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ESMAP TRACE

Tool for Rapid Assessment of City Energy (TRACE 2.0)

A Manual for Experts and City Officials

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TRACE 2.0 software and manual are available at https://esmap.org/TRACE

FOREWORD

Welcome to TRACE 2.0!

The Tool for Rapid Assessment of City Energy (TRACE) was first developed in 2008 by ESMAP's Energy Efficient Cities Program (http://www.esmap.org/Energy_Efficient_Cities), which seeks to help cities expand their municipal services through energy efficiency.

It was designed to give city authorities a quick and easy way to assess their energy use and to identify cost-effective and feasible measures they can take to improve energy efficiency in a variety of public sectors including lighting, water and wastewater, buildings, transportation, and power and heating.

After almost a decade of successful implementation in more than 80 cities across the globe,[1] TRACE has now undergone a major upgrade. Trace 2.0 now incorporates almost 100 built-in recommendations for energy efficiency measures as well as simple intervention models for each measure selected. With the help of the intervention "calculators," users can now quickly calculate the costs and benefits related to each recommendation.

As before, TRACE 2.0 will be hosted on https://esmap.org/TRACE. This manual is not designed to be a comprehensive user guide to the entire tool. Rather, it is a practical guide for local city officials, and crucially, for the energy experts who will have the training and experience necessary to use the tool to its fullest capacity.

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[1] For a list of cities, see http://www.esmap.org/node/4368.

1 | ABOUT TRACE

CONTEXT

More than 50 percent of the world's people live in cities, a figure that is expected to climb to as much as 64 percent by 2050, with 94 percent of the rise occurring in developing countries. At the same time, cities generate 80 percent of the world's gross domestic product, consume two-thirds of its energy, and emit 70 percent of its greenhouse gases. The current rapid pace of urbanization represents a challenge for both dwellers and local authorities in developing countries as rising incomes and improved living standards exert additional pressure on often already insufficient municipal infrastructure, and services such as electricity and water supply, which are essential to ensure sