Report No. 57685

Rapid Assessment Framework

An Innovative Decision Support Tool for Evaluating Energy Efficiency Opportunities in Cities

Final Report

October 2010

Energy Sector Management Assistance Program

Document of the World Bank

ESMAP Mission

The Energy Sector Management Assistance Program (ESMAP) is a global knowledge and technical assistance trust fund program administered by the World Bank and assists low- and middle-income countries to increase know-how and institutional capacity to achieve environmentally sustainable energy solutions for poverty reduction and economic growth.

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SYNOPSIS

The Rapid Assessment Framework (RAF) is designed to present a quick, first-cut, sectoral analysis on city energy use. This assessment framework prioritizes sectors with significant energy savings potential, and identifies appropriate energy efficiency interventions. The RAF covers energy efficiency across six sectors—transport, buildings, water and waste water, public lighting, solid waste, and power and heat. It is a simple, low-cost, user-friendly, and practical tool that can be applied in any socioeconomic setting.

The RAF consists of three principal components: (i) a city energy benchmarking tool, (ii) a process for prioritizing sectors and, (iii) a “playbook” of tried-and-tested energy efficiency interventions. These three components are woven into a user-friendly software application that takes the user through a series of sequential steps: from initial data gathering to a report containing a matrix of energy efficiency recommendations tailored to the city’s individual context, with implementation and financing options. These steps are described next.

① Collation of Candidate RAF City Energy Use Data

The RAF contains a database of 29 key performance indicators (KPIs). Each of the data points making up these KPIs, as well as a range of city-specific contextual information, is collected prior to the application of the RAF.

KPIs have been collected from a number of sources, including the World Resources Institute, the UN-HABITAT Urban Indicators, and the Little Green Data Book, to populate a city database. One of the ultimate goals of the RAF is to facilitate the establishment of a comprehensive database of city data, and as the RAF is rolled out, this collection of information will grow with current and reliable data. Field testing in Quezon City, Philippines, indicated that it is most important to focus on identifying a minimum number of data points for each KPI; that is, each city will not have values for every KPI, but each KPI will have a minimum number of cities with data.

② Analysis of City Energy Use against a Range of Peer Cities

Prior to the city review, city data are incorporated into a benchmarking tool containing KPI data from 54 cities of varying populations, climates, and wealth. The RAF user city’s performance is compared with a range of peer cities, selectable by the user, to determine the city’s relative performance in each of the six sectors (two to five KPIs per sector). The benchmarking process provides an overview of energy performance in the RAF city across all sectors.

③ Assessment and Ranking of Individual Sectors

During city review, numerous meetings and interviews are conducted, and additional data are collected across city departments and agencies, to augment benchmarking results. At the end of the first phase of the review, a formal prioritization process takes place in order to identify sectors with the greatest technical energy savings potential. Energy costs are also weighted based on the ability of city authorities to control or influence the outcome. Consequently, two or three sectors are reviewed in detail in the second phase of the mission. In Quezon City, the transportation, public lighting, and buildings sectors were chosen based on their potential energy efficiency improvement, percentage energy use, and the city's level of control.

④ Investigation of Individual Energy Efficiency Recommendations

The RAF contains a playbook of 59 practical and effective energy efficiency recommendations in each of the sectors. Some examples include:

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

Recommendations in each priority sector are quantitatively and qualitatively evaluated based on key data, including institutional requirements, energy savings potential, and co-benefits. Energy savings potential is calculated where possible to provide an estimate of the benefit of each intervention. At this stage some recommendations will be carried forward and these will be supported by implementation options, case studies, and references to tools and best practices. Field testing in Quezon City showed that a quantitative approach to recommendation selection is essential to identifying recommendations with the best potential and that contextual analysis is essential to ensure that recommendations are appropriate for a specific location.

⑤ Report Submission of Recommendations and Possible Implementation Strategies

Finally, after completion of the city review, a City Energy Efficiency Report is produced that records the process undertaken during the city review. Along with city background information and various records of the city mission included in introductory sections and addendum, this report also provides:

- a summary of the benchmarking results along with analysis of city performance and implications;
- background information to, and summary of, sector prioritization on the city government and city-wide scales; and
- a draft strategy for implementing recommendations, provided in summary form as the City Action Plan and in more comprehensive form as recommendations sheets.

The key purpose of the City Energy Efficiency Report is to enable the city to take forward recommendations in a structured and logical manner to maximize energy savings in a way that makes sense given the city's context, structure, and resources.

Acknowledgments

This report has been prepared by Happold Consulting International, UK, under the technical guidance of ESMAP's Energy Efficient Cities Initiative (EECI) core team led by Ranjan Bose. EECI team members are Jas Singh, Feng Liu, Tao Xue, and Alain G. Ouedraogo. The core team was assisted by Heather Austin, Nyra Wallace, and Gloria Jean Whitaker at different stages of the RAF development.

Given the complex and multi-sectoral nature of the Rapid Assessment Framework (RAF), the EECI core team had set up a Virtual Panel of eight practitioners on urban and energy/environmental issues from different stakeholder groups, including city administrations, research establishments, partner organizations, and the development community. The design and development of the RAF has benefitted from their timely review comments and advice on key RAF interim deliverables (e.g. Inception Report, draft RAF design, Quezon City RAF report, city benchmark database, validation report, final report). The RAF team is grateful to the members of the RAF Virtual Panel:

- Ms. See Toh Kum Chun, President, Singapore Institute of Planners, Singapore;
- Mr. Toru Hashimoto, Co-Governance and Creation Task Force, City of Yokohama, Japan;
- Mr. Anatoliy Kopets, Executive Director, Association of Energy Efficient Cities of Ukraine ;
- Ms. Maria Malmkvist, Head of Unit, Energy Management Department, Swedish Energy Agency, Eskilstuna Sweden;
- Mr. Tetsuya Nakajima, Director, Climate Change Policy Headquarter, Yokohama, Japan;
- Dr. Michael Sutcliffe, City Manager, Durban, South Africa;
- Engr. Isagani R. Verzosa, Jr., Building Official of Quezon City, Philippines; and
- Engr. Jeriel Dan M. Niguidula, Building Official of Quezon City, Philippines.

The report benefited from peer review by the members of the RAF Virtual Panel, and colleagues from the World Bank: Hiroaki Suzuki, Daniel Hoornweg, Ashok Sarkar, Arish Adi Dastur, and Rama Chandra Reddy. The help and support provided by the World Bank Country office (in the Philippines) in organizing the field trip to Quezon City for field testing and validation of the RAF, and the full support and cooperation the RAF team received from the Quezon City Mayor and the city government officials to successfully implement the RAF, is gratefully acknowledged.

The financial and technical support by the ESMAP is gratefully acknowledged. ESMAP — a global knowledge and technical assistance partnership administered by the World Bank and sponsored by official bilateral donors — assists low- and middle-income countries, its "clients," to provide modern energy services for poverty reduction and environmentally sustainable economic development. ESMAP is governed and funded by a Consultative Group (CG) comprised of official bilateral donors and multilateral institutions, representing Australia, Austria, Canada, Denmark, Finland, France, Germany, Iceland, the Netherlands, Norway, Sweden, the United Kingdom, and the World Bank Group.

Abbreviations

CA	City Authority
CD	Compact Disc
CDM	Clean Development Mechanism
CEMTPP	Center for Energy, Marine Transportation and Public Policy
EECI	Energy Efficient Cities Initiative
EE	Energy Efficiency
ESCo	Energy Services Company
ESMAP	Energy Sector Management Assistance Program
ESP	Energy Savings Potential
EU	European Union
GCIF	Global City Indicators Facility
GDP	Gross Domestic Product
GHG	Greenhouse gas
HCI	Happold Consulting International
HTML	Hyper Text Markup Language
IBNET	International Benchmarking Network for Water and Sanitation Industries
ICLEI	International Council for Local Environmental Initiatives
IPCC	Intergovernmental Panel on Climate Change
Kg	Kilogram
Km	Kilometer
KPI	Key Performance Indicator
kWh_e	Kilowatt Hour (electricity)
kWh_{th}	Kilowatt Hour (thermal)
MJ	Megajoule
NGO	Non-governmental Organization
QC	Quezon City
QCG	Quezon City Government
RAF	Rapid Assessment Framework
REI	Relative Energy Intensity
SME	Small and Medium Enterprises
SWF	Shock Wave Flash
T & D	Transmission and Distribution
ToR	Terms of Reference
UCLG	United Cities and Local Governments
UITP	International Association of Public Transport
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
XML	Extensible Markup Language

1 Executive Summary

The Rapid Assessment Framework (RAF) is a central component of the Energy Efficient Cities Initiative (EECI), launched by the Energy Sector Management Assistance Program (ESMAP) in collaboration with the Urban Anchor in 2008. The World Bank's key objective for the RAF is to create: "a practical tool for conducting rapid assessment in cities to identify and prioritize sectors and suggest specific energy efficiency interventions." Thus, the RAF will be used to help identify areas of energy use for further focus, develop an outline energy efficiency strategy, and guide potential future investment by ESMAP.

In August 2009 the World Bank selected a team composed of experts from Happold Consulting International (HCI) and Columbia University's Center for Energy, Marine Transportation and Public Policy to undertake the development of the RAF. The team began work in early September 2009.

This report reviews the development of the RAF from when the Happold team started work in September 2009, lays out its structure, and defines its use. The components and workings of the RAF are described in detail.

1.1 Overview

The principal aim of the RAF is to provide a practical analytical framework for conducting rapid assessment of a developing country city's energy profile and performance for different activities across different sectors. This information is then used to identify sectors where the most improvements can be made, and provide a range of energy efficiency recommendation options for each sector, along with a list of possible actions. An outline energy efficiency strategy should ultimately be generated from this information to guide potential policy and investment options, helping the city to save energy and money. The sectors include transport, buildings, water/waste water, public lighting, solid waste, and power/heating. The organizational management practices of the city authority (CA) that span all of the sectors are also considered to capture cross-sector integration and achieve an overall efficiency in the urban system.

The RAF has been designed to present a quick, first-cut, sectoral analysis of city energy use. This assessment framework prioritizes sectors with significant energy savings potential and identifies contextualized and reasoned energy efficiency interventions. The RAF consists of three principal components:

- a city energy benchmarking tool;
- a process for prioritizing sectors that offer the greatest potential with respect to energy efficiency; and
- a "playbook" of tried-and-tested energy efficiency recommendations.

1.2 Development of the RAF

The principal phases of the RAF development and their associated content were as follows:

- Inception Phase (September–November 2009): involving a precedent study and preliminary framework and concept for the RAF.
- Preliminary RAF Design (November−January 2010): establishing the RAF model requirements and initial design concept.
- Field Test and Validation, Quezon City, Philippines (February−April 2010): where a detailed framework for the RAF was developed and applied during a two-week mission to Quezon City.
- Detailed RAF Design and Production (May−August 2010): full-scale production of the detailed design, production of content, and tool architecture for the completion of the RAF.

1.3 Review of Existing Tools and Interviews with Tool Developers

A desktop review was undertaken to evaluate a list of related tools, typically covering greenhouse gas (GHG) emissions, at a city scale. After the initial evaluation, the RAF team selected specific tools that seemed to be the most relevant to the development of the RAF, including:

- Project 2 Degrees Emissions Tracker;
- ICLEI's Torrie-Smith Emissions Software; and
- Climate Alliance Toolkit.

Specific aspects of these tools reviewed included benchmarking, recommendations/measure sections, case study databases, data and/or indicators, useful methodologies for integrating the individual tools elements, ease of use, and visual interface. The team also conducted interviews with individuals with expertise in the areas of data collection, modelling, and the creation of diagnostic and measurement tools for emissions reduction and energy efficiency at city level. Numerous important lessons were learned from this exercise, which were of particular use in the development of the RAF. In summary these were as follows:

- differing methods for determining city boundaries;
- limitations on data availability;
- political sensitivities over city benchmarking data;
- the need to support CAs through the RAF process; and
- the application of a cautious approach on the basis of a relatively high-level initial assessment.

These lessons were utilized during the design of the tool to avoid pitfalls.

1.3.1 Benchmarking Tool

The benchmarking tool enables individual cities to compare and benchmark energy use, represented within the tool by a graphical, sector-by-sector summary of performance, in comparison with a range of peer cities. The benchmarking tool contains performance data for 54 cities varying in population, climate, and economic profile. Data for these cities have been gathered by the RAF team from 132 secondary data sources, ranging from global databases to city reports and academic papers. Although full sets of data for each key performance indicator (KPI) were not found by the RAF team, 691 separate data points have been included in the database, with each KPI having a minimum of 8 data points.

To undertake benchmarking for his or her city, the RAF user will be prompted to input specific data for 28 KPIs across the six principal sectors. Initially it was considered that KPIs should be of sufficient detail to enable the identification of energy efficiency recommendations from the results of the benchmarking process (e.g., pump replacement program for potable water systems). In reality, this would have required a level of detail that is usually inaccessible at the city level, so higher-level KPIs were chosen that provided indicative comparisons of sector performance only. The RAF team adopted the use of “relative” indicators that provide a snapshot of energy intensity, as these provide a common platform for comparison.

Where it is not possible to gather data in an RAF city, then proxy values (from national data) can be used, although less accurate data reduce the reliability of the output. It is therefore considered critical for RAF users to obtain the necessary information prior to starting the process wherever possible.

The benchmarking process was used to good effect during the field test and validation exercise in Quezon City. Benchmarking graphs (outputs from the module) caused much debate and acted to engage participants at an early stage.

1.3.2 Sector Prioritization

The sector prioritization process takes place after the RAF user has been able to obtain greater insight into the contextual conditions of the city through further data gathering, interviews with CA personnel and other agencies, site visits, and walkthroughs. The Quezon City field test and validation exercise enabled the RAF team to clearly define the principal factors that would be required in prioritization, which were: energy spend (either by the CA or on a city-wide basis), the opportunity for energy efficiency improvements in the sector (or subsector where control of sectors is divided), and the degree of control or influence the CA has over the sector or issue.

The prioritization process utilizes these factors in a simple calculation to rank sectors. Energy spend information is available through budget offices in the CA, and energy use across the city can be converted to a value relatively easily. With respect to “opportunity,” the RAF team has chosen KPIs from the benchmarking process that are most indicative of the energy use across a particular sector or subsector. To define opportunity, a calculation is undertaken to establish the mean value of each of the better-performing cities in the peer group, providing a goal or target for the CA; this is termed the relative energy intensity of the sector (REI). It is understood by the RAF team that there may be significant contextual differences between the RAF city and its peers; therefore a simple estimation tool has been incorporated into the RAF that enables the RAF user to roughly estimate the potential for energy savings in any given sector on the basis of site visits, walkthroughs, and interviews. The RAF user may override the REI calculation on the basis of energy efficiency potential witnessed on-site. Finally, for each sector and subsector, the RAF user is asked to establish the degree of control or influence that the CA has over the issue. This is achieved by establishing, for each sector, where the CA sits in a range from national stakeholder (minimum influence) to full budgetary and regulatory control (maximum control). There are seven options in the range, each with a range of values, so that the RAF user can determine, on the basis of evidence gained, where the CA's control or influence is located in each sector. This final component is used as a weighting factor, with values ranging from 0.01 to 1.

The prioritization calculation works on a simple multiplication of each factor. The RAF tool ranks each sector, and the RAF user is advised to establish priority sectors in collaboration and agreement with the RAF leadership team.

1.3.3 Recommendations Tool

The Energy Efficiency Recommendations module is home to all of the energy efficiency interventions across the six principal sectors and their subsectors. For each of the principal RAF sectors, a "sector specialist" was appointed within the RAF team. The role of the sector specialist was to advise on energy efficiency recommendations in his or her sector of expertise. Recommendations may be summarized as follows:

- recommendations are geared toward energy efficiency in areas that are controlled or significantly influenced by CAs;
- for each recommendation, numerous implementation activities (or "levers") and scales of implementation are defined to suit the widest range of city contexts;
- for each implementation activity, a representative case study, external guidance, or toolkit is identified and described with live web linkages; and
- each recommendation has suggestions regarding the method of measuring and monitoring progress, including KPIs.

Each recommendation should have a common set of attributes defined; *attributes* is the term given to facets of the recommendation that are key to decision making. The attributes included in the recommendations are:

- energy savings potential;
- first cost (i.e., capital investment); and
- speed of implementation.

In total, 59 recommendations and 191 case studies have been developed.

To establish the viability of the individual recommendations, the technical energy savings potential should be estimated wherever possible. Of the 59 recommendations, 23 have energy savings calculators (in the form of an Excel workbook). RAF users are required to capture the necessary base information to enable the calculator to work. For the 36 remaining recommendations, energy savings was deemed either inaccessible or indirect, for instance, planning-related recommendations.

The options available to CAs to finance energy efficiency interventions are incorporated into the RAF as separate documents accessed through the Recommendations module. The finance document is designed to apply across the broad spectrum of recommendations and provide summary guidance to established, as well as innovative, mechanisms.

The recommendations tool takes the form of a series of modules that will take into consideration key pieces of information that may prevent a recommendation from being successfully deployed.

The first module is termed “Initial Appraisal.” This module utilizes the concept of critical success factors. Using literature to define key barriers to energy efficiency in cities, the RAF team synthesised the factors found in the literature into a workable group of critical success factors that could be applied in the context of the RAF, as follows:

- finance: defines the level of sophistication and experience of the CA with respect to funding mechanisms;
- human resources: defines both the capacity and expertise of CA resources;
- data and information: defines the availability of data and sophistication of measuring and collection systems;
- policy, regulation, and enforcement: defines the CA’s powers to introduce and enforce legislation; and
- assets and infrastructure: defines the presence, ownership, and control of assets or infrastructure

For each critical success factor, a range of levels was defined for each sector and subsector. Critical success factors were used to:

- define minimum requirements for the successful implementation of the recommendation (each recommendation was assessed against the ranges to determine the minimum requirements for successful implementation); and
- assess the status of the RAF city with respect to each prioritized sector and subsector, using the ranges to determine where they should be positioned.

The results of the Initial Appraisal module are displayed utilizing a simple traffic light system that indicates which recommendations are most ideally suited to implementation in the RAF city. No recommendations are automatically ruled out through this process, although the RAF user is required to use the process to focus upon those recommendations that offer the most promise.

After the Initial Appraisal has taken place, the RAF user is directed to undertake the energy savings assessments for those recommendations that have been selected, using the Excel workbooks. The output from this calculation is utilized in the next module.

Recommendations that are selected as a result of the initial appraisal are displayed in the next module, “Recommendations Review.” Here the RAF user is encouraged to review attributes (see above) assigned to the individual recommendations and, once satisfied that they reflect the opportunity and status in the RAF city, utilize a matrix tool that enables recommendations to be plotted on the basis of two attributes on to a 3 x 3 matrix (energy savings potential and first cost), with an additional filter that enables the user to screen recommendations on the basis of their speed of implementation. The tool is designed so that recommendations in the top right-hand corner of the matrix are more favorable than those in the bottom left-hand corner.

The role of the matrix is as a decision support tool. Cities may have a range of needs and desires—some may wish for a speedy implementation, others a short payback. The matrix allows the RAF user and city to optimize the selection process, and identify those recommendations that are most advantageous to them.

The final output from the RAF will be a basic strategy for city-wide energy efficiency improvements. The outputs will include activities that will lead to efficiency in the short term, as well as a selection of activities that have longer-term potential. The RAF will also include a module that will guide the CA so that monitoring and evaluation of the strategy may be undertaken.

1.4 Field Test and Validation in Quezon City

As part of the design development process, the RAF was subjected to field testing and validation in Quezon City, Philippines, in February 2010. Originally it had been intended that the field testing component of the commission would take place toward the end of the development process (June 2010); however, for political reasons (an impending city election), the field testing schedule was brought forward to February (prior to the election) to ensure the participation of the city leadership team.

The issue of the timing of the field test is relevant because it meant that the RAF was "partially" developed when it was applied. The disadvantage of this is that a true validation of the RAF "as designed" was not possible; however, the overwhelming advantage was that it enabled the experience and outcome to positively influence the RAF design at a critical stage.

The field test and validation exercise had two principal objectives: to provide Quezon City government (QCG) with recommendations to improve energy performance, and to validate and test the RAF.

Most of the energy efficiency activities currently under way in Quezon City were successfully identified by the RAF process, although not pursued further due to their ongoing nature. Of the energy efficiency recommendations identified through the RAF process, eight were deemed a high priority for Quezon City. These covered the water, buildings, and transport sectors, as well as improvements to current procurement processes, investment programs, and the administration of energy efficiency activities across QCG departments.

The RAF team learned a number of valuable lessons as a result of the field testing and validation of the RAF regarding both content and process that were usefully applied in its subsequent development. These included:

- the use of local consultants was highly beneficial to the logistical and data gathering components of the mission;
- data requirements prior to the mission have been pared back to more realistic levels;
- comparing performance of the RAF city to peer cities was a particularly effective means of engaging CA representatives; and
- difficulties in effectively ranking between energy use under the direct purview of the CA (i.e., QCG spend) and city-wide energy use.

The Quezon City mission has benefited the consultant by focusing attention on the challenges of:

- the linking of energy performance benchmarking results to the sector prioritization process;
- the definition of levels of control or influence that a CA may exercise over a particular issue; and
- the aggregation and relative comparison of two quite separate, but intrinsically linked, components of city energy use: whole city energy use and CA energy use.

These challenges were taken up post-mission, through the development of a number of options to define a logical process that may be consistently applied. In Quezon City, it was apparent that the RAF results were no surprise to QCG representatives. This was beneficial insofar as it served to confirm both their actions and prior assumptions, although Quezon City had not compared all the sectors together in the way the RAF compared them on a quantifiable basis.

It is inherently challenging to create an analytical framework and decision support tool such as the RAF. A fine balance needs to be struck between its formal processes that deliver reliability and consistency, and its adaptability to a wide range of city contexts. The RAF team has debated at length the pros and cons of individual system components, how they may perform and with what level of accuracy. Numerous iterations of component design were undertaken in order to allow for a broad range of potential city characteristics and institutional arrangements. The result is an analytical tool that firmly guides users, while providing flexibility to refine inputs and outputs if there is a sound rationale for doing so.

2 Introduction

2.1 Background

The rapid urbanization of developing countries over the last 50 years has led to challenges in achieving environmental, social, and economic sustainability. While cities in developing countries continue to face significant environmental challenges, they remain the primary engines of economic growth within the developing world. Minimizing negative environmental impact while maintaining and enhancing these emerging economies has come to the front of the global agenda as globalization and climate change continue to dominate international issues.

Recognizing the growing importance of energy use in cities, the Energy Efficient Cities Initiative (EECI) was launched by the Energy Sector Management Assistance Program (ESMAP) in cooperation with the Urban Anchor to help bring urban sustainable energy efficiency and climate change mitigation considerations into the mainstream.

An Energy Efficient Cities Practitioners Roundtable was held October 21, 2008, in Washington, D.C. The Roundtable had over 50 participants, with one-third from developing country cities and several potential partners. Some key messages from the discussions included:

- energy is a cross-cutting issue and affects budgets, local jobs, competitiveness, energy security, and the environment;
- energy efficiency is considered a “win – win” scenario, so donors should frame energy efficiency in the context of city socio-economic priorities and not the environmental/climate change agenda; and
- the multi-sectoral nature of energy systems in cities was a key challenge that required strong political will to overcome.

The outcome of the Roundtable framed the future development work of the EECI over the next five years, culminating in an action plan that covers the following activities:

- development of an analytical framework for energy-efficient cities;
- a small grants program;
- urban energy efficiency good practice awards and database;
- focus on delivery of a few World Bank urban energy efficiency projects; and
- outreach and dissemination.

The first item on the action plan relates to the development of the EECI Rapid Assessment Framework (RAF), which is discussed in more detail next.

2.2 Objectives

The main objective of the RAF is to provide a practical analytical framework for conducting rapid assessment of a developing country city's energy profile and performance for different activities, across different sectors, taking into account the cross-sectoral linkages. This information should then be used to identify sectors where the most improvements can be made, and provide a range of energy efficiency recommendation options for each sector, along with a list of possible actions. An outline energy efficiency strategy should ultimately be generated from this information to guide potential policy and investment options, helping the city to save energy and money. The sectors include transport, buildings, water/waste water, public lighting, solid waste, and power/heating. The organizational management practices of the city authority (CA) that span all of the sectors are also considered.

In summary, the objectives for the RAF are to:

- create a simple and practical diagnostic tool;
- operate with minimal data (and associated cost);
- be quickly applied in any socioeconomic setting;
- provide high-level analysis based on available data and extensive interviews; and
- produce a basic strategy for choosing and pursuing solutions.

The ultimate aim of the RAF is to identify ways in which energy efficiency can be improved by the CA and therefore reduce the city's expenditure on energy.

2.3 Development Methodology

2.3.1 The RAF Development Team

The RAF development team is a partnership between London-based Happold Consulting International (HCI) and the Urban Energy Program at the Center for Energy, Marine Transportation and Public Policy (CEMTPP) at Columbia University in New York City. The partnership brings considerable experience and expertise to the Energy Efficient Cities Initiative. HCI is renowned for creative excellence and technological foresight in the fields of building and infrastructure design, urban planning and regeneration, and environmental and strategic management. CEMTPP is an internationally recognized center of excellence in urban energy use, energy technologies, and city-scale energy efficiency research.

2.3.2 Development Phases

The development methodology for the RAF was summarized in the original terms of reference (ToR) for the assignment and has evolved throughout the design and refinement of the RAF components. Development has taken place during a program of design sprints, where all of the key members of the design team came together in New York to discuss increasingly more detailed components of the RAF and agree on design proposals. Progress with the development of the RAF components was communicated to the ESMAP team through a series of presentations and workshops over the course of the project. The principal phases of the RAF development and their associated content are summarized next.

2.3.2.1 Inception Phase (September – November 2009)

During this initial phase the team began the process by analyzing a number of precedent case studies and forming a preliminary framework and concept for the RAF. The precedent case studies informed the design by highlighting strengths and limitations of previous tools and exposing areas of energy efficiency that are not addressed by the tools that are currently available.

2.3.2.2 Preliminary RAF Design (November−January 2010)

Using the ToR, precedent studies, and initial workshops and meetings, the team was able to establish the RAF model requirements and initial design concept. An important initial step of RAF development was the establishment of city key performance indicators (KPIs) and data collection methods. This helped guide the team in RAF development and constituted a key part of the preparation for RAF field testing in Quezon City, Philippines, in February 2010.

2.3.2.3 Field Test and Validation: Quezon City, Philippines (February−April 2010)

A detailed framework for the RAF was developed and applied during a two-week mission in Quezon City. Over the course of the field test, all RAF sectors were reviewed and considerable benefit was derived from the process, serving to refine and augment the RAF process and design. The field test clarified the application of specific modules and hitherto unforeseen requirements. The field test culminated in a City Energy Efficiency Report that was issued to city officials in Quezon City.

2.3.2.4 Detailed RAF Design and Production (May−August 2010)

After field testing, numerous detailed decisions relating to discrete aspects of the RAF were discussed and agreed on between the RAF development team and ESMAP, leading to full-scale production of all of the relevant components required for the completion of the assignment. This included:

- development of 59 energy efficiency interventions (termed "recommendations" in the RAF);
- researching case studies to support and illustrate the recommendations (191 case studies have been incorporated);
- supporting guidance documents (such as presentations and workbooks); and
- software development to provide the required interactivity.

2.4 Existing Energy Efficiency Tools and Frameworks

During the early part of the assignment, a study of existing tools and frameworks (the precedent study) was undertaken to provide familiarity of both the coverage and relevance of existing tools, as well as developer experiences. The study was necessary to establish the existence of relevant processes and to be forewarned of some of the challenges and potential blind alleys.

The precedent study consisted of two main activities: a desktop review of existing tools and frameworks and a series of interviews with principals involved in the development of similar tools.

The first part of the desktop review entailed examining a long list of potentially related tools (the full review can be found the Inception Report dated November, 2009). Following this review, the team selected those tools that seemed to be the most relevant to the development of the RAF. Although these shortlisted tools all address climate change, rather than energy efficiency, their functionality was still relevant to the development of the RAF. These are as follows:

- Project 2 Degrees: Emissions Tracker;
- ICLEI's Torrie-Smith Emissions Software; and
- Climate Alliance Tool Kit.

These tools were selected as precedents as each has a number of features that would be essential components of the RAF. These features include a benchmarking tool, sections to help users develop intervention measures, case study databases, data and/or indicators, and useful methodologies for integrating the individual tools' elements. These tools also were generally easy to use and had logical and easily understandable interfaces. The following section introduces each tool and presents the team's conclusions about their strengths and weaknesses.

Alongside the tool review, the team compiled literature and information on existing projects and research in the areas of energy efficiency, climate accounting, and urban-level data collection. Of particular interest were the Global City Indicators Project, the Kitakyushu Initiative, and the International Council for Local Environmental Initiative's (ICLEI) work on developing emissions trackers for municipalities over last 20 years.

The second task covered a series of interviews with a number of international experts. Experts interviewed could be categorized either as individuals who had experience developing and using a tool similar to the RAF, or those who had significant experience collecting data at a city level. Interviewees are listed in Table 1.

Table 1: Interviewees during the Precedent Study

Interviewee	Affiliation
Chris Kennedy	University of Toronto Department of Civil Engineering. Director of Greenhouse Gas Emission baseline project for the World Bank.
Kathryn Murdoch	Program Director, Project 2 Degrees.
Wayne Westcott	Former Executive Director of ICLEI-Oceania. Now with United Cities and Local Governments (UCLG) Asia Pacific.
Ralph Torrie	Former ICLEI consultant. Now Managing Director, Navigant Consulting.
Charlie Heaps	Director of Stockholm Environment Institute's U.S. Center; Senior Scientist in SEI's Climate and Energy Program.

