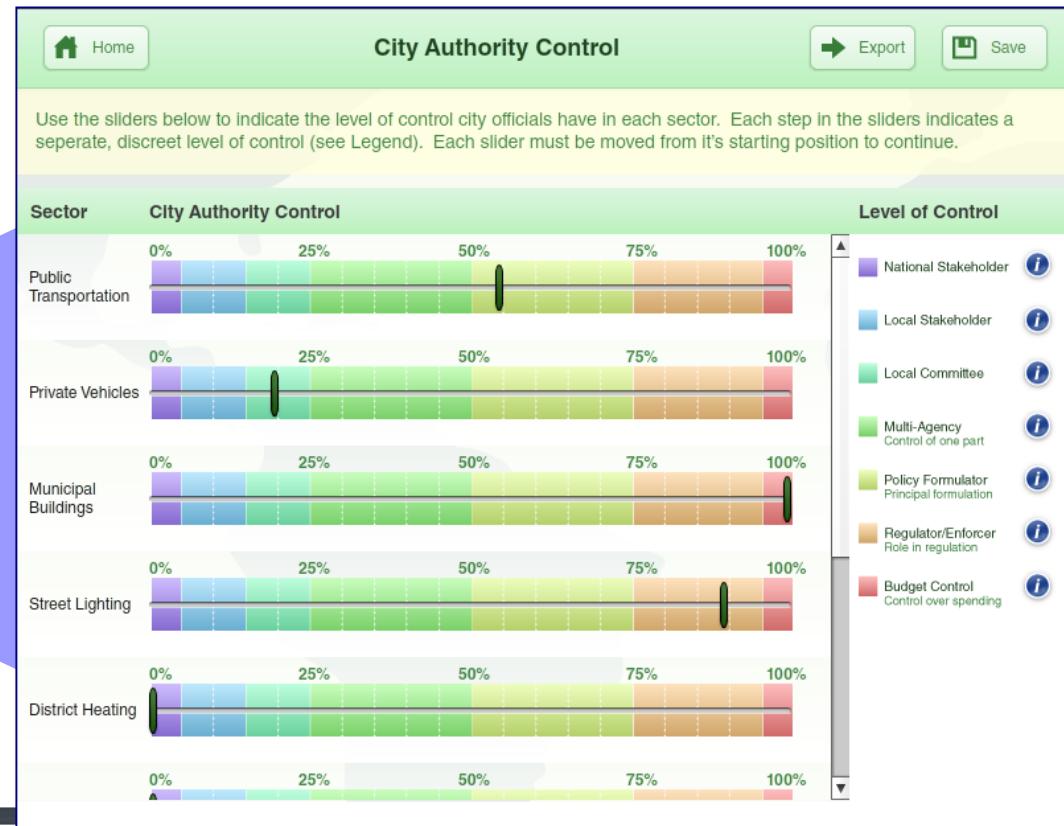
# Evaluating Energy Efficiency

Data Collection Phase		TRACE Implementation			City Report
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Identify the sectors with highest priority

- Relative Energy Intensity
- Sector Energy Spending
- City Authority Control**
- Sector Priority Results



# Evaluating Energy Efficiency

Data Collection Phase		TRACE Implementation			City Report
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## Sector Prioritization

Identify the sectors with highest priority

- Relative Energy Intensity
- Sector Energy Spending
- City Authority Control
- Sector Priority Results**

 **Sector Prioritization**  

Based upon the answers to the sector prioritization questions, two separate lists of sectors have been created: CA Control and City-wide.

**4 of 8 selected**

City Authority Sector Ranking				
Rank	Sector	REI%	Spending CA (US \$) Control	Score Check to Select
1	Potable Water	86.0	20,046,760 0.80	13,799,229 <input type="checkbox"/>
2	Municipal Buildings	54.8	13,836,029 1.00	7,586,851 <input checked="" type="checkbox"/>
3	Solid Waste	48.2	500,000 0.75	180,803 <input type="checkbox"/>
4	Wastewater	5.0	1,194,840 0.95	56,754 <input type="checkbox"/>

City Wide Sector Ranking				
Rank	Sector	REI%	Spending CA (US \$) Control	Score Check to Select
1	Public Transportation	42.4	51,518,994 0.55	12,021,098 <input checked="" type="checkbox"/>
2	Private Vehicles	29.4	182,328,446 0.20	10,752,703 <input checked="" type="checkbox"/>
3	Street Lighting	51.2	13,547,485 0.90	6,251,823 <input checked="" type="checkbox"/>
4	Power	31.5	538,517,487 0.01	1,701,657 <input type="checkbox"/>

# Evaluating Energy Efficiency

Data Collection Phase		TRACE Implementation				City Report
Gather data	Benchmark city energy use	Introduce TRACE / hold sector meetings	Assess most promising sectors	Review recommendations in priority sectors	Prepare final recommendations	Prepare final city report
6 weeks		4 days	1 day	4 days	1 day	4 weeks
<b>Energy Efficiency Recommendations</b> Find ways to improve your city's energy efficiency		 The image shows the TRACE software interface for the 'Initial Appraisal' phase. It features a sidebar with buttons for 'Recommendations', 'Initial Appraisal' (which is highlighted with a yellow border), 'Energy Savings Assessment', 'Review', and 'User Guide & Documents'. The main area is titled 'Initial Appraisal' and contains a matrix for comparing recommendations across various sectors (Public Transportation, Private Vehicles, Solid Waste, Potable Water, Wastewater, Power, District Heating, Street Lighting, Municipal Buildings, CA Management) against competency levels (Low, Medium, High) and opportunity levels (C, F, H, D, P, A).				



# Evaluating Energy Efficiency

Data Collection Phase		TRACE Implementation				City Report
Gather data	Benchmark city energy use	Introduce TRACE / hold sector meetings	Assess most promising sectors	Review recommendations in priority sectors	Prepare final recommendations	Prepare final city report

-  **Recommendations**
-  **Initial Appraisal**
-  **Energy Savings Assessment**
-  **Review**
-  **User Guide & Documents**

Home

## Energy Savings Assessment

For each recommendation that has an energy savings calculator, undertake the calculation and enter the estimated energy savings in the box below.

