ESMAP
Energy Sector Management Assistance Program

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

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

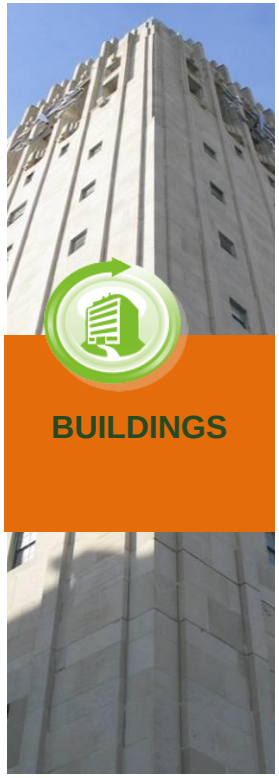
Key Advantages of TRACE

- 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

TRACE

Evaluating Energy Efficiency Opportunities in 6 Municipal Sectors

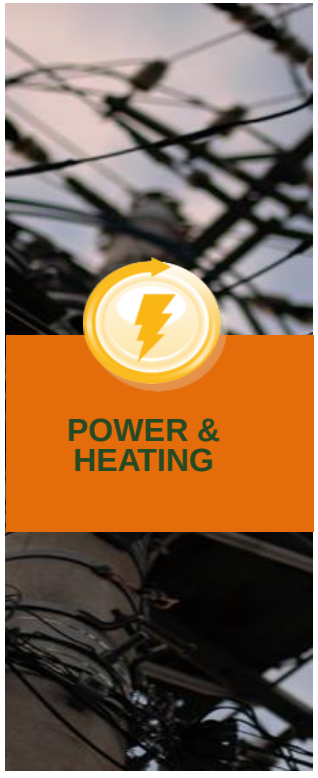
TRANSPORT



BUILDINGS

PUBLIC LIGHTING

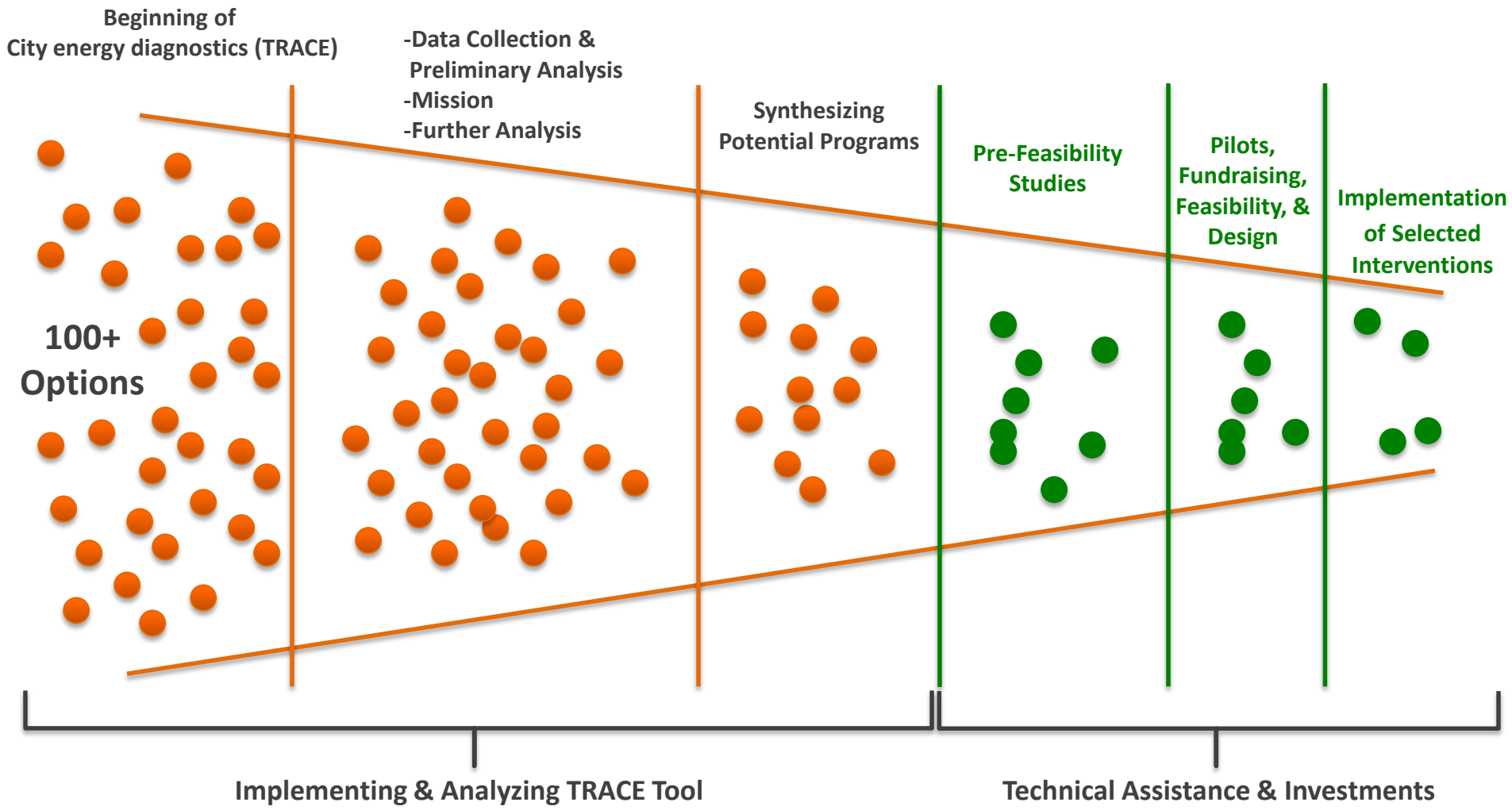
WATER & WASTEWATER



POWER & HEATING

SOLID WASTE

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



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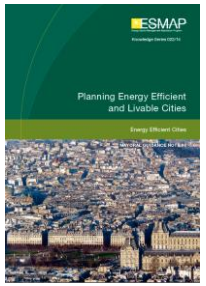
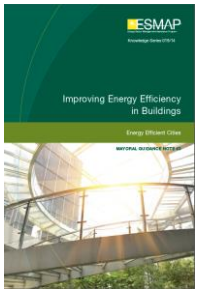
City Energy Efficiency Transformation Initiative

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

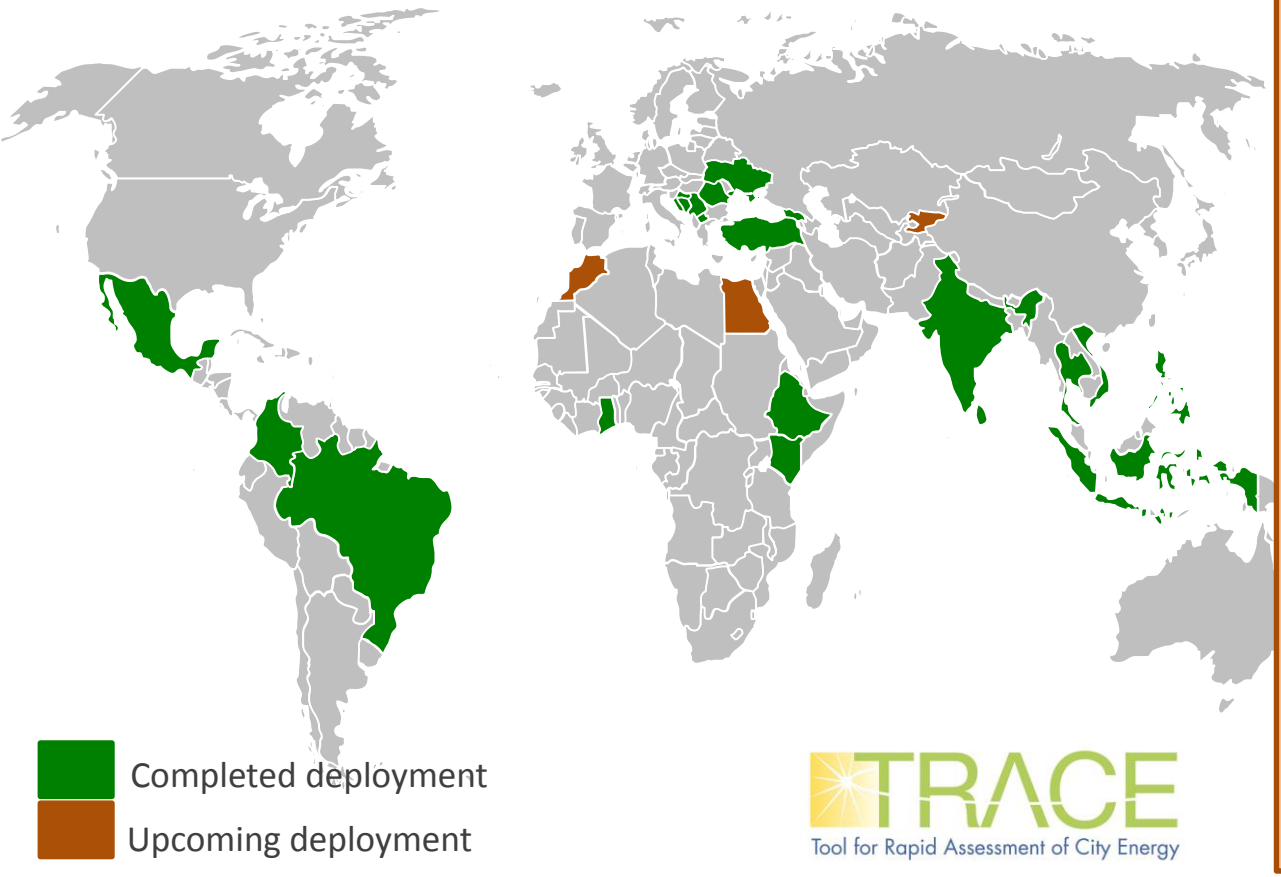
- Bring urban and energy practitioners together
- Extend reach of CEETI program
  - **Energy Efficiency Project Resource Center Resource Center** EEPRC) –in cooperation with the open wiki-platform Energypedia