Anu Ramaswami	IGERT: Sustainable Urban Infrastructure, Department of Civil Engineering, University of Colorado at Denver.
Ulrike Janssen	Executive for Local Climate Protection at the Climate Alliance.

A number of themes emerged from the literature and in interviews. The major points raised in relation to each of these themes are discussed next.

1. Boundaries

The impact of how city boundaries are defined on the validity of city-level data presents one of the most salient challenges for a project such as the RAF. Different countries have different methods for determining city boundaries, which poses a significant challenge for researchers hoping to compare city-level data across countries. According to UN-HABITAT, the most important issue for data collectors is what will be the most convenient and reliable urban boundary that will allow them to assemble the data for the requested indicators.[1] How the issue of boundaries is addressed can have a significant impact on the validity of overall methodology. In an interview with Chris Kennedy about his work inventorying greenhouse gas emissions from 10 cities around the world,[2] he mentioned that his team's methodology was criticized for using a mixture of central cities and metro regions.

The World Bank−sponsored Global City Indicators Facility uses the local municipality as an area of reference, though it also uses data from metropolitan areas or urban agglomerations. UN-HABITAT, on the other hand, uses the urban agglomeration as the standard area of reference. The user manual for Project 2 Degrees notes that there are two approaches commonly used for setting organizational boundaries: financial control and operational control (operational control relates to areas of jurisdiction of the CA, regardless of their ownership, for instance, policy and regulatory control). These approaches are adapted from financial accounting principles, and were originally developed by the GHG Protocol and ISO 14064. Project 2 Degrees elected to use the operational control approach, believing this is more applicable to cities.

2. Selection of benchmark cities

One of the major considerations flagged as potentially affecting the selection of the benchmark cities is data availability. Interviews confirmed that there are few data points available for some parts of the developing

[1] UN-HABITAT. (2004). Urban Indicators Guidelines: Monitoring the Habitat Agenda and the Millennium Development Goals.
[2] Kennedy, C et al. (2009). Methodology for inventorying greenhouse gas emissions from global cities. *Energy Policy*, doi:10.1016/j.enpol.2009.08.050.

world, in particular sub-Saharan Africa and Latin America. However, the interviewees suggested that data were available for some cities in South-East Asia and China.

3. Benchmarking

The issue of benchmarking city data came up several times during interviews. A number of interviewees cautioned the team about the politics that invariably arise in such an exercise. Chris Kennedy found that cities complained about the comparability of data between cities. Wayne Wescot, who has significant experience with such exercises, said that every benchmarking exercise he has done with a city over the years has been challenging.

4. Capacity to use tools

User capacity to use tools similar to the RAF was varied, and highlighted the challenges that will be faced when applying the RAF in developing countries. Project 2 Degrees found that the amount of support users needed varied widely. Some cities had teams dedicated to climate change, while others had neither staff nor data. Wayne Wescott's experience applying ICLEI tools in Indonesia was that while large cities could generally use their tools, in medium-sized cities even finding a computer may be a challenge. An additional concern is that the expertise and information required to use tools is often dispersed within a municipality. Without a central team pulling data together, applying a tool will require finding the appropriate technical staff in a number of departments. Project Two Degrees also found that many people, particularly in developing countries, needed a great deal of support to do their carbon accounting. Wayne Wescott recommended working with cities already competent in gathering and processing data, as starting from scratch in a city would be difficult.

5. User feedback on tools

ICLEI evaluated its tools in Australia and found that they met with the approval of about half the cities surveyed. They found that most cities understood the need for the type of software they were producing, but some people found the process time consuming and didn't want to do it. Users who wanted to manage their data in a specific way or format were not happy with the ICLEI tools, as the software didn't allow that.

The development of the RAF has benefited significantly from both the precedent study and the RAF interviews with tool developers. This knowledge has been useful during the development process, refining the aims of the RAF to include:

- phased requirements for detailed data (i.e., fine-grain data are only required when related to a specific recommendation);
- the RAF is applied by a consultant: reducing the training requirements for tool use and concentrating familiarity with the tool among practitioners; the benefit to the CA is that the CA benefits from the tool output without the need to invest time and resources in learning about its application;
- RAF users only need to input data once: it does not determine how data are managed by the CA; and

- applying the RAF over the course of a concentrated two-week mission: ensuring that the consultant is tasked with finding data from a diversity of CA departments.

It also became clear that the RAF would need to be developed in a way that leaves scope for the diversity of locally specific issues facing cities in the developing world.

3 Overview of the Rapid Assessment Framework

The Rapid Assessment Framework (RAF) has been designed to present a quick, first-cut, sectoral analysis of city energy use. This assessment framework prioritizes sectors with significant energy savings potential and identifies contextualized and reasoned energy efficiency interventions. The RAF consists of three principal components:

- a city energy benchmarking tool;
- a process for prioritizing sectors that offer the greatest potential with respect to energy efficiency; and
- a "playbook" of tried-and-tested energy efficiency recommendations.

These three components are woven into an interactive software application that takes the user through a series of sequential steps: from initial data gathering to a report containing a matrix of energy efficiency recommendations tailored to the city's individual context, with implementation and financing options.

It is noteworthy that the RAF is not designed to provide user cities with a detailed analysis or audit of energy systems; rather, this may be a consequential step.

The RAF process is designed to be undertaken by an international consultant appointed by the World Bank. The international consultant will have been given adequate training in the application of the RAF and have significant experience in city infrastructure, planning, and energy systems. The international consultant will lead the entire process, supported by a local energy consultant. The local consultant will be actively working to collate appropriate background information and data on energy use across the various sectors in the weeks before the RAF mission.

The RAF mission is scheduled to be a two-week long visit to the city by the international consultant team. The mission is highly structured to ensure that the time in the city is used to maximum effect. Significant effort is required from the consultant during this time, and it is imperative that the host city actively enables this process by helping to arrange access to both internal departments and personnel, as well as external agencies and, possibly, private-sector companies such as utilities.

At the end of the two-week RAF mission, the international consultant will present his or her findings to the city's appointed leadership team. Following this presentation, approximately two to four weeks later, the international consultant will produce a City Energy Efficiency Report for the city.

3.1 RAF Process and Application

The RAF implementation process has a duration of approximately 12 weeks, broken down into three main stages:

- pre-mission (approximately 6 weeks) data collection and preparation – local consultants working within the host city, and the rest of the team (international consultant) working remotely;

- mission (2 weeks), RAF implementation within the host city – entire RAF team working locally within the host city; and
- post-mission (2−4 weeks) finalization – the bulk of the local consultants' work is finished, but some loose ends are tied up locally, with the rest of the team (international consultant) working remotely to finalize the City Energy Efficiency Report.

Further detail on the activities in each stage is provided next.

1. Pre-mission collation of city energy use data

The RAF requires data on sector-specific key performance indicators (KPIs) and each of the data points that make up these KPIs, as well as a range of city-specific contextual information. This would be collected, with the help of the city, prior to the application of the RAF.

KPIs for other cities have been collected from a number of sources, including the World Resources Institute, the UN-HABITAT Urban Indicators, and the Little Green Data Book, to populate a city database. One of the ultimate goals of the RAF is to facilitate the establishment of a comprehensive database of city data, and as the RAF is rolled out, this collection of information will grow with current and reliable data.

2. City energy benchmarking

Prior to the city review, city data are incorporated into a benchmarking tool containing KPI data from 54 cities of varying populations, climates, and wealth. Using the city energy benchmarking tool, the host city is compared to a range of peer cities selected by the RAF user to assess the city's performance in each of the six sectors.

3. Prioritization of individual sectors

During the city review, numerous meetings and interviews are conducted and additional data are collected across city departments and agencies to augment benchmarking results. At the end of the first phase of the review, a formal prioritization process takes place in order to identify sectors with the greatest opportunity for energy savings. In addition, energy costs are weighted based on the ability of city authorities (CAs) to control or influence the outcome. Prioritized sectors are reviewed in detail following the prioritizing process.

4. Investigation of individual energy efficiency recommendations

The RAF contains a playbook of practical and effective energy efficiency recommendations related to the organizational management of the CA and in each of the six sectors. Some examples include:

- organizational management: energy efficiency municipal task force;
- transport: vehicle emission standards;
- waste: waste management fuel efficiency standards;
- water and waste water: demand reduction measures;

- power and heat: district cogeneration network;
- public lighting: street lighting retrofit; and
- buildings: procurement guidelines for lighting.

Recommendations in each priority sector are first qualitatively evaluated based on a number of critical success factors, such as asset and infrastructure requirements. The RAF sorts recommendations based upon the individual city context and the requirements of the individual recommendations.

For recommendations that will result in direct energy savings, the technical energy savings potential is calculated using an Excel tool. A link to this is contained within the RAF.

The RAF collates all information collected as part of this process and presents it in a matrix that indicates key attributes of each recommendation. Each recommendation is linked within the RAF tool and is supported by a wealth of implementation options, case studies, references to other existing tools, and best practice guidelines.

5. Post-mission: City Energy Efficiency Report

After completion of the city review using the RAF, a City Energy Efficiency Report is produced that records the RAF process and outcomes. Along with city background information and various records of the city mission, this report also provides:

- a summary of the benchmarking results along with analysis of city performance and implications;
- background information on, and summary of, sector prioritization; and
- a draft strategy for implementing the final recommendations, provided in summary form as the City Action Plan and in more comprehensive form as recommendations sheets.

The key purpose of the City Energy Efficiency Report is to enable the city to take forward recommendations in a structured and logical manner and thereby maximize energy savings in a way that makes sense given the city's context, structure, and resources.

3.2 RAF Design Philosophy

The detailed RAF design concept presented in this report is based on four key sources:

- ESMAP's vision for the project as described in the project terms of reference (ToR) and clarified in discussions with members of the ESMAP team;
- the RAF development team's collective experience working on or analyzing energy efficiency strategies in cities around the world;
- interviews with the developers of similar tools; and
- interviews with people experienced in collecting energy data at the urban level.

Bringing together the information and ideas that emerged from these sources has involved making challenging decisions about a number of fundamental design issues. The project team has endeavored to keep the design of the RAF consistent with ESMAP's stated objectives. For some issues, this has involved a process of reconciling the desire to create a new, innovative, and industry-leading tool to evaluate energy efficiency with the realities associated with producing a practical tool that has genuine, lasting value in a developing city context.

3.3 Key Design Issues

This section outlines in brief the major design aspects and decisions made by ESMAP and the RAF development team during the course of the RAF's design development. The purpose of this section is to highlight specific issues and justify why a particular path was chosen. Specific design details are covered in later sections of this report.

1. How to Use the RAF

One of the principal questions debated at the outset of the preliminary design phase related to the degree to which the RAF can be relied upon to provide credible and consistent policy prescriptions. The RAF team's view was that the tool cannot be used in isolation; however, it still structures and informs:

- the process;
- the discussions to be had; and
- the selection of specific policy measures.

As such, the RAF and associated documentation are designed to be used in conjunction with a range of qualitative processes such as meetings, workshops, and the application of subject matter expertise. This approach provides the requisite flexibility to ensure that the RAF is adaptable to almost any situation, while providing a defined "process" to be applied. An important prerequisite to this approach is that the personnel leading the mission are familiar with the RAF sectors, which requires consultant personnel who possess a multidisciplinary skill base.

2. Boundary Issues

The issue of boundaries was raised in section 2.4. Boundary issues in the RAF relate to both how a city is defined (metropolitan, municipal, operational control, etc.) as well as the limits to control or influence that the CA may exert over a specific sector.

The definition of city boundaries was considered a key challenge for the RAF during the benchmarking exercise. Comparing like-for-like is essential to obtain meaningful results, even though there may be contextual reasons for differing levels of energy intensity. This issue has been largely resolved at the benchmarking stage by choosing to adopt KPIs that are "relative" or "normalized" to provide an indicator of sector performance rather than a comparison of cities on the basis of their aggregate energy use in each sector.

As the RAF is designed specifically for CAs, the RAF's implicit boundary relates to "municipal operational control"; however, the RAF development team considered that the application of the RAF may incorporate elements of the city infrastructure that are outside the jurisdiction of the CA, as long as it is able to exert significant influence. For instance, the water, waste, and power sectors may often be outside the operational control of the CA, but they may have significant influence over future investment and energy-related issues through its strategic planning function.

3. Level of Detail in Key Performance Indicators (KPIs)

The primary challenge in developing the KPIs was the team's concern about data availability for both the benchmark database of global cities as well as cities wishing to use the RAF. The team's experience, discussions with experts in the field, and reviews of city data demonstrated that, even in developed countries, detailed energy efficiency data can be challenging to obtain. In some cities, key data may not exist, or may be under the control of a number of agencies. Collecting this will be a challenge, as CA staff responsible for gathering data for the RAF may have limited time, resources, and knowledge.

Several discussions with the ESMAP team questioned the level of detail that should be included in KPIs. The primary debate was whether KPIs should be defined to precisely determine energy efficiency in a sector or to reflect a realistic assumption of what data were likely to be readily available in each host city to populate the global city database.

Ultimately, a compromise was reached. All parties accepted that the granularity of data required to determine the effectiveness of a specific energy efficiency intervention would not be available without sustained information gathering during the pre-mission stage. For example, it was decided that if detailed information relating to municipal vehicle fuel efficiency was required, it would be gathered in later stages of the mission at a point when it was clear that a specific intervention or recommendation was likely to be pursued. In short, the RAF process would require data at the point at which such data would be needed.

Second, with respect to gathering data for the global cities, although significant secondary research activity was undertaken to populate the database, significant gaps in data availability remained. This was addressed in two ways:

- the number of cities used in the RAF database was expanded from an initial 25 to 54. The purpose of this was to include a wider range of cities with partial data into the RAF database, ultimately leading to increased coverage of KPIs (albeit as a mosaic of data). This was considered acceptable as long as a minimum of eight cities was represented in the database for each KPI.
- Finally, for some of the toughest KPIs, national figures have been used to augment city KPIs. The use of national proxies is largely confined to the power and heat and buildings sectors.

4. Sector Prioritization

The RAF team and ESMAP have devoted considerable effort to the development of mechanisms that could be employed to undertake the sector prioritization process during the course of the mission. Initially the team considered using only the results of the benchmarking tool to perform this task, and numerous automated algorithms for calculating sector priority were discussed. However, the team ultimately concluded that to use the benchmarking results in isolation may be too formulaic and will likely miss important contextual information.

This component of the RAF development was aided considerably by the field test and validation exercise in Quezon City, where a "framework" approach was utilized, found to be successful, and developed further. The "opportunity" for energy efficiency in individual sectors was determined on the basis of the product of the following factors:

- relative energy intensity (REI) of individual sectors when compared to peer cities;
- energy spend; and
- the degree of control or influence exerted by the CA on the sector.

The final factor (control or influence) is used as a weighting mechanism: the greater the degree of control, the higher the weight assigned.

However, it was acknowledged that using the REI, calculated on the basis of the benchmarking results, may not provide sufficient contextual definition of the status or potential of the sector in the host city. It was decided therefore that the REI calculation could be amended by the international consultant when necessary on the basis of *predicted* technical energy savings potential. This would be derived through building walkthroughs and site visits, and utilizing a prescribed methodology. The resultant process provides for a degree of flexibility and contextualization prior to calculating sector priority ranking.

5. Selecting and justifying energy efficiency recommendations

Fifty-nine energy efficiency recommendations are included in the RAF. After a host city has been through a prioritization process, it is likely that two or three sectors will be selected for further consideration. Dependent upon the number of sectors selected, a large number of recommendations may be associated with prioritized sectors. In order to focus upon those recommendations that are likely to be most effective in the host city, a form of "filtering" was deemed necessary. Initially this took the form of a qualitative appraisal that reviewed key requirements for the success of each recommendation. This approach was highly focused upon the recommendation, but possibly required too much information up front. A "decision tree" approach was considered, but this required a similar level of detail. To overcome this challenge, a generic set of critical success factors was developed. These factors relate to minimum requirements for the success of any given recommendation with respect to:

- finance;
- human resources;
- assets and infrastructure;
- data and information; and
- policy, regulation, and enforcement.

These are coded into the tool for each recommendation. The tool has been designed such that for each sector in the host city, an appraisal of the status of the city is entered into the RAF by the international consultant. The RAF is then able to automatically determine which recommendations meet the host city's profile and have the most likelihood of success. The latter is defined through "traffic light color coding. It is important to note that none of the recommendations are ruled out through this process, as the consultant is required to use his or her expertise and judgment to select appropriate recommendations.

3.4 Application Architecture

The RAF software is designed using the Adobe Flex Platform, and compiled as both a web application (HTML/SWF) and desktop application (using the Adobe Air Framework and packaged on a CD for distribution to teams of consultants, along with other RAF documents and materials). Both the HTML and Air versions of the software will be available on the RAF CD. An overview of the RAF is provided in Appendix 8: RAF Guidance; this is the guidance document for the RAF and provides an overview of each module and its application.

3.4.1 Data Model

The system relies on two XML data files for all inputs and outputs. The core data in the RAF will be stored in a single XML file that can be updated by the RAF team during development, and by the World Bank after project completion. The data the user enters into the system will be stored in a second XML file that can be saved, reopened each time the application is opened, and sent to the World Bank and consultant team via email for analysis/collation. In addition to this, the complete library of recommendations will be stored as a series of HTML files. When the user is presented with his or her final list of preferred recommendations, clicking on one of these in the RAF application will open the associated HTML file for that recommendation.

4 RAF Modules

The Rapid Assessment Framework (RAF) consists of three principal components (or modules) with integral guidance and related documentation. In this section, each of the modules is discussed in order to define the approach adopted and how it was refined during the development of the RAF.

4.1 Energy Benchmarking Module

4.1.1 Introduction

Energy sector benchmarking has been an integral component of the RAF from the outset. Benchmarking is a simple approach that enables a user to establish how performance compares to either norms or standards or, as in this case, peers.

The terms of reference (ToR) for the project state the rationale for city energy benchmarking, as follows:

Of the major steps taken to develop an energy management program in a city, benchmarking energy use (by comparing current energy performance to that of a similar entity) is critical. Regardless of the application in each sector, benchmarking enables CAs to determine whether better energy performance can be expected.[3]

The original intention for the benchmarking component of the RAF was to identify three to five key performance indicators (KPIs) per sector for which city-specific information could be gathered. This would then be repeated for 20 to 30 cities with differing characteristics in order to obtain a broad database of relevant performance information. City data could then be used to establish, for cities using the RAF, where performance fell short of their peers, and where opportunities for energy efficiency gains were most likely to be found.

The process for the application of the Energy Benchmarking module is as follows:

- Step 1: Benchmark data collection: general data and data for each of the six sectors are taken from the City Background Report and input into the RAF.
- Step 2: Benchmark city selection: the city authority (CA) selects from a list of peer cities to compare their relative energy performance in each sector.

[3] Terms of Reference: Energy Efficient Cities Program: Development of Rapid Assessment Framework, para. 22.

- Step 3: Benchmark results comparison: the results of the benchmarking process are presented in an interactive module that allows the CA to browse and filter information to achieve a comprehensive view of relative performance for each sector. This can then be formatted as a bar chart for reference or presentation.

4.1.2 Benchmark City Selection

Selection of benchmark cities involved a process of balancing ideal cities in terms of diversity, with cities for which the RAF team was likely to be able to obtain data. The physical factors that enable characterization of cities (and help to identify comparable city peers) that the RAF team considered from the outset were:

- population (within municipal boundary);
- level of development (Human Development Index [HDI]); and
- climate zone.

Originally, the RAF team considered both “density” and “urban form” as comparators; however, the team developed reservations regarding their use. To use these indicators assumes, to a greater degree than the RAF team members were comfortable with, a clear relationship between them and energy use. The RAF team considered that for the developing world the relationship is not sufficiently evidenced for these indicators to provide any real value in helping a city select appropriate benchmarks for comparison. For example, while a great deal of research has been conducted into the relationship between density and energy consumption, there is no consensus on a fundamental causal relationship. The causes of density in the developed and developing world are not necessarily the same, and most of the research in this area has focused on the former.

The RAF team identified a large number of cities that would create a balanced mix of the factors that characterize the city; however, a relatively small number of these cities actually had current and reliable energy use data across the six sectors. The RAF team therefore focused the initial city selection process on the basis of data availability, as this seemed to frequently inhibit selection. First, a list of cities with varying degrees of data availability was compiled, followed by a balancing exercise to create a reasonable spread of cities across each of the three factors.

In order to obtain a reasonable number of completed sets of data for each KPI, it was agreed that the number of cities should be expanded from the original 20 to 30. In total 54 cities have been included within the benchmark cities database; the cities are presented in Appendix 1, 2, and 3 categorized according to their climate zone, population, and level of development (using the HDI), respectively.

4.1.3 Selection of KPIs

Significant effort was applied to the identification of KPIs. KPIs must be applicable to many different cities to provide reliable comparisons of sector energy use. Sufficient data must also be available to populate the database so that comparisons may be made. In reality, very few developed cities are able to provide accurate data across each of the sectors identified, and sources of accessible information become even more limited in less developed cities. This is discussed further in section 4.1.4.

Considerable debate between the RAF team and ESMAP informed the final selection of KPIs. Initially it was felt that KPIs should be of sufficient detail to enable the identification of energy efficiency recommendations from the results of the benchmarking process (e.g., pump replacement program for potable water systems). In reality, this would have required a level of detail that is usually inaccessible at the city level, so higher-level KPIs were chosen that provided indicative comparisons of sector performance. Only after a sector had been prioritized later in the RAF process would the RAF user focus on a more granular level of detail to determine the relevance of specific energy efficiency interventions.

The KPI selection process adopted the use of “relative” indicators that provide a snapshot of energy intensity early in the process, as these provide a common platform for comparison.

The principal KPIs that are used in the performance benchmarking component of the RAF are described next.

City-Wide KPIs

City-wide indicators usually include all sectors to provide an initial gauge of energy consumption. Many developed country cities have collected these indicators for carbon footprint initiatives, and many developing country cities intend to collect these indicators for the Global City Indicators Facility (GCIF). The RAF Energy Benchmarking module includes the following city-wide indicators:

1. Electricity consumption (kWhe/capita) – Electricity consumption throughout the city per person.
2. Electricity consumption (kWhe/GDP) – This is a common benchmarking indicator and normalizes for levels of economic development and industrialization. This benchmark begins to indicate a city’s overall energy efficiency across all sectors and is a good long-term tracking indicator.
3. Primary energy consumption (MJ/capita)—As in point 1, but this is a more holistic indicator for city energy use, as it includes all energy sources.
4. Primary energy consumption (MJ/GDP)—As in point 2, but this is a more holistic indicator for city energy use, as it includes all energy sources.

Transportation

Indicators in this sector benchmark transportation energy consumption for personal automobiles, public buses, waste hauling, construction vehicles, and local trains and subways. The RAF Energy Benchmarking module includes the following transportation indicators:

1. Total transport MJ/capita – Total primary energy consumption, including: electricity and fuel for trains; gasoline and diesel for cars, trucks, and buses.
2. Public transport MJ/passenger km – A good indicator of the efficiency of public transport, establishing the energy needed to move a single passenger one kilometer.

3. Private transport MJ/passenger km – A good indicator of the efficiency of private transport, establishing the energy needed to move a single passenger one kilometer.
4. Transportation non-motorized mode split (%) – Percentage of commuting trips made by non-motorized transportation modes (e.g., walking and cycling).
5. Public transportation mode split (%) – Percentage of commuting trips made by public bus, light rail, or heavy rail.
6. Meters high-capacity transit/1000 residents – Indicates the penetration of high-capacity transit systems in any city.

Buildings

This sector covers energy consumption in buildings, including: heating, cooling, ventilation, lighting, small power (appliances and electronics), domestic hot water, cooking, and other miscellaneous uses. The RAF Energy Benchmarking module includes the following buildings indicators:

1. Municipal buildings electricity consumption (kWh_e/m^2) — This indicator includes electricity used within municipal buildings, including that used for cooling, ventilation, lighting, and small power (electronics, servers, etc.).
2. Municipal buildings heat consumption (kWh_{th}/m^2) — This indicator includes heat used within municipal buildings.
3. Municipal buildings energy spend as a percentage of municipal budget — Data for this indicator are not normally readily available from public sources, but will be added to over time as the RAF is applied across user cities.

Public Lighting

This sector includes energy consumption for the illumination of roads and highways as well as traffic signals and signage. Though this sector is not necessarily a large component of a city's total energy consumption, it is a sector that has a high potential for energy efficiency investment, as it is usually controlled by the public sector and initiatives can be expanded at large scale. The RAF Energy Benchmarking module includes the following public lighting indicators:

1. Electricity consumed per km of lit roads (kWhe/km) – This indicator includes electricity consumption for illumination of streets and highways. A degree of variability will exist due to level of illumination, pole spacing, and lamp height.
2. Percentage of city roads lit — This gives an indication of the relative extent of street lighting.
3. Electricity consumed per light pole (kWh/light head) – This indicator includes electricity consumption for traffic signaling.

Power and Heating

This sector covers energy efficiency opportunities in the electrical power generation, transmission, and distribution aspects of the city energy consumption of cities. The RAF Energy Benchmarking module includes the following power and heating indicators:

1. Percentage heat loss from network — applies to district heating systems.
2. Percentage total transmission and distribution (T & D) losses — includes all losses, both technical and non-technical.
3. Percentage of T & D loss due to non-technical factors — provides an early indication if improvements in this area are worth pursuing before contacting the network operator.

Water and Waste Water

This sector includes energy consumption for drinking water supply and waste water treatment in cities. The energy used for water includes pumping energy (for extraction if groundwater is the supply), pumping energy (if water supply requires long-distance transmission), transportation fuel (if water is distributed by vehicles rather than a piped network), water treatment processes, and pumping energy throughout the water mains network. Energy use associated with waste water treatment includes pumping energy for lift stations through the collection network, waste water treatment processes, treatment/disposal of liquid/solid by-products of the treatment process, and ground transportation consumption if waste water is transported using this method. The RAF Energy Benchmarking module includes the following water and waste water indicators:

1. Water consumption (L/capita/day) – Gives a broad indication of the city-wide water consumption rate.
2. Energy density of potable water production (kWh_e/m^3) – Provides an indication of the energy efficiency of potable water networks.
3. Energy density of waste water treatment (kWh_e/m^3) — Provides an indication of the energy efficiency of waste water treatment networks.
4. Percentage of non-revenue water — Indicates total system losses, such as leakage and theft.
5. Electricity cost for water treatment (potable and waste water) as a percentage of the total water utility expenditures – Provides an indication of the relative energy intensity of water systems.

Waste

This sector is difficult to connect directly to energy efficiency, as the principal energy consuming component of a solid waste network is fuel consumed in transporting waste from buildings to treatment facilities. This will be accounted for in the transportation sector. The indicators selected will ultimately drive the reduction of energy consumption in the waste sector, but they are not directly energy indicators. The RAF Energy Benchmarking module includes the following waste indicators:

1. Waste per capita (kg/capita) — Total municipal solid waste generated.

2. Percentage capture rate of solid waste – The capture rate refers to the proportion of a targeted material that has been collected by the municipality.
3. Percentage of solid waste recycled — Indicates the sophistication of waste separation and recycling.
4. Percentage of solid waste that goes to landfill – This is indicative of the ultimate level of recovery and recycling.

4.1.4 Capturing City Data

The RAF team utilized a wide variety of sources for obtaining KPI information across each city and sector. Of most value were existing city databases, including:

- UITP (International Association of Public Transport);
- Global City Indicators Facility;
- IBNET (International Benchmarking Network for Water and Sanitation Industries); and
- ICLEI (International Council for Local Environmental Initiatives) 54 South East Asian Cities.

The UITP database was extremely useful for obtaining city transport data, providing 30 data points for each of the five transport KPIs.

The GCIF database was less helpful, as the team selected 14 cities and 9 KPIs based on their inclusion, but only Amman and Bogota contained full data sets. The GCIF provided a few data points for Toronto and Quezon City, but 10 of the GCIF cities had zero data publicly available. The RAF team is hoping that, over time, more data will be released, and these remaining 10 cities will greatly bolster the database.

The IBNET database is an extensive database for the water sector, but the critical KPIs of kWh/m3 (for potable water and waste water) are not tracked by IBNET. Since the IBNET database does not have this data, the team has undertaken city-by-city searches, including over 20 specific requests to cities that produced data for Tokyo and Hong Kong, with others coming from city development plans and utilities reports.

The ICLEI 54 South East Asian cities database was used to select 12 cities, as it had relatively high-quality data for small cities in the developing world. This database did not report on building energy use on a kWh/m2 basis, water energy on a kWh/m^3 basis, or street lighting on a relative basis.

All of these databases continue to expand every year, so over the course of the next few years greater availability of data should aid the RAF database.

No databases have been found for data relating to three entire sectors: buildings, public lighting, and power and heat. Data points for these areas have been collated or calculated from individual reports. Many of the data points for power and heat are based on national figures. The RAF team has also researched databases in the World Bank, United Nations, International Energy Agency, Watergy, and many others. The team reviewed hundreds of reports on climate change plans, energy policies, annual utility reports, and city development plans, as well as academic papers and professional journals, searching for specific data points. The RAF team is therefore confident that the level of data contained in the RAF database is appropriate for what exists in the public sphere.

The numbers of data points collected for each KPI are presented in Table 2.