Download the Energy Savings Calculator here: [Download](#)

Recommendation	Value (kWh/annum)
Municipal Schools Audit & Detroit Program	
Municipal Offices	
Municipal Residential Program	
Municipal Hospitals	
Street Lighting	
Municipal Buildings	
CA Management	

### Municipal Buildings Upgrade Calculator

**Background Information**

Total floor area of Municipal Buildings: 100,000 m<sup>2</sup>

Average cost of electricity for municipal buildings: 0.15 \$/kWh

Sector Annual Energy Spend (\$): \$2,000,000

### Municipal Offices Audit and Retrofit Program

Attribute	Current Office Space			Post-Retrofit Office Space		
	m <sup>2</sup> cooled	m <sup>2</sup> heated	m <sup>2</sup> private	Ownership	m <sup>2</sup> cooled	m <sup>2</sup> private
Ownership	20,000	0	0	20,000	0	0
Cooled area	15,000	0	0	15,000	0	0
Heated area	0	0	0	0	0	0
% Worst	% Bad	% Good	% Best	Run Hours	Total kWh	
Lighting	30%	30%	20%	20%	2000	724,000
Cooling	30%	30%	30%	10%	1000	310,500
Heating	0%	0%	0%	0%	0	0
Computers / IT	30%	30%	30%	10%	2000	453,000
Appliances	30%	30%	30%	10%	2500	213,750
Other 1	0%	0%	0%	0%	0	0
Other 2	0%	0%	0%	0%	0	0
Other 3	0%	0%	0%	0%	0	0
Other 4	0%	0%	0%	0%	0	0
Total						1,701,250
Total Energy Savings			AUDITOR CHECK on total spend			
Percentage Improvement			528 MWh / annum			
Total Potential Cost Savings			31% 20% AUDITOR CHECK on %			
579,215 \$ / annum						



# Evaluating Energy Efficiency

Data Collection Phase		TRACE Implementation			City Report
Gather data	Benchmark city energy use	Introduce TRACE / hold sector meetings	Assess most promising sectors	Review recommendations in priority sectors	Prepare final recommendations

### Energy Efficiency Recommendations

Find ways to improve your city's energy efficiency

-  [Recommendations](#)
-  [Initial Appraisal](#)
-  [Energy Savings Assessment](#)
-  [Review](#)
-  [User Guide & Documents](#)

**Recommendation Review**

All recommendations that were selected in the Initial Appraisal are displayed below along with their attributes. Where user input has been entered for Energy Savings Potential, the value has been updated to show a standard range in which the

Recommendation	Sector	Speed
Municipal Buildings Energy Efficie...	Municipal Blds	<1yr
Buildings Benchmarking Program	Municipal Bld	1-2yrs
Municipal Schools Audit & Retrofit ...	Municipal Bld	1-2yrs
Municipal Offices Audit & Retrofit P...	Municipal Bld	1-2yrs
Municipal Residential (Public Hou...	Municipal Bld	1-2yrs
Municipal Hospitals Audit & Retrof...	Municipal Bld	1-2yrs
Computer PowerSave Project	Municipal Bld	<1yr
Solar Hot Water Program	Municipal Bld	<1yr
Mandatory Building Energy Efficien...	Municipal Bld	>2yrs
Green Building Guidelines for Ne...	Municipal Bld	>2yrs
Enforcement of Vehicle Emission...	Public Transp	>2yrs
Taxi Vehicle Replacement Program	Public Transp	>2yrs
Traffic Flow Optimization	Public Transp	>2yrs

**Recommendations Matrix**

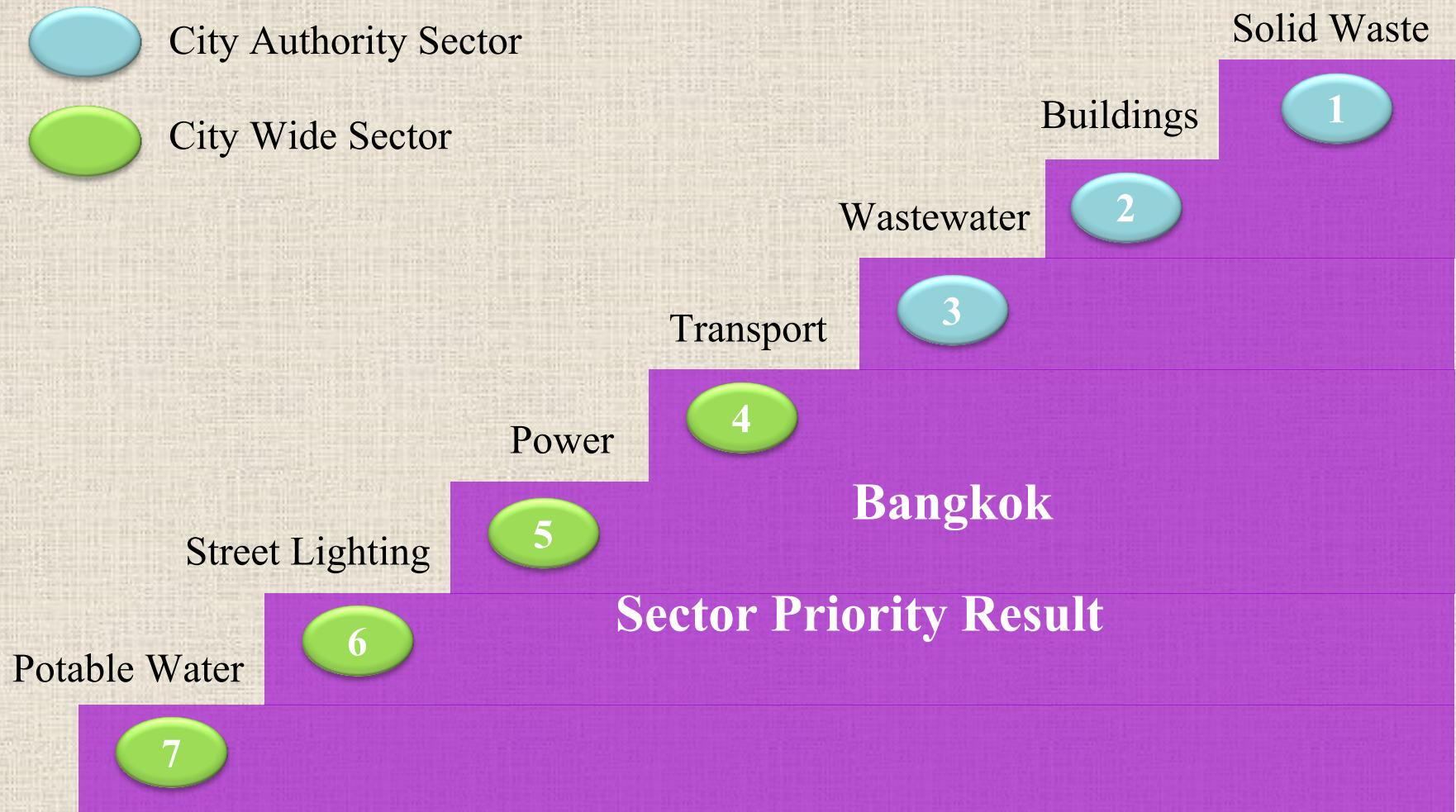
The matrix below shows all recommendations from prioritized sectors sorted by First Cost and Energy Efficiency. The check boxes allow the user to alter the display based on Speed of Implementation.