    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://einstitute.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



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)

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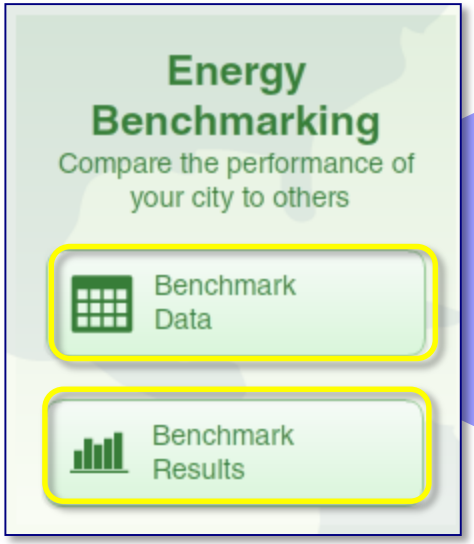
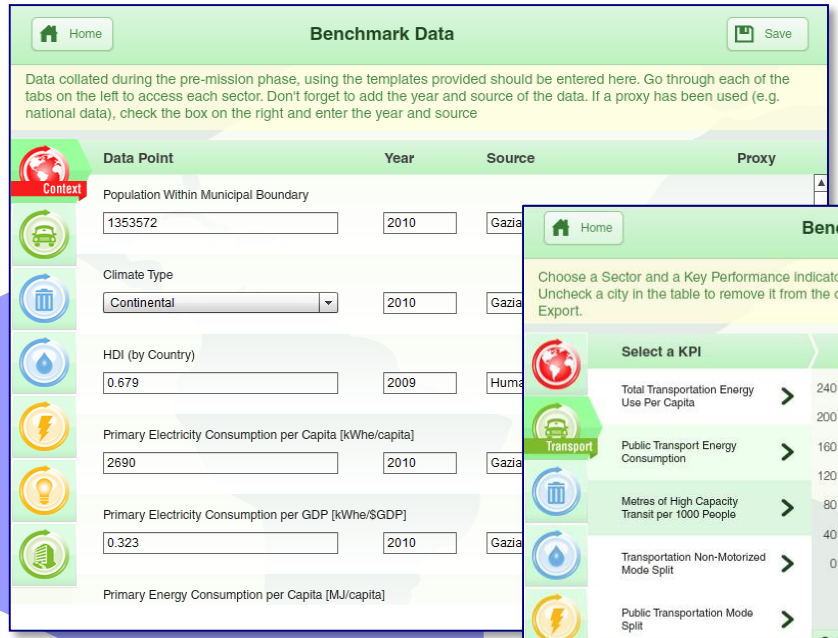
Energy Benchmarking

TRACE
Tool for Rapid Assessment of City Energy

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





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Evaluating Energy Efficiency

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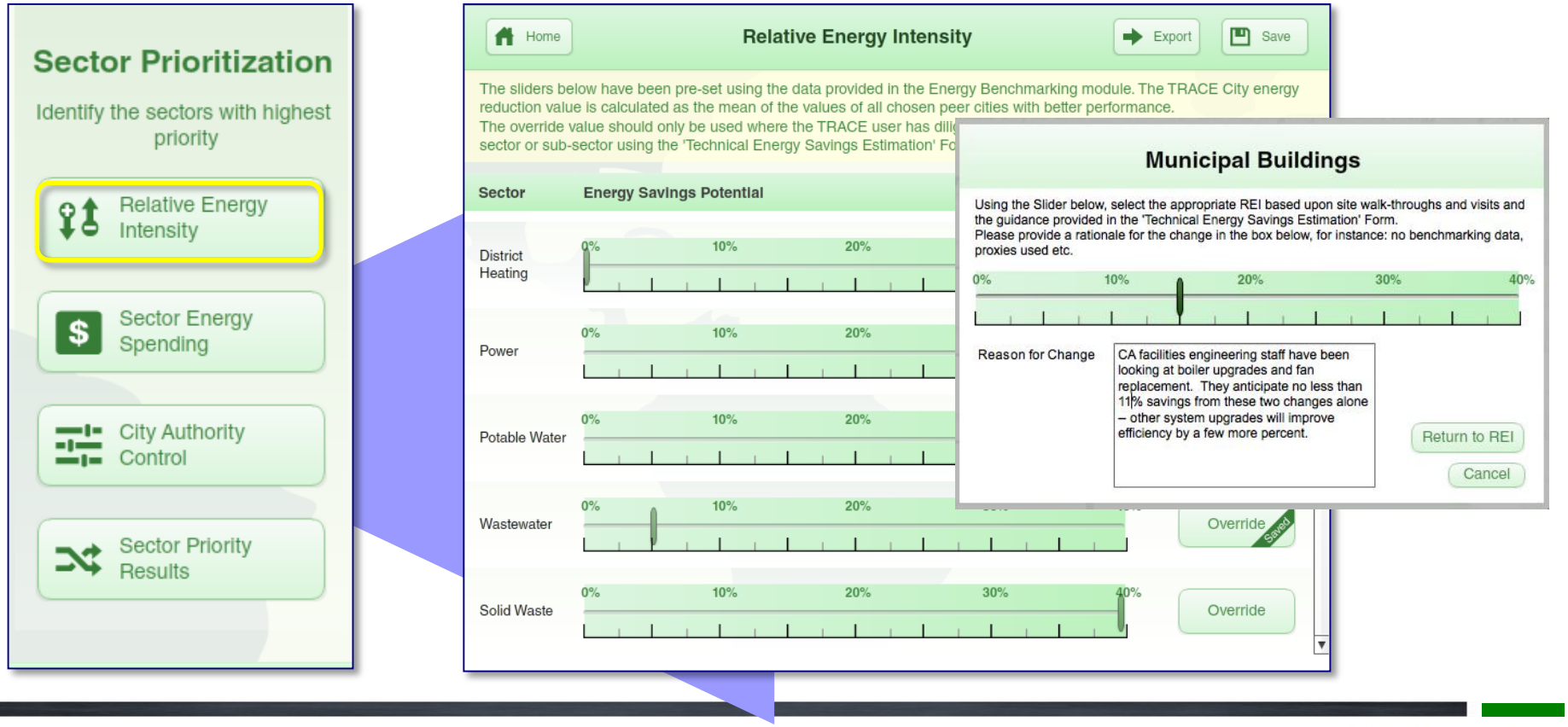