Table 2: Data Points for each KPI in the RAF Benchmarking Tool

KPI Id.	Key Performance Indicator	Number of Cities Cited (with sources)
City-Wide KPIs		
CW1	Electricity consumption (kWhe/capita)	52
CW2	Electricity consumption (kWhe/GDP)	11
CW3	Primary energy consumption (MJ/capita)	44
CW4	Primary energy consumption (MJ/GDP)	14
Transportation KPIs		
T1	Total transport (MJ/capita)	40
T2	Public transport (MJ/passenger km)	27
T3	Private transport (MJ/passenger km)	26
T4	Transportation non-motorized mode split (%)	32
T5	Public transportation mode split (%)	32
T6	Kilometers of high-capacity transit per 1,000 people	28
Buildings KPIs		
B1	Municipal buildings electricity consumption (kWh_e/m^2)	10
B2	Municipal buildings heat consumption (kWh_{th}/m^2)	10
B3	Municipal buildings energy spend as percentage of municipal budget	1
Street Lighting KPIs		
SL1	Electricity consumed per km of lit roads (kWh_e/km)	11
SL2	Percentage of city roads lit	11
SL3	Electricity consumed per light pole (kWh/pole)	11
Power and Heat KPIs		
PH1	Percentage heat loss from network	11
PH2	Percentage total T & D losses	54
PH3	Percentage of T & D loss due to non-technical factors	27
Water and Waste Water KPIs		
WW1	Water consumption (L/capita/day)	44
WW2	Energy density of potable water production (kWh_e/m^3)	10
WW3	Energy density of waste water treatment (kWh_e/m^3)	9
WW4	Percentage of non-revenue water	35
WW5	Electricity cost for water treatment (potable and waste water) as a percentage of the total water utility expenditures	10
Waste KPIs		
W1	Waste per capita (kg/capita)	31
W2	Percentage capture rate of solid waste	7
W3	Percentage of solid waste recycled	15

W4	Percentage of solid waste that goes to landfill	15
	TOTAL	**691**

Of the 691 KPI figures, 107 are national figures and are applied to the city. The use of national figures is restricted to contextual data (23 /52 data points for CW1), buildings (3/10 data points for B1), and power and heat (9/11 data points for PH1-national, 45/54 data points for PH2 and all data points [27] for PH3).

Within the database and the RAF, each data point is referenced with respect to both year and source to ensure transparency. 132 data sources are used in the RAF, with many more having been researched and reviewed for pertinent data. Appendix 4 presents all of the sources used in the preparation of the benchmark database.

4.2 Sector Prioritization Module

4.2.1 Background

The second module in the RAF relates to the application of the benchmarking information, as well as some contextual city information, and its use to determine which of the RAF sectors offer the most promise for realizing energy efficiency gains. Sector prioritization filters out "less promising" areas in terms of energy efficiency potential, so that the focus of the RAF is directed on those areas that demonstrate real opportunity over the remaining part of the RAF process.

The prioritization process takes place after approximately four days of interviews and site visits, across the six RAF sectors. It is important that a "filtering" stage takes place at (or near) this point, otherwise it would limit the amount of remaining time the consultant has to further study more promising sectors.

In defining a process that can be consistently applied, readily understood, and relatively intuitive to the user, the following aspects were considered:

- the principal factors that help identify the energy efficiency opportunities;
- whether these factors are of equal importance;
- the availability of information at the stage of the mission at which it is applied; and
- the logic of the process.

This section presents the approach to prioritization and challenges that have been addressed during the design of the process.

4.2.2 High-Level Considerations

4.2.2.1 City-wide versus City-Authority-Controlled Sector Analysis

The intention of the RAF is to address energy efficiency opportunities that will ultimately benefit both the CA and the wider inhabitants of the city (i.e., city-wide). However, the CA is the principal focus for the RAF, ensuring that energy efficiency opportunities are deliverable and that energy savings are realized by the CA. However, city-wide energy efficiency opportunities are likely to be considerable, although not directly controlled by the CA, and the RAF should recognize opportunities at this level, even if implementation may be challenging due to the CA's limited capacity to act.

The first major challenge for the prioritization process was, therefore, whether to consider sectors on the basis of:

- CA control (i.e., all areas or services that a CA has jurisdiction over and consequent spend on energy), and/or
- City-wide basis (i.e., the energy consumed by private- and public-sector activities over which the CA may have limited jurisdiction).

Having worked with this challenge during the RAF validation process in Quezon City, and using both CA and city-wide approaches, the RAF team found that utilizing both approaches provided a holistic picture of city energy use. It also enabled the representatives from Quezon City government to understand energy use from the perspective of the whole city, before focussing on municipal energy use. For this reason, the RAF adopts both analyses in sector prioritization. Priorities from both analyses are used in a facilitated meeting with the RAF user and the representatives of the RAF city, to decide which of highest-priority areas to take forward.

4.2.2.2 Splitting Sectors into Subsectors

The RAF considers six energy-consuming sectors in each city:

- buildings;
- public lighting;
- transportation;
- power and heat;
- water and waste water; and
- waste.

If the RAF process used these high-level categorizations without splitting them further at the prioritization stage, there is a distinct possibility that subsectors would not be given adequate focus. For instance, a CAy may not control potable water supply, but may still be responsible for waste water collection and treatment. The RAF must therefore recognize the natural lines of possible jurisdiction in each sector, and utilize these subsector breakdowns in the prioritization process. Adopting this approach, sectors become split as follows:

- transport: public transport, private transport
- water: potable water, waste water
- buildings: municipal buildings, all buildings

All other sectors remain unaffected.

4.2.3 Prioritization Process

The prioritization process should be a practical and logical process that is relatively intuitive and easily understood by the RAF user, which provides an appropriate framework for selecting the most promising sectors for energy efficiency in a city. The principal considerations and consequent process adopted by the RAF is described in the following section.

4.2.3.1 Principal Factors Influencing the Prioritization Process

Three key considerations that are likely to be reasonably understood at the stage of the mission where sector prioritization takes place are:

- the proportionate importance of sector (or subsector) energy use or spend;
- relative energy intensity of the sector (when compared to peer cities); and
- the level of control or influence the CA exerts over a sector or subsector.

Energy Spend

The proportionate importance of sector (or subsector) energy use or spend is the first factor to consider during prioritization because it accurately apportions energy use across individual sectors.

In the field test conducted in Quezon City (see chapter 5), a sector-by-sector breakdown of energy spend at the CA level was relatively straightforward to collate (from municipal budgets and accounts). City-wide energy use was more challenging to build up; nevertheless, this was successfully achieved. On the basis that this information is likely to be available in each RAF city, it is possible to calculate the proportion of energy spend in each sector (or subsector) for the CA, and total energy consumption for each sector for the entire city.

Relative Energy Intensity (REI)

Relative energy intensity is a measure of the “potential” for energy efficiency gains in a sector, based upon the performance in the RAF user city, relative to other peer cities. Though this measure is indicative of energy saving potential and provides focus for targeting specific sectors early on in the RAF’s application, it is a relatively limited measure, as it cannot account for contextual differences between cities or the constraints and opportunities within the RAF city.

In order that the prioritization process accounts for both the results of the benchmarking exercise and the limited review of sectors in each city (to provide contextual guidance), the RAF team developed a two-stage process to enable the most refined indication of the potential for energy saving in each sector, as described next.

<u>Step 1: REI benchmarking calculation method</u>

In order to calculate an REI, it is necessary to select a single KPI for each sector (or subsector) from the list of sector KPIs that provides an indicative summary of the sector’s performance in that city.

Note that it is not practical to calculate REI on the basis of all KPIs for each sector. For instance, in the transport sector, there are six KPIs: one refers to the availability of infrastructure (meters of high-capacity transit per 1,000 people), two refer to modal preferences (transportation mode split [%]), two relate to energy use in private- and public-sector transportation (public transport MJ/passenger km and private transport MJ/passenger km), and one relates to the aggregation of the last two (total transport MJ/capita). Clearly, only one or two of these KPIs will likely be of value when using benchmarking results to indicate energy saving potential. Therefore, the RAF team identified one or two KPIs per sector that provided "indicative" performance for REI calculation purposes.

Table 3: Sector and Subsector KPIs Used to Determine REI

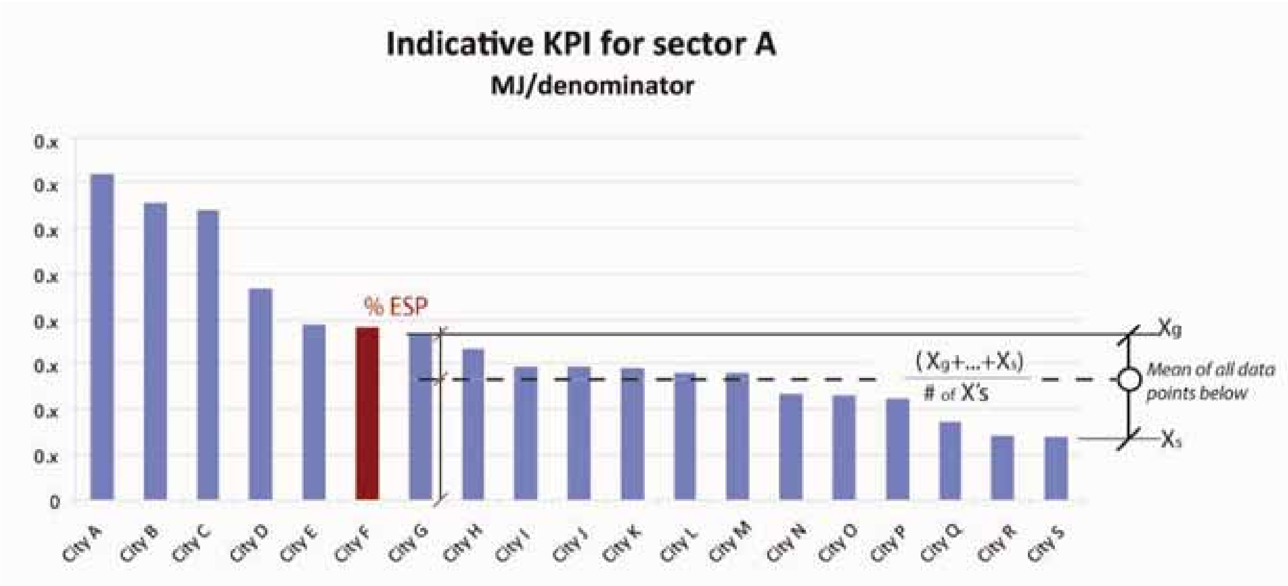
Sector	Subsector	KPI
Buildings	Municipal Buildings	B1—Municipal Building Energy Consumption (kWh_e/m^2)
Transportation	Public Vehicles	T2—Public Transportation MJ /Passenger km
	Private Vehicles	T3—Private Transportation MJ/Passenger km
Water	Supply Water	WW2—Energy Density of Potable Water (kWh_e/m^3)
	Waste Water	WW3—Energy Density of Waste Water Treatment (kWh_e/m^3)
Public Lighting	Street Lighting	SL3—Electricity Consumed per Light Pole (kWh/pole/annum)
Power and Heat	Electricity	PH2—Percentage Total Transmission and Distribution Losses
	Heating	PH1—Percentage Heat Lost from Network
Waste	Waste	W1—Average Waste per Capita (kg/capita/annum)

Using the indicative KPI, the RAF city is compared to all cities with better energy performance. The RAF city reduction target value is calculated as the mean of the values of all cities with better performance. REI is calculated using the equation 1 shown in Figure 1. Figure 1 illustrates the process of calculating REI using the Benchmarking Calculation Method, and Figure 2 provides a diagram of the REI Benchmarking Calculation Method.

Figure 1: REI Benchmarking Calculation

$$\frac{\text{(RAF city KPI value – mean value of all “better cities”)}}{\text{(RAF city KPI value)}} = \text{\% REI}$$

Figure 2: REI Benchmarking Calculation Method Diagram



This method of benchmarking is acceptable where no detailed information about a city beyond a city-wide KPI number is known. It is worth bearing in mind that benchmarking is commonly understood to be a rough method for comparing and ranking, not a rigorous method to assess improvement potential.

Step 2: Energy saving potential (ESP) estimation method

Step 2 augments Step 1 and allows the sector prioritization process to be informed by knowledge gathered as part of the early reconnaissance work undertaken by the consultant. This method requires walkthroughs of buildings, transportation, water, waste, and other networks. Additionally, it would be informed by interviews with reliable and knowledgeable individuals who know the general standards and conditions of the equipment in each sector.

Step 2 provides a series of "estimations" with pre-assigned values for differing conditions and standards. Thus, the consultant may undertake a series of building walkthroughs and interviews, and be able to quickly assign an appropriate "level" in that sector. It is important to note that this method does not require the international consultant to estimate the percentage savings of the end-use subsector, but rather to categorize the general conditions and standards of the systems and equipment in that sector. This allows a technical assessment of actual conditions in the city to be used to estimate ESP. Table 4 is an illustration of ESP estimation using Quezon City municipal buildings.

Table 4: Illustration of ESP Estimation for Municipal Buildings in Quezon City

Subsector	Subsector's % Energy Use in Sector	Category of Subsector
Offices	30%	D—20%
Schools	20%	A—0%

Hospitals	20%	C—10%
Fire/Police	30%	C—10%
Housing	0%	n/a
Aggregate Sector ESP Estimate		**11%**
Category	**Descriptions**	**Typical Savings Range (%)**
A	Some buildings have opportunity for basic lighting upgrades, but most systems are new *or* most buildings are underserviced and designed very sparsely	0−2
B	Mix of old and new buildings where lighting upgrades seem consistent, and some A/C or heating systems could be upgraded	2−5
C	Some large buildings with major upgrade opportunities, but mostly old, smaller buildings	5−10
D	Majority of old buildings with: old lighting at >20W/m2, old A/C with COP < 3.0, old heating with efficiency < 0.7, old elevator/pump motors	10−20

The RAF is designed to calculate the REI value for each sector when the benchmarking process has been completed. Therefore Step 1 is calculated automatically. When the RAF user goes into the REI section of the Sector Prioritization module, there is an "override" button that enables the user to refine the REI score based upon Step 2. Where this is used, the RAF user is directed to complete a comments box to indicate why the changes have been made.

The determination of REI has been one of the most challenging aspects of the RAF design. The RAF team has developed an approach that links the benchmarking process to prioritization, while allowing for modification based upon site context. While the overall accuracy of this process may be questioned, two issues should be kept in mind. The prioritization process takes place with limited detailed information, and that information is used to decide between sectors, not define energy efficiency recommendations. On balance, given the challenges, the RAF team members are confident that the two-step process will provide adequate guidance on the energy saving potential of the sector.

Control or Influence

The level of control or influence the CA exerts over a sector (or subsector) is of particular importance, as it defines the CA's capacity to act, and therefore its ability to implement change. This is particularly challenging to define; however, the RAF team has endeavored to establish attributes (or scores) to help classify levels of influence or control to guide the consultant in the prioritization process. These are shown in Table 5.

Table 5: Definition of Weighting Ranges for Varying Levels of CA Control or Influence

Control Level (Range)	Definition of Level of Control or Influence
(0.01–0.05)	**National Stakeholder**—CA is represented or consulted, alongside other CAs, at national-level policy formulation. CA has no specific advantage over other CAs.
(0.05–0.15)	**Local Stakeholder—**CA is represented or consulted as a local stakeholder on issues outside of its jurisdiction.
(0.15–0.25)	**Local Committee Representation**—CA leads or takes significant role in local policy formulation (e.g., planning).
(0.25–0.50)	**Multi-agency**—CA has some control of one or more aspects of the sector (regional, regulatory, budgetary), but will need to work with other agencies to introduce change.
(0.50–0.75)	**Principal Policy Formulator**—CA is responsible for formulating policy or local regulations, but may not have an enforcement role.
(0.75–0.95)	**Regulator/ Enforcer**—CA has strong regulatory control over the sector and is able to create and enforce legislation, and where possible sanction perpetrators.
(0.95–1)	**Budget Control**—CA has full financial control over the provision of services, purchase of assets, and development of infrastructure.

The CA's ability to control or influence a specific sector or subsector is used as a weighting factor in the prioritization process. The RAF module allows the user to define both the level of control and where in the range the city should be positioned.

4.2.3.2 Assessing Priority Sectors

In order to provide an overview of the relative priority of individual sectors or subsectors in both the CA control and city-wide analyses, a simple multiplication of the three factors takes place:

Energy Spend ($) x Relative Energy Intensity (%) x CA Control or Influence (weight) = Output

4.2.4 Choosing Priority Sectors

The final output of the Sector Prioritization module is a screen with two tables (CA Control and City-wide) of ranked sectors.

The RAF user is guided to present these tables to the city leadership team and, through discussion and agreement, decide upon the most appropriate and viable sectors for further focus in the next stage of the RAF application. This process is a necessary step to engender understanding and buy-in with the city leadership.

4.3 Energy Efficiency Recommendation Module

The third module of the RAF is perhaps the most significant in terms of both information resource and process. The Energy Efficiency Recommendations module is home to all of the energy efficiency interventions across the six principal sectors and their subsectors. The module also includes guidance on the financial options available to CAs to fund energy-efficient investments. The module incorporates a process through which recommendations in priority sectors may be reviewed against the contextual opportunities or constraints within the city, a set of Excel-based calculator tools that can be utilized by the RAF user to estimate energy savings associated with technical interventions, and a means of structuring and reviewing recommendations based upon specific criteria, such as "first cost" and "speed."

4.3.1 Energy Efficiency Recommendations Content

The principal aims of the recommendation are two-fold:

- to provide enough information to the RAF city to inform the city of the intervention, its benefits, and the various methods through which it can be implemented; and
- to capture and utilize information on each recommendation that accurately characterizes a range of factors or attributes that define it—for instance, speed of implementation or first cost. This information can then be used in a comparative manner, to help determine which recommendations are likely to be useful in the context of the RAF city.

Recommendations are not intended or designed to provide detailed implementation advice, nor provide a guarantee of viability or practicability in a given city context. Moreover, they are provided as a starting point for further examination and consideration both during the RAF process and thereafter.

4.3.1.1 Energy Efficiency Recommendations Development

Energy efficiency recommendations were conceived in the project ToRs for the RAF as "*an analytical toolkit...to guide the CA to various intervention options – each with links to existing tools, reports and case studies.*"[4]

For each of the principal RAF sectors, a "sector specialist" was appointed within the RAF team. The specialist's principal role was to advise on energy efficiency recommendations in his or her sector of expertise. The sector

[4] Terms of Reference: Energy Efficient Cities Program: Development of Rapid Assessment Framework, Para.26

specialist's scope was not unnecessarily constrained at the outset of the project, save for the necessity to gear recommendations to the aims identified in section 4.3.1. Guidance used to develop recommendations can be summarized as follows:

- the RAF's principal focus is CAs: recommendations should be geared toward energy efficiency in areas that are controlled or significantly influenced by CAs. As such, private residential areas and industry are largely excluded from the process, unless issues may be managed through legislation (e.g., green building codes);
- for each recommendation, a number of implementation activities (or "levers") and scales of implementation should be defined to suit the widest range of city contexts;
- for each implementation activity, a representative case study, external guidance, or toolkit is identified and described with live linkages (wherever possible) and other references;
- each recommendation should have suggestions regarding the method of measuring and monitoring progress, including KPIs; and
- each recommendation should have a common set of attributes defined.

In total, 59 recommendations and 191 case studies have been developed that are consistent with this guidance. A complete list of the recommendations and case studies is provided in Appendix 5 and 6.

4.3.1.2 Recommendation Components

Each recommendation has been designed with a generic document structure. The documents are stored in the body of the RAF in HTML format, and can be easily printed for reference. The structure is as follows:

Description: this provides a brief overview of the recommendation and highlights the key benefits with respect to energy efficiency and other co-benefits such as air quality improvement or carbon reduction.

Implementation Options: each recommendation usually has a number of different options for implementation. These may relate to the type of lever (e.g., regulatory intervention, direct investment, etc.) or to the scale. In some instances, low-key implementation activities are identified that require low capital investment and partnering relationships; these may become capital intensive to implement when scaled up. In each case, the purpose of the descriptive text in this section is to introduce the concept. The RAF team has endeavored to provide case studies for each implementation activity, and these provide more detail regarding the application of the implementation option.

Monitoring: each recommendation contains generic text providing guidance on how a monitoring program should be established, followed by some suggested measures that relate to the recommendation. KPIs are also identified where these are the most practical means of undertaking monitoring. This forewarns the city of the type of data that will be needed before the recommendation is implemented.

Case Studies: a significant proportion of the effort required to develop the recommendations has gone into case study research. The RAF team adopted the view that case studies provide practical guidance, innovative approaches to challenges, and useful quantitative data that provide an indication of the possible financial benefits. In many cases they also cover procurement routes.

Tools and Guidance: where possible, the RAF team has identified existing guidance or tools that provide finer detail on the application of specific measures. Tools and guidance are provided by a range of organizations in both the public and private sectors. Where they have been identified, tools and guidance are hyperlinked or referenced in the text of the recommendation.

Attributes: attributes is the term given to facets of the recommendation that are key to decision making. The attributes included in the recommendations are:

- energy savings potential;
- first cost (i.e., capital investment); and
- speed of implementation.

Initially, information was collected through case studies, where available, and the intention was to use this information to populate attribute "ranges" (e.g., first cost \$10−12 m). However, in many cases, insufficient quantitative information was available or values varied widely within recommendations, depending upon the implementation activity adopted.

Attribute data are used in the "process component" of the recommendations section to help differentiate between different recommendations (see section 4.3.2.2). It was therefore necessary to ensure that reliable and credible information was incorporated, bearing in mind the challenges identified earlier.

The issue was resolved by adopting attribute ranges (three per attribute) based upon the quantitative information provided in case studies. Each recommendation has an attribute score based upon the mid-range of this information. Where this was absent, the sector specialist was asked to choose an appropriate range. Quantitative information specific to individual case studies has been retained within the case studies. This gives the user the opportunity to identify the implementation option that is most suitable and check the attribute information contained within the accompanying case study.

Attribute ranges used within the recommendations tools are shown in Table 6.

Table 6: Attribute Ranges Used in the Energy Efficiency Recommendations Module

Attribute	Lower		Higher
energy savings potential	Minimal <100,000 kWh/annum	Moderate (also indirect/ inaccessible*) 100,000 kWh/annum< x < 200,000kWh/annum	Significant >200,000 kWh/annum
first cost (i.e., capital investment)	< 100,000 USD	100,000< x <1m USD	>1 m U.S. dollars (USD)
speed of implementation	<1 year	1–2 years	>2 years

Numerous recommendations have indirect or inaccessible energy savings potential when the RAF is applied, but in many cases they may be measurable at a later stage. Recommendations relating to "Traffic Restraint Measures" or a "Water Meter Program," for example, should not be placed in the minimal range. They have instead been placed in the moderate range. The RAF user has the opportunity to upgrade or downgrade this position in the Recommendations Review component of the Recommendations module.

4.3.1.3 Energy Savings Assessment

To establish the viability of the individual recommendations, the technical energy savings potential should be estimated wherever possible. Recommendations within the RAF tend to fall into two categories: those for which an estimate of savings is possible, and those for which the savings are either indirect or inaccessible during the course of the mission. Twenty-three recommendations have been identified for which energy savings assessments can be made. For each of these recommendations a calculator has been produced. All the calculators are contained within a single Excel workbook—"Energy Savings Assessment Calculator"—accessed through the Documents tab on the home screen. A screen shot of the "Water Fixture and Fittings" calculators is shown in Figure 3. RAF users are required to capture the necessary base information to enable the calculator to work (light green cells). Information requirements for all calculators are contained within sector workbooks found in the Documents tab on the home screen.

Figure 3: Screen Shot of the Water Fixtures and Fittings Calculator

Fixtures and Fittings Calculator

Recommendations Reference: 07 Water Efficient Fixtures and Fittings

Attributes	Current Water Consumption							Post-Upgrade Water Consumption						
	Uses per day	Flow Rate (l/min or l/flush)	Flow Duration (min or flush)	litres/use	l/person/day	Energy per litre (kWh)	Total kWh per day	Uses per day	Flow Rate (l/min or l/flush)	Flow Duration (min or flush)	litres/use	l/person/day	Energy per litre (kWh)	Total kWh per day
Shower	1	15	4	60	60	0.0013	0.08	1	9.5	3	29	29	0.0012	0.03
Toilet	7	10	1	10	70	0.0013	0.09	7	6	1	6	42	0.0012	0.05
Taps	10	12	0.3	4	36	0.0013	0.05	10	8.3	0.3	2	25	0.0012	0.03
Total							**0.22**							**0.11**

Total Energy Savings	37 kWh / annum /person
Percentage Improvement	0 %
Total Cost Savings	6 $ / annum /person

Guidance:

The calculation tool provides for an estimate for the energy consumption in light of potential changes to the fixtures and fittings to indirectly reduce water consumption. The user should also include details of any cost saving that may also be incurred through arrangement of a new electricity tariff (regardless of if any energy savigs can be achieved). To begin using the tool, the user is required to complete the information required in the orange shaded cells. The user nees to provide the following in the 'Current Energy Consumption' table:

i. Uses per day
ii. Flow Rate (litres/day or litres/flush)
iii. Flow Duration
iv. Energy required to supply one litre of water (kWh)
v. Electricity Tariff

Inputting all of these factors will create the baseline energy use. To determine the Total Energy Savings, the user needs to determine which attribute they wish to target in the 'Post-Retrofit Energy Consumption'. The tool will assume that all fixtures and fitting systems selected for upgrade are improved to a benchmark efficiency rating, and therefore calculate the maximum possible Total Energy Savings, Percentage Improvement, and Total Cost / Carbon Savings.

[COMP: in "Guidance" section of Figure 3, 1st para, last line, use double quotes; in list, cap first word of each item only; in last para, first line, change "they" to "he or she wishes"; last para, 2nd line, use double quotes and place end period inside quotes; last para, last line, close up spaces around slash]

4.3.1.4 Financing

The options available to CAs to finance energy efficiency interventions are incorporated into the RAF as a separate document accessed through the Recommendations and Documents and Guidance modules. Initially it was proposed to incorporate funding within the context of individual recommendations, but these became confused with implementation options, and repetitive. The finance document is designed to apply across the broad spectrum of recommendations and provide summary guidance to established, as well as innovative, mechanisms. A summary table of finance options contained within the RAF is presented in Appendix 7.

4.3.1.5 CA Management Recommendations

CA management recommendations refer to aspects of energy efficiency management in the CA that are not readily incorporated in the sector analysis. The need for a selection of recommendations that relate to how energy efficiency improvements could be accessed through changes to common practices in the CA was identified in the Quezon City field test and validation phase of the RAF's development. These recommendations are related to procurement, capital investment, and internal practices, and are given a "free pass" in the RAF process on the basis that if the CA is not doing them already, the CA should consider them. CA management recommendations first appear in the Recommendations module. They can be filtered (for instance, if the CA is already implementing such measures), but more realistically many of them will make their way to the final recommendations on the basis of their strength. They are likely to be low-cost, relatively easy and quick to implement, and will help the CA to undertake some of the more significant recommendations that will be adopted as a result of the RAF's application.

4.3.2 Energy Efficiency Recommendation Selection Process

The RAF's principal purpose is to provide a practical analytical framework that enables users to identify the most suitable energy efficiency recommendations for their city. It is therefore necessary to ensure that, after priority sectors have been identified, the list of potential recommendations is reviewed using a logical and practical process to filter out those that are unsuitable to the RAF city.

The energy efficiency recommendation selection process has been designed to match final recommendations to the contextual conditions within a user city, and provide a flexible analytical framework for deciding between those that compete. This process is described and illustrated in the following sections.

4.3.2.1 Initial Appraisal

The initial appraisal process is designed to match city conditions with minimum requirements for the successful application of the recommendation. This process may be summarized as follows:

- The RAF user selects a sector or subsector in the initial appraisal section of the recommendations tool;
- The RAF user is directed to choose a statement that most accurately describes the existing situation in the city with respect to five critical success factors (described in the following section);
- The RAF user is presented with a table that displays the city conditions alongside individual "minimum" conditions for each recommendation. Recommendations are ranked using a simple traffic light coding system based upon the number of matches; and
- All recommendations are selected as a default; un-checking them deselects and rejects the recommendation from further consideration in the module.

Defining City Context and Minimum Requirements for Recommendations

A number of factors may be used to categorize a variety of barriers to implementing energy efficiency activities. The RAF team undertook research in this area, and the principal literature sources and factors are outlined in Table 7.

Table 7: Classification of Barriers to Energy Efficiency Improvement in Two Key Literature Sources

UNEP (2006)[5]	IPCC (2001)[6]
Management	Market structure and functioning
Knowledge/information	Information provision
Financing	Financing
Policy	Institutional frameworks
	Social, cultural, and behavioral norms and aspirations
	Prices
	Trade and environment

These factors were synthesised into a workable group of critical success factors that could be applied in the context of the RAF, as follows:

- finance: defines the level of sophistication and experience of the CA with respect to funding mechanisms;
- human resources: defines both the capacity and expertise of CA personnel;
- data and information: defines the availability of data and sophistication of measuring and collection systems;
- policy, regulation, and enforcement: defines the CA's powers to introduce and enforce legislation; and

5 UNEP (United Nations Environment Program). (2006). Barriers to energy efficiency in industry in Asia—Review and policy guidance. Available online from http://www.energyefficiencyasia.org/brochure_pub.html.

6 IPCC (Intergovernmental Panel on Climate Change). (2001). Chapter 5. Barriers, opportunities, and market potential of technologies and practices. Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Available online from http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg3/index.htm.

- assets and infrastructure: defines the presence, ownership, and control of assets or infrastructure.

For each critical success factor, a range of levels was defined for each sector and subsector. This is illustrated in Table 8.