First Cost		Energy Savings Potential	
\$100,000 - \$1,000,000		< \$100,000	
Filter by speed of implementation	<input checked="" type="checkbox"/> < 1 year	<input checked="" type="checkbox"/> 1-2 years	<input checked="" type="checkbox"/> > 2 years
> \$1,000,000  Municipal Offices Audit & Retrofit Program Municipal Residential (Public Housing) ... Municipal Hospitals Audit & Retrof... Public Transportation Development	Solar Hot Water Program Enforcement of Vehicle Emissions Stan. Taxi Vehicle Replacement Program Traffic Flow Optimization Enforcement of Vehicle Emissions Stan.		
	Traffic Restraint Measures Energy Efficiency Municipal Task Force Energy Efficiency Strategy and Action Pla...		
	Non-Motorized Transport Modes Congestion Pricing Non-Motorized Transport Modes		
	Capital Investment Planning Purchasing and Service Contracts		
	Municipal Schools Audit & Retrofit Prog... Traffic Signals Audit and Retrofit Program		
Computer PowerSave Project Street Signage Lighting Audit and Retrof...			

# TRACE results for Bangkok



# 1. Sector Priority Result

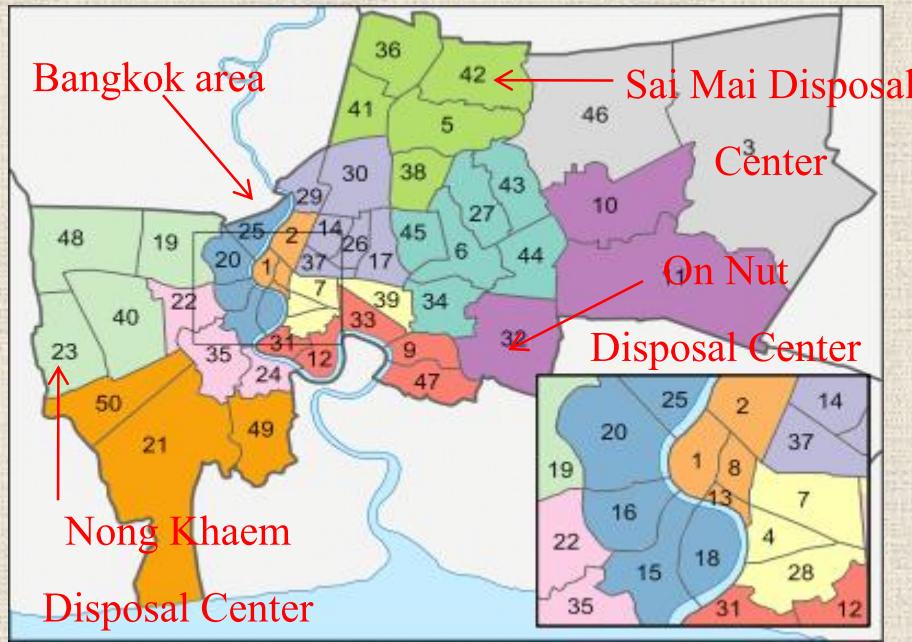




1

Realizing the Energy Efficiency Opportunities in the  
**Solid Waste Sector**

# Waste findings in Bangkok



Bangkok Waste Intermediate Stations

## Findings:

- The generated waste in year 2013 was 9,963 ton/day.
- There are 3 intermediate stations before transferring the waste to the sanitary landfill sites;
  - 1) Nong Khaem Disposal Center (4,000 tons/day)
  - 2) On Nut Disposal Center (4,000 tons/day)
  - 3) Sai Mai Disposal Center (2,000 tons/day)