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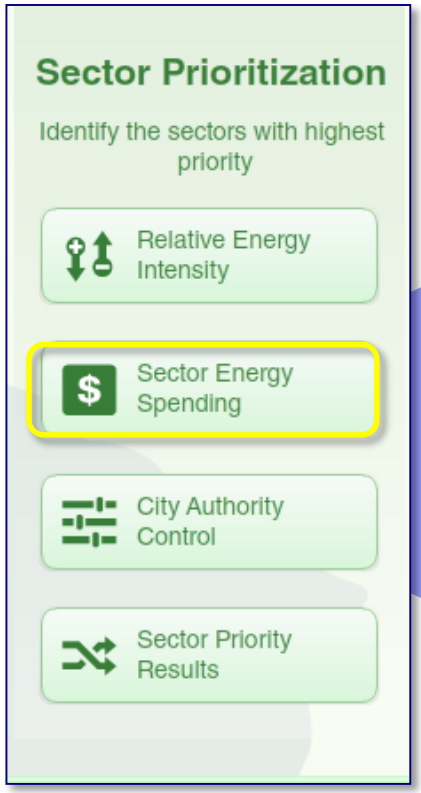

TRACE Tool for Rapid Assessment of City Energy

ESMAP Energy Sector Management Assistance Program

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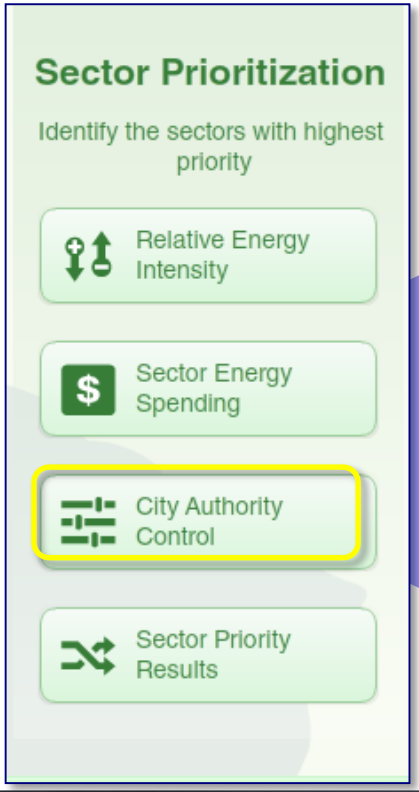

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Sector Prioritization

Identify the sectors with highest priority

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

Home | **Sector Prioritization** | Export | Save

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 (US $)	CA Control	Score	Check to Select
1	Potable Water	86.0	20,046,760	0.80	13,799,229	☐
2	Municipal Buildings	54.8	13,836,029	1.00	7,586,851	☑
3	Solid Waste	48.2	500,000	0.75	180,803	☐
4	Wastewater	5.0	1,194,840	0.95	56,754	☐

City Wide Sector Ranking

Rank	Sector	REI%	Spending (US $)	CA Control	Score	Check to Select
1	Public Transportation	42.4	51,518,994	0.55	12,021,098	☑
2	Private Vehicles	29.4	182,328,446	0.20	10,752,703	☑
3	Street Lighting	51.2	13,547,485	0.90	6,251,823	☑
4	Power	31.5	538,517,487	0.01	1,701,657	☐

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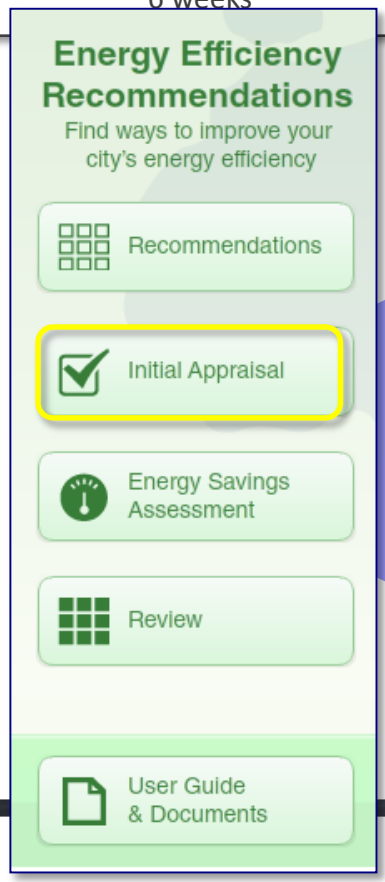
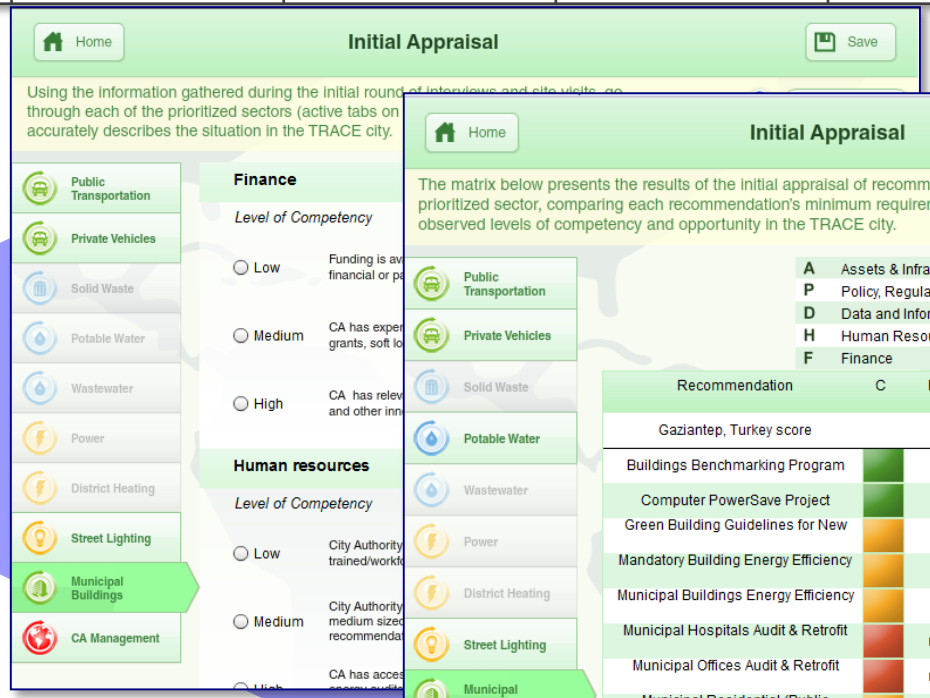
6 weeks		4 days	1 day	4 days	1 day	4 weeks





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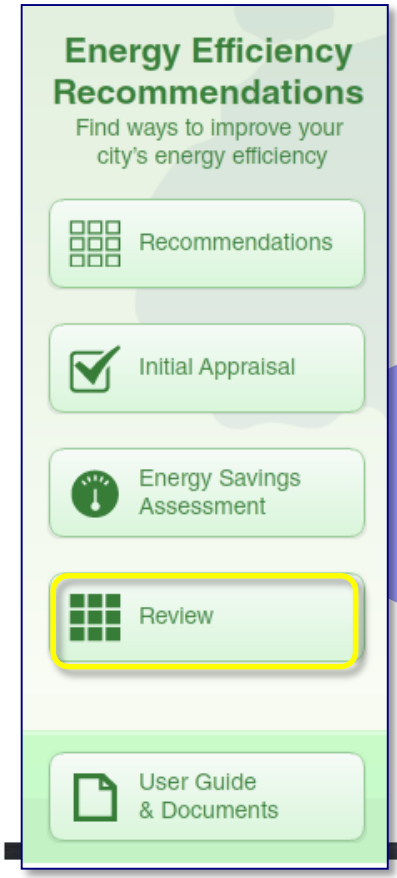