Table 8: Typical Levels of CA Competency and Energy Efficiency Opportunity for Each Critical Success Factor

Level of CA Competency			
Success Factor	**Low**	**Medium**	**High**
Finance	Funding is available from municipal funding streams only. CA has no experience of other financial or partnering mechanisms.	CA has experience of: public private partnerships, some experience of other streams such as grants, soft loans, and commercial funding.	CA has relevant experience of some of the following: performance contracting, carbon finance, and other innovative funding mechanisms.
Human resources	CA has few technically skilled staff and/or a small available workforce. Staff can be trained/workforce expanded as part of the recommendation.	CA has access to a highly trained/skilled person to lead the initiative and/or a medium-sized workforce available. Staff can be trained/workforce expanded as part of the recommendation.	CA has access to considerable trained/technically proficient staff resources.
Data and information	Little reliable data. No advanced information collection capabilities. This can be developed as part of the recommendation.	Some reliable and accurate record keeping/data exist. Data management systems are relatively unsophisticated. This can be developed as part of the recommendation.	CA has reliable and accurate data and sound survey/monitoring systems. CA has advanced information collection capabilities.
Policy, regulation, and enforcement	CA is responsible for strategic planning, but engagement with other agencies is weak. CA has limited capacity to regulate at the local level. Enforcement is weak.	CA has freedom to regulate elements of the "issue." Enforcement is in need of strengthening.	CA is responsible for all strategic planning. CA engages effectively with other agencies. CA has enforcement powers that it uses effectively.
Level of Energy Efficiency Opportunity			
Assets and infrastructure	"Issue" assets or infrastructure is either owned by others (national or private sector) or maintained by others; minimal "issue" alternatives; infrastructure non-existent or badly maintained.	CA owns components of the "issue" assets or infrastructure. CA has undertaken feasibility work or trials in the past.	City has reliable and effective "issue" assets. CA owns infrastructure and assets. CA has not undertaken trials or feasibility work.

The use of critical success factors and the definition of levels proved to be a useful mechanism for assigning minimum requirements for individual recommendations and thereby differentiating between them. As the

RAF city is assessed against the same factors, a straightforward appraisal of the suitability of recommendations in each sector is possible. Suitability is displayed utilizing traffic light coding, determined as follows:

- red: city meets or exceeds one or less minimum requirements;
- amber: city meets or exceeds two to three minimum requirements; and
- green: city meets or exceeds four or more minimum requirements.

The initial appraisal process provides an indication of the potential success of each recommendation within the RAF city. However, variability and complexity exist in both cities and recommendations. In recognition of this, the Initial Appraisal module does not actively filter out any recommendations. It is instead the role of the RAF user to take account of the appraisal and select recommendations for further development on the basis of this and any additional contextual knowledge he or she may possess.

4.3.2.2 Recommendations Review

The recommendations review component of the Energy Efficiency Recommendations module gives the RAF user the opportunity to:

- review all selected recommendations with respect to their “attributes” (see section 4.3.1.2) to ensure satisfaction with the levels assigned; and
- assess all recommendations on the basis of their attributes using a simple matrix.

These two facilities are expanded upon in more detail in the following section.

Final Review of Recommendations

The output of the Initial Appraisal guides the RAF user to a detailed examination of a number of specific recommendations. This will include the estimated energy savings potential for technical recommendations. The RAF user will have gathered progressively more detailed data and information, explored different implementation options with responsible CA departments, and developed an understanding of the recommendations with greatest potential.

The review component of the tool enables the RAF user to revisit each recommendation and ensure that all the attributes accurately reflect the observed situation. In section 4.3.1.2 ,the way in which attributes have been developed is discussed. The RAF user has the ability to modify attributes in the Review screen by using an override button. Attributes can be changed from the selected range to another, but the RAF user must record the reason for the change so that this may be reviewed if required. The rationale for refining attribute designations relates largely to the choice of implementation option, especially where implementation options differ widely. For instance, in the waste sector, the “Waste Composting Program” recommendation includes implementation options ranging from household composting to city-wide green waste collections. Similarly, in the transport sector, the “Parking Restraint Measures” recommendation starts with planning measures and extends to the development of park-and-ride facilities. Thus, it is the responsibility of the RAF user to ensure that the attributes assigned to each recommendation are appropriate.

Assessing Recommendations

The final tool within the Energy Efficiency Recommendations module enables the RAF user to compare recommendations with respect to each attribute. The tool uses a 3 x 3 matrix that displays energy savings potential against first cost; a further attribute (speed of implementation) is also displayed through the application of a simple screen (check boxes above the matrix). For instance, if the user only wanted to view recommendations that are usually implemented within 12 months, only that box would be checked. When the matrix is displayed, those recommendations in the top right-hand corner are the most favorable (i.e., least cost, highest energy savings potential, etc.), and those in the bottom left, least favourable. The matrix can be exported if required for presentation or reporting purposes by using the Export button, although it is envisioned that the RAF user would utilize the matrix during the final meeting with the city leadership team to compare and select recommendations.

A final screen in the RAF allows the user to select and prioritize recommendations for development. This information would be used to complete the City Energy Efficiency Report.

4.4 Supporting Documentation

In order to ensure a consistency of approach to the RAF process, regardless of user, the RAF team has produced a series of guidance documents and templates accessed through the Home Screen/Documents tab. The documents enable the smooth running of the process and ensure that the RAF user is adequately briefed to collect appropriate information at the correct time. Documents are organized into pre-mission, mission, and post-mission phases. The guidance documents are listed and described in Table 9.

Table 9: Supporting Documentation in the RAF

#	Document	File Type	Description
Pre-mission			
City Starter Pack			
1	Introduction to the RAF	Word	RAF overview, objectives, mission requirements, data requirements, logistics, outputs, etc.
2	RAF City Contact Details Pro Forma	Word	Who's who in the city/details
3	RAF team Contact Details Pro Forma	Word	Who's who in the RAF team/details
Consultant Starter Pack			
4	Typical Mission Agenda	PDF	Generic requirements for context, sector agencies/frameworks, CA boundaries, CA policies, benchmarking data
5	City Background Data Requirements	Excel/ PDF	
6	Background City Report Template	Word	Report template
7	Background City Report Template Appendix	Word	
Mission			
8	RAF Tool Guidance Document	PDF	How the tool works
9	Meeting Register	Word	Pro Forma
10	Meeting Notes	Word	Pro Forma
11	RAF Intro Presentation	PowerPoint	Generic content + benchmarking results
12	Prioritization Presentation	PowerPoint	Generic content + consultant inputs
13	Workbook: Transport	PDF	WORKBOOKS: Sector and process-wide elements for undertaking the RAF, structured as follows: organizations/ structures, initial meeting checklists, data and energy cost checklists, recommendations matrices, initial appraisal questions, detailed data requirements for recommendations
14	Workbook: Water	PDF	
15	Workbook: Waste	PDF	
16	Workbook: Public Lighting	PDF	
17	Workbook: Power and Heat	PDF	
18	Workbook: Buildings	PDF	
19	Energy Savings Assessment Calculator	Excel	Technical energy savings potential calculation workbook for recommendations
20	Final Presentation	PowerPoint	Generic content + consultant inputs
Post-mission			
21	Final City Report Template	Word	Pro Forma
22	Final City Report Appendix Template	Word	Pro Forma
23	Financing Energy Efficiency Services	PDF	Guidance document

5 RAF Testing and Validation: Quezon City, Philippines

5.1 Background

As part of the design development process, the Rapid Assessment Framework (RAF) was subjected to field testing and validation in Quezon City, Philippines, in February 2010.

Originally it had been intended that the field testing component of the commission would take place toward the end of the development process (June 2010); however, for political reasons (an impending city election), the field testing schedule was brought forward to February (prior to the election) to ensure the participation of the city leadership team.

The issue of the timing of the field test is relevant because it meant that the RAF was “partially” developed when it was applied. The disadvantage of this is that a true validation of the RAF ‘”s designed” was not possible; however, the overwhelming advantage was that it enabled the experience and outcome to positively influence the RAF design at a critical stage.

The field test and validation exercise had two principal objectives: to provide Quezon City government (QCG) with recommendations to improve energy performance, and to validate and test the RAF.

5.2 Field Test

Utilizing information gathered during the pre-mission stage through a combination of local consultants and researchers, the RAF Energy Benchmarking module was utilized at the outset. This analysis provided a number of significant insights that helped focus activity during the early part of the study and contributed to the definition of priority sectors for further research. Principal findings included:

- high electricity use per capita;
- high patronage of public transport, but equally very high energy consumption by public transport,
- low city-wide energy use on public lighting (although this was later found to be a major component of QCG energy expenditure); and
- high water consumption per capita.

At an early stage, interviews were held with a range of QCG departmental personnel and representatives from a range of city agencies. Information gathered during this period enabled a classification of each sector based upon the degree of control exerted by the QCG, the potential for technical energy savings in the sector, and the relative spend on energy in each sector. On the basis of these findings, a sector prioritization process was undertaken. Although this process was subject to further development after the field test, the analysis concluded that the transport, buildings, and public lighting sectors were priority sectors for further investigation. However, as the study also had the objective of validating the RAF, all sectors were reviewed further during the course of the mission.

The latter part of the study involved further interviews and site visits. These enabled detailed systematic filtering of all of the RAF energy efficiency recommendations currently contained within the RAF to examine their suitability in Quezon City. This process demonstrated that a large number of recommendations were:

- potentially technically and/or financially unviable;
- outside of the direct control of the QCG; or
- already being implemented or put through trials.

The review established that there was considerable sectoral energy efficiency activity taking place in Quezon City currently, as follows:

- Public lighting: programs were currently under way, including audit and retrofit, new design guidance, and the trial of new lighting technologies.
- Buildings sector: a new green building code was in place, and Quezon City was undergoing a detailed buildings energy efficiency program sponsored by the World Bank.
- Privatized water companies: seemed particularly adept at managing energy use and considered energy efficiency as a central component of their ongoing efficiency programs.
- QCG has no jurisdiction over the supply of power and heat and no recommendations were found to be suitable in this sector.
- Waste sector: collection and transportation was contracted out to third parties and no financially viable recommendations were considered practicable. Good practice with respect to wastes management was observed with neighborhood waste recovery taking place at the Barangay level and, at the larger scale, a landfill gas capture and energy generation project at the Payatas landfill site.
- Transport: the major city-wide energy consumer was proving difficult to control by the QCG. Much of the transport sector is either under private ownership (jeepneys and tricycles), licensed by national authorities, or, in the case of infrastructure, planned and developed at a metropolitan level.

5.3 Energy Efficiency Recommendations for Quezon City

Most of the activities currently under way in Quezon City were successfully identified by the RAF, although not pursued further due to their ongoing nature. Of the energy efficiency recommendations currently incorporated into the RAF, eight were deemed a high priority for Quezon City. These covered the water, buildings, and transport sectors, as well as improvements to current procurement processes, investment programs, and the administration of energy efficiency activities across QCG departments. These were as follows:

- Municipal fleet maintenance program: the fleet maintenance program was selected because there are 850 vehicles owned and maintained directly by QCG and, currently, there is no existing maintenance procedure specifically focused on fuel efficiency.

- Engine efficiency improvement program: this program applies to the 17,000 tricycles in Quezon City that would benefit from an engine replacement program. As Quezon City is the sole regulator for franchised tricycles, the mayor has complete control to legislate and enforce this program. Tricycles with replacement engines will result in lower operational costs for owners and cleaner air for the residents of Quezon City.
- Walking/cycle path development program: the walking and cycle path program was selected due to the high mode split of walking and cycling (21%) and the observed limited number of dedicated cycle lanes. A goal of 10 km of new bike paths per year for the next four years could be achievable, with corresponding increases in the safety, access to, and integration of bike paths.
- Procurement guidelines for life cycle costing: this recommendation requires changes to existing procurement processes for buildings and capital equipment to incorporate whole life costing (i.e., capital and operational expenditure) rather than just capital expenditure.
- Five-year capital planning for energy efficiency retrofits: this relates to the development and approval of a five-year planning strategy for upgrading existing QCG buildings. The strategy should be incorporated into the annual budget to provide for expenditure on building renovation. Such a long-term plan can be used to attract energy efficiency funding or capital funds to realize the many opportunities Quezon City has for energy efficiency.
- Water infrastructure planning: this recommendation relates to QCG support to Manila Water and Maynilad to locate critical water infrastructure equipment in the most energy-efficient locations. Electricity costs for pumping water are over 15% of the total operational costs for both Manila Water and Maynilad, which is their second largest operational expense after staff costs.
- Energy efficiency task force: the mayor's task force on energy efficiency is an important recommendation because it allows for a central driving force to focus the city's efforts on energy efficiency in one team, enabling prioritization of efforts and resources according to the highest opportunity and lowest costs.
- Advanced energy efficiency procurement: this recommendation requires the introduction of procurement guidelines to support energy performance labeling and standards for smaller purchases, such as computers and fax machines.

5.4 Lessons Learned

These energy efficiency proposals are supported by Recommendation sheets providing further information to help the QCG implement each measure and monitor its progress.

With respect to the second objective of the mission, the field testing and validation of the RAF, the team learned a number of valuable lessons regarding both content and process that were usefully applied in its subsequent further development.

The principal observations were as follows.

General Observations

Quezon City is possibly too advanced, on the basis of existing energy efficiency programs, to be a typical candidate for the application of the RAF. It already has a number of programs in place assisted by both the World Bank and the Asian Development Bank. Data were therefore possibly easier to obtain, and recommendations less technical, as many of the major opportunities, such as public lighting retrofits and building energy efficiency measures, are already being pursued.

The use of local consultants was highly beneficial, but many doors remain closed to them. The international consultant fared much better, but it was the presence of World Bank staff that seemed to ensure that both arrangements and access were guaranteed. Future RAF missions must take account of the importance of these observations and try to ensure that representation from the funder is available wherever possible.

Pre-mission

During the pre-mission information gathering stage, the international and local consultant found difficulty in communicating effectively with Quezon City officials. Both parties found that access to representatives of the QCG and background energy use data were difficult to obtain. This was largely because:

- QCG representatives wished to deal directly with the World Bank rather than the international consultant; and
- the local consultant did not manage to obtain written authorization (requested by the international consultant and the World Bank) ahead of the mission, making it challenging for the local consultant to gather essential data.

Allied to this, there was the possibility for confusion among QCG representatives as to the exact nature of the study, as at least two other World Bank–funded programs with similar energy efficiency aims were under way concurrently. This challenge highlighted the need, during the design and implementation of the RAF, to ensure that a clear and prescriptive approach to the pre-mission stage be defined. This should include a pre-mission information packet introducing the RAF and the exact nature of the data and information requirements to the city authority (CA), pre-assignment of representatives in the CA to aid data gathering in specific areas, and mayoral endorsement of the project and written authorization to galvanize support for the local and international consultant. In addition, it was suggested that a longer schedule would enable information gathering to take place. The consultant also reconsidered and reduced the range and depth of information required pre-mission to concentrate on those elements that are absolutely essential to both the city-specific context and the benchmarking process.

Energy Performance Benchmarking

While there were initial challenges to obtaining energy performance data, enough information was obtained to enable performance comparisons across each of the six sectors (largely due to publicly available information provided on the QCG website). In practice, the consultant found that comparing performance of the RAF city to peer cities was a particularly effective means of engaging QCG representatives. They were keen to review and understand more about benchmarking (where data was derived from, boundaries, etc.), and its presentation was of evident interest.

Energy performance benchmarking is undoubtedly a process that provides a high-level indication of where, in the context of the RAF, further effort and focus should be applied. But, the results should be interpreted with a degree of caution due to the current relative scarcity of principal datasets. While the database of energy performance in cities is developing, it will, during the initial phases of the RAF implementation, provide a mosaic of data. It is suggested, therefore, that ESMAP require RAF candidate cities to agree to share their city energy performance data (i.e., incorporating it into the RAF) so that the RAF database of energy performance data grows over time.

The response to energy performance benchmarking by QCG representatives leads the consultant to believe that the presentation of energy performance must be carefully considered prior to the delivery of any message to a wider audience. There are potentially significant implications to demeaning city performance that may be counterproductive in the remaining phases of the RAF mission. Benchmarking must therefore both engage the CA and garner the CA's support to make the mission productive through positive and constructive communication.

Identifying Priority Sectors

The identification of priority sectors is required after the consultant has had approximately four to five days to interview representatives across all six sectors, and assimilate information and observations. While prioritizing sectors can be aided by quantitative information such as "city spend," in practice there is not a straightforward and empirically based formula for deciding upon priority sectors. During the course of the Quezon City mission, it was clear that the principal factors in prioritization were:

- relative energy intensity/technical energy savings potential (i.e., by what sort of percentage could energy demand be reduced across the sector);
- the CA's ability to control or influence the issue; and
- spend or proportionate energy use.

Difficulties were experienced in effectively ranking between energy use under the direct purview of the CA (i.e., QCG government spend) and city-wide energy use.

The Quezon City mission benefited the consultant by focusing attention on the challenges of:

- linking energy performance benchmarking results to the sector prioritization process;
- the definition of levels of control or influence that a CA may exercise over a particular issue; and

- the aggregation and relative comparison of two quite separate, but intrinsically linked, components of city energy use: whole city energy use and CA energy use.

These challenges were taken up post-mission, through the development of a number of options to define a logical process that may be consistently applied. This process assimilates contextual, quantitative, and qualitative information to derive a sound means for identifying priority sectors. In Quezon City, it was apparent that the RAF sector prioritization results were no surprise to QCG representatives. This was beneficial insofar as it served to confirm both their actions and prior assumptions, although Quezon City had not compared all of the sectors together in the way that the RAF compared them on a quantifiable basis.

6 Conclusion and Next Steps

It is inherently challenging to create an analytical framework and decision support tool such as the Rapid Assessment Framework (RAF). A fine balance needs to be struck between its formal processes that deliver reliability and consistency and its adaptability to a wide range of city contexts. The RAF team has debated at length the pros and cons of individual system components, how they may perform and with what level of accuracy. Numerous iterations of component design were undertaken in order to allow for a broad range of potential city characteristics and institutional arrangements. The result is an analytical tool that firmly guides users, while providing flexibility to refine inputs and outputs if there is a sound rationale for doing so.

Considering the major components of the RAF design and development, summary observations relating to both the current situation and future possibilities are discussed next.

6.1 Energy Benchmarking Module

From the outset, the RAF team struggled to find data from existing, concentrated sources. The population of the RAF database resulted in extended research using disparate sources. The scarcity of a concentrated source of data on city energy use suggests, first, that such data have not been aggregated in this way before, and, second, that the current RAF database is both unique and valuable. The RAF database will grow in size and complexity as cities use the tool and incorporate their city data. More granular data can also be collected through incorporation of data from the recommendation calculators and, cities willing, monitoring data from recommendations that have been implemented. Potentially this data source has value well beyond the application of the RAF.

6.2 Sector Prioritization Module

The basis for the prioritization process was tested in Quezon City and proved both credible and practical. Potentially, further factors could be incorporated into the process at a later stage if deemed relevant. The definition of relative energy intensity (REI) is possibly the most challenging factor to determine, as it is based either on the relative performance of higher-order key performance indicators (KPIs) or estimations based on walkthroughs or site visits, all within a short period of time within the city. The RAF team is interested in establishing the extent to which the REI calculation is considered accurate by practitioners, and if there are regular inconsistencies between REI calculations and consultant estimates.

6.3 Energy Efficiency Recommendations Module

A wealth of information has been published on energy efficiency interventions at all scales. The RAF Energy Efficiency Recommendations tool has sought to select the most appropriate range of interventions for application by a city authority (CA), and provide suitable options for implementation as well as practical guidance with respect to suitability for the RAF city. One of the principal challenges for RAF in its current form relates to the broad range of implementation options (each with differing attributes) and the assignment of a single set of attributes to the recommendation. This is significant because the Review component of the

Recommendations module utilizes attribute information to help distinguish between competing recommendations. While it is possible for the RAF user to update attribute information using quantitative information contained within associated case studies, this is an imperfect solution, as a significant number of case studies relating to a recommendation are part of a wider program of initiatives, or quantitative information is not revealed. Reliance may therefore be placed upon the skill and judgement of the RAF user to determine the most appropriate attributes. The assignment of attributes is clearly an issue that would benefit from further consideration in future refinements of the RAF; further detailed focus in this area through primary research may elicit the quantitative information that is often lacking or aggregated with other elements of an energy efficiency program.

6.4 Quezon City Field Test and Validation

The field test and validation exercise undertaken in Quezon City was hugely beneficial to the testing of RAF concepts and options. It brought fundamental RAF practicalities into sharp focus, prompting the preparation of the supplementary guidance section in the RAF tool. Developments during this phase of the design are now firmly embodied within the RAF design.

Despite the design benefits of the early application of the RAF in Quezon City, the final concept is currently un-tested, and this remains a concern to the RAF team. The finalized RAF concept would benefit from application in one or two cities with subsequent refinements before being released for general use by ESMAP and its partner organizations.

6.5 Post-RAF Support

The RAF is the starting point for cities wishing to gain an understanding of both how their energy use and intensity compares to a range of peer cities and where they can make progress in specific sectors with viable energy efficiency interventions. What comes next for these cities is less clear and must be addressed by ESMAP and other partner organizations that adopt the RAF at an early stage to manage expectations in RAF cities.

6.6 Future Application

It is clear that the application of the RAF across a broad range of cities will provide a rich source of detailed performance data across the range of recommendations. Not only can this data expand the existing benchmark database, but such data may also be used to create and populate an even more detailed database of recommendation-specific data requirements. This would have significant value in a subsequent version of the RAF, potentially enabling the current gap between KPI benchmarking and the choice of individual recommendations to be bridged.

In its early days, it is appropriate that the RAF is applied by experienced and trained personnel, be they consultants or other sources of expertise. The experiences of these individuals, and those working to apply the RAF in their respective cities, should be canvassed to enable refinements to be made with subsequent versions. This may be undertaken on a project-by-project basis, or through a workshop after a certain number of cities have used the RAF.

If the ESMAP team wishes to consider a step change in how the RAF is applied, there is potential for the RAF to be adapted as an open resource, similar to many of the products reviewed in the precedent study. This would take the form of a web-mounted tool that cities could apply themselves. This may require greater sophistication with respect to both data resources and guidance.

Appendices

Appendix 1: Benchmark Cities by Climate Type

	CITY	CLIMATE TYPE
1	Amman, Jordan	Arid
2	Cairo, Egypt	Arid
3	Jeddah (Jiddah), Saudi Arabia	Arid
4	Karachi, Pakistan	Arid
5	Tehran, Iran	Arid
6	Urumqi, China	Arid
7	Bratislava, Slovakia	Continental
8	Kiev, Ukraine	Continental
9	Toronto, Canada	Continental
10	Warsaw, Poland	Continental
11	Addis Ababa, Ethiopia	Temperate
12	Bhopal, India	Temperate
13	Bogota, Colombia	Temperate
14	Budapest, Hungary	Temperate
15	Cape Town, South Africa	Temperate
16	Casablanca, Morocco	Temperate
17	Guangzhou, China	Temperate
18	Hong Kong, China	Temperate
19	Jabalpur, India	Temperate
20	Johannesburg, South Africa	Temperate
21	Kanpur, India	Temperate
22	Kathmandu, Nepal	Temperate
23	Ljubljana, Slovenia	Temperate
24	Mexico City, Mexico	Temperate
25	New York, USA	Temperate
26	Paris, France	Temperate
27	Patna, India	Temperate
28	Porto, Portugal	Temperate
29	Rio de Janeiro, Brazil	Temperate
30	Shanghai, China	Temperate
31	Sydney, Australia	Temperate

	CITY	CLIMATE TYPE
32	Tallinn, Estonia	Temperate
33	Tokyo, Japan	Temperate
34	Bangkok, Thailand	Tropical
35	Belo Horizonte, Brazil	Tropical
36	Bengaluru (Bengalore), India	Tropical
37	Colombo, Sri Lanka	Tropical
38	Dakar, Senegal	Tropical
39	Dhaka, Bangladesh	Tropical
40	Guntur, India	Tropical
41	Ho Chi Minh City, Vietnam	Tropical
42	Indore, India	Tropical
43	Jakarta, Indonesia	Tropical
44	Kuala Lumpur, Malaysia	Tropical
45	Lima, Peru	Tropical
46	Mumbai, India	Tropical
47	Mysore, India	Tropical
48	Phnom Penh, Cambodia	Tropical
49	Pokhara, Nepal	Tropical
50	Pune, India	Tropical
51	Quezon City, Philippines	Tropical
52	Sangli, India	Tropical
53	Singapore, Singapore	Tropical
54	Vijaywada, India	Tropical

Appendix 2: Benchmark Cities by Population within Municipal Boundary

	CITY	POPULATION WITHIN MUNICPAL BOUNDARY
1	Mumbai, India	19,350,000
2	Karachi, Pakistan	18,500,000
3	Shanghai, China	13,831,900
4	Tokyo, Japan	12,790,000
5	Mexico City, Mexico	8,841,916
6	Jakarta, Indonesia	8,792,000
7	New York, USA	8,310,212
8	Lima, Peru	7,605,742
9	Hong Kong, China	7,280,000
10	Tehran, Iran	7,241,000
11	Ho Chi Minh City, Vietnam	7,162,864
12	Bangkok, Thailand	7,025,000
13	Dhaka, Bangladesh	7,000,940
14	Bogota, Colombia	6,800,000
15	Cairo, Egypt	6,758,581
16	Rio de Janeiro, Brazil	6,186,710
17	Bengaluru (Bengalore), India	5,438,065
18	Singapore, Singapore	4,588,600
19	Sydney, Australia	4,344,675
20	Guangzhou, China	4,261,800
21	Johannesburg, South Africa	3,888,180
22	Cape Town, South Africa	3,497,097
23	Jeddah (Jiddah), Saudi Arabia	3,600,000
24	Pune, India	3,337,481
25	Casablanca, Morocco	3,299,428
26	Kiev, Ukraine	2,819,566
27	Addis Ababa, Ethiopia	2,738,248
28	Kanpur, India	2,721,000
29	Urumqi, China	2,681,834
30	Quezon City, Philippines	2,679,450

	CITY	POPULATION WITHIN MUNICPAL BOUNDARY
31	Toronto, Canada	2,503,281
32	Belo Horizonte, Brazil	2,452,617
33	Patna, India	2,250,000
34	Amman, Jordan	2,200,000
35	Paris, France	2,153,600
36	Bhopal, India	2,000,000
37	Kuala Lumpur, Malaysia	1,887,674
38	Budapest, Hungary	1,712,210
39	Warsaw, Poland	1,711,466
40	Indore, India	1,600,000
41	Phnom Penh, Cambodia	1,077,853
42	Dakar, Senegal	1,030,594
43	Jabalpur, India	951,469
44	Kathmandu, Nepal	949,486
45	Vijaywada, India	851,000
46	Guntur, India	818,330
47	Mysore, India	780,000
48	Colombo, Sri Lanka	647,100
49	Sangli, India	601,214
50	Bratislava, Slovakia	428,791
51	Tallinn, Estonia	410,000
52	Pokhara, Nepal	293,696
53	Ljubljana, Slovenia	280,000
54	Porto, Portugal	238,950

Appendix 3: Benchmark Cities by Human Development Index (HDI)

	CITY	HDI (BY COUNTRY)
1	Hong Kong, China	Very High
2	Ljubljana, Slovenia	Very High
3	New York, USA	Very High
4	Paris, France	Very High
5	Porto, Portugal	Very High
6	Singapore, Singapore	Very High
7	Sydney, Australia	Very High
8	Tokyo, Japan	Very High
9	Toronto, Canada	Very High
10	Belo Horizonte, Brazil	High
11	Bogota, Colombia	High
12	Bratislava, Slovakia	High
13	Budapest, Hungary	High
14	Jeddah (Jiddah), Saudi Arabia	High
15	Kuala Lumpur, Malaysia	High
16	Lima, Peru	High
17	Mexico City, Mexico	High
18	Rio de Janeiro, Brazil	High
19	Tallinn, Estonia	High
20	Warsaw, Poland	High
21	Bangkok, Thailand	Medium
22	Bengaluru (Bengalore), India	Medium
23	Bhopal, India	Medium
24	Cape Town, South Africa	Medium
25	Guangzhou, China	Medium
26	Guntur, India	Medium
27	Indore, India	Medium
28	Jabalpur, India	Medium
29	Johannesburg, South Africa	Medium
30	Kanpur, India	Medium

	CITY	HDI (BY COUNTRY)
31	Karachi, Pakistan	Medium
32	Mumbai, India	Medium
33	Mysore, India	Medium
34	Patna, India	Medium
35	Phnom Penh, Cambodia	Medium
36	Pokhara, Nepal	Medium
37	Pune, India	Medium
38	Quezon City, Philippines	Medium
39	Sangli, India	Medium
40	Shanghai, China	Medium
41	Urumqi, China	Medium
42	Vijaywada, India	Medium
43	Amman, Jordan	Medium
44	Cairo, Egypt	Medium
45	Casablanca, Morocco	Medium
46	Colombo, Sri Lanka	Medium
47	Dhaka, Bangladesh	Medium
48	Ho Chi Minh City, Vietnam	Medium
49	Jakarta, Indonesia	Medium
50	Kathmandu, Nepal	Medium
51	Kiev, Ukraine	Medium
52	Tehran, Iran	Medium
53	Addis Ababa, Ethiopia	Low
54	Dakar, Senegal	Low