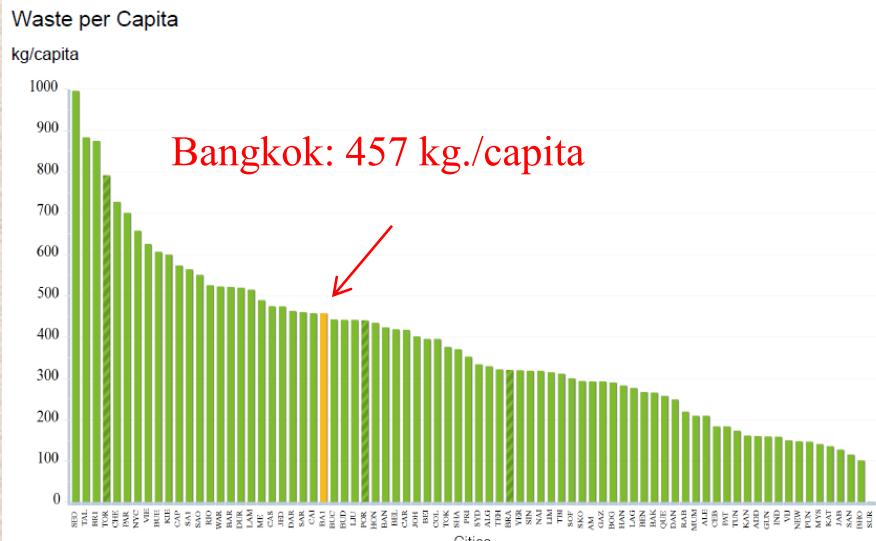


Sanitary landfill operation



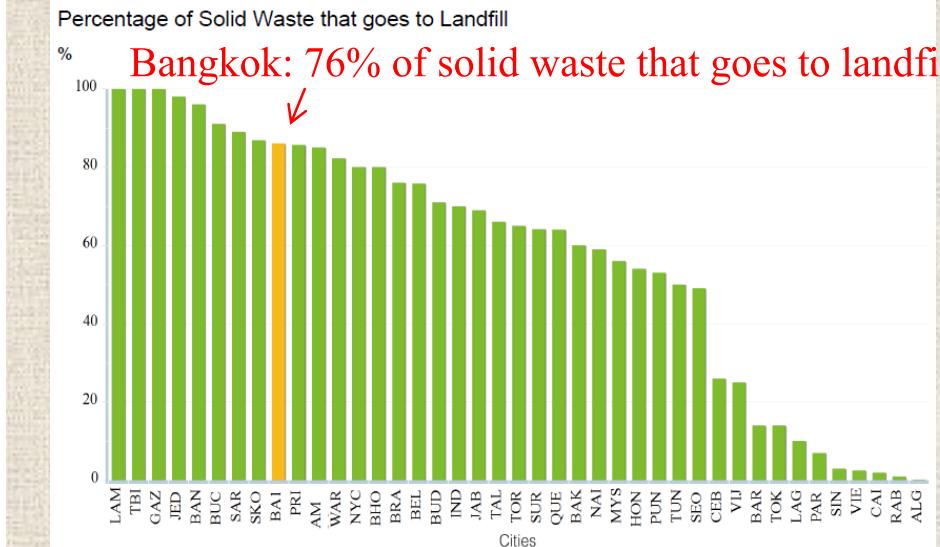
Leachate collection system

# Waste per capita, percentage of solid waste recycled and goes to landfills



## Findings:

- Waste per capita in Bangkok is 457 kg./capita which is in between the cities of Bucharest, Romania (422 kg./capita) and Cairo, Egypt (457 kg./capita)
- Percentage of waste recycled in Bangkok (24%) is quite low when compared to the other big cities (Tokyo: 99%, Barcelona: 72, singapore:59, Seoul 49% and Hong Kong 46%).
- Apart from recycle process, all the waste (76% of total waste) are sent to the sanitary landfills Percentage of waste that goes to landfills.



# Opportunities and recommendations



## Finding:

- According to the BMA's 12-year development plan (2009-2020) the waste per capita is expected to be reduced to 0.7 kg/capita/day.

## Opportunities:

- There is opportunity to increase more percentage of waste recycled by adding more recycling process and also waste separated at sources by color coding bin.
- There is opportunity to use all 76% that goes to the landfills by converting to energy as per the waste to energy program.

## Recommendations:

- Waste to Energy Program
- Waste Infrastructure Planning
- Waste Vehicle Fleet Maintenance Audit and Retrofit Program.
- Fuel-Efficient Waste Vehicle Operations.



2

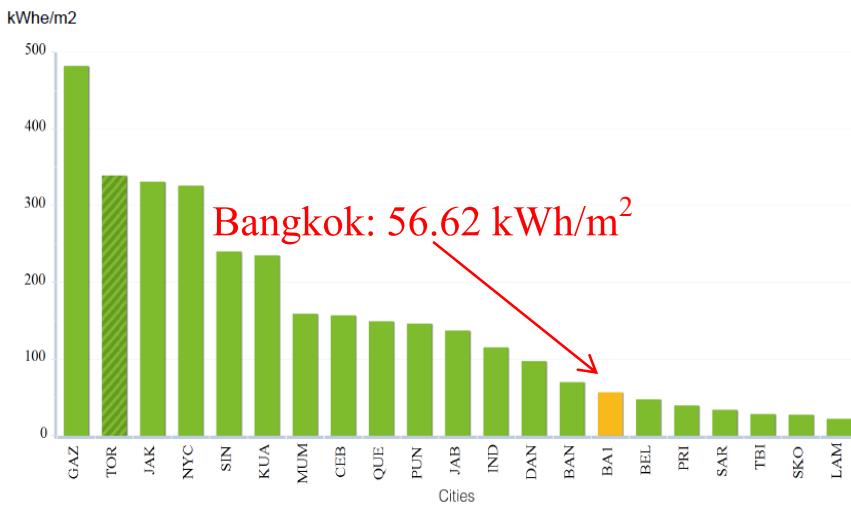
Realizing the Energy Efficiency Opportunities in the  
**Buildings Sector**

# Municipal buildings electricity consumption



Municipal school building

Municipal Buildings Electricity Consumption



## Findings:

- BMA owns 622 municipal buildings, as of now only 86% of the building data available.
- 70% of total buildings are the school municipal buildings which most area are open air class room.
- The municipal hospital building is the highest energy consumption as its service hour is 24 hours for every day.
- Municipal building electricity consumption is 56.62 kWh/m<sup>2</sup> which is in between the cities of Belgrade, Serbia (47.26 kWh/m<sup>2</sup>) and Banja Luka, Bosnia and Herzegovina (69.74 kWh/m<sup>2</sup>)
- The municipal energy consumption is around 50% higher than those who consumed least energy such as Lampang municipality: 21.97 kWh/m<sup>2</sup> and Skopje :27.31 kWh/m<sup>2</sup>

# Opportunities and Action plan

## Opportunities:

- There are a lot of energy efficiency opportunities by replacing the many old air conditioners or chillers in the municipal offices and hospitals.



**Municipal hospital building**

The recommendations for action plan of this sector listed below:

- 1.BMA should implement first with those low hanging fruit projects which are the municipal hospital energy efficiency improvement projects.
- 2.The action plan for municipal hospital energy efficiency project development should first pick up the first 10 projects that consumed most energy as demonstration project.
- 3.To select the first 10 projects, BMA should identify the readiness and barriers such as regulations, budget, etc. and select the most appropriate existing tools such as ESCO services. There are many types of ESCO schemes exist in the country such as ESCO with or without investment. Therefore, to start implementing those energy efficiency projects will depend on BMA's requirements and barriers.
- 4.After the first 10 demonstration projects then BMA should already learn how to scale up covering the rest hospital buildings.



Municipal office building

## Recommendations

### Recommendations:

The TRACE recommendations can be grouped into three major steps:

- 1) Creating an EE municipal task force,
  - EE municipal task force
  - EE strategy and action plan
- 2) Implementing the audit and retrofit programs, and
- 3) Expanding EE programs to city wide buildings.
  - Green Guidelines for Energy Efficient Buildings
  - Mandatory Building Energy Efficiency Codes for New Buildings