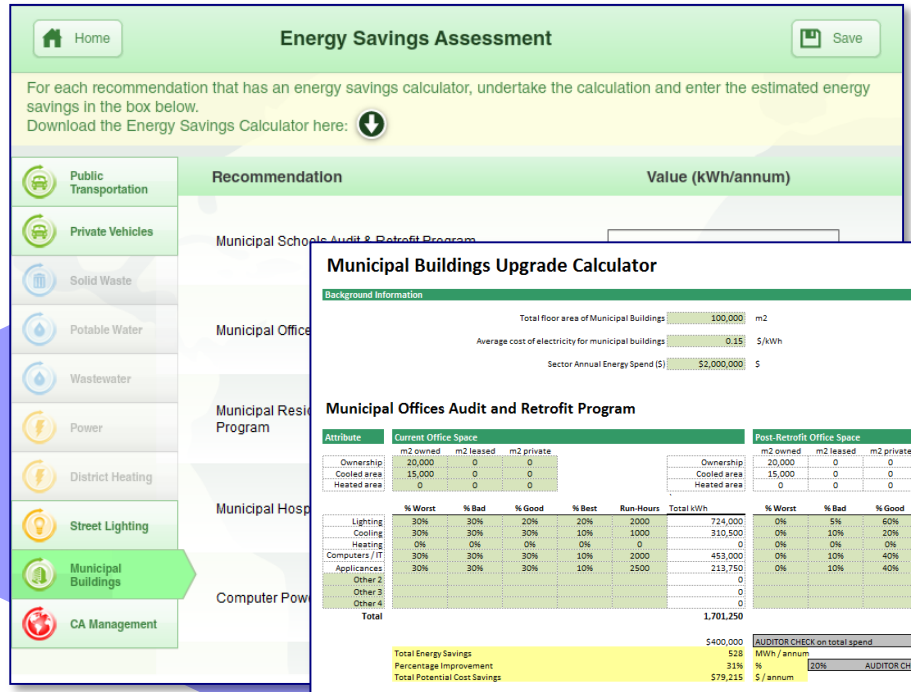

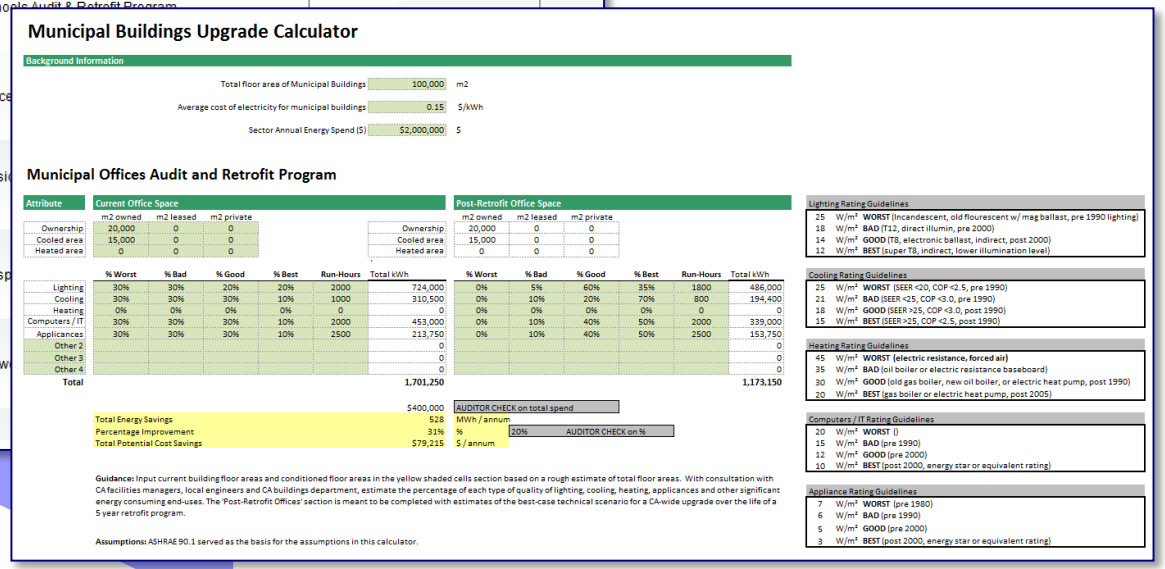

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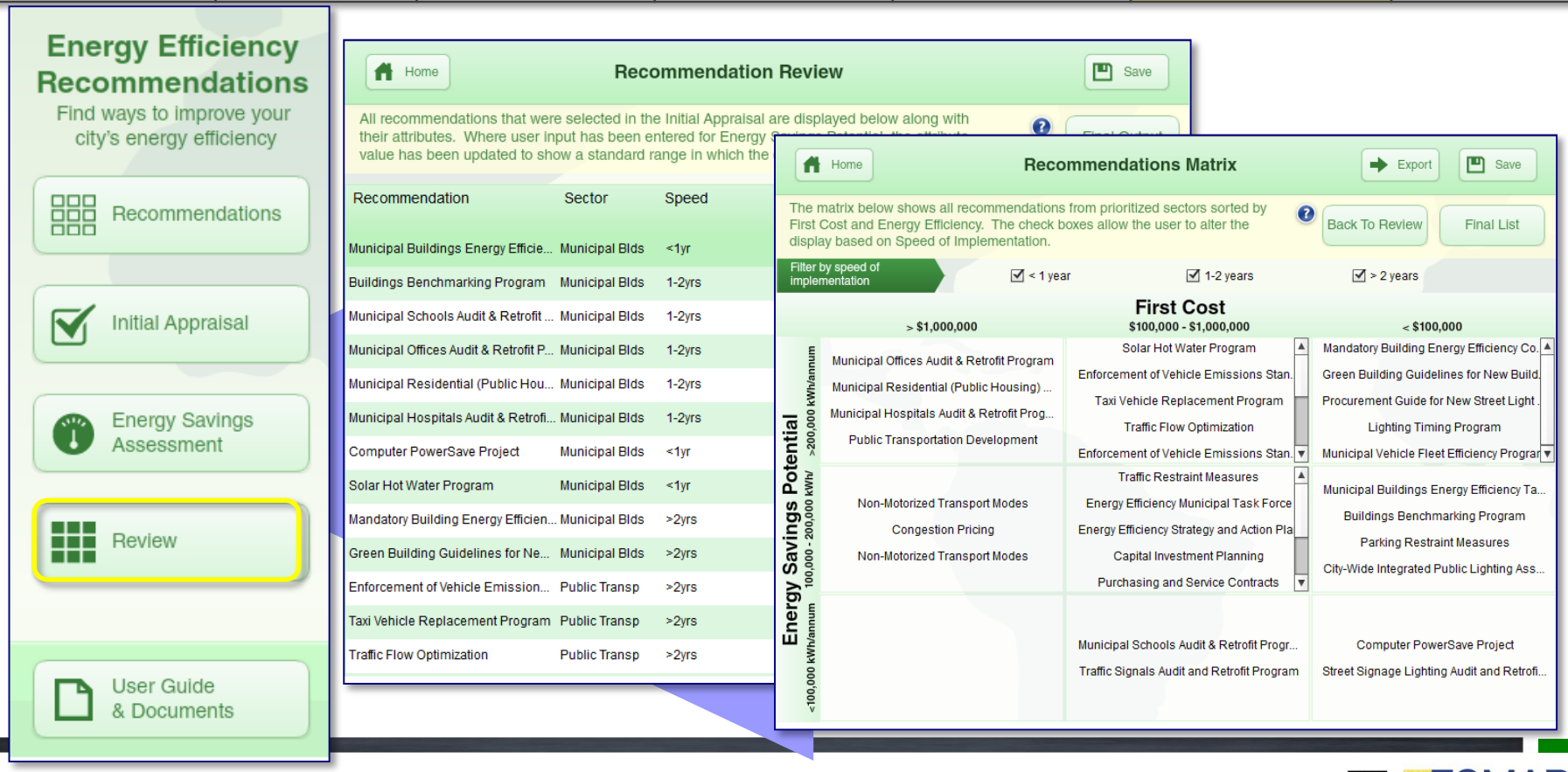