Appendix 4: Key Performance Indicator (KPI) Data Sources

CITY-WIDE KPI: CW1

Electricity Consumption	**kWhe/capita**		
	Value	**Year**	**Source**
New York, USA	6,228	2008	Inventory of New York City greenhouse gas emissions, http://www.census.gov/popest/cities/SUB-EST2008.html
Tokyo, Japan	6,638	2004	http://www.c40cities.org/bestpractices/energy/tokyo_companies.jsp, http://www.metro.tokyo.jp/ENGLISH/PROFILE/overview03.htm
Toronto, Canada	10,198	2006	Toronto PWC climate action plan (background report on the energy plan for Toronto), http://www.toronto.ca/toronto_facts/diversity.htm
Paris, France	1,489	2007	1163 KWh (OECD), http://www.urba2000.com/club-ecomobilite-DUD/IMG/pdf/SALAT.pdf
Sydney, Australia	1,039	2008/09	State of the Environment Report 2008/09, City of Sydney, Australian Bureau of Statistics
Mexico City, Mexico	2,028	2007	NATIONAL Population Council, * 11.628 (OECD) data in kgoe, World Bank Data Indicators
Cape Town, South Africa	2,926	2003	State of Energy Report for Cape Town, Statistics South Africa
Singapore, Singapore	8,268	2008	http://www.singstat.gov.sg
Hong Kong, China	6,126	2008	https://www.cia.gov/library/publications/the-world-factbook/, PWC estimates
Quezon City, Philippines	1,317	2007	Report: Quezon City: The envisioned City of Quezon and PWC estimates for Matero Manila, normalized for QC ,http://www.quezoncity.gov.ph/images/Downloadables/cityindicators/demographics08.pdf
Jeddah (Jiddah), Saudi Arabia	4,925		http://www.ryanlshelby.com/uploads/1/9/8/6/1986376/ryan_shelby_cares_09_kaust.pdf, Jeddah Municipality Estimates
Shanghai, China	6,666	2005	PPT: Energy Consumption and Supply in Shanghai, Shanghai Municipal Bureau of Statistics
Budapest, Hungary	3,976	2007	Eurostat (NATIONAL—IEA)
Addis Ababa, Ethiopia	40	2007	http://www.csa.gov.et/docs/Cen2007_firstdraft.pdf (NATIONAL—IEA)
Mysore, India	1,260	2007/08	ICLEI—South Asia, Local Governments for Sustainability, http://www.mysorecity.gov.in/
Vijaywada, India	884	2007/08	ICLEI—South Asia, Local Governments for Sustainability, ADB Water Utility Profile Document
Jabalpur, India	305	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Jabalpur Municipal Corporation
Pokhara, Nepal	206	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Pokhara Sub-Metropolitan City Authority
Bengaluru (Bengalore), India	1,517	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Municipal Corporation Official Estimate
Indore, India	486	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Indore Municipal Development Plan

Electricity Consumption	kWhe/capita		
	Value	Year	Source
Pune, India	1,415	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Pune Municipal Development Plan
Belo Horizonte, Brazil	2,154	2007	Belo Horizonte Municipality
Bogota, Colombia	2,053	2007	UN HABITAT
Phnom Penh, Cambodia	93	2007	UN HABITAT
Karachi, Pakistan	475	2007	UN World Urbanization Prospects
Urumqi, China	2,328	2007	Statistical Bureau of Urumqi (NATIONAL—IEA)
Lima, Peru	982	2007	Lima City Authority Estimate (NATIONAL—IEA)
Warsaw, Poland	3,662	2007	City of Warsaw Authority (NATIONAL—IEA)
Jakarta, Indonesia	564	2007	Penduduk Provinsi DKI Jakarta (NATIONAL—IEA)
Kuala Lumpur, Malaysia	3,668	2007	Kuala Lumpur Federal Territory Statistical Authority (NATIONAL—IEA)
Guangzhou, China			Statistical Bureau of Guangzhou
Bangkok, Thailand	2,157	2007	National Statistical Office Thailand (NATIONAL—IEA)
Ho Chi Minh City, Vietnam	728	2007	General Statistics Office of Vietnam (NATIONAL—IEA)
Cairo, Egypt	1,468	2007	Central Agency for Mobilization and Statistics (NATIONAL—IEA)
Casablanca, Morocco	715	2007	UN World Urbanization Prospects (NATIONAL—IEA)
Dakar, Senegal	122	2007	UN World Urbanization Prospects (NATIONAL—IEA)
Tehran, Iran	2,325	2007	UN World Urbanization Prospects (NATIONAL—IEA)
Rio de Janeiro, Brazil	2,154	2007	Instituto Brasiliero de Geografia e Estastica (NATIONAL—IEA)
Kiev, Ukraine	3,539	2007	Census Data (NATIONAL—IEA)
Tallinn, Estonia	6,271	2007	Tallinn e-Government Portal (NATIONAL—IEA)
Ljubljana, Slovenia	7,138	2007	Province of Ljubljana Statistical Authority (NATIONAL—IEA)
Porto, Portugal	5,558	2004	Report: Matriz Energética do Porto
Bratislava, Slovakia	5,251	2007	Bratislava City Council (NATIONAL—IEA)
Dhaka, Bangladesh	144	2007	Bangladesh Bureau of Statistics (NATIONAL—IEA)
Amman, Jordan	2,160	2008	Amman Metropolitan Area Estimate (GCIF)
Bhopal, India	293	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Bhopal Municipal Corporation Transportation Department Estimate
Guntur, India	744	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Municipal Corporation Estimate Based upon 2001 Census
Kanpur, India	626	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Municipal Corporation Estimate
Patna, India	394	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Patna Municipal Corporation Development Plan
Sangli, India	244	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Sangli Miraj Kupwad Municipal Corporation
Kathmandu, Nepal	519	2007/08	ICLEI—South Asia, Local Governments for Sustainability, kathmandu.gov.np
Colombo, Sri Lanka	1,718	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Municipal Council of Colombo

CITY-WIDE KPI: CW2

Electricity Consumption	kWhe/$GDP		
	Value	Year	Source
New York, USA	0.04	2008	Inventory of New York City greenhouse gas emissions, http://www.census.gov/popest/cities/SUB-EST2008.html, Metropolitan area PWC estimates for GDP (normalized)
Tokyo, Japan	0.06	2004/2008	http://www.c40cities.org/bestpractices/energy/tokyo_companies.jsp, http://www.metro.tokyo.jp/ENGLISH/PROFILE/overview03.htm, Metropolitan area PWC estimates
Toronto, Canada	0.10	2006/2008	Toronto PWC climate action plan (background report on the energy plan for Toronto), http://www.toronto.ca/toronto_facts/diversity.htm, Metropolitan area PWC estimates
Sydney, Australia	0.02	2008	State of the Environment report 2008/09, City of Sydney, Australian Bureau of Statistics, PWC estimates
Cape Town, South Africa	0.10	2003/2008	State of Energy Report for Cape Town and PWC estimates for GDP
Singapore, Singapore	0.18	2008	http://www.singstat.gov.sg and PWC estimates for GDP
Hong Kong, China	0.14	2008	http://www.cia.gov/library/publications/the-world-factbook/ and PWC estimates for GDP
Quezon City, Philippines	0.02	2008	Report: Quezon City: The envisioned City of Quezon and PWC estimates for Matero Manila, normalized for QC
Jeddah (Jiddah), Saudi Arabia	0.25	2006/2008	http://www.ryanlshelby.com/uploads/1/9/8/6/1986376/ryan_shelby_cares_09_kaust.pdf (2006) and PWC estimates for GDP 2008
Shanghai, China	0.40	2005/2008	PPT: Energy Consumption and Supply in Shanghai and PWC estimates for GDP
Porto, Portugal	0.30	2004	Report: Matriz Energética do Porto

CITY-WIDE KPI: CW3

Primary Energy Consumption	GJ/capita	Year	Source
New York, USA	124	2008	Inventory of New York City greenhouse gas emissions, http://www.census.gov/popest/cities/SUB-EST2008.html
Tokyo, Japan	66	2004/2008	http://www.c40cities.org/bestpractices/energy/tokyo_companies.jsp, http://www.metro.tokyo.jp/ENGLISH/PROFILE/overview03.htm
Toronto, Canada	173	2006	Toronto PWC climate action plan (background report on the energy plan for Toronto), http://www.toronto.ca/toronto_facts/diversity.htm
Paris, France	97		From metropolitan area 2006 (calculation)
Sydney, Australia	43		State of the Environment report 2008/09, City of Sidney, http://www.abs.gov.au/ausstats/abs@.nsf/Products/3218.0~2007-08~Main+Features~Main+Features?OpenDocument#PARALINK0
Mexico City, Mexico	21		National Population Council
Cape Town, South Africa	53		State of Energy Report for Cape Town, Statistics South Africa
Singapore, Singapore	40		http://www.singstat.gov.sg/stats/themes/people/hist/popn.html (calculation)
Hong Kong, China	25		PWC estimates (calculation)
Quezon City, Philippines	69		http://www.quezoncity.gov.ph/images/Downloadables/cityindicators/demographics08.pdf (calculation)
Jeddah (Jiddah), Saudi Arabia	51		Jeddah Municipality Estimates (calculation)
Shanghai, China	13		Shanghai Municipal Bureau of Statistics (calculation)
Budapest, Hungary	108		Eurostat (calculation)
Addis Ababa, Ethiopia	68		http://www.csa.gov.et/docs/Cen2007_firstdraft.pdf (calculation)
Mysore, India	237		http://www.mysorecity.gov.in/ (calculation)
Vijaywada, India	217		ADB Water Utility Profile Document (calculation)
Jabalpur, India	194		Jabalpur Municipal Corporation (calculation)
Pokhara, Nepal	629		Pokhara Sub-Metropolitan City Authority (calculation)
Bengaluru (Bengalore), India	34		Municipal Corporation Official Estimate (calculation)
Indore, India	116		Indore Municipal Development Plan (calculation)
Pune, India	55		Pune Municipal Development Plan (calculation)
Mumbai, India	10		Population for GDP ranks from PWC report (calculation)
Johannesburg, South Africa	48		Statistics South Africa (calculation)
Belo Horizonte, Brazil	75		Belo Horizonte Municipality (calculation)
Bogota, Colombia	27		UN HABITAT (calculation)
Phnom Penh, Cambodia	171		UN HABITAT (calculation)
Karachi, Pakistan	10		UN World Urbanization Prospects (calculation)
Urumqi, China	69		Statistical Bureau of Urumqi (calculation)
Lima, Peru	24		Lima City Authority Estimate (calculation)
Warsaw, Poland	50		European Green City Index, Warsaw detailed report

Primary Energy Consumption	GJ/capita	Year	Source
Kiev, Ukraine	87		European Green City Index, Kiev detailed report
Tallinn, Estonia	90		European Green City Index, Tallinn detailed report
Ljubljana, Slovenia	106		European Green City Index, Ljubjana detailed report
Porto, Portugal	85		Report: Matriz Energética do Porto 2004; Report: Matriz Energética do Porto 2004
Bratislava, Slovakia	31		Bratislava City Council (calculation)
Dhaka, Bangladesh	2		Bangladesh Bureau of Statistics (calculation)
Amman, Jordan	6		Amman Metropolitan Area Estimate (calculation)
Bhopal, India	7		Bhopal Municipal Corporation Transportation Department Estimate (calculation)
Guntur, India	16		Municipal Corporation Estimate Based upon 2001 Census (calculation)
Kanpur, India	5		Municipal Corporation Estimate (calculation)
Patna, India	6		Patna Municipal Corporation Development Plan (calculation)
Sangli, India	22		Sangli Miraj Kupwad Municipal Corporation (calculation)
Kathmandu, Nepal	14		http://kathmandu.gov.np (calculation)
Colombo, Sri Lanka	21		Municipal Council of Colombo (calculation)

CITY-WIDE KPI: CW4

Primary Energy Consumption	MJ/$GDP	Year	Source
New York, USA	0.73		Inventory of New York City greenhouse gas emissions, Metropolitan area PWC estimates
Tokyo, Japan	0.57		Tokyo Climate Change Strategy 2004, Metropolitan area PWC estimates
Toronto, Canada	1.71		Toronto PWC climate action plan (background report on the energy plan for Toronto), Metropolitan area PWC estimates
Paris, France	2.00		European Green City Index, Paris detailed report, Metro Paris number, Metropolitan area PWC estimates
Cape Town, South Africa	1.79		State of Energy Report for Cape Town 2003, PWC estimates
Singapore, Singapore	11.33		http://www.bp.com/.../2009_downloads/statistical_review_of_world_energy_full_report_2009.pdf, PWC estimates
Hong Kong, China	3.11		http://www.bp.com/.../2009_downloads/statistical_review_of_world_energy_full_report_2009.pdf, PWC estimates
Quezon City, Philippines	1.94		Derived from different sources, see calculations to the side
Shanghai, China	10.61		Paper: Energy demand and carbon emissions under different development scenarios for Shanghai, China, PWC estimates
Budapest, Hungary	3.17		European Green City Index, Budapest detailed report, PWC estimates
Bengaluru (Bengalore), India	1.77		ICLEI—South Asia 2007–08 data, PWC estimates
Warsaw, Poland	1.25		European Green City Index, Warsaw detailed report, PWC estimates
Porto, Portugal	4.60		Report: Matriz Energética do Porto
Kanpur, India	2.11		ICLEI—South Asia 2007–08 data, PWC estimates
Colombo, Sri Lanka			Inventory of New York City greenhouse gas emissions, Metropolitan area PWC estimates

Transportation KPI: T1

Total Transportation Energy Use Per Capita	MJ/capita	Year	Source
New York, USA	44,287	1995	Millennium Database of Towns and Regions (UITP)
Tokyo, Japan	11,532	1995	Millennium Database of Towns and Regions (UITP)
Toronto, Canada	35,679	1995	Millennium Database of Towns and Regions (UITP)
Paris, France	16,000	2001	Millennium Database of Towns and Regions (UITP)
Sydney, Australia	29,797	1995	Millennium Database of Towns and Regions (UITP)
Mexico City, Mexico	19,369	1995	Millennium Database of Towns and Regions (UITP)
Cape Town, South Africa	7,209	1995	Millennium Database of Towns and Regions (UITP)
Singapore, Singapore	14,700	2001	Millennium Database of Towns and Regions (UITP)
Hong Kong, China	5,420	2001	Millennium Database of Towns and Regions (UITP)
Quezon City, Philippines	7,356	2008	Ms. Rita S. Escandor, supervising science research specialist, DOE in Philippines
Shanghai, China	1,963	1995	Millennium Database of Towns and Regions (UITP)
Budapest, Hungary	11,100	2001	Millennium Database of Towns and Regions (UITP)
Mysore, India	3,898	2007-08	ICLEI—South Asia, Local Governments for Sustainability
Vijaywada, India	4,854	2007-08	ICLEI—South Asia, Local Governments for Sustainability
Jabalpur, India	3,192	2007-08	ICLEI—South Asia, Local Governments for Sustainability
Pokhara, Nepal	2,809	2007-08	ICLEI—South Asia, Local Governments for Sustainability
Bengaluru (Bengalore), India	2,039	2007-08	ICLEI—South Asia, Local Governments for Sustainability
Indore, India	3,318	2007-08	ICLEI—South Asia, Local Governments for Sustainability
Pune, India	7,059	2007-08	ICLEI—South Asia, Local Governments for Sustainability
Mumbai, India	1,519	1995	Millennium Database of Towns and Regions (UITP)
Johannesburg, South Africa	12,490	1995	Millennium Database of Towns and Regions (UITP)
Bogota, Colombia	7,382	1995	Millennium Database of Towns and Regions (UITP)
Warsaw, Poland	9,850	2001	Millennium Database of Towns and Regions (UITP)
Jakarta, Indonesia	4,227	1995	Millennium Database of Towns and Regions (UITP)
Kuala Lumpur, Malaysia	11,865	1995	Millennium Database of Towns and Regions (UITP)
Guangzhou, China	3,100	1995	Millennium Database of Towns and Regions (UITP)
Bangkok, Thailand	15,324	1995	Millennium Database of Towns and Regions (UITP)
Ho Chi Minh City, Vietnam	981	1995	Millennium Database of Towns and Regions (UITP)
Cairo, Egypt	2,812	1995	Millennium Database of Towns and Regions (UITP)
Dakar, Senegal	3,393	1995	Millennium Database of Towns and Regions (UITP)
Tehran, Iran	6,798	1995	Millennium Database of Towns and Regions (UITP)
Rio de Janeiro, Brazil	9,774	1995	Millennium Database of Towns and Regions (UITP)
Porto, Portugal	27,857	2004	Report: Matriz Energética do Porto 2004
Bhopal, India	555	2007-08	ICLEI—South Asia, Local Governments for Sustainability
Guntur, India	569	2007-08	ICLEI—South Asia, Local Governments for Sustainability
Kanpur, India	397	2007-08	ICLEI—South Asia, Local Governments for Sustainability
Patna, India	1,542	2007-08	ICLEI—South Asia, Local Governments for Sustainability

Total Transportation Energy Use Per Capita	MJ/capita	Year	Source
Sangli, India	1,474	2007-08	ICLEI—South Asia, Local Governments for Sustainability
Kathmandu, Nepal	693	2007-08	ICLEI—South Asia, Local Governments for Sustainability
Colombo, Sri Lanka	2,096	2007-08	ICLEI—South Asia, Local Governments for Sustainability

Transportation KPI: T2

Public Transport Energy Consumption	MJ/passenger km	Year	Source
New York, USA	1.09	1995	Millennium Database of Towns and Regions (UITP)
Tokyo, Japan	0.19	1995	Millennium Database of Towns and Regions (UITP)
Toronto, Canada	0.98	1995	Millennium Database of Towns and Regions (UITP)
Paris, France	1.35	2001	Millennium Database of Towns and Regions (UITP)
Sydney, Australia	0.71	1995	Millennium Database of Towns and Regions (UITP)
Mexico City, Mexico	0.93	1995	Millennium Database of Towns and Regions (UITP)
Cape Town, South Africa	0.45	1995	Millennium Database of Towns and Regions (UITP)
Singapore, Singapore	0.69	2001	Millennium Database of Towns and Regions (UITP)
Hong Kong, China	0.78	2001	Millennium Database of Towns and Regions (UITP)
Quezon City, Philippines	1.44	1995	Millennium Database of Towns and Regions (UITP)
Shanghai, China	0.15	1995	Millennium Database of Towns and Regions (UITP)
Budapest, Hungary	0.72	2001	Millennium Database of Towns and Regions (UITP)
Mumbai, India	0.08	1995	Millennium Database of Towns and Regions (UITP)
Johannesburg, South Africa	0.46	1995	Millennium Database of Towns and Regions (UITP)
Bogota, Colombia	1.31	1995	Millennium Database of Towns and Regions (UITP)
Warsaw, Poland	0.73	2001	Millennium Database of Towns and Regions (UITP)
Jakarta, Indonesia	0.59	1995	Millennium Database of Towns and Regions (UITP)
Kuala Lumpur, Malaysia	0.56	1995	Millennium Database of Towns and Regions (UITP)
Guangzhou, China	0.56	1995	Millennium Database of Towns and Regions (UITP)
Bangkok, Thailand	1.28	1995	Millennium Database of Towns and Regions (UITP)
Ho Chi Minh City, Vietnam	0.59	1995	Millennium Database of Towns and Regions (UITP)
Cairo, Egypt	0.73	1995	Millennium Database of Towns and Regions (UITP)
Casablanca, Morocco	0.76	1995	Millennium Database of Towns and Regions (UITP)
Dakar, Senegal	0.67	1995	Millennium Database of Towns and Regions (UITP)
Tehran, Iran	0.58	1995	Millennium Database of Towns and Regions (UITP)
Rio de Janeiro, Brazil	0.47	1995	Millennium Database of Towns and Regions (UITP)
Tallinn, Estonia	1.16	2001	Millennium Database of Towns and Regions (UITP)

Transportation KPI: T3

Private Transport Energy Consumption	MJ/passenger km	Year	Source
New York, USA	3.38	1995	Millennium Database of Towns and Regions (UITP)
Tokyo, Japan	2.44	1995	Millennium Database of Towns and Regions (UITP)
Toronto, Canada	5.06	1995	Millennium Database of Towns and Regions (UITP)
Paris, France	2.68	2001	Millennium Database of Towns and Regions (UITP)
Sydney, Australia	2.67	1995	Millennium Database of Towns and Regions (UITP)
Mexico City, Mexico	3.32	1995	Millennium Database of Towns and Regions (UITP)
Cape Town, South Africa	2.01	1995	Millennium Database of Towns and Regions (UITP)
Singapore, Singapore	2.31	2001	Millennium Database of Towns and Regions (UITP)
Hong Kong, China	2.16	2001	Millennium Database of Towns and Regions (UITP)
Quezon City, Philippines	1.44	1995	Millennium Database of Towns and Regions (UITP)
Shanghai, China	2.07	1995	Millennium Database of Towns and Regions (UITP)
Budapest, Hungary	2.82	2001	Millennium Database of Towns and Regions (UITP)
Mumbai, India	2.02	1995	Millennium Database of Towns and Regions (UITP)
Johannesburg, South Africa	2.19	1995	Millennium Database of Towns and Regions (UITP)
Bogota, Colombia	2.08	1995	Millennium Database of Towns and Regions (UITP)
Warsaw, Poland	2.47	2001	Millennium Database of Towns and Regions (UITP)
Jakarta, Indonesia	1.99	1995	Millennium Database of Towns and Regions (UITP)
Kuala Lumpur, Malaysia	1.91	1995	Millennium Database of Towns and Regions (UITP)
Guangzhou, China	1.63	1995	Millennium Database of Towns and Regions (UITP)
Bangkok, Thailand	2.28	1995	Millennium Database of Towns and Regions (UITP)
Ho Chi Minh City, Vietnam	0.68	1995	Millennium Database of Towns and Regions (UITP)
Cairo, Egypt	1.66	1995	Millennium Database of Towns and Regions (UITP)
Dakar, Senegal	0.97	1995	Millennium Database of Towns and Regions (UITP)
Tehran, Iran	2.54	1995	Millennium Database of Towns and Regions (UITP)
Rio de Janeiro, Brazil	2.98	1995	Millennium Database of Towns and Regions (UITP)

Transportation KPI: T4

Transportation Mode Split	Non-motorized Modes over All Trips (%)	Motorized Public Modes over All Trips (%)	Motorized Private Modes over All Trips (%)	Year	Source
New York, USA	16%	9%	75%	1995	Millennium Database of Towns and Regions (UITP)
Tokyo, Japan	37%	31%	32%	1995	Millennium Database of Towns and Regions (UITP)
Toronto, Canada	7%	14%	79%	1995	Millennium Database of Towns and Regions (UITP)
Paris, France	36%	46%	18%	2001	Millennium Database of Towns and Regions (UITP)
Sydney, Australia	17%	7%	75%	1995	Millennium Database of Towns and Regions (UITP)
Mexico City, Mexico	8%	46%	46%	1995	Millennium Database of Towns and Regions (UITP)
Cape Town, South Africa	35%	15%	50%	1995	Millennium Database of Towns and Regions (UITP)
Singapore, Singapore	14%	45%	41%	2001	Millennium Database of Towns and Regions (UITP)
Hong Kong, China	38%	16%	46%	2001	Millennium Database of Towns and Regions (UITP)
Quezon City, Philippines	21%	59%	20%	1995	Millennium Database of Towns and Regions (UITP)
Shanghai, China	78%	15%	7%	1995	Millennium Database of Towns and Regions (UITP)
Budapest, Hungary	0.234	0.331	0.435	2001	Millennium Database of Towns and Regions (UITP)
Vijaywada, India	33%	13%	54%	2008	Vijaywada City Development Plan, Vijaywada City Corporation
Jabalpur, India	39%	7%	54%	2008	Jabalpur City Development Plan Review Document
Pune, India	28%	11%	61%	2008	Pune City Development Plan, Pune City Municipal Corporation
Mumbai, India	50%	41%	9%	1995	Millennium Database of Towns and Regions (UITP)
Johannesburg, South Africa	53%	12%	35%	1995	Millennium Database of Towns and Regions (UITP)
Bogota, Colombia	23%	47%	30%	1995	Millennium Database of Towns and Regions (UITP)
Warsaw, Poland	20%	29%	52%	2001	Millennium Database of Towns and Regions (UITP)
Jakarta, Indonesia	46%	26%	28%	1995	Millennium Database of Towns and Regions (UITP)
Kuala Lumpur, Malaysia	24%	7%	69%	1995	Millennium Database of Towns and Regions (UITP)
Guangzhou, China	69%	14%	16%	1995	Millennium Database of Towns and Regions (UITP)

Transportation Mode Split	Non-motorized Modes over All Trips (%)	Motorized Public Modes over All Trips (%)	Motorized Private Modes over All Trips (%)	Year	Source
Bangkok, Thailand	12%	43%	46%	1995	Millennium Database of Towns and Regions (UITP)
Ho Chi Minh City, Vietnam	44%	2%	54%	1995	Millennium Database of Towns and Regions (UITP)
Cairo, Egypt	36%	23%	41%	1995	Millennium Database of Towns and Regions (UITP)
Casablanca, Morocco	54%	17%	30%	1995	Millennium Database of Towns and Regions (UITP)
Dakar, Senegal	35%	47%	18%	1995	Millennium Database of Towns and Regions (UITP)
Tehran, Iran	30%	20%	51%	1995	Millennium Database of Towns and Regions (UITP)
Rio de Janeiro, Brazil	22%	43%	35%	1995	Millennium Database of Towns and Regions (UITP)
Kiev, Ukraine	15%	74%	11%		
Tallinn, Estonia	30%	31%	39%	2001	Millennium Database of Towns and Regions (UITP)
Ljubljana, Slovenia	15%	22%	64%		

Transportation KPI: T5 and T6

Metres of High Capacity Transit per 1,000 People	m/1,000 people		
	Value	Year	Source
New York, USA	92.44	1995	Millennium Database of Towns and Regions (UITP)
Tokyo, Japan	92.39	1995	Millennium Database of Towns and Regions (UITP)
Toronto, Canada	96.14	1995	Millennium Database of Towns and Regions (UITP)
Paris, France	152	2001	Millennium Database of Towns and Regions (UITP)
Sydney, Australia	225.01	1995	Millennium Database of Towns and Regions (UITP)
Mexico City, Mexico	12.13	1995	Millennium Database of Towns and Regions (UITP)
Cape Town, South Africa	88.62	1995	Millennium Database of Towns and Regions (UITP)
Singapore, Singapore	29.3	2001	Millennium Database of Towns and Regions (UITP)
Hong Kong, China	22.4	2001	Millennium Database of Towns and Regions (UITP)
Quezon City, Philippines	5.78	1995	Millennium Database of Towns and Regions (UITP)
Shanghai, China	1.67	1995	Millennium Database of Towns and Regions (UITP)
Budapest, Hungary	197	2001	Millennium Database of Towns and Regions (UITP)
Mumbai, India	16.17	1995	Millennium Database of Towns and Regions (UITP)
Johannesburg, South Africa	57.18	1995	Millennium Database of Towns and Regions (UITP)
Bogota, Colombia	2.69	1995	Millennium Database of Towns and Regions (UITP)
Warsaw, Poland	178	2001	Millennium Database of Towns and Regions (UITP)
Jakarta, Indonesia	7.74	1995	Millennium Database of Towns and Regions (UITP)
Kuala Lumpur, Malaysia	38.88	1995	Millennium Database of Towns and Regions (UITP)
Guangzhou, China	0	1995	Millennium Database of Towns and Regions (UITP)
Bangkok, Thailand	19.75	1995	Millennium Database of Towns and Regions (UITP)
Ho Chi Minh City, Vietnam	0	1995	Millennium Database of Towns and Regions (UITP)
Cairo, Egypt	20.62	1995	Millennium Database of Towns and Regions (UITP)
Casablanca, Morocco	0	1995	Millennium Database of Towns and Regions (UITP)
Dakar, Senegal	14.96	1995	Millennium Database of Towns and Regions (UITP)
Tehran, Iran	3.97	1995	Millennium Database of Towns and Regions (UITP)
Rio de Janeiro, Brazil	35.32	1995	Millennium Database of Towns and Regions (UITP)
Tallinn, Estonia	63.9	2001	Millennium Database of Towns and Regions (UITP)
Amman, Jordan	16.1	2008	GCIF

Buildings KPI: B1

Municipal Buildings Electricity Consumption	kWh_e/m^2 Value	Year	Source
New York, USA	326	2009	NYC 2030—Energy Conservation Steering Committee Annual Update
Toronto, Canada	339	2007	NATIONAL—Canadian Office of Energy Efficiency, Commercial and Institutional Consumption of Energy Survey, Summary Report – June 2007
Singapore, Singapore	240	2003	"ENERGY EFFICIENCY Designing Low Energy Buildings Using Energy 10," Ar Chan Seong Aun, PAM
Quezon City, Philippines	149	2009	Quezon City Budget Office
Jabalpur, India	137	2008	Review of Energy Conservation Act 2001, Bureau of Energy Efficiency, Ministry of Power, Government of India
Indore, India	115	2010	NATIONAL—World Bank, Improving Building Sector Energy Efficiency in India: Strategies and Initiatives
Pune, India	146	2007	Alliance to Save Energy India, Project Case Study, EE Global Forum
Mumbai, India	159	2008	Review of Energy Conservation Act 2001, Bureau of Energy Efficiency, Ministry of Power, Government of India
Belo Horizonte, Brazil	170.8	2006	NATIONAL—Brasilia: Daylighting analysis of public buildings, http://www.unige.ch/cuepe/html/plea2006/Vol2/PLEA2006_PAPER922.pdf
Jakarta, Indonesia	331	2001	ADB, PREGA Indonesia, Improvement of Air-Conditioning System in the Building Sector: Case of Cardiac Center Hospital "Harapian Kita," Jakarta, a Pre-Feasibility Study Report
Kuala Lumpur, Malaysia	235	2002	NATIONAL—"ENERGY EFFICIENCY Designing Low Energy Buildings Using Energy 10," Ar Chan Seong Aun, PAM
Rio de Janeiro, Brazil	170.8	2006	NATIONAL—Brasilia: Daylighting analysis of public buildings, http://www.unige.ch/cuepe/html/plea2006/Vol2/PLEA2006_PAPER922.pdf