Private buildings

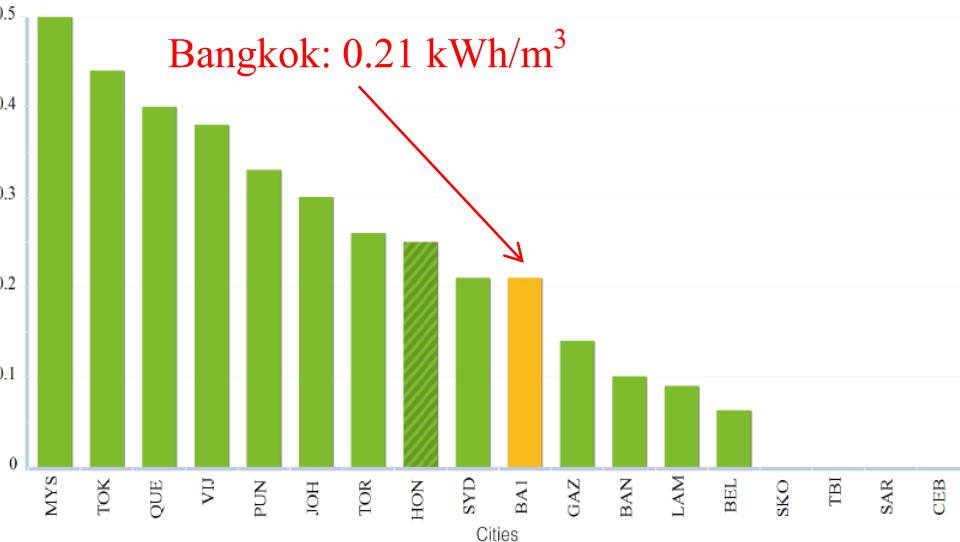
# 3

Realizing the Energy Efficiency Opportunities in the  
**Wastewater Sector**

# Energy density of wastewater treatment

Energy Density of Wastewater Treatment

kWh/m<sup>3</sup>



## Findings:

- There are 7 large wastewater treatment plants
- At present, the public sewage system is covered around 20% (992,000 m<sup>3</sup>/day) of total wastewater and then by year 2020, 5 more wastewater treatment plants will be installed to increase the capacity to 1,765,000 m<sup>3</sup>/day or 50% of total generated wastewater.
- Energy density of wastewater treatment in Bangkok is 0.21 kWh/m<sup>3</sup> which is the same as its of Sydney, Australia.



1. Si Phraya plant



2. Rattanakosin plant



3. Chong Nonthri plant

# Opportunities and recommendations



4. Nong Khaem plant



5. Thung Khru plant



6. Din Daeng plant



7. Chatuchak plant

## Finding:

- There is a plan to increase the capacity of wastewater treatment plant to cover 50% of total generated wastewater,

## Opportunity:

- There is opportunity to produce biogas or reuse sludge in the coming wastewater treatment plants.

## Recommendations:

- Improve Efficiency of Pumps and Motors.
- Active Leak Detection and Pressure Management Program.
- Auditing and Retrofit of Treatment Facilities.
- Sludge Beneficial Reuse Program.
- Improve Performance of System Networks

# 4

## Realizing the Energy Efficiency Opportunities in the **Transport Sector**

# Public transports in Bangkok



1. Sky train-BTS



2. Underground train-MRT



3. Train

## Findings:

- There are 7 types of public transport in Bangkok;
- 1. Sky train-BTS,
- 2. Underground train-MRT,
- 3. Train,
- 4. Airport Rail Link,
- 5. Public bus by Bangkok Mass Transit Authority (BMTA) / private companies,
- 6. Minibus,
- 7. Boat.



4. Airport Rail Link

# Total transportation energy use per capita



## 5. Public Bus



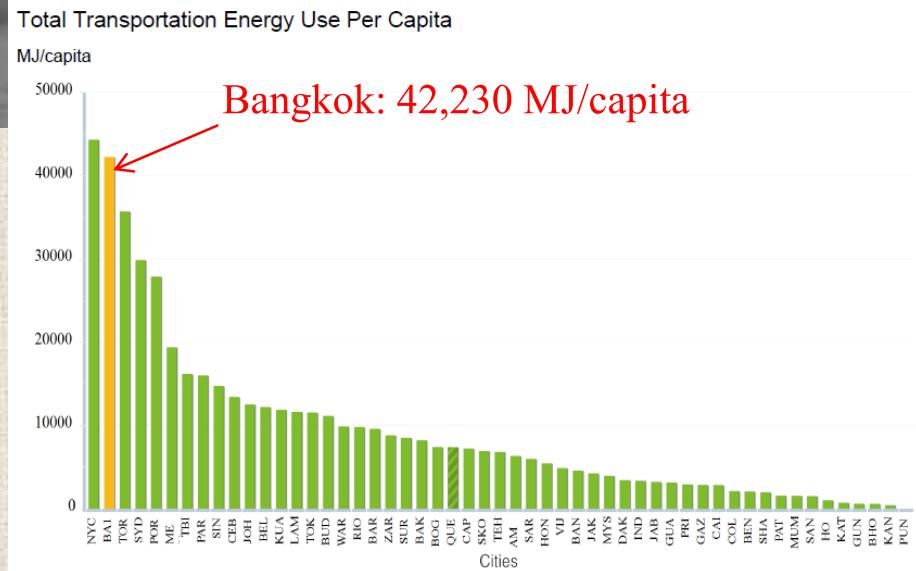
## 6. Minibus



## 7. Boat

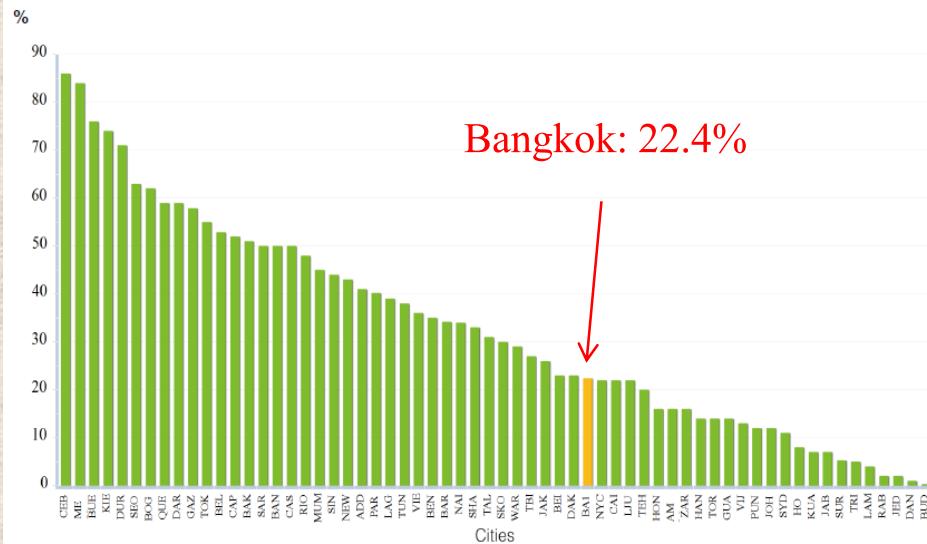
### Findings:

- There are 6,776,644 private vehicles.
- 12 lines (classified by color coding) of sky / underground train have been implemented which are expected to be in service by year 2019.
- Total transportation energy use per capita in Bangkok is 42,230 MJ/capita (the 2<sup>nd</sup> highest) which is lower than the New York city at 44,287 MJ/capita (the first highest).