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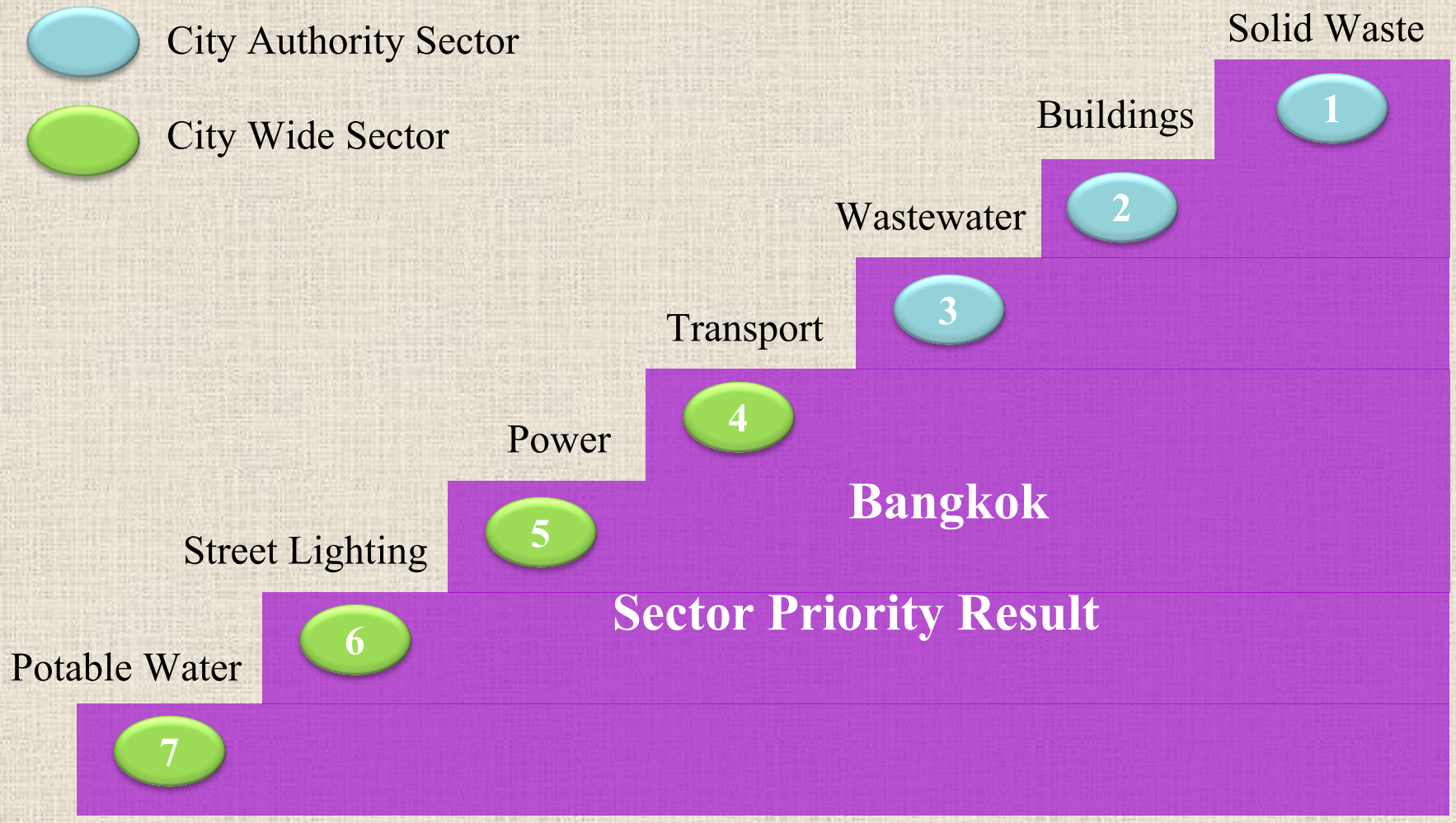
TRACE results for Bangkok

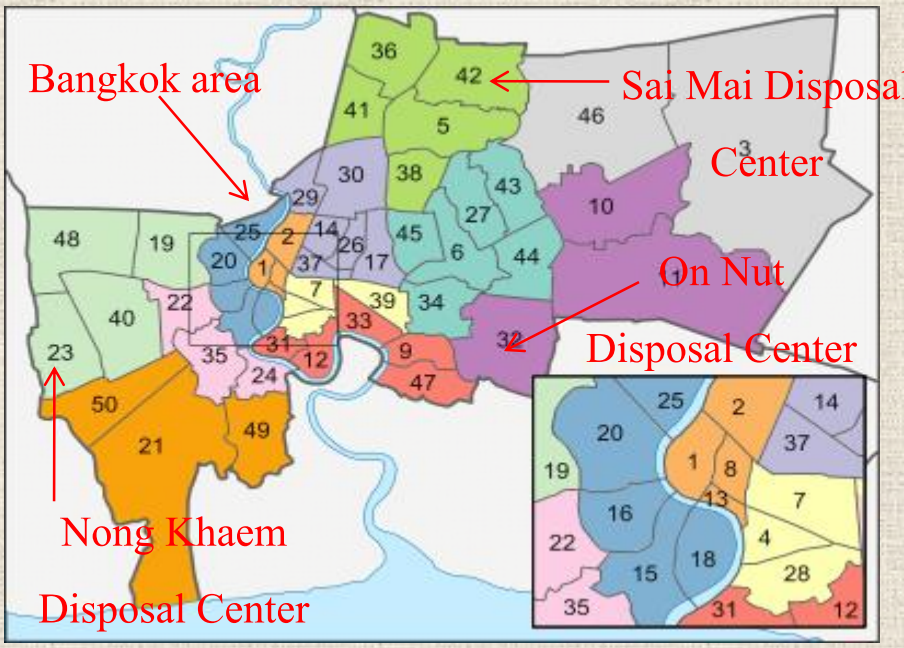
1. Sector Priority Result



Realizing the Energy Efficiency Opportunities in the

Solid Waste Sector

Waste findings in Bangkok

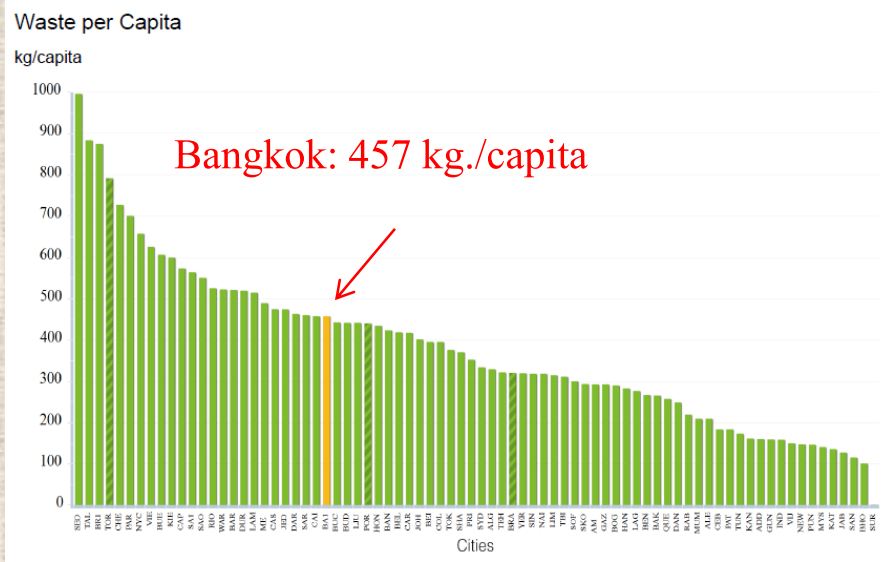


Bangkok Waste Intermediate Stations

Findings:

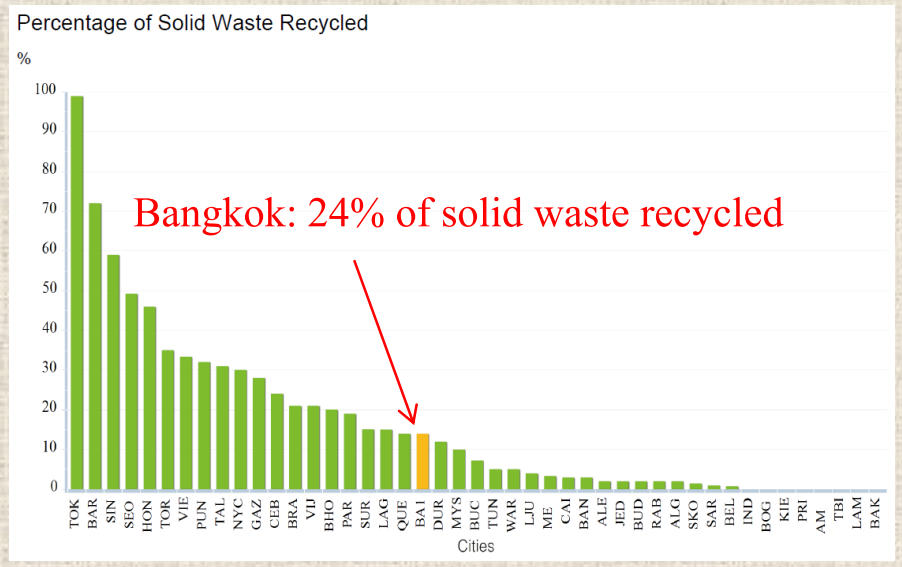
- The generated waste in year 2013 was 9,963 ton/day.
- There are 3 intermediate stations before transferring the waste to the sanitary landfill sites;
  1) Nong Khaem Disposal Center (4,000 tons/day)
  2) On Nut Disposal Center (4,000 tons/day)
  3) Sai Mai Disposal Center (2,000 tons/day)