Buildings KPI: B2

Municipal Buildings Heat Consumption	kWh/m² Value	Year	Source
Tokyo, Japan	133.8	2007	The Energy Consumption of the Public Buildings in Japan, Proceedings: Building Simulation 2007, SiQiang Lu, Kazuo Emura, Norio Igawa, and Hideyo Nimiya, Osaka City University
Toronto, Canada	130.04	2007	Toronto City Hall and Nathan Phillips Square Sustainability and Energy Efficiency Charrette, http://www.sbcanada.org/online_pdf/Charrettes/Toronto-City-Hall-Charrette-Report-06-21-07.pdf
Paris, France	159	2006	NATIONAL—EnerData EU Heat Consumption Report
Quezon City, Philippines	0	2010	Quezon City Budget Office (no heating demand in Manila and no domestic hot water in any municipal building)
Warsaw, Poland	170	2006	NATIONAL—EnerData EU Heat Consumption Report
Tallinn, Estonia	186	2001	Heat Energy and Water Consumption in Estonian Buildings, Tallinn Technicla University, http://www.kirj.ee/public/va_te/tt7-3-4.pdf
Ljubljana, Slovenia	152	2006	NATIONAL—EnerData EU Heat Consumption Report
Bratislava, Slovakia	155	2006	Energy Centre Bratislava—Inofin Progress Meeting Report

Buildings KPI: B3

Municipal Buildings Energy Spend as a Percent of Municipal Budget	% Value	Year	Source
Quezon City, Philippines	1.57%	2009	Field visit to Quezon City

Street Lighting KPI: SL1

Electricity Consumed per km of Lit Roads	kWhe/km	Year	Source
	Value		
New York, USA	35,194		New York City Annual Accounts, New York DoT (statutory responsibility to provide lighting on all roads)
Cape Town, South Africa	17,815		State of Energy Report for Cape Town, Cape Town Municipality Transport Assessment Report
Quezon City, Philippines	21,082	2009	Field visit to Quezon City
Mysore, India	17,624		ICLEI—South Asia, Local Governments for Sustainability, Mysore City Development Plan, Mysore City Municipal Corporation
Vijaywada, India	12,868		ICLEI—South Asia, Local Governments for Sustainability, Vijaywada City Development Plan, Vijaywada City Corporation
Jabalpur, India	13,013		ICLEI—South Asia, Local Governments for Sustainability, Jabalpur City Development Plan, Jabalpur Municipal Authority
Pokhara, Nepal	2,016		ICLEI—South Asia, Local Governments for Sustainability, Pokhara Sub-Municipal Corporation
Pune, India	22,571		ICLEI—South Asia, Local Governments for Sustainability, Pune City Development Plan, Pune City Municipal Corporation
Bhopal, India	31,306		ICLEI—South Asia, Local Governments for Sustainability, Bhopal City Development Plan, Bhopal City Municipal Corporation
Kanpur, India	24,986		ICLEI—South Asia, Local Governments for Sustainability, Kanpur City Development Plan, Kanpur City Municipal Corporation
Kathmandu, Nepal	14,752		ICLEI—South Asia, Local Governments for Sustainability, Kathmandu Metropolitan City Office

Street Lighting KPI: SL2

Percentage of City Roads Lit	% Value	Year	Source
New York, USA	100%		New York City Annual Accounts, New York DoT (statutory responsibility to provide lighting on all roads)
Cape Town, South Africa	62%		Cape Town Municipality Transport Assessment Report
Quezon City, Philippines	60%	2009	Field visit to Quezon City
Mysore, India	77%		Mysore City Development Plan, Mysore City Municipal Corporation
Vijaywada, India	67%		Vijaywada City Development Plan, Vijaywada City Corporation
Jabalpur, India	87%		Jabalpur City Development Plan, Jabalpur Municipal Authority
Pokhara, Nepal	27%		Pokhara Sub-Municipal Corporation
Pune, India	94%		Pune City Development Plan, Pune City Municipal Corporation
Bhopal, India	55%		Bhopal City Development Plan, Bhopal City Municipal Corporation
Kanpur, India	67%		Kanpur City Development Plan, Kanpur City Municipal Corporation
Kathmandu, Nepal	37%		Kathmandu Metropolitan City Office

Street Lighting KPI: SL3

Electricity Consumed per Light Pole	kWhe/pole	Year	Source
	Value		
New York, USA	1,095		New York City Annual Accounts, New York City Mayor's Management Report 2010
Cape Town, South Africa	1,069		State of Energy Report for Cape Town, Calculation made on basis of National Design Standards, 60-m spacing
Quezon City, Philippines	1,893		Field visit to Quezon City
Mysore, India	435		ICLEI—South Asia, Local Governments for Sustainability, Mysore City Development Plan, Mysore City Municipal Corporation
Vijaywada, India	386		ICLEI—South Asia, Local Governments for Sustainability, ESCO in Streetlighting BID Document, Vijaywada City Corporation
Jabalpur, India	634		ICLEI—South Asia, Local Governments for Sustainability, Jabalpur City Development Plan, Jabalpur Municipal Authority
Pokhara, Nepal	333		ICLEI—South Asia, Local Governments for Sustainability, Pokhara Sub-Municipal Corporation
Pune, India	381		ICLEI—South Asia, Local Governments for Sustainability, Pune Municipal Corporation
Bhopal, India	612		ICLEI—South Asia, Local Governments for Sustainability, Bhopal Municipal Corporation, Public Works Department
Kanpur, India	749		ICLEI—South Asia, Local Governments for Sustainability, Kanpur Municipal Authority PPP Bid Documentation
Kathmandu, Nepal	738		ICLEI—South Asia, Local Governments for Sustainability, Calculation made on basis of National Design Standards, 50-m spacing

Power and Heat KPI: PH1

Percent Heat Lost from Network	% Value	Year	Source
New York, USA	11.99%	2007	NATIONAL—International Energy Agency
Tokyo, Japan	9.13%	2008	NATIONAL—International Energy Agency
Paris, France	10.40%	2008	CITY—Copenhagen Energy Summit, Global District Energy Report
Shanghai, China	12.32%	2007	NATIONAL—International Energy Agency
Budapest, Hungary	18.45%	2007	NATIONAL—Euro Heat and Power
Urumqi, China	14.80%	2009	CITY—ADB Project Brief
Warsaw, Poland	17.28%	2007	NATIONAL—Euro Heat and Power
Kiev, Ukraine	25.00%	2007	NATIONAL—International Energy Agency
Tallinn, Estonia	13.03%	2007	NATIONAL—Euro Heat and Power
Ljubljana, Slovenia	16.25%	2007	NATIONAL—International Energy Agency
Bratislava, Slovakia	24.17%	2007	NATIONAL—Euro Heat and Power

Power and Heat KPI: PH2

Percent Total T & D Loss	%		
	Value	Year	Source
New York, USA	6.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=1
Tokyo, Japan	5.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2
Toronto, Canada	8.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2
Paris, France	6.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2
Sydney, Australia	7.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2
Mexico City, Mexico	30.60%	2009	Mexican Presidential Decree, http://portal.sre.gob.mx/santalucia/pdf/decree.doc
Cape Town, South Africa	5.58%	2006	ESCOM Annual Report 2007 (Western Cape Specific Loss Factor)
Singapore, Singapore	5.00%	2007	World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2
Hong Kong, China	13.00%	2007	World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2
Quezon City, Philippines	8.21%	2010	Manila Electric Company and Subsidiaries, first quarter report
Jeddah (Jiddah), Saudi Arabia	7.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=1
Shanghai, China	6.00%	2007	NATIONAL—World Bank World Development Indicators & Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2
Budapest, Hungary	10.00%	2007	NATIONAL—World Bank World Development Indicators & Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2
Addis Ababa, Ethiopia	9.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=3

Percent Total T & D Loss	%		
	Value	Year	Source
Mysore, India	25.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2
Vijaywada, India	25.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=3
Jabalpur, India	25.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=4
Pokhara, Nepal	22.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=5
Bengaluru (Bengalore), India	25.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2
Indore, India	25.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=3
Pune, India	25.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=4
Mumbai, India	25.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=5
Johannesburg, South Africa	8.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=6
Belo Horizonte, Brazil	16.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=7
Bogota, Colombia	20.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=8
Phnom Penh, Cambodia	12.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=9
Karachi, Pakistan	19.00%	2007	NATIONAL—World Bank World Development Indicators & Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=10

Percent Total T & D Loss	% Value	Year	Source
Urumqi, China	6.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2
Lima, Peru	10.79%	2005	Total Distribution Losses (National Figure) World Bank Benchmarking Data of the Electricity Distribution Sector in the Latin America and Caribbean Region 1995–2005
Warsaw, Poland	9.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=1
Jakarta, Indonesia	11.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=0
Kuala Lumpur, Malaysia	2.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=1
Guangzhou, China	6.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2
Bangkok, Thailand	3.60%	2007	Data and Statistic on Power Distribution System, Draft Annual Report 2007, Metropolitan Electricity Authority
Ho Chi Minh City, Vietnam	6.18%	2009	ADB Supplementary Appendix, "Proposed Guarantee to Commercial Banks for a Loan in Connection with the Investment Support Program for Vietnam Electricity (Viet Nam)"
Cairo, Egypt	11.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=3
Casablanca, Morocco	19.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2
Dakar, Senegal	25.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=1
Tehran, Iran	19.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=0
Rio de Janeiro, Brazil	16.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=1
Kiev, Ukraine	12.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=1

Percent Total T & D Loss	% Value	Year	Source
			2&id=4&CNO=2
Tallinn, Estonia	11.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=3
Ljubljana, Slovenia	6.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=4
Porto, Portugal	7.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=5
Bratislava, Slovakia	0.84%	2005	Slovak Electricity Transmission System Technical Data, http://www.sepsas.sk/seps/en_OdborUkazovatele.asp?kod=108
Dhaka, Bangladesh	7.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=0
Amman, Jordan	14.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=1
Bhopal, India	25.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2
Guntur, India	25.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=3
Kanpur, India	25.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=4
Patna, India	25.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=5
Sangli, India	25.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=6
Kathmandu, Nepal	22.00%	2007	NATIONAL—World Bank World Development Indicators and & Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=7
Colombo, Sri Lanka	16.00%	2007	NATIONAL—World Bank World Development Indicators and Global Development Finance, http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=8

Percent Total T & D Loss	%		
	Value	Year	Source
Hanoi, Vietnam	8.00%	2008	ADB Supplementary Appendix, "Proposed Guarantee to Commercial Banks for a Loan in Connection with the Investment Support Program for Vietnam Electricity (Viet Nam)"
Helsinki, Finland	3.50%	2006	National Energy Company Energia, http://www.energia.fi/en/news/energy%20year%202006%20electricity.html

Power and Heat KPI: PH3

Percent of T & D Loss Due to Non-technical Factors	% Value	Year	Source
New York, USA	0.60%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Sydney, Australia	0.60%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Cape Town, South Africa	10%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Hong Kong, China	10%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Quezon City, Philippines	7.25%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Shanghai, China	10%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Mysore, India	30%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Vijaywada, India	30%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Jabalpur, India	30%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Bengaluru (Bengalore), India	30%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Indore, India	30%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Pune, India	30%	2008	Pune City Development Plan, Pune City Municipal Corporation
Mumbai, India	30%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Johannesburg, South Africa	10%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Belo Horizonte, Brazil	13%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Bogota, Colombia	12.74%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Urumqi, China	10%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Jakarta, Indonesia	8.96%	2004	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Guangzhou, China	10%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Bangkok, Thailand	0.32%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Rio de Janeiro, Brazil	13%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Amman, Jordan	4%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Bhopal, India	30%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Guntur, India	30%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs

Percent of T & D Loss Due to Non-technical Factors	% Value	Year	Source
Kanpur, India	30%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Patna, India	30%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs
Sangli, India	30%	2007	NATIONAL—AMEU proceedings, 2009 summary of worldwide non-technical loss reduction programs

Waste Water KPI: WW1

Water Consumption	L/capita/day		
	Value	Year	Source
New York, USA	501	2005	PLANYC 2030, http://www.census.gov/popest/cities/SUB-EST2008.html
Tokyo, Japan	330	2008	General Affairs Division, Bureau of Waterworks, TMG, http://www.metro.tokyo.jp/ENGLISH/PROFILE/overview03.htm
Toronto, Canada	248		http://www.toronto.ca/watereff/home.htm
Paris, France	300	2008	European Green City Index, Paris detailed report (Metro Paris number) (proxy) (calculation)
Sydney, Australia	305		IBNET 2007 and Sydney Water Corporation
Mexico City, Mexico	364	2000	Finnish Water Institute, http://www.water.tkk.fi/wr/tutkimus/glob/publications/Haapala/pdf-files/CASE%20STUDY%20OF%20MEXICO%20CITY.pdf
Cape Town, South Africa	223		State of environment report Cape Town 2008, Cape Town Metro
Singapore, Singapore	155	2009	Response to inquiry to pubone@singnet.com.sg
Hong Kong, China	220	2008-09	http://www.wsd.gov.hk/filemanager/en/share/annual_reports/rpt0809/main.htm
Quezon City, Philippines	285	2009	Manila Water meeting in Quezon City, March 2010, IBNET 2004
Jeddah (Jiddah), Saudi Arabia	200		http://www.ryanlshelby.com/uploads/1/9/8/6/1986376/ryan_shelby_cares_09_kaust.pdf
Shanghai, China	251	2005	Asian Development Bank, Water Utilities Report 2007
Budapest, Hungary	232	2007	European Green City Index, Budapest detailed report
Mysore, India	135	2008	Mysore City Development Plan, Mysore City Municipal Corporation
Vijaywada, India	140	2008	Vijaywada City Development Plan, Vijaywada City Corporation
Jabalpur, India	85	2008	Jabalpur City Development Plan Review Document
Bengaluru (Bengalore), India	94		IBNET 2005
Indore, India	150		IBNET 2005
Pune, India	191		IBNET 2005
Mumbai, India	135		http://www.bcpt.org.in/webadmin/publications/pubimages/watersupply.pdf
Johannesburg, South Africa	244		IBNET 2006, Johannesburg Water
Belo Horizonte, Brazil	135		IBNET 2007, Campanhia de Saneamento de Minas Gerais
Bogota, Colombia	79		GCIF 2007 data
Phnom Penh, Cambodia	172		IBNET 2007, Phnom Penh Water Supply Authority
Karachi, Pakistan	139	2007	UN World Urbanization Prospects, KWSB
Urumqi, China	247	2000	"Chinese Science Bulletin" 2006, Vol. 51 Supp. I, 189–195
Lima, Peru	159		Co-adaptation between modern oasis urbanization and water resources exploitation: A case of Urumqi
Warsaw, Poland	495	2007	Du Hongru, Zhang Xiaolei, and Wang Bin,

Water Consumption	L/capita/day		
	Value	Year	Source
Jakarta, Indonesia	77	2005	IBNET 2006, Servicio de Agua Potable y Alcantarillado de Lima S.A.
Kuala Lumpur, Malaysia	379		European Green City Index, Warsaw detailed report
Bangkok, Thailand	342	2004	IBNET 2007, Syarikat Bekalan Air Selangor Sdn Bhd
Ho Chi Minh City, Vietnam	141		
Dakar, Senegal	62		
Rio de Janeiro, Brazil	204		IBNET 2006, Senegal National Water Utility
Kiev, Ukraine	728	2007	
Tallinn, Estonia	138	2008	IBNET 2007, Companhia Estadual de Águas e Esgotos
Ljubljana, Slovenia	231	2008	European Green City Index, Kiev detailed report
Bratislava, Slovakia	198		European Green City Index, Ljubjana detailed report
Dhaka, Bangladesh	115		
Amman, Jordan	94	2008	IBNET 2007, Bratislavská vodárenská spolocnost, a.s.
Bhopal, India	135	2008	IBNET 2009, Dhaka Water Supply and Sewerage Authority
Kanpur, India	92	2008	Bhopal City Development Plan, Bhopal City Municipal Corporation
Kathmandu, Nepal	68	2004	
Colombo, Sri Lanka	119	2005	
Seoul, South Korea	205	2006	Asian Development Bank, Water Utilities Report 2006

Waste Water KPI: WW2

Energy Density of Potable Water Production	kWhe/m3 Value	Year	Source
Tokyo, Japan	0.49	2008	General Affairs Division, Bureau of Waterworks, TMG
Toronto, Canada	0.17	2008	City of Toronto Treatment Facilities Factsheet, Toronto Water
Sydney, Australia	0.10	2009	"Approaching EEO as part of an integrated response to climate change," Sydney Water
Hong Kong, China	0.59	2008/09	http://www.wsd.gov.hk/filemanager/en/share/annual_reports/rpt0809/main.htm
Quezon City, Philippines	0.14	2009	Manila Water meeting in Quezon City, March 2010
Mysore, India	0.27	2008	Mysore City Development Plan, Mysore City Municipal Corporation
Vijaywada, India	0.30	2008	Vijaywada City Development Plan, Vijaywada City Corporation
Jabalpur, India	0.24	2008	Jabalpur City Development Plan Review Document
Pune, India	0.17	2008	Pune City Development Plan, Pune Municipal Corporation
Johannesburg, South Africa	0.13	2008/2009	Johannesburg Water Annual Financial Report

Waste Water KPI: WW3

Energy Density of Waste Water Treatment	kWhe/m3		
	Value	Year	Source
Tokyo, Japan	0.44	2008	General Affairs Division, Bureau of Waterworks, TMG
Toronto, Canada	0.26	2008	Wastewater Treatment Plants Annual Reports 2009, Toronto Water
Sydney, Australia	0.21	2009	"Approaching EEO as part of an integrated response to climate change," Sydney Water
Hong Kong, China	0.25	2008/09	http://www.wsd.gov.hk/filemanager/en/share/annual_reports/rpt0809/main.htm
Quezon City, Philippines	0.40	2009	Manila Water meeting in Quezon City, March 2010
Mysore, India	0.50	2008	Mysore City Development Plan, Mysore City Municipal Corporation
Vijaywada, India	0.38	2008	Vijaywada City Development Plan, Vijaywada City Corporation
Pune, India	0.33	2008	Pune City Development Plan, Pune Municipal Corporation
Johannesburg, South Africa	0.30	2008/2009	Johannesburg Water Annual Financial Report

Waste Water KPI: WW4

Percentage of Non-revenue Water	%		
	Value	Year	Source
Tokyo, Japan	5%		General Affairs Division, Bureau of Waterworks, TMG
Paris, France	7%	2008	European Green City Index, Paris detailed report
Sydney, Australia	2%	2007	IBNET
Cape Town, South Africa	18%	2006	IBNET
Singapore, Singapore	4%	2008	IBNET
Hong Kong, China	36%		http://www.wsd.gov.hk/filemanager/en/share/annual_reports/rpt0809/main.htm
Quezon City, Philippines	15%	2009	Manila Water meeting in Quezon City, March 2010
Jeddah (Jiddah), Saudi Arabia	28%	2008	Jeddah Water Balance Model
Shanghai, China	16%	2005	Asian Development Bank, Water Utilities Report 2006
Budapest, Hungary	25%	2007	European Green City Index, Budapest detailed report
Vijaywada, India	60%	2008	Vijaywada City Development Plan, Vijaywada City Corporation
Jabalpur, India	69%	2008	Jabalpur City Development Plan Review Document
Bengaluru (Bengalore), India	40%	2005	IBNET
Indore, India	20%	2005	IBNET
Pune, India	39%	2005	IBNET
Johannesburg, South Africa	31%	2006	IBNET
Belo Horizonte, Brazil	31%	2007	IBNET
Phnom Penh, Cambodia	6%	2007	IBNET
Karachi, Pakistan	30%	2001	IBNET
Lima, Peru	39%	2006	IBNET
Warsaw, Poland	18%	2008	European Green City Index, Warsaw detailed report
Jakarta, Indonesia	51%	2005	Asian Development Bank, Water Utilities Report 2007
Kuala Lumpur, Malaysia	35%	2007	IBNET
Ho Chi Minh City, Vietnam	43%	2007	IBNET
Dakar, Senegal	19%	2006	IBNET
Rio de Janeiro, Brazil	58%	2007	IBNET
Kiev, Ukraine	7%	2007	European Green City Index, Kiev detailed report
Tallinn, Estonia	26%	2008	European Green City Index, Tallinn detailed report
Ljubljana, Slovenia	35%	2008	European Green City Index, Ljubjana detailed report
Bratislava, Slovakia	31%	2007	IBNET
Dhaka, Bangladesh	36%	2009	IBNET
Amman, Jordan	50%	1998	IBNET
Bhopal, India	64%	2008	Bhopal City Development Plan, Bhopal City Municipal Corporation
Kathmandu, Nepal	37%	2005	Asian Development Bank, Water Utilities Report 2006
Colombo, Sri Lanka	55%	2005	Asian Development Bank, Water Utilities Report 2007
Seoul, South Korea	25%	2005	Asian Development Bank, Water Utilities Report 2008

Waste Water KPI: WW5

Energy Cost for Water Treatment (Potable and Waste Water) as a Percentage of the Total Water Operating Cost	%		
	Value	Year	Source
Quezon City, Philippines	15%		Manila Water meeting in Quezon City, March 2010
Indore, India	74%	2005	IBNET
Pune, India	34%	2005	IBNET
Belo Horizonte, Brazil	12%	2007	IBNET
Phnom Penh, Cambodia	42%	2007	IBNET
Warsaw, Poland	6%	2007	IBNET
Kuala Lumpur, Malaysia	3%	2007	IBNET
Ho Chi Minh City, Vietnam	25%	2007	IBNET
Rio de Janeiro, Brazil	7%	2007	IBNET
Dhaka, Bangladesh	39%	2009	IBNET

Solid Waste KPI: SW1

Waste per Capita	kg/capita		
	Value	Year	Source
New York, USA	975		http://www.consumersunion.org/other/zero-waste/, http://www.census.gov/popest/cities/SUB-EST2008.html
Tokyo, Japan	348		Waste Management in Tokyo I, http://www.metro.tokyo.jp/ENGLISH/PROFILE/overview03.htm
Toronto, Canada	791	2005	NATIONAL—The Conference Board of Canada, Municipal Waste Generation, http://www.toronto.ca/toronto_facts/diversity.htm
Paris, France	556	2007	European Green City Index, Paris detailed report, http://www.paris.fr/portail/accueil/Portal.lut?page_id=5427&document_type_id=5&document_id=8717&portlet_id=11661
Sydney, Australia	2,028	2004	City of Sidney Environmental Management Plan, http://www.abs.gov.au/ausstats/abs@.nsf/Products/3218.0~2007-08~Main+Features~Main+Features?OpenDocument#PARALINK0
Mexico City, Mexico	320	2002	National Population Council (NATIONAL—OECD)
Cape Town, South Africa	620		State of environment report Cape Town 2008, Statistics South Africa
Singapore, Singapore	620		http://www.zerowastesg.com/2009/03/17/2008-waste-statistics-and-current-waste-situation-in-singapore-part-one/, http://www.singstat.gov.sg/stats/themes/people/hist/popn.html
Hong Kong, China	1,765	2008	Monitoring of solid waste in Hong Kong, waste statistics for 2008, PWC estimates
Quezon City, Philippines	257		Accomplishment report 2009 solid waste, http://www.quezoncity.gov.ph/images/Downloadables/cityindicators/demographics08.pdf
Budapest, Hungary	441	2007	European Green City Index, Budapest detailed report, Eurostat
Mysore, India	140	2007/08	ICLEI—South Asia, Local Governments for Sustainability, www.mysorecity.gov.in/
Vijaywada, India	150	2007/08	ICLEI—South Asia, Local Governments for Sustainability, ADB Water Utility Profile Document
Jabalpur, India	127	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Jabalpur Municipal Corporation
Pokhara, Nepal	57	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Pokhara Sub-Metropolitan City Authority
Bengaluru (Bengalore), India	338	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Municipal Corporation Official Estimate
Indore, India	137	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Indore Municipal Development Plan
Pune, India	131	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Pune Municipal Development Plan
Warsaw, Poland	522	2007	European Green City Index, Warsaw detailed report, City of Warsaw Authority

Waste per Capita	**kg/capita**		
	Value	**Year**	**Source**
Tehran, Iran	321	2005	x365 kg/capita/per diem given in "Municipal solid waste management in Tehran: Current practices, opportunities and challenges," Abdolmajid Mahdavi Damghani, Gholamreza Savarypour, Eskandar Zand, Reza Deihimfard, *Waste Management 28* (2008) 929–934, UN World Urbanization Prospects
Kiev, Ukraine	599		European Green City Index, Kiev detailed report, Census Data
Tallinn, Estonia	883		European Green City Index, Tallinn detailed report, Tallinn e-Government Portal
Ljubljana, Slovenia	441		European Green City Index, Ljubjana detailed report, Province of Ljubljana Statistical Authority
Porto, Portugal	440	2002	Report: Matriz Energética do Porto 2004 (NATIONAL—OECD)
Bratislava, Slovakia	320	2002	Bratislava City Council (NATIONAL—OECD)
Bhopal, India	100	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Bhopal Municipal Corporation Transportation Department Estimate
Guntur, India	159	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Municipal Corporation Estimate Based Upon 2001 Census
Kanpur, India	161	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Municipal Corporation Estimate
Patna, India	183	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Patna Municipal Corporation Development Plan
Sangli, India	115	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Sangli Miraj Kupwad Municipal Corporation
Kathmandu, Nepal	135	2007/08	ICLEI—South Asia, Local Governments for Sustainability, kathmandu.gov.np
Colombo, Sri Lanka	395	2007/08	ICLEI—South Asia, Local Governments for Sustainability, Municipal Council of Colombo

Solid Waste KPI: SW2

Capture of Solid Waste	%		
	Value	Year	Source
Cape Town, South Africa	99.15%	2006	City of Cape Town Economic and Human Development Department
Singapore, Singapore	100%	2007	UN Environmental statistics database
Quezon City, Philippines	99%	2009	Accomplishment report 2009 solid waste
Mysore, India	80%	2008	Mysore City Development Plan, Mysore City Municipal Corporation
Vijaywada, India	87%	2008	Vijaywada City Development Plan, Vijaywada City Corporation
Jabalpur, India	70%	2008	Jabalpur City Development Plan Review Document
Pune, India	76.1%	2008	Pune City Development Plan, Pune City Municipal Corporation
Bogota, Colombia	69.71%	2007	GCIF

Solid Waste KPI: SW3

Percentage of Solid Waste Recycled	%		
	Value	Year	Source
New York, USA	33%	2009	New York City Mayor's Management Report 2010
Tokyo, Japan	13%	2000	Institute for Global Environment Strategies, "Urban energy use and greenhouse gas emissions in Asian mega-cities—policies for a sustainable future," http://www.globalcarbonproject.org/global/pdf/MegacitiesAsia&GHGs.IGES2004.pdf
Toronto, Canada	35%	2007	GCIF
Paris, France	19%		European Green City Index, Paris detailed report
Hong Kong, China	46%		Monitoring of solid waste in Hong Kong, waste statistics for 2008
Quezon City, Philippines	14%	2009	Accomplishment report 2009 solid waste
Jeddah (Jiddah), Saudi Arabia	2%	2009	Jeddah Municipality Landfill Department
Budapest, Hungary	2%		European Green City Index, Budapest detailed report
Mysore, India	10%	2008	Mysore City Development Plan, Mysore City Municipal Corporation
Vijaywada, India	21%	2008	Vijaywada City Development Plan, Vijaywada City Corporation
Bogota, Colombia	0%		GCIF 2007 data
Warsaw, Poland	5%	2004	http://www.urbanaudit.org
Kiev, Ukraine	0%		European Green City Index, Kiev detailed report
Tallinn, Estonia	31%		European Green City Index, Tallinn detailed report
Ljubljana, Slovenia	4%		European Green City Index, Ljubjana detailed report
Bratislava, Slovakia	21%	2004	http://www.urbanaudit.org
Amman, Jordan	0%	2008	GCIF
Bhopal, India	20%	2008	Bhopal City Development Plan, Bhopal City Municipal Corporation
Seoul, South Korea	43%	2000	Institute for Global Environment Strategies, "Urban energy use and greenhouse gas emissions in Asian mega-cities—policies for a sustainable future," http://www.globalcarbonproject.org/global/pdf/MegacitiesAsia&GHGs.IGES2004.pdf