# Public transportation mode split, Opportunity and Recommendations

Public Transportation Mode Split



Bangkok: 22.4%

## Findings:

- The transportation mode split in Bangkok is 22.4% which is very closed to New York city at 22%.  
the development plan of 12 sky train lines would help reduce the total energy per capita which then increase the percentage of public mode split.

## Opportunities:

- The traffic congestion has been a long time problem which every previous government had tried to tackle the problem, but none of them has successfully done. In this regards, there are opportunities to relieve or solve this problem.



Construction progress of Red line sky train

## Recommendations:

The TRACE recommendations are listed;

- Traffic Flow Optimization
- Traffic Restraint Measures.
- Congestion Pricing



5

Realizing the Energy Efficiency Opportunities in the  
**Power Sector**

# Percentage of Total T&D Loss



## Opportunity:

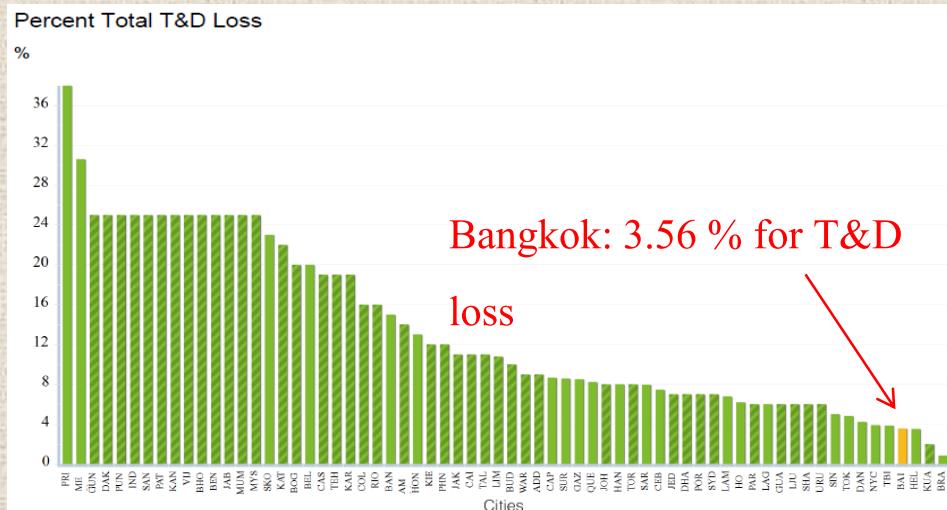
- There is an opportunity to reduce the technical T&D loss to be the same those levels as Helsinki, Sweden (3.5%) and Kuala Lumpur, Malaysia (2%).

## Findings:

- Electricity in Bangkok is provided by Metropolitan Electricity Authority (MEA), an independent organization under Ministry of Interior.
- The percentage of total T&D loss in Bangkok is 3.56% which is higher than the cities of Helsinki, Sweden (3.5%) and Kuala Lumpur, Malaysia (2%).

## Recommendations:

- In order to reduce the T&D loss, the commendations “Transformer upgrade program” and “Power factor correction program” would be implemented.



# Percentage of Total T&D Loss due to Non-technical

Connecting point for Non-technical loss



Loss due to non-technical

## Recommendation:

- In order to reduce or protect this loss, the auditing program is needed to find out the actual loss and then the recommendation “non-technical loss reduction program” could be applied

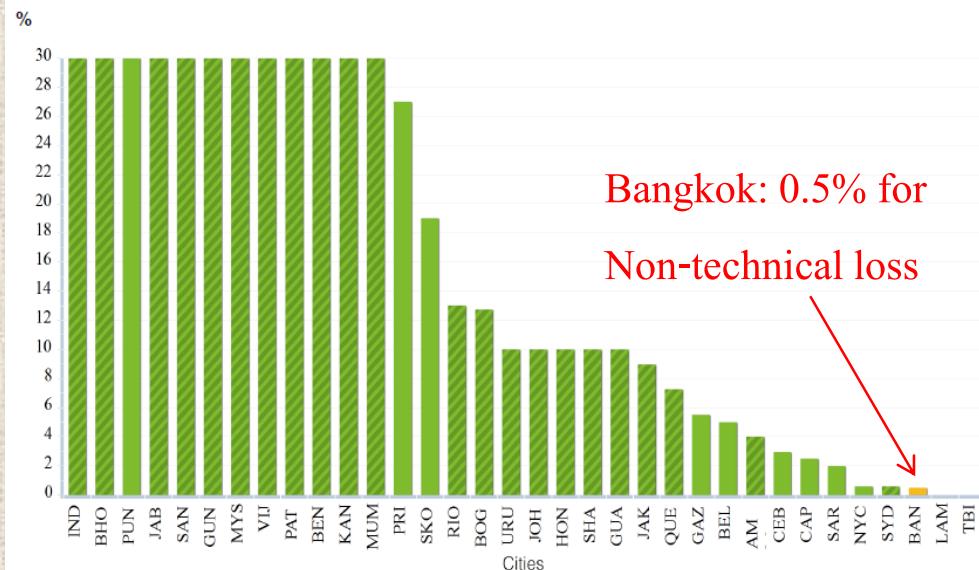
## Findings:

-The percentage of T&D loss due to non-technical is estimated 0.5%.

## Opportunity:

- Due to the actual loss is not available, thus this loss is estimated. In this regards there is an opportunities to measure the actual loss and reduce it to be zero or least.

Percent of T&D Loss due to Non-Technical

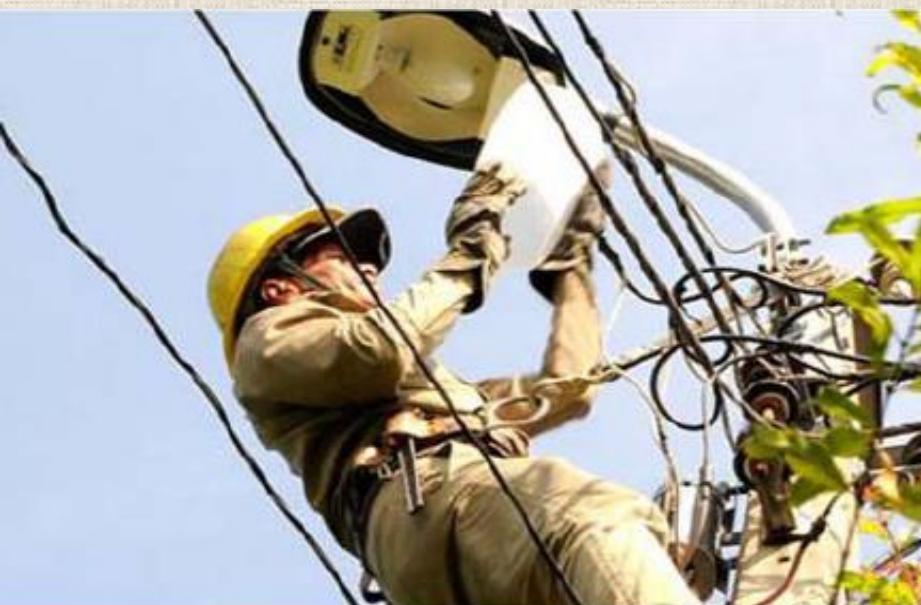


Bangkok: 0.5% for  
Non-technical loss

# 6

Realizing the Energy Efficiency Opportunities in the  
**Street Lighting Sector**