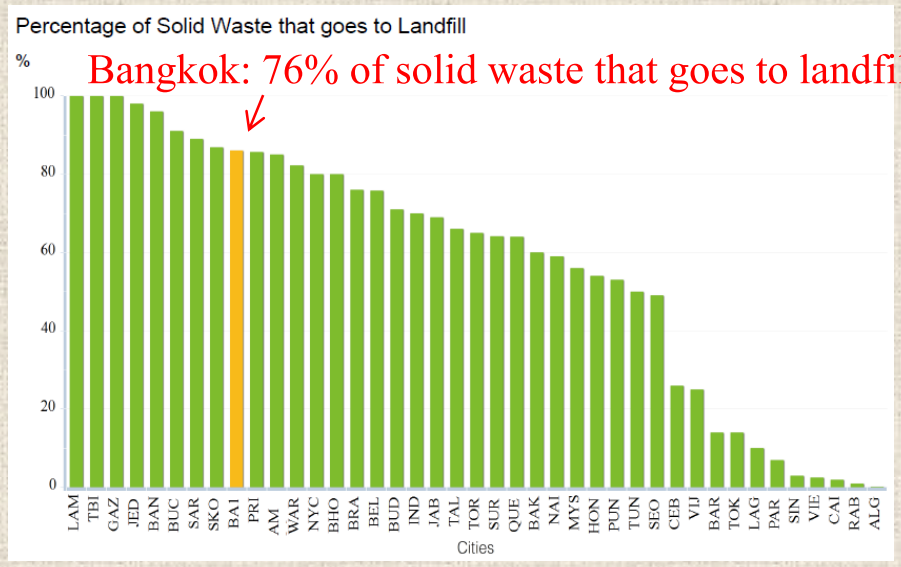
Waste per capita, percentage of solid waste recycled and goes to landfills



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

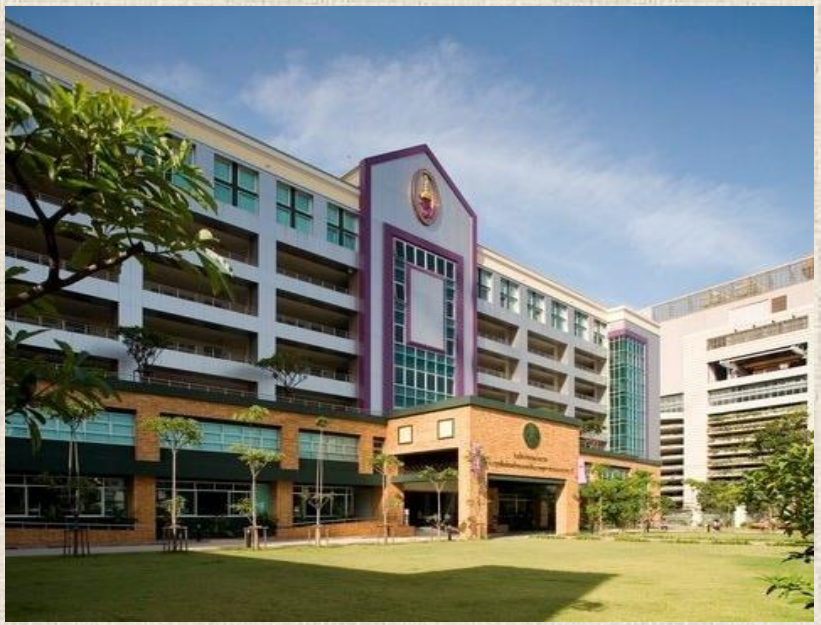
- Waste Vehicle Fleet Maintenance Audit and Retrofit Program.

-Fuel-Efficient Waste Vehicle Operations.

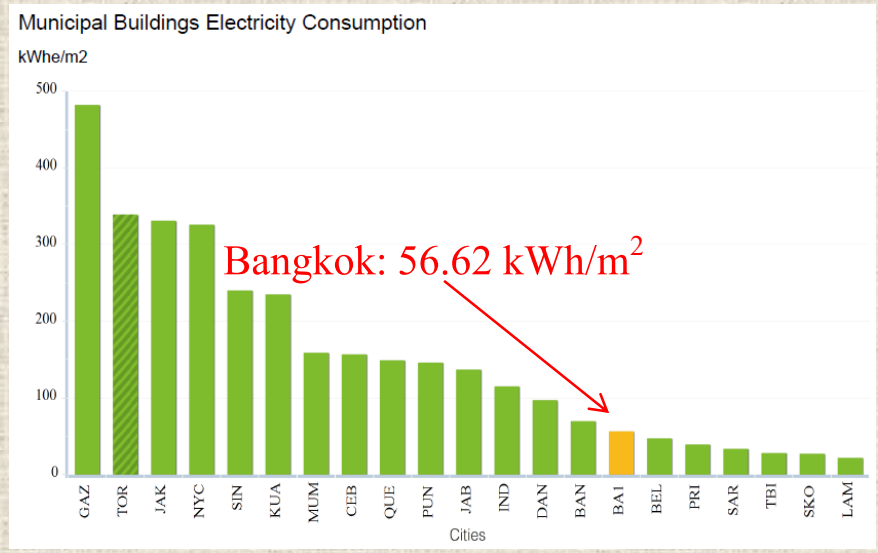
Realizing the Energy Efficiency Opportunities in the

Buildings Sector

Municipal buildings electricity consumption



Municipal school building



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^2 which is in between the cities of Belgrade, Serbia (47.26 kWh/m^2) and Banja Luka, Bosnia and Herzegovina (69.74 kWh/m^2)
- The municipal energy consumption is around 50% higher than those who consumed least energy such as Lampang municipality: 21.97 kWh/m^2 and Skopje :27.31 kWh/m^2

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

Private buildings

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.

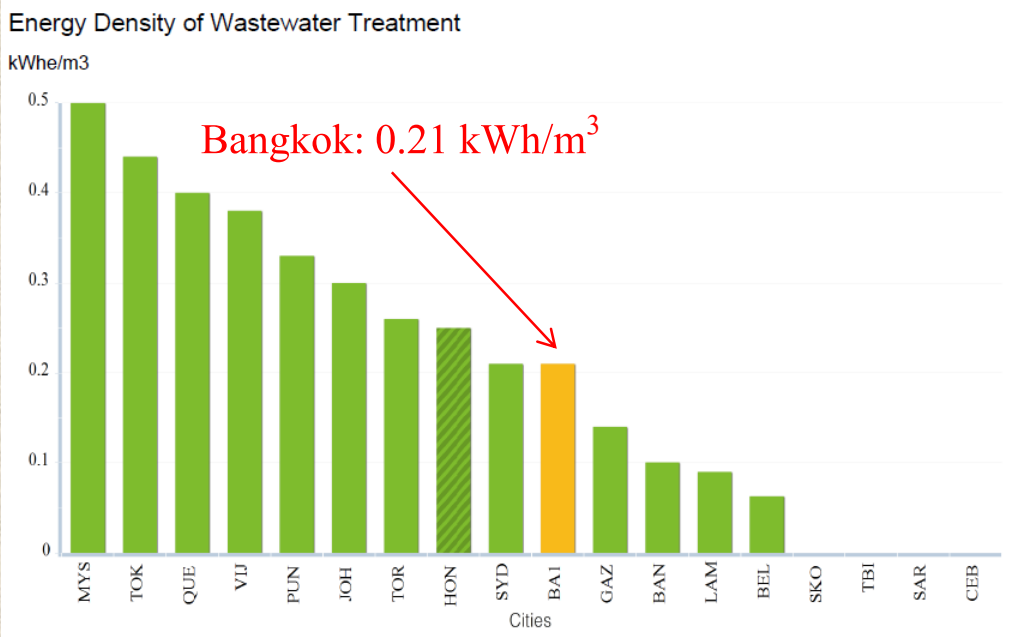
-Green Guidelines for Energy Efficient Buildings

-Mandatory Building Energy Efficiency Codes for New Buildings

Realizing the Energy Efficiency Opportunities in the

Wastewater Sector

Energy density of wastewater treatment



Findings:

- There are 7 large wastewater treatment plants
- At present, the public sewage system is covered around 20% (992,000 m^3/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^3/day or 50% of total generated wastewater.
- Energy density of wastewater treatment in Bangkok is 0.21 kWh/m^3 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

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.