Solid Waste KPI: SW4

Percentage of Solid Waste That Goes to Landfill	Value	Year	Source
New York, USA	62%	2009	New York City Mayor's Management Report 2010
Tokyo, Japan	14%	2000	Institute for Global Environment Strategies, "Urban energy use and greenhouse gas emissions in Asian mega-cities—policies for a sustainable future," http://www.globalcarbonproject.org/global/pdf/MegacitiesAsia&GHGs.IGES2004.pdf
Toronto, Canada	65%	2007	GCIF
Paris, France	7%	1996	http://www.urbanaudit.org
Singapore, Singapore	44%		http://www.zerowastesg.com/2009/03/17/2008-waste-statistics-and-current-waste-situation-in-singapore-part-one/
Hong Kong, China	54%		Monitoring of solid waste in Hong Kong, waste statistics for 2008
Quezon City, Philippines	64%	2009	Quezon City field visit, February 2010, Accomplishment report 2009 solid waste
Jeddah (Jiddah), Saudi Arabia	98%	2009	Jeddah Municipality Landfill Department
Shanghai, China			
Budapest, Hungary	71%	2004	http://www.urbanaudit.org
Addis Ababa, Ethiopia			
Mysore, India	56%	2008	Mysore City Development Plan, Mysore City Municipal Corporation
Vijaywada, India	25%	2008	Vijaywada City Development Plan, Vijaywada City Corporation
Jabalpur, India	69%	2008	Jabalpur City Development Plan Review Document
Warsaw, Poland	82.22%	2004	http://www.urbanaudit.org
Tallinn, Estonia	66.03%	2004	http://www.urbanaudit.org
Bratislava, Slovakia	76%	2004	http://www.urbanaudit.org
Bhopal, India	80%	2008	Bhopal City Development Plan, Bhopal City Municipal Corporation
Seoul, South Korea	49%	2000	Institute for Global Environment Strategies, "Urban energy use and greenhouse gas emissions in Asian mega-cities—policies for a sustainable future," http://www.globalcarbonproject.org/global/pdf/MegacitiesAsia&GHGs.IGES2004.pdf

Appendix 5: RAF Energy Efficiency Recommendations

Meta-Sector	ID	Recommendation
Transportation	1	Enforcement of Vehicle Emissions Standards
	2	Taxi Vehicle Replacement Program
	3	2-Stroke Engine Replacement or Retrofit
	4	Parking Restraint Measures
	5	Traffic Flow Optimization
	6	Traffic Restraint Measures
	7	Congestion Pricing
	8	Non-motorized Transport Modes
	9	Public Transport Development
Waste	1	Waste Vehicle Fleet Maintenance Audit and Retrofit Program
	2	Fuel-Efficient Waste Vehicle Operations
	3	Waste Infrastructure Planning
	4	Waste Composting Program
	5	Landfill Gas Capture Program
	6	Intermediate Transfer Stations
	7	EE Sorting and Transfer Facilities
	8	Waste to Energy Program
Water	1	Improve Efficiency of Pumps and Motors
	2	Active Leak Detection and Pressure Management Program
	3	Prioritizing Energy-Efficient Water Resources
	4	Auditing and Retrofitting Treatment Facilities
	5	Sludge Beneficial Reuse Program
	6	Educational Measures
	7	Water Efficient Fixtures and Fittings
	8	Water Meter Program
	9	Improve Performance of System Networks
	10	Formation of Ring Main
Power and Heat	1	District Cogeneration Thermal Network
	2	Non-technical Loss Reduction Program
	3	Transformer Upgrade Program
	4	Power Factor Correction Program
	5	Power Generation Plant Maintenance and Upgrade Program
	6	District Heating Network Maintenance and Upgrade Program
Public Lighting	1	Integrated Public Lighting Assessment Program
	2	Street Lights Audit and Retrofit Program
	3	Procurement Guide for New Street Light Installations
	4	Traffic Signals Audit and Retrofit Program
	5	Street Signage Lighting Audit and Retrofit Program
	6	Public Spaces Lighting Audit and Retrofit Program

Meta-Sector	ID	Recommendation
	7	Lighting Timing Program
Buildings	1	Municipal Buildings Energy Efficiency Task Force
	2	Municipal Buildings Benchmarking Program
	3	Municipal Schools Audit and Retrofit Program
	4	Municipal Offices Audit and Retrofit Program
	5	Municipal Residential (Public Housing) Audit and Retrofit Program
	6	Municipal Hospitals Audit and Retrofit Program
	7	Computer Power Save Project
	8	Solar Hot Water Program
	9	Mandatory Building Energy Efficiency Codes for New Buildings
	10	Green Building Guidelines for New Buildings
CA Management	1	Energy Efficiency Municipal Task Force
	2	Energy Efficiency Strategy and Action Plan
	3	Capital Investment Planning
	4	Purchasing and Service Contracts
	5	Energy Performance Contracting
	6	Awareness-raising Campaign
	7	Travel Planning
	8	Municipal Vehicle Fleet Efficiency Program

Appendix 6: List of Case Studies

#	Country	Case Study Title	Sector	Recommendation Number (s)
1	Australia	Boroondara Energy Saving Team, Boroondara	CA Management	1
2	Australia	Siemens Energy Efficiency Academy	CA Management	6
3	Australia	Power Factor Correction, the University of Adelaide	Power and Heat	4
4	Australia	The Metropolitan Waste and Resource Recovery Strategic Plan, Melbourne	Solid Waste	3
5	Australia	Waste Recycling Model, Sydney	Solid Waste	4
6	Australia	"Lighting the Way" Project	Street Lighting	3
7	Australia	Public Square Lights Retrofit, Adelaide	Street Lighting	6
8	Australia	Park and Waterfront Lights Retrofit, Melbourne	Street Lighting	6
9	Australia	Water Pressure Management Program, Sydney	Water	2
10	Australia	Best Practice Sustainable Design, Sydney	Water	6
11	Austria	Durnrohr EfW Facility	Solid Waste	8
12	Bangladesh	Solid Waste Management Project, Dhaka	Solid Waste	3, 4
13	Bangladesh	Educational Baby Taxis program, Dhaka	Transport	3
14	Brazil	Linking Development Densities to Public Transport Availability, Curitiba	Transport	9
15	Brazil	Improving the Distribution of Water, Fortaleza	Water	1
16	Bulgaria	Municipal Energy Efficiency Network	Buildings	2
17	Bulgaria	Municipality of Smolyan	Buildings	3
18	Bulgaria	Street Light Retrofits, Dobrich	Street Lighting	2
19	Cambodia	Phnom Penh Water Supply and Drainage Project	Water	2, 8, 9
20	Canada	Upper Canada College, Centennial College	Buildings	3
21	Canada	Better Buildings Partnership (BBP)	Buildings	6
22	Canada	Toronto Atmospheric Fund	CA Management	1, 3
23	Canada	Energy Efficiency Office	CA Management	6
24	Canada	Municipal Solid Waste Guidelines, British Columbia	Solid Waste	6
25	Canada	Water Efficiency Awards, Toronto	Water	6
26	Central and Eastern Europe and the Commonwealth of Independent States	Municipal Network for Energy Efficiency (MUNEE) Program	Buildings	1
27	Chad	Solar Water Pumps, Kayrati	Water	3
28	China	District Heating Network Upgrade, Jiamusi	Power and Heat	6
29	China	NENT Landfill Gas Utilisation Scheme, Hong Kong	Solid Waste	5
30	China	Vehicle Bans: Motorcycle Ban, Guangzhou	Transport	6
31	Colombia	Dedicated Cycle Network, Bogota	Transport	8
32	Colombia	BRT System, Bogota	Transport	9
33	Denmark	Sustainable Procurement Campaign	CA Management	4
34	Denmark	Contracted Bus Fleet, Copenhagen	CA Management	8
35	Denmark	District Heating Network, Copenhagen	Power and Heat	1
36	Denmark	Contracted Bus Fleet, Copenhagen	CA Management	8
37	Egypt	Taxi Vehicle Replacement Program, Cairo	Transport	2
38	England	Pedestrianization with Road Closures, Oxford	Transport	8
39	EU	EU and Display Campaign Case Studies	Buildings	3, 4, 6
40	Finland	District Heating Network, Kotka	Power and Heat	1

#	Country	Case Study Title	Sector	Recommendation Number (s)
41	France	Isseane EfW and Materials Recycling Facility, Paris	Solid Waste	2
42	France	Bicycle Rental, Velib, Paris	Transport	8
43	Germany	Energy Management System	Buildings	1, 5
44	Germany	Model for Improving Energy Efficiency in Buildings	Buildings	4
45	Germany	Internal Contracting	Buildings	4
46	Germany	Energy Management System, Frankfurt	Buildings	4
47	Germany	Berlin Energy Saving Partnership	CA Management	5
48	Germany	Economical Pumping Solutions, Lichetenau	Water	1
49	Greece	Sofia Energy Centre	Water	5
50	India	Bhubane Solid Waste at Municipal Hospital	Buildings	6
51	India	Performance Contracting, Akola	CA Management	5
52	India	Communication Program, Indian State Electricity Boards	Power and Heat	2
53	India	GPOBA Improved Electricity Access to Indian Slum Dwellers Program	Power and Heat	2
54	India	Capacitor Leasing ESCO, Ahmedabad	Power and Heat	4
55	India	ESCO Street Light Retrofit, Akola	Street Lighting	2
56	India	Free Maintenance Clinics, Delhi	Transport	3
57	India	No- and Low-cost Energy Efficiency Measures, Pune	Water	1
58	India	Rainwater Harvesting, Delhi	Water	3, 7
59	India	Reducing Power Consumption, Ahmedabad	Water	9
60	Indonesia	Bus Inspection and Maintenance Program, Jakarta	CA Management	8
61	Indonesia	Bus Inspection and Maintenance Program, Jakarta	CA Management	8
62	Ireland	Green-Schools, Ireland	Buildings	3
63	Ireland	Energy Awareness Week	CA Management	6
64	Ireland	Springfort Cross Waste Transfer Station Reporting Scheme, Nenagh	Solid Waste	7
65	Italy	Local Authorities' Waste Management	Solid Waste	2, 3
66	Ivory Coast	Abidjan Municipal Solid Waste-To-Energy Project, Abidjan	Solid Waste	8
67	Korea	District Heating Network Pipe Maintenance, Seoul	Power and Heat	6
68	Malaysia	Kuala Lumpur Waste Structure Plan 2020, Kuala Lumpur	Solid Waste	6
69	Malaysia	Motorway intelligent Lights Retrofit, Kuala Lumpur	Street Lighting	7
70	Mexico	Promoting an Energy-Efficient Public Sector	CA Management	4
71	Mexico	Inspection Program, Mexico City	Transport	1
72	Mexico	Taxi Substitution Program, Mexico City	Transport	2
73	New Zealand	Waitakere City Council Website	Water	6, 7
74	Norway	Integrated Waste Management System, Oslo	Solid Waste	4
75	Norway	Intelligent outdoor city lighting system, Oslo	Street Lighting	7
76	People's Republic of China	Voluntary Energy Efficiency Labelling Scheme	Buildings	7
77	People's Republic of China	Solar Water Heating	Buildings	8
78	People's Republic of China	Shek Wu Hui Sewage Treatment Works	CA Management	3
79	People's Republic of	LED Traffic Lights Retrofit, Hong Kong	Street Lighting	4

#	Country	Case Study Title	Sector	Recommendation Number (s)
	China			
80	Peru	Bicycle Micro Credits, Lima	Transport	8
81	Philippines	Legal Mandate and Hotline, Manila	Power and Heat	2
82	Philippines	Garbage Collection Efficiency Project, General Santos City	Solid Waste	2
83	Philippines	Community Materials Recovery Scheme, Naga City	Solid Waste	7
84	Philippines	Micro-finance Retrofits, Puerto Princesa	Transport	3
85	Philippines	No-driving Days, One Day Rest, Puerto Princesa	Transport	6
86	Portugal	Energy Study on Oeiras' Municipal Fleet, Oeiras	Solid Waste	1, 2
87	Portugal	Energy-Efficient Public Lighting, Gaia	Street Lighting	1
88	Puerto Rico	Water Treatment Plant, San Juan	Water	1
89	Romania	SMEU Software	Buildings	2
90	Romania	USAID-Funded Ecolinks Project, Galati	Water	1, 2
91	Romania	Pilot Leak Detection and Abatement Program, Iasi	Water	2, 6
92	Sierra Leone	Gravity-fed Schemes, Moyamba Township	Water	3, 9
93	Singapore	Building Energy Efficiency Master Plan (BEEMP), Singapore	Buildings	2
94	Singapore	Energy Efficiency Program Office (E2PO),	CA Management	1
95	Singapore	Low Carbon, Singapore	CA Management	6
96	Singapore	Car Clubs, Singapore	CA Management	7
97	Singapore	Singapore Waste Management Project	Solid Waste	8
98	Singapore	Rationing, Singapore	Transport	6
99	Singapore	Congestion Charge, Singapore	Transport	7
100	Slovenia	Energy Agency of Podravje	Buildings	3
101	Slovenia	Energy Management in Hospitals	Buildings	6
102	Slovenia	Eco-Driving Project, Maribor	Solid Waste	2
103	South Africa	Ekurhuleni Metropolitan Municipality (EMM) Energy Efficiency Strategy	Buildings	1, 8
104	South Africa	Green Building Guidelines	Buildings	9
105	South Africa	Durban Landfill-to-Electricity Clean Development Mechanism, eThekwini	Solid Waste	5
106	South Africa	Pressure Management, Emfuleni	Water	2
107	South Africa	Rehabilitation of the Water Network and Private Plumbing Fixtures, Soweto	Water	7, 8, 9
108	South Africa	Kagiso Project, Mogale City	Water	8
109	Spain	BARNAMIL Project	Buildings	8
110	Spain	Barcelona Energy Agency	CA Management	1
111	Spain	Energy Efficiency Strategy	CA Management	2
112	Spain	Sustainable Procurement Campaign	CA Management	4
113	Spain	Effitrafo Replacement of Transformers, Endesa	Power and Heat	3
114	Spain	High-Occupancy Vehicle Lane, Madrid	Transport	5
115	Sweden	Clean Vehicles Program, Stockholm	CA Management	8
116	Sweden	Renova Waste Vehicle Fleet, Gothenburg	Solid Waste	1
117	Sweden	Gothenburg Waste Management Project, Gothenburg	Solid Waste	8
118	Sweden	Environmental Zone, Stockholm	Transport	1
119	Sweden	Clean Vehicles Program, Stockholm	CA Management	8
120	Sweden	Congestion Charge, Stockholm	Transport	8
121	Switzerland	Sustainable Procurement Campaign, Zurich	CA Management	4
122	Tanzania	Landfill Gas Recovery and Electricity Generation	Solid Waste	5

#	Country	Case Study Title	Sector	Recommendation Number (s)
		Project, Dar Es Salaam		
123	The Netherlands	Keep the Sun Project	Buildings	3
124	The Netherlands	Warm and Comfortable Living Campaign	Buildings	5
125	Turkey	Route Optimization for Solid Waste Collection, Trabzon City	Solid Waste	2
126	Uganda	Wagga Wagga Primary School, Mbarara District	Buildings	3
127	UK	Energy Efficient Office of the Future (EoF)	Buildings	4
128	UK	Royal Gwent Hospital	Buildings	6
129	UK	Carbon Management Energy Efficiency (CMEE) Program	CA Management	6
130	UK	Travel Plans, Nottingham Hospital	CA Management	7
131	UK	Social Housing District Network ESCO, Aberdeen	Power and Heat	1
132	UK	Drax Power Station Upgrade, Selby	Power and Heat	5
133	UK	Master Map Integrated Transport Study, Daventry	Solid Waste	2
134	UK	London Municipal Waste Strategy, London	Solid Waste	3
135	UK	WRAP Project, Scotland	Solid Waste	4
136	UK	Veolia Environmental Services Waste Transfer, Birmingham	Solid Waste	6
137	UK	Midlands Highway Alliance (MHA)	Street Lighting	3
138	UK	M25 Motorway Light Retrofit, Surrey	Street Lighting	4
139	UK	Control System for Public Lighting, Kirklees	Street Lighting	7
140	UK	Low Emission Zone, London	Transport	1
141	UK	Parking standards, London Plan, London	Transport	4
142	UK	Park-and-Ride, Oxford	Transport	4
143	UK	Variable Message Signs, Milton Keynes	Transport	5
144	UK	Congestion Charge, London	Transport	7
145	UK	Ashford STC Expansion	Water	4
146	UK	Mogden Sewage Treatment Works, London	Water	5
147	UK	Energy Action Plan, Leicester,	Water	6
148	UK	Reducing Water Demand in Social Housing, Preston	Water	7
149	UK	Energy and Water Conservation Fund, Kirklees Metropolitan Council	Water	7
150	UK	Victorian Mains, London, UK	Water	9
151	UK	Ring Main, Thames Water, London	Water	10
152	Ukraine	Public Building Energy Management Program, Lviv	Buildings	2
153	USA	DCAS Division of Energy Management (DEM), NYC	Buildings	1
154	USA	Energy Plan, Ann Arbor	Buildings	1
155	USA	NYC Greener Buildings	Buildings	2
156	USA	Power Management Programs	Buildings	7
157	USA	Verdiem's SURVEYOR Software	Buildings	7
158	USA	Austin Energy Green Building (AE/GB)	Buildings	9
159	USA	Sustainable Building Action Plan	Buildings	9
160	USA	PlaNYC, New York	CA Management	1, 3, 6
161	USA	Ann Arbour, Municipal Energy Fund	CA Management	1, 3
162	USA	Municipal Initiatives to Address Climate Change	CA Management	2
163	USA	Driver Education, SmarTrips	CA Management	7
164	USA	NYPD Hybrid Vehicle Program, New York	CA Management	8
165	USA	Prison Transformer Upgrades, Arizona	Power and Heat	3
166	USA	National Efficiency Standard, NEMA	Power and Heat	3
167	USA	Bethlehem Steel Turbine Upgrade, Burns Harbour	Power and Heat	5

#	Country	Case Study Title	Sector	Recommendation Number (s)
168	USA	Solar-Powered Trash Compacter Project, Philadelphia	Solid Waste	1
169	USA	Solid Waste Collection Vehicles, California	Solid Waste	1
170	USA	New York Composting Project, New York	Solid Waste	4
171	USA	Altamont Landfill and Resource Recovery Program, California	Solid Waste	5
172	USA	Solid Waste Management Plan, New York City	Solid Waste	6
173	USA	Summit County Material Recovery Facility, Summit County	Solid Waste	7
174	USA	Waste Management Sorting Line, Irvine, California	Solid Waste	7
175	USA	LED Traffic Lights Retrofit, Chicago	Street Lighting	4
176	USA	Highway Sign Retrofit, San Diego	Street Lighting	5
177	USA	LEDs for Traffic Signals, Portland, USA	Street Lighting	4
178	USA	NYPD Hybrid Vehicle Program, New York	CA Management	8
179	USA	Parking Fees, Aspen	Transport	4
180	USA	Arterial “Green Wave” Traffic Flow Optimization, Portland	Transport	5
181	USA	Energy Efficiency Strategies, Moulton Niguel, USA	Water	1
182	USA	Energy Management Program, Madera Valley	Water	1
183	USA	Water Treatment Plant Retrofit, Columbine	Water	4
184	USA	Point Loma Wastewater Treatment Plant, San Diego	Water	5
185	USA	Rebates, Albuquerque	Water	6, 7
186	USA	Energy Efficiency Strategies, Moulton Niguel, USA	Water	9
187	Uzbekistan	Solid Waste Management Project, Tashkent	Solid Waste	1
188	Venezuela	Social Tariff, Caracas	Power and Heat	2
189	Vienna	Energy Performance Contracting (EPC) in Viennese Schools	CA Management	5
190	Vietnam	Sanitary Landfill Gas CDM Project, Ho Chi Minh City	Solid Waste	5
191	Vietnam	Energy Efficiency Public Lighting Project	Street Lighting	1

Appendix 7: Comparison of Financing Options

Financing Mechanism	Prerequisites	Funding Source	Advantages	Disadvantages
Internal Municipal Financing				
General Municipal Financing Mechanisms	- Dependent on revenue-raising capacity	Internal	• Control over planning and implementation	• Own risk • Difficult to find and sustain funding needed
Incentive Programs	- Dependent on revenue-raising capacity	Internal	• Suitable when risks are high, and commercial financing is limited • Implementation is driven by community	• High cost, difficult to find and sustain funding needed • High transaction costs
Special Area Taxes	- Requires planning and taxation powers	Internal	• More sustainable financing method	• Relies on community willingness
Municipal Bonds	- Suitable to large-scale, high-cost initiatives	Internal	• Control over planning and implementation • Ability to finance high-cost initiatives • Can be tax exempt	• High financial risk to municipality • Requires investor confidence
Partnership with Private Sector	- Range of options from direct service outsourcing to complex PPP arrangements	Internal	• Leverage technical expertise of private sector • Public Private Partnerships (PPPs) can leverage financial and technical resources from the private sector	• Still requires financing sources for implementation • Requires strong financial and legal capacity on government's side
Special Purpose Funds				
Grants	- Limited availability	International agencies, IFCs, multilateral agencies, charitable agencies	• Smaller risk • More lenient financing terms or no repayment	• Difficult to find and obtain • Complex and often delayed process
Soft Loans	- Suitable when cost of finance is high	International agencies, IFIs, multilateral agencies, national government	• Lower cost of financing	• Complex process • Often additional conditions to adhere to
Loan Guarantees	- Suitable when risk is main barrier to financing	International agencies, IFIs, multilateral agencies, national government	• Assists municipalities to overcome barriers to commercial finance (i.e., lack of collateral) • Grows commercial sector's involvement in energy efficiency investment	• Complex process

Financing Mechanism	Prerequisites	Funding Source	Advantages	Disadvantages
Revolving Funds	- Requires initial investment - Management of the funds operation - Possible private-sector participation	Any source, finance dispersed through commercial banks	• Ability to leverage funds for multiple initiatives • Banks take commercial risk • Overcomes traditional bank loan barriers • Grows commercial sector's involvement in energy efficiency investment	• Ensuring funds are repaid • Delays subsequent projects
Bank "Windows"	- Specifically targeted outreach to specific sectors, i.e., small and medium enterprises (SMEs)	National government, any commercial bank	• Targets potential growth sectors/ industries	• High transaction costs • Same commercial risks
Carbon Finance	- Project methodologies must be allowed under Clean Development Mechanism (CDM) criteria, or other accreditation criteria	Through the United Nations Framework Convention on Climate Change (UNFCCC), European Union, or other Joint Implementation initiatives	• Ability to leverage funds externally without repayment	• Long, complex process with high technical reporting requirements
Third-Party Financing				
Commercial Bank Loans	- Ability to leverage credit	Any commercial bank	• If accessible, allows long-term access to funds	• Limited availability • Higher cost of financing
Leasing	- Willing supplier/lessee - Suited to small capital investments	Supplier or intermediary	• Transfers risk	• Higher cost for lease than outright purchase
Vendor Credit	- Willing supplier/lessee - Suited to small capital investments	Supplier or intermediary	• Longer repayment period	• Assumes municipality's capacity to purchase in the short term
Performance Contracting	- Existence of sufficient-scale energy savings potential (ESP)	Contract with Energy Services Company (ESCo), EU Energy Centre, non-governmental organization (NGO), consulting firm	• Shares substantial risk • Allows off-balance-sheet financing • Implementation and management by private sector with expertise	• Requires strong monitoring and management, including strong legal and financial infrastructure • Lack of ESCos with sufficient capacity and ability to leverage financing • Lack of bank confidence and

Financing Mechanism	Prerequisites	Funding Source	Advantages	Disadvantages
				experience

Appendix 8: RAF Tool Guidance Document

RAF Tool Guidance

Introduction

This document lays out step-by-step instruction for how to use the RAF. The rationale behind the RAF module algorithms and organization are not described here.

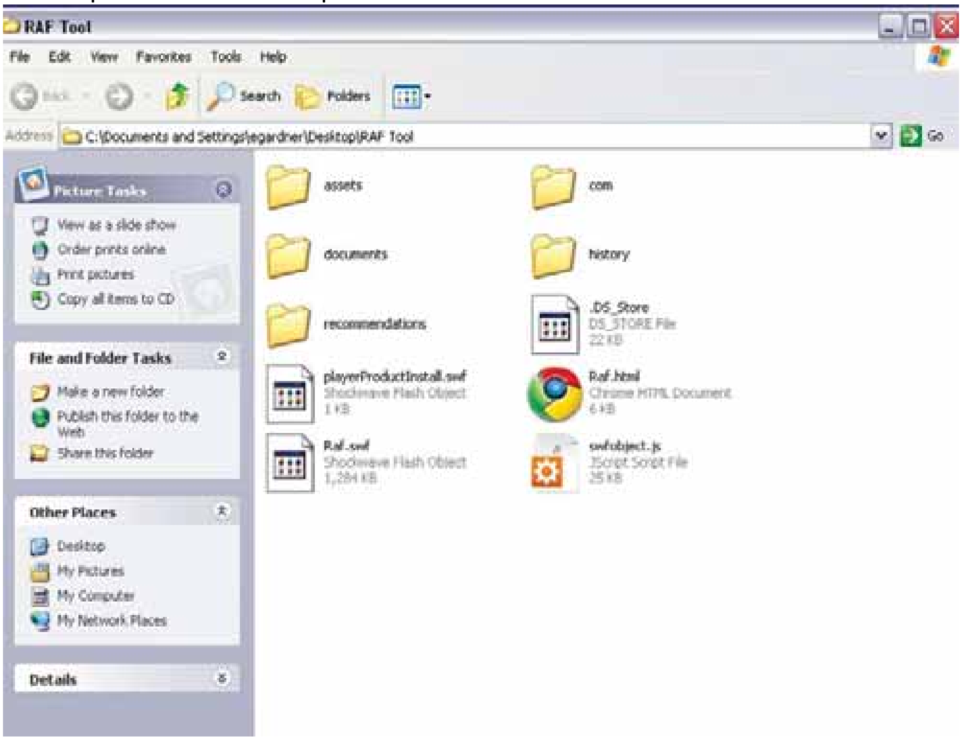
In order to use the RAF, the user's system must be equipped with at least:

> Windows XP or higher, Mac OS 10;
> Flash 10 browser plug-in;
> IE 7 or higher, Firefox 2 or higher, any version of Google Chrome, or Safari 4 or higher; and
> Adobe Reader, Bluebeam, or similar PDF reader.

Getting Started

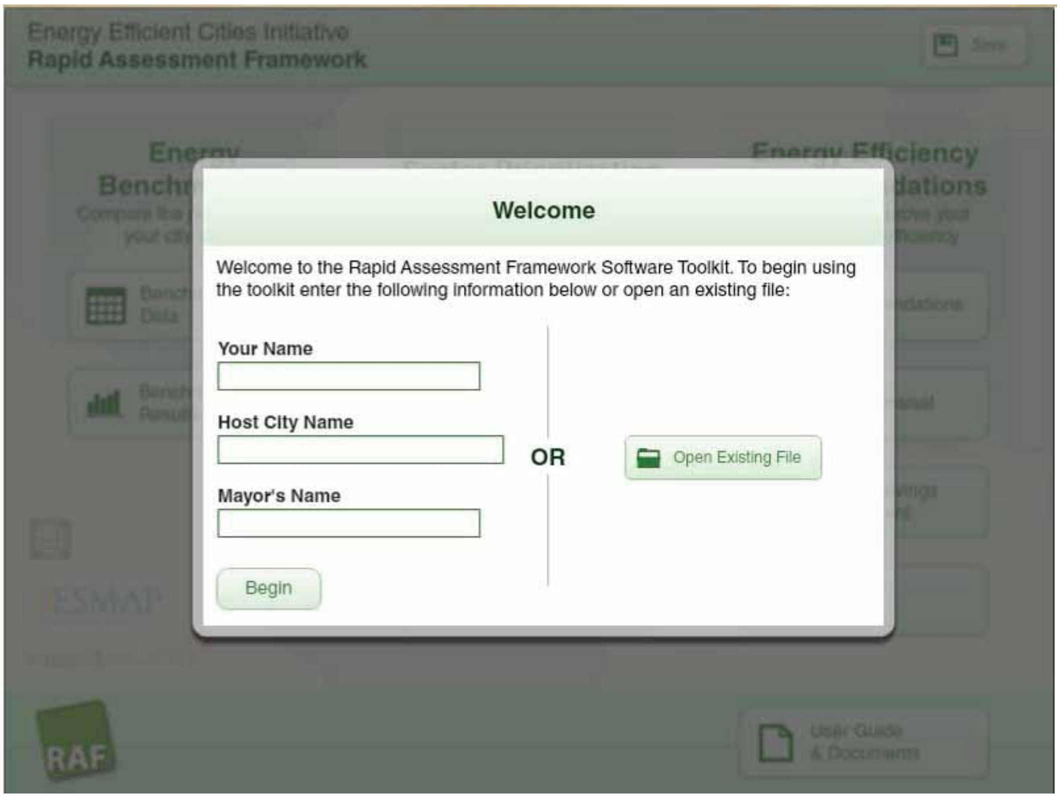
Step 1. If the RAF is started from a zipped folder, the user extracts the RAF Tool folder – it is important that the user does not move the files in the folder. If the RAF is started from a CD, the user simply opens the CD.

Step 2. The user opens the RAF Tool folder and double clicks on the RAF.html icon.



Step 3. When the RAF launches, the Welcome Screen is opened. If the user is starting a new RAF file, the user enters his or her city information as prompted and clicks Begin. If the user is opening an existing file, click Open Existing File and select the appropriate file.

Please note that input is saved within the tool each time the user navigates between screens and the user can save information to a file at any time by using the Save button in the upper right of each RAF screen. Each time the user clicks Save, a prompt for a new file name will appear. This is required due to security settings.