# Street Lighting in Bangkok

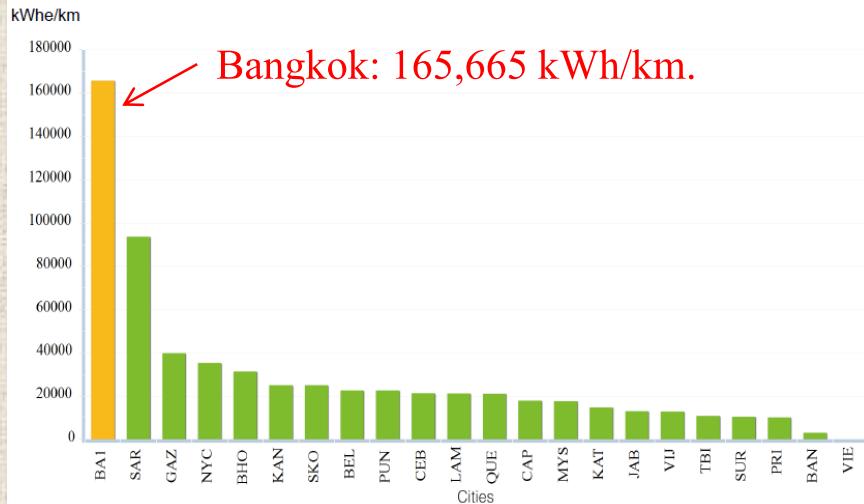


## Findings:

- In year 2013, there are 320,872 light bulbs;
  - Mercury Vapor 73%
  - High Pressure Sodium 19%
  - Metal halide 0.2%
  - Other 8%
- All the light bulb facilities are owned by the BMA, but electricity is supplied by Metropolitan Electricity Authority (MEA) for free of charge. Therefore MEA will be the investor with the consent of BMA.
- There were no LED lights installed in street lighting prior to year 2013. The LED replacement program (LED 140 watt to replace HPS 250 watt) has just been starting up in year 2014 by MEA. There are 4 streets implemented this program:
  - 1) Phahurat Road
  - 2) Tri-Petch Road,
  - 3) Chak-Petch Road
  - 4) Tessaban soi 1.
- MEA plans to expand the LED replacement program in Yaowarat Road within year 2014.

# Electricity consumption per km and light pole

Electricity Consumed per km of Lit Roads



Bangkok: 165,665 kWh/km.

## Findings:

- Electricity consumed per km of lit roads is 165,665 kWh/km which is the highest ranking.
- Electricity consumed per light pole is 661 kWh/pole which is in the between the cities of Cebu, Philippines (656 kWh/pole) and Skopje, Macedonia (733 kWh/pole).

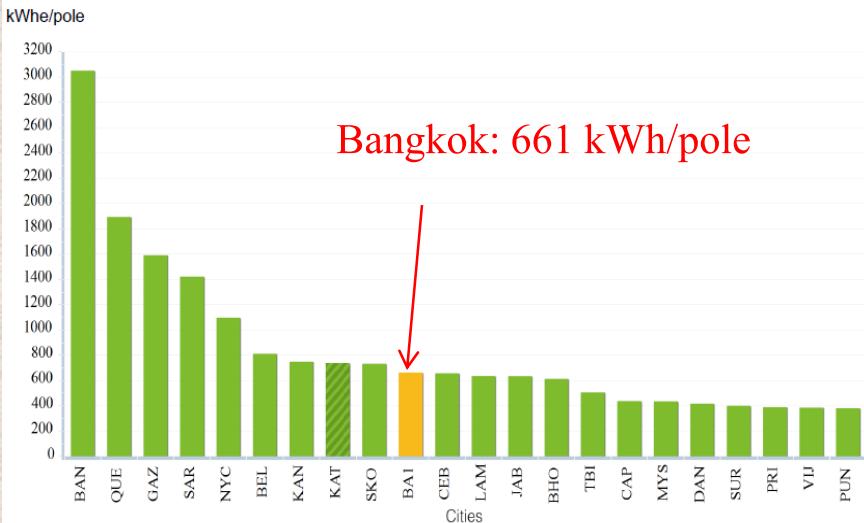
## Opportunities:

- LED replacement program could be expanded to all street lightings in Bangkok area.

## Recommendations:

- Street Lighting Audit and Retrofit Programs
- Procurement Guide for New Street Light Installation.
- Traffic Signals Audit and Retrofit Program
- Public Space Lighting and Retrofit Program.
- Lighting Timing Program

Electricity Consumed per Light Pole



Bangkok: 661 kWh/pole



7

Realizing the Energy Efficiency Opportunities in the  
**Potable Water Sector**

# Potable water in Bangkok



## Findings:

- Water in Bangkok is supplied by Metropolitan Waterworks Authority (MWA), an independent organization under Ministry of Interior.
- There are 4 water production plants with total capacity of 5,270,000 m<sup>3</sup>/day
  1. Mahasawad water treatment plant (capacity: 800,000 m<sup>3</sup>/day)
  2. Bang Khen water treatment plant (capacity: 3,600,000 m<sup>3</sup>/day)
  3. Samsen water treatment plant (capacity: 700,000 m<sup>3</sup>/day)
  4. Thonburi water treatment plant (capacity: 170,000 m<sup>3</sup>/day)