6. Din Daeng plant

7. Chatuchak plant

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

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

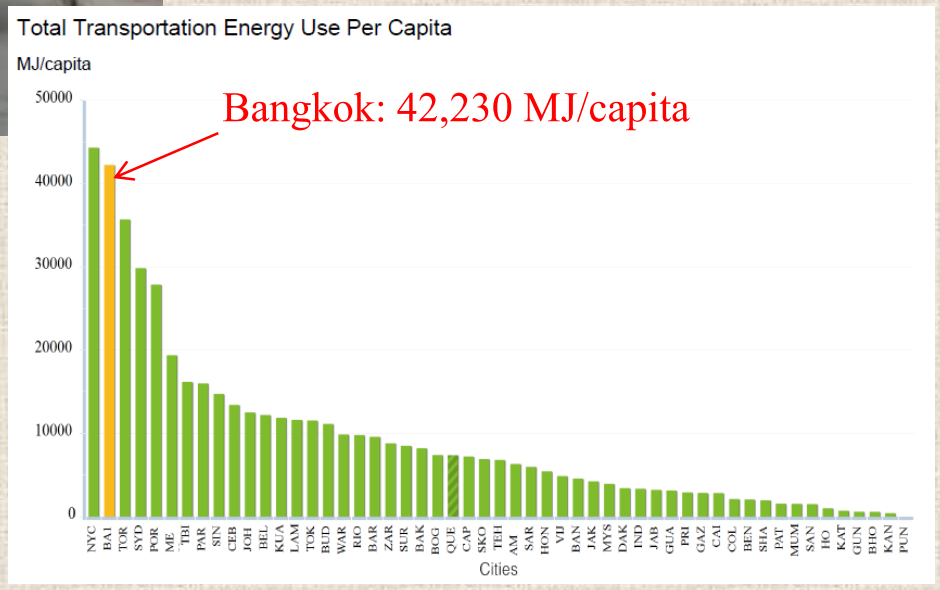
7. Boat

Findings:

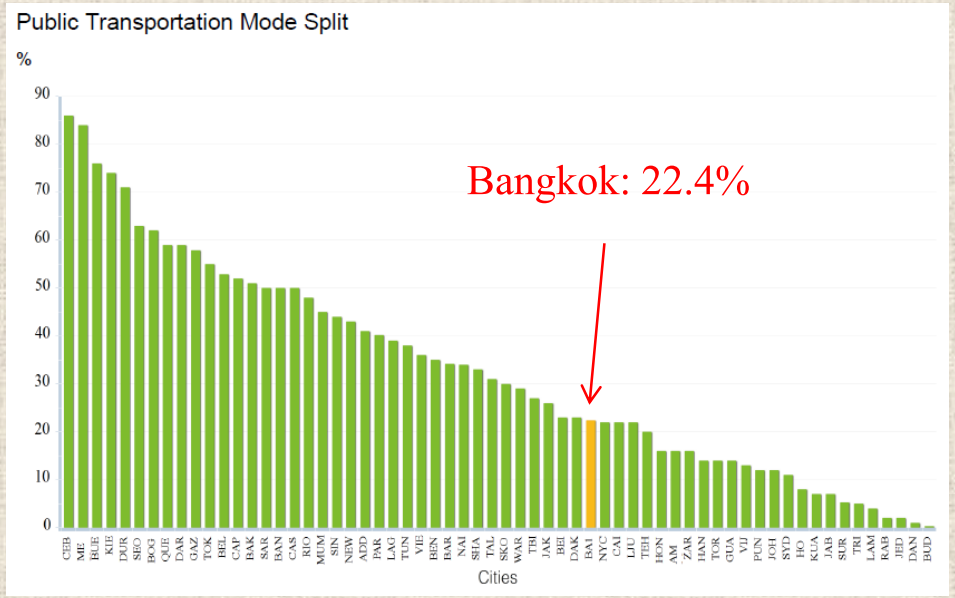
- There are 6,776,644 private vehicles.

-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 2nd highest) which is lower than the New York city at 44,287 MJ/capita (the first highest).



Public transportation mode split, Opportunity and Recommendations



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 non of them has successfully done. In this regards, there are opportunities to relieve or solve this problem.

Recommendations:

The TRACE recommendations are listed;

-Traffic Flow Optimization

-Traffic Restraint Measures.

-Congestion Pricing

Construction progress of Red line sky train

Realizing the Energy Efficiency Opportunities in the

Power Sector

Percentage of Total T&D Loss

Findings:

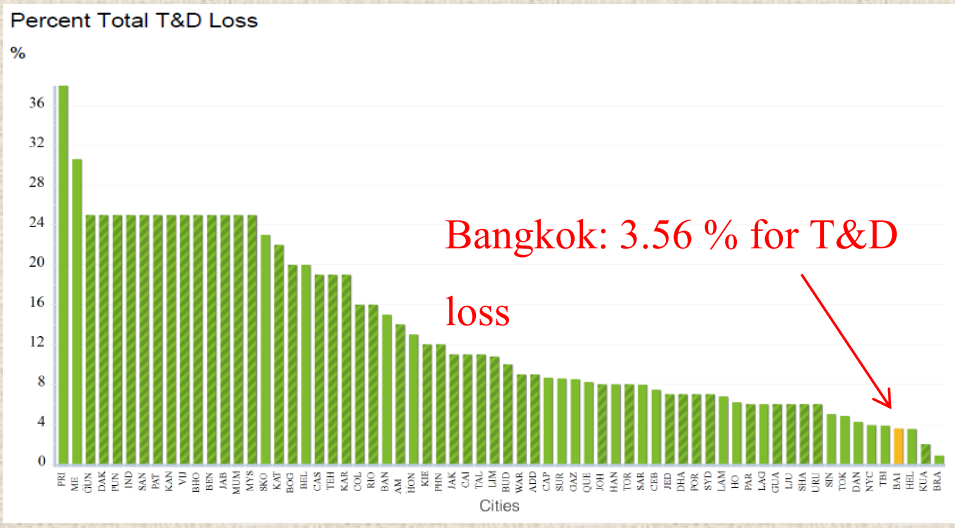
- Electricity in Bangkok is provided by Metropolitan Electricity Authority (MEA), an independent organization under Ministry of Interior.
- The percentage of total T&D loss in Bangkok is 3.56% which is higher than the cities of Helsinki, Sweden (3.5%) and Kuala Lumpur, Malaysia (2%).

Recommendations:

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

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%).



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

Loss due to non-technical

Findings:

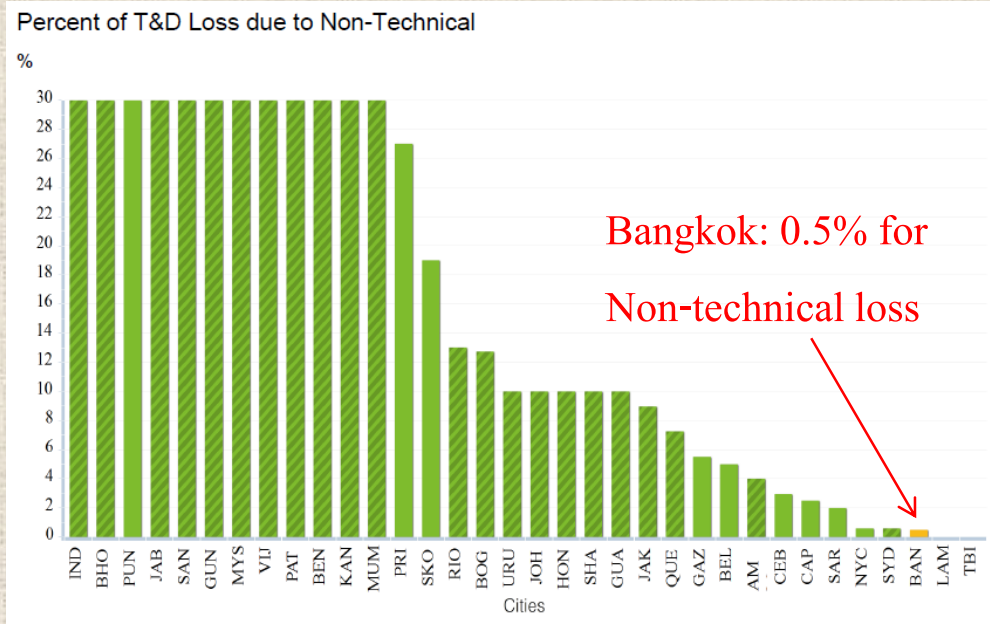
-The percentage of T&D loss due to non-technical is estimated 0.5%.