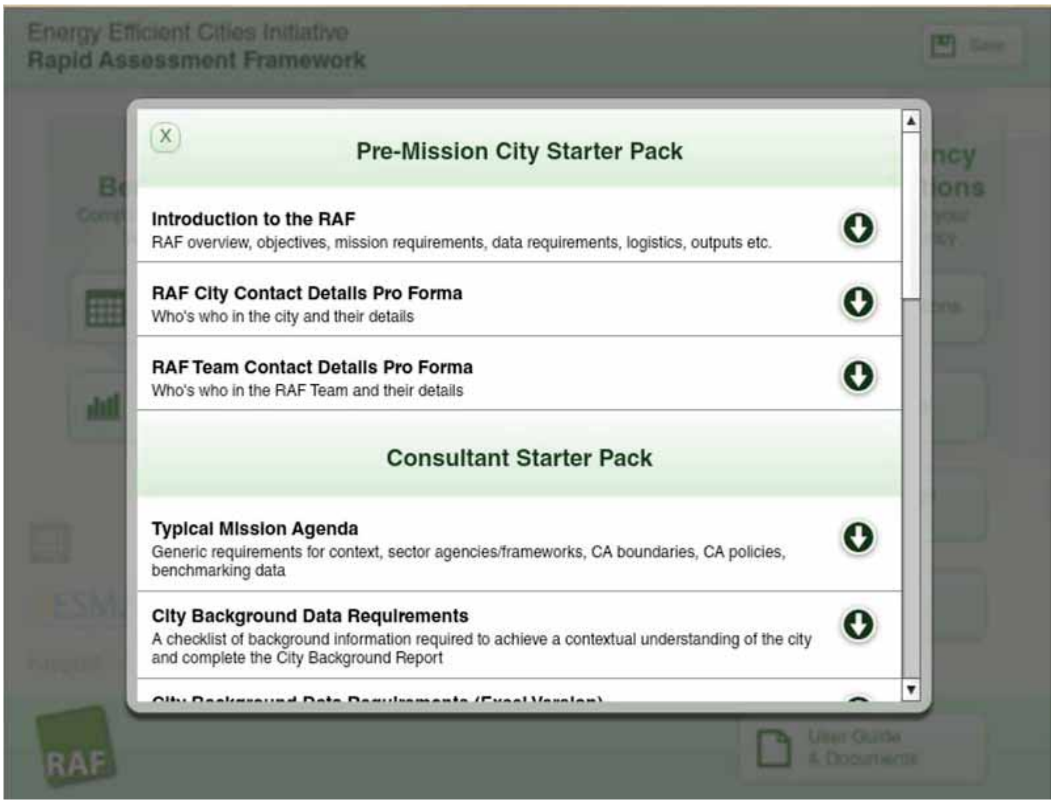


Step 4. The user will next see the RAF Home screen, to which the user can return at any time in the process by clicking the Home icon that appears in all modules at the upper left of the screen.

This screen allows the user to access any of the three modules—Energy Benchmarking, Sector Prioritization, Energy Efficiency Recommendations—at any time. There are no data field requirements to access any of the modules; that is, it is not necessary to enter benchmarking data before entering the Benchmark Results screen. It should be noted that if modules are entered before the relevant data have been entered, they will display incorrect or incomplete results and some sub-modules will not be available.

The modules are ordered left to right in the Home screen in a logical progression; that is, information from Energy Benchmarking feeds Sector Prioritization which in turn feeds the Energy Efficiency Recommendations module.

Step 5. Clicking on the Documents button from the Home screen allows the user to access all auxiliary documentation for the RAF, including the User Guide.



Energy Benchmarking Module

Step 1. Clicking on the Benchmark Data button from the Home screen allows the user to access the benchmark data input section of the RAF. In this section, the user enters benchmarking data collected during the pre-mission phase in each sector. The various sectors are accessed through the tabs on the left-hand side of the screen.

Step 2. After the benchmarking data are entered, the user can return to the Home screen by clicking Homein order to access the Benchmark Results screen by clicking Benchmarking Results. The benchmark results for the various KPIs can be accessed by clicking on the KPI name in the Select a KPI column. The KPIs are organized by sector and the various sectors can be accessed by clicking through the sector tabs on the left.

The RAF city is always shown in orange, peers in dark green, and proxy data in hatched (light and dark green).

It is possible to compare key city characteristics using the buttons—P (Population), C (Climate), H (Human Development Index), and N (No Filters) to the left of the KPI graph. Roll-overs give a full description of each characteristic. Clicking once reveals cities with similar values for the selected characteristic on the complete KPI graph. Double clicking eliminates all cities that do not have similar values for the selected characteristic, P, C, H, or N.

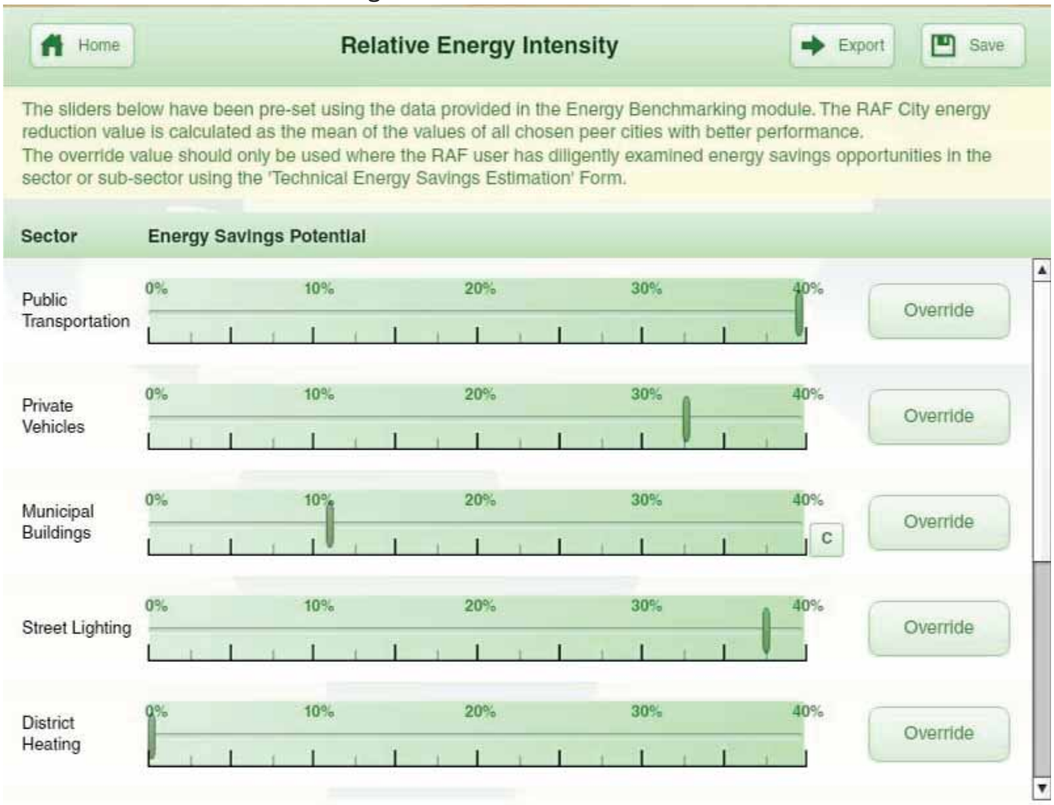
The user can also indicate which cities to include in the benchmarking graphs by un-checking the ones that are inappropriate for comparison.

Last, roll-over information gives the KPI value, year, and source for each city when the user hovers the mouse over each bar in the KPI chart.

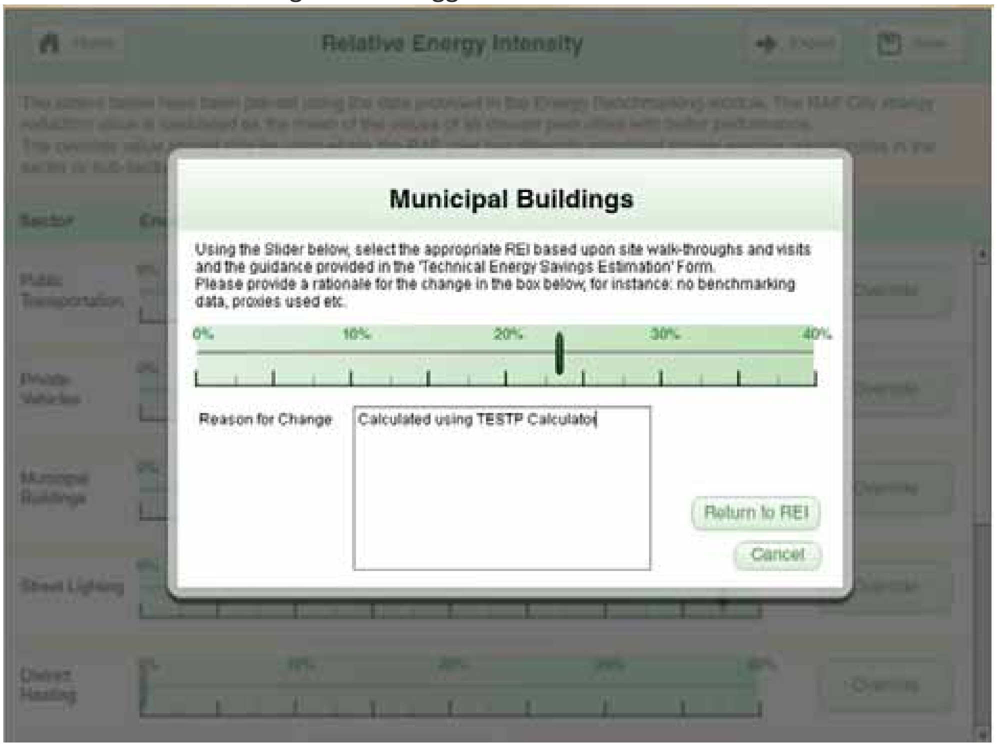
Step 3. Benchmarking graphs can be exported using the Export button at the top right of the page.

Sector Prioritization Module

Step 1. By clicking on the Relative Energy Intensity screen, the user accesses the first screen of the Sector Prioritization module. This screen is pre-populated with REI values determined from the Benchmarking module.



Step 2. The pre-populated REI calculation may be changed by punching the Override button and changing the REI value in the pop-up screen. The override rationale must be included before the change can be logged.



Step 3. The Sector Energy Spending screen is accessed through the Home screen, and allows the user to input the total energy spending in USD for each sector. The user must also indicate whether the city authority is responsible for energy costs or if the sector is city wide and energy costs are distributed.

Step 4. The City Authority Control screen is accessed through the Home screen. The user indicates the level of control the city authority has over each sector using the slider.

Step 5. The Sector Prioritization screen is accessed from the Home screen. If all information has been entered in the Sector Prioritization module (second column of buttons on the Home screen), this screen will show the ranking of sectors. The user checks the sectors to be taken forward to the Energy Efficiency Recommendations module (third column of buttons on the Home screen). The score shown on this page is calculated using the Relative Energy Intensity, Sector Energy Spending, and City Authority Control information inputted by the user. The value given is related to potential cost savings but should not be taken as a meaningful figure.


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.

5 of 9
selected

City Authority Sector Ranking

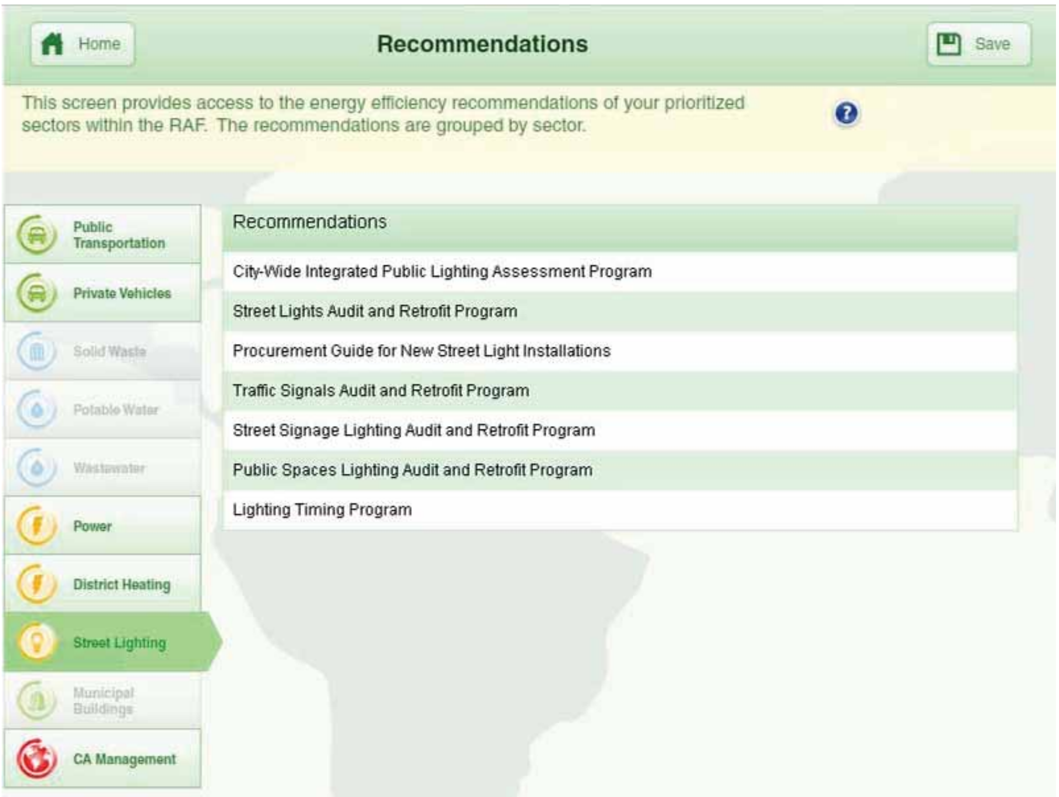
Rank	Sector	REI%	Spending (US $)	CA Control	Score	Check to Select
1	District Heating	5.3	10,000,000	0.79	418,700.00	☑
2	Street Lighting	38.2	1,000,000	1.00	382,664.52	☑
3	Municipal Buildings	10.9	1,000,000	1.00	109,619.69	☐
4	Solid Waste	48.2	10,000,000	0.85	4,103,923.48	☐

City Wide Sector Ranking

Rank	Sector	REI%	Spending (US $)	CA Control	Score	Check to Select
1	Power	30.5	10,000,000	0.22	672,594.40	☑
2	Private Vehicles	32.6	10,000,000	0.13	424,305.56	☑
3	Public Transportation	50.4	10,000,000	0.20	1,008,012.82	☑
4	Potable Water	17.8	10,000,000	0.24	428,571.43	☐
5	Wastewater	27.9	10,000,000	0.12	335,000.00	☐

Energy Efficiency Recommendations Module

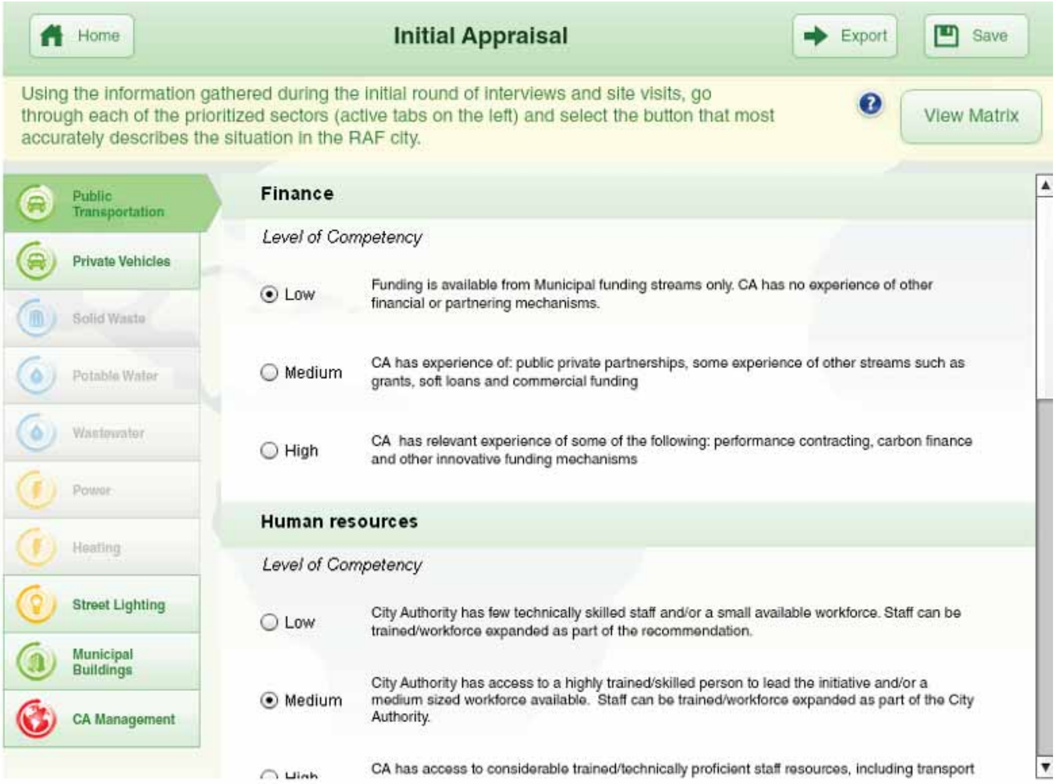
Step 1. From the Home screen the user can access the Recommendations module. The first screen, Recommendations, lists all the recommendations in the sectors that have been prioritized. The user can flick between sectors using the tabs on the left of the screen. Sectors that have not been prioritized are grayed out and are not accessible.



Step 2. If the user clicks on a recommendation title, the Recommendation sheet will appear in a separate browser window. Please note that the attributes shown here are generic and not calculated from RAF input.

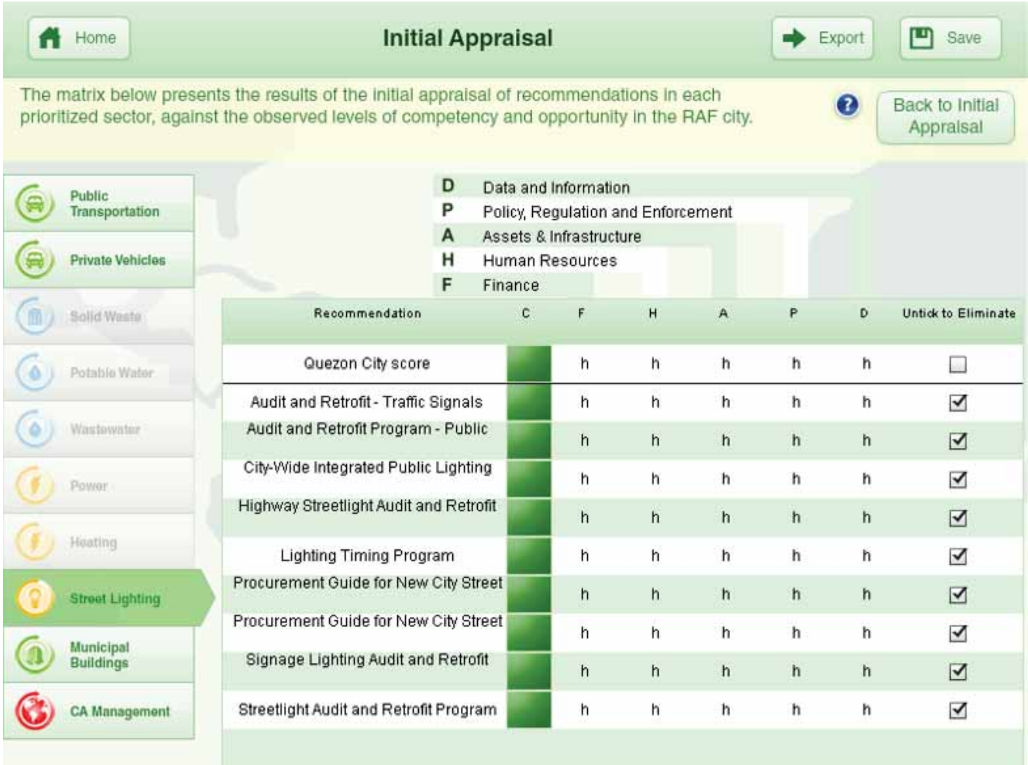
Step 3. After browsing the recommendations as desired, the user can access the Initial Appraisal screen from the Home screen. Initial Appraisal questions can be accessed for each

sector by clicking through the sector tabs on the left-hand side of the window. The Initial Appraisal questions are answered using radio buttons.

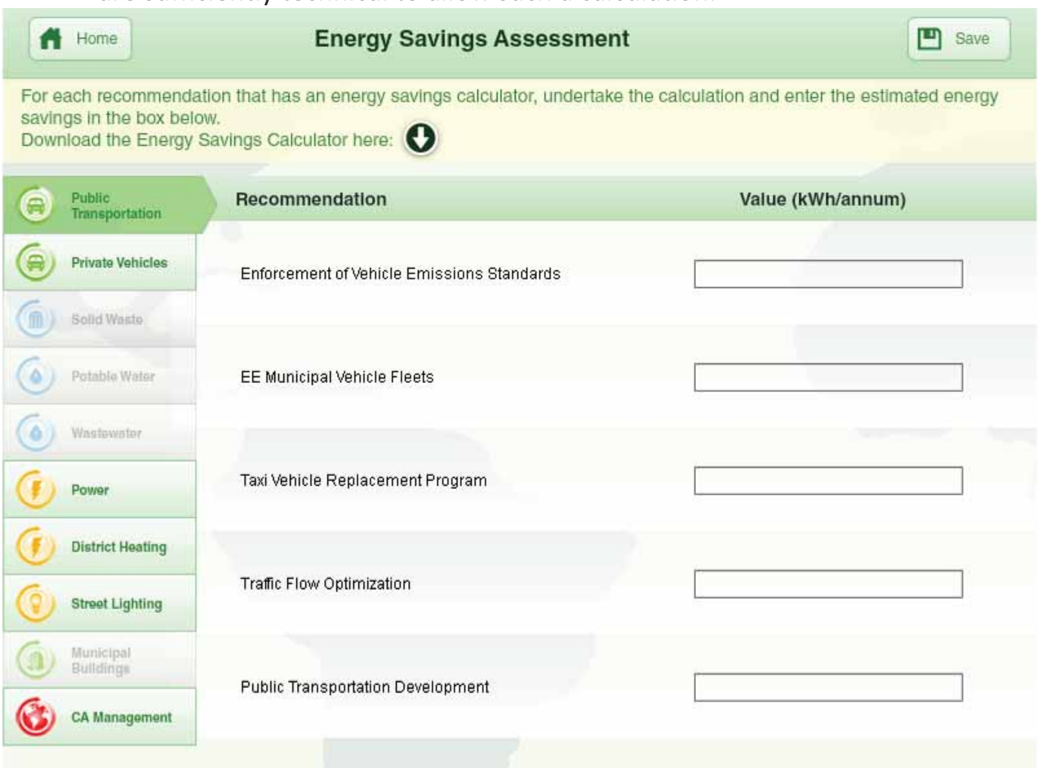


Step 4. By clicking the View Matrix button in the upper right of the screen, the user then accesses a comparison matrix that shows the city's characteristics and how they match to the competency/capability requirements of each recommendation. A traffic light indicates the potential for each recommendation; green means the recommendation is a good match for the city, yellow means the recommendation could potentially be a reasonable match for the city, and red means the recommendation is unlikely to work well in the city.

Once the user has analyzed the data, the recommendations to be taken forward are left checked so that they appear in subsequent screens. Recommendations that are inappropriate for the city are un-checked.



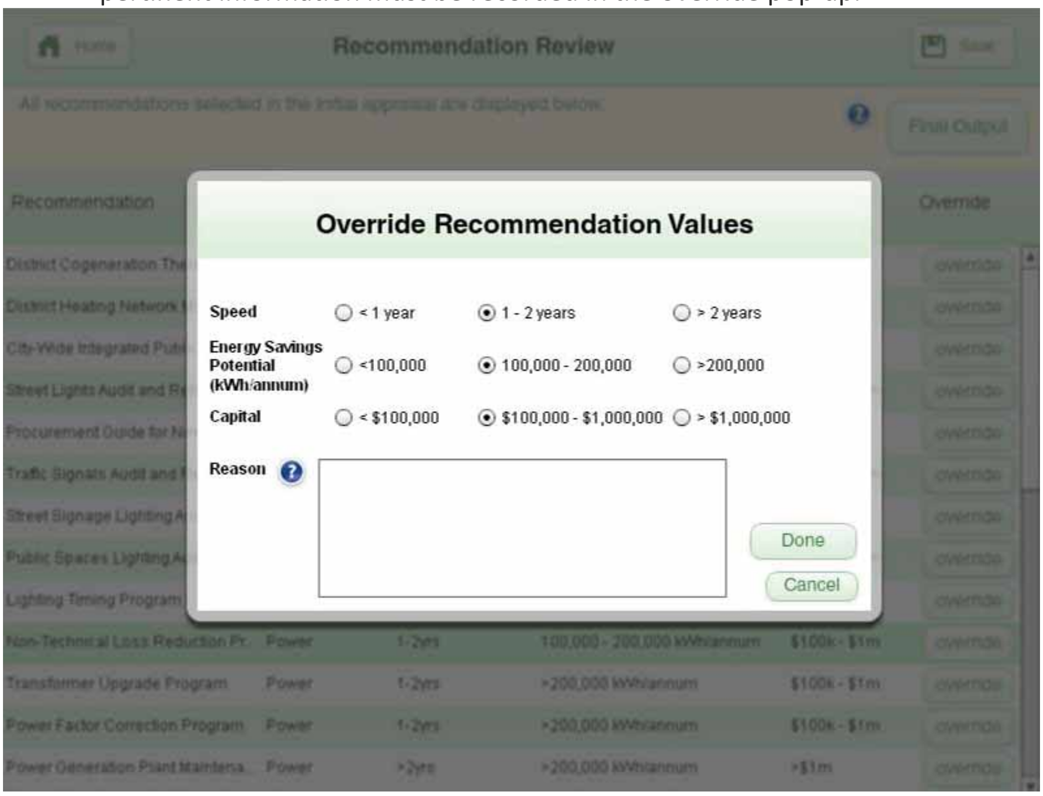
Step 5. The user accesses the Energy Savings Assessment screen from the Home screen. Here, the user enters data calculated from the Energy Savings Assessment Calculator, which is an Excel tool stored in the Documents section of the RAF. This tool uses rough engineering rules of thumb to calculate potential energy savings for Recommendations that are sufficiently technical to allow such a calculation.



Step 6. The last screen in the Recommendations module is the Recommendations Review. This screen lists all selected Recommendations and their attributes. Please note that the

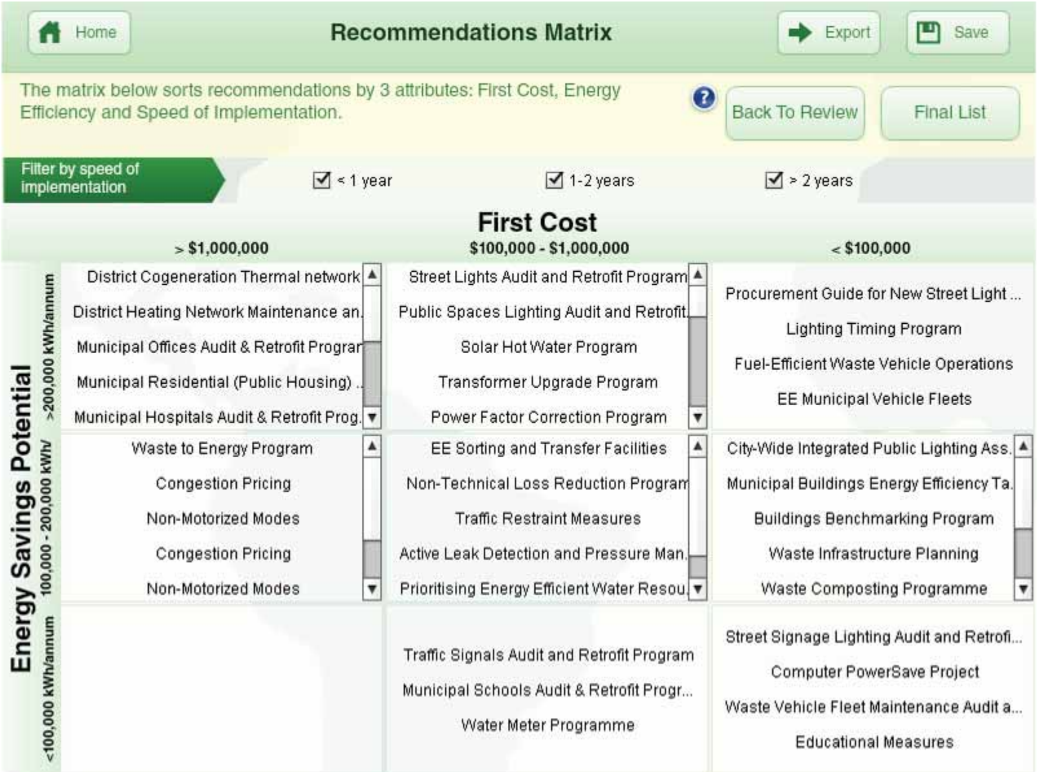
attributes shown here are calculated from user RAF input, whereas the attributes shown on the Recommendations sheets are generic values.

Step 7. The user may override attribute values if there is sufficient rationale to do so. All pertinent information must be recorded in the override pop-up.



Step 8. By clicking the View Matrix button, the user can examine a McKinsey-style matrix representation of the recommendations plotted by "First Cost" and "Energy Efficiency." The

user can filter the recommendations by “Speed of Implementation” using the check boxes in the upper left of the screen.



Step 9. Once the user is satisfied, the Final List screen can be accessed by clicking the Final List button at the top right of the screen. This gives the final list of all selected recommendations from the Initial Appraisal analysis. The user can further filter recommendations by selecting the final measures to be recommended to the city, and indicating which ones are a particular priority. As in previous screens, Recommendation sheets can be accessed in a separate browser window by clicking on the recommendation name.

Step 10. The user can save all information to a final XML file by clicking on the Save button in the upper right of the screen and giving the file an appropriate name.