## Metropolitan Waterworks Authority (MWA)



1. Mahasawad water treatment plant



2. Bang Khen water treatment plant

## Water consumption



### 3. Samsen water treatment plant



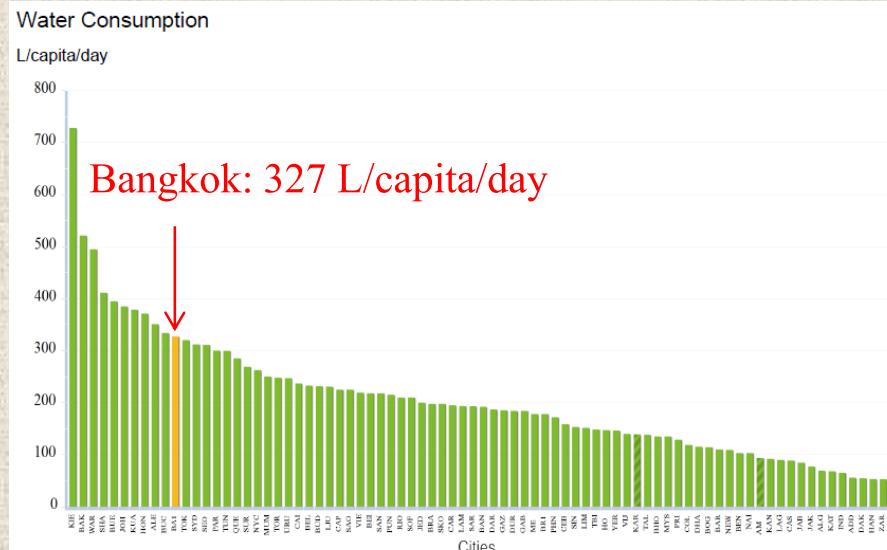
#### 4. Thonburi water treatment plant

## Finding:

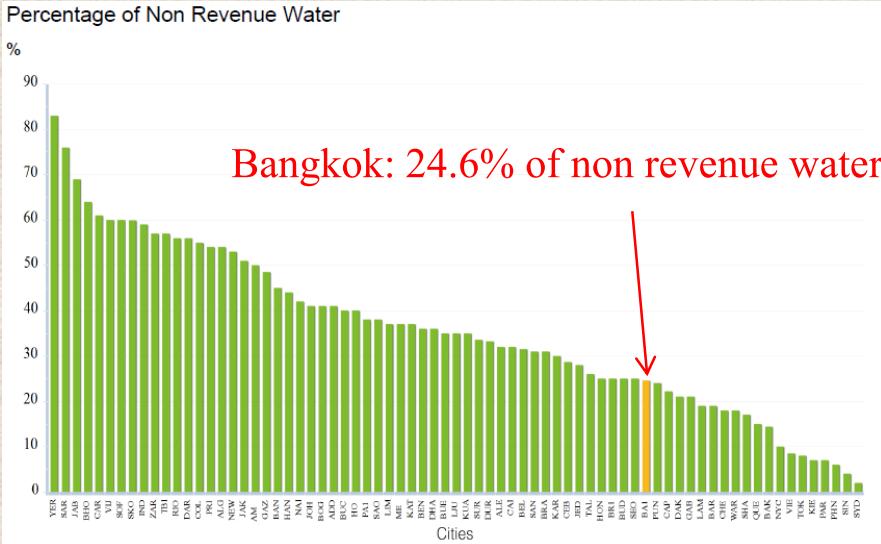
- The water consumption in Bangkok is 327 L/capita/day which is in between the cities of Tokyo, Japan (320.2 L/capita/day) and Bucharest, Romania (334 L/capita/day).

## Opportunity:

- The water consumption could be decreased to the level of other big cities; Tokyo 320.2, Sydney 312, Paris 300, New York 262.3 and Toronto 248 L/capita/day.



# Percentage of non revenue water



Bangkok: 24.6% of non revenue water

## Finding:

- Percentage of non revenue water is 24.6% which is in the between the cities of Pune, India (24%) and Seoul, South Korea (25%).

## Opportunity:

- The percentage of non revenue water could be decreased to the level of other big cities; New York 10%, Vienna 8.5%, Tokyo 8%, Paris 7% or Sydney 2%



Bangkok flood by pipe broken on 16 Oct 2013

## Recommendations for this sector are listed below:

- Improve Efficiency of Pumps and Motors.
- Active Leak Detection and Pressure Management Program.
- Improve Performance of System Networks.

## 2. Recommendations Summary

### Summary of Energy Efficiency Opportunities for Bangkok

#### Solid Waste

- Waste Vehicle Fleet Maintenance Audit and Retrofit Program.
- Fuel-Efficient Waste Vehicle Operations
- Waste to Energy Program.
- Waste Infrastructure Planning.

1

#### Buildings; There are 3 major steps:

- 1) creating an EE municipal task force
  - EE municipal task force
  - EE strategy and action plan
- 2) Implementing the audit and retrofit programs
  - Municipal audit and retrofit programs
  - Municipal buildings benchmarking program
- 3) Expanding EE programs to city wide buildings
  - Green Guidelines for EE Buildings
  - Mandatory Building EE Codes for New Buildings

2

#### Wastewater

- Improve Efficiency of Pumps and Motors.
- Active Leak Detection and Pressure Management Program.
- Auditing and Retrofit of Treatment Facilities.
- Sludge Beneficial Reuse Program.
- Improve Performance of System Networks

3

#### Transport

- Traffic Flow Optimization.
- Traffic Restraint Measures
- Congestion Pricing

4

#### Power

- Non-technical Loss Reduction Program
- Transformer Upgrade Program
- Power Factor Correction Program

5

#### Street Lighting

- Street Lighting Audit and Retrofit Program
- Procurement Guide for New Street Light Installation
- Traffic Signals Audit and Retrofit Program
- Public Space Lighting and Retrofit Program
- Lighting Timing Program

6

#### Potable Water

- Improve Efficiency of Pumps and Motors.
- Active Leak Detection and Pressure Management Program.
- Improve Performance of System Networks

7



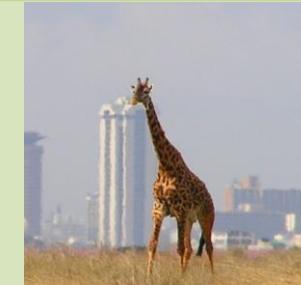
### Brazil : Rio de Janeiro & Belo Horizonte

TRACE was implemented in Rio de Janeiro (hosting 2016 Olympics & 2014 FIFA World Cup) and Belo Horizonte (hosting FIFA World Cup). In Rio, WB is helping the city to prepare a US\$300million RFP for implementing LED lighting across the entire city, and helping Belo Horizonte prepare similar investments (US\$100million).



### Romania : 7 Cities

TRACE was used to identify EE interventions and priority sectors for the Romania Regional Development. Program funded by the EU, and TRACE has been implemented in 7 cities as part of a regional investment program



### Kenya: Nairobi

TRACE was used to identify EE interventions, feeding into a program funded by the WB to fund the energy efficiency investments under the NAMSIP project.



### Turkey: Gaziantep

TRACE identified the need for investments in the water sector. The city is one of the a few cities in Turkey which are participating in a US\$300million dollar project though the urban department, and they intend to finance the water sector investments.

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# Thank You.

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