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.

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



Realizing the Energy Efficiency Opportunities in the

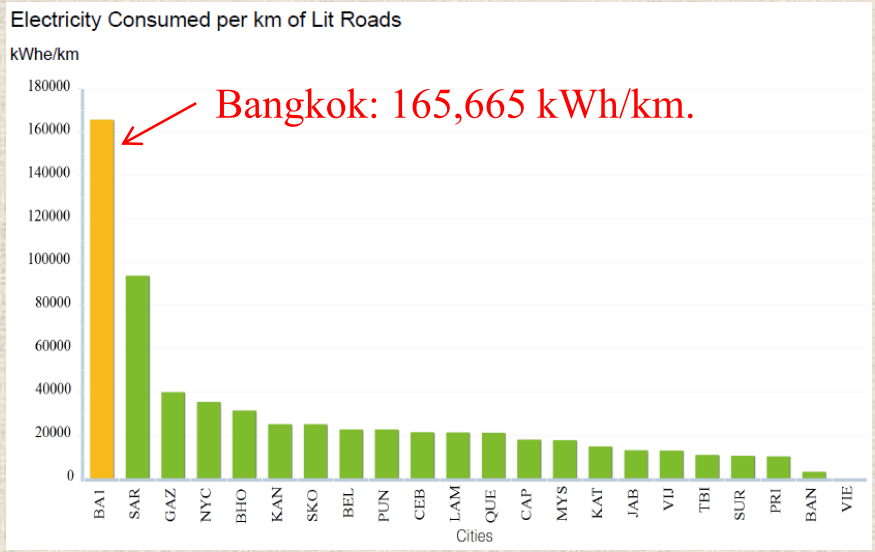
Street Lighting Sector

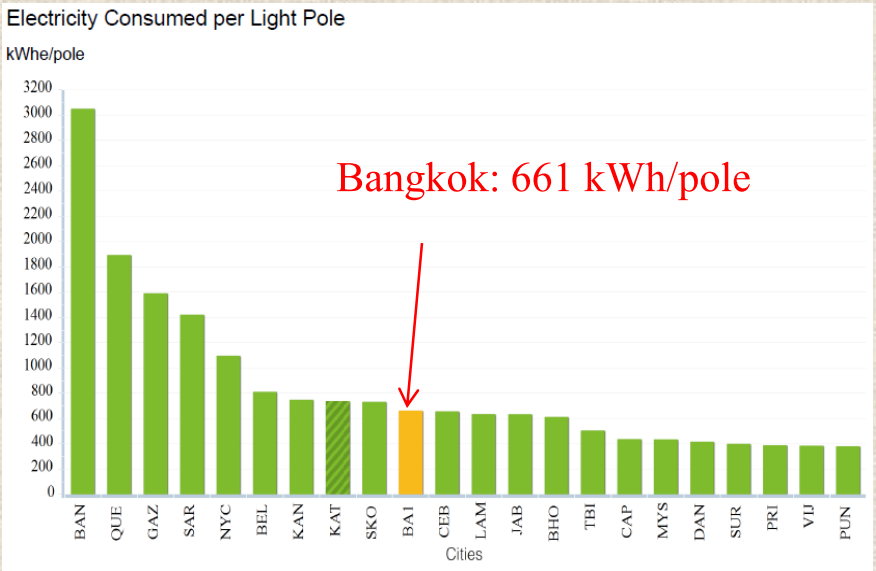
Street Lighting in Bangkok

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





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

Realizing the Energy Efficiency Opportunities in the

Potable Water Sector

Potable water in Bangkok

Metropolitan Waterworks Authority (MWA)

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^3/day
  1. Mahasawad water treatment plant (capacity: 800,000 m^3/day)
  2. Bang Khen water treatment plant (capacity: 3,600,000 m^3/day)
  3. Samsen water treatment plant (capacity: 700,000 m^3/day)
  4. Thonburi water treatment plant (capacity: 170,000 m^3/day)

1.Mahasawad water treatment plant

2.Bang Khen water treatment plant

Water consumption

3. Samsen water treatment plant

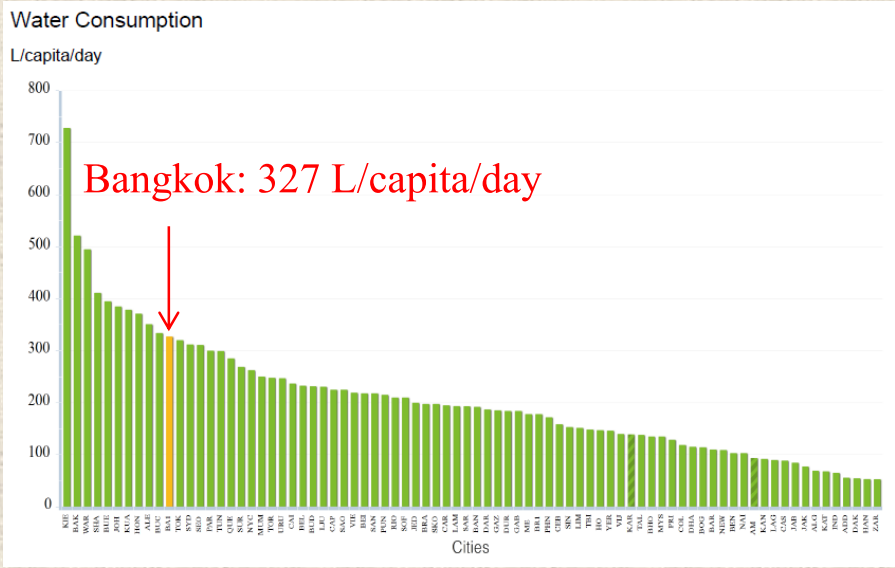
4. Thonburi water treatment plant

Finding:

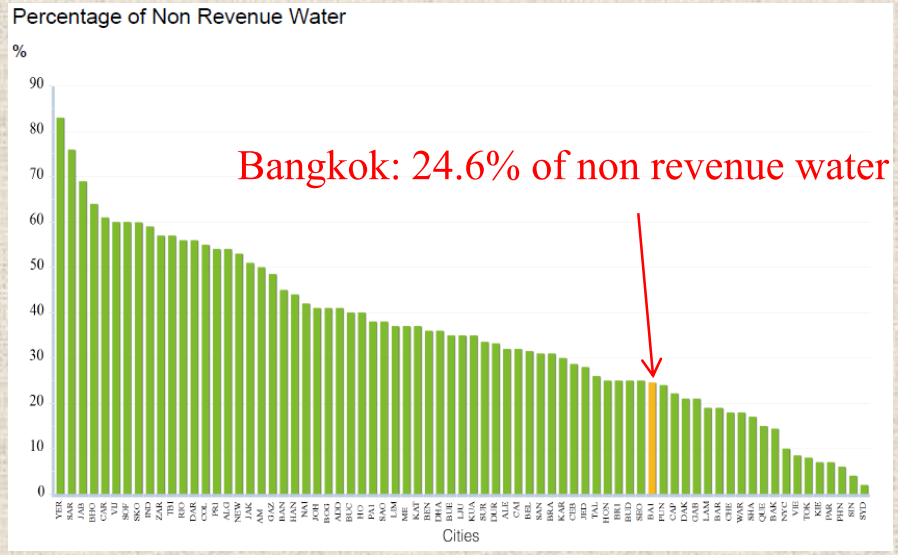
- The water consumption in Bangkok is 327 L/capita/day which is in between the cities of Tokyo, Japan (320.2 L/capita/day) and Bucharest, Romania (334 L/capita/day).

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



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 on16 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

1 Solid Waste

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

2 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

3 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

4 Transport

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

5 Power

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

6 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

7 Potable Water

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

Examples of TRACE impact

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).

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.

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

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.

ESMAP
Energy Sector Management Assistance Program

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Thank You.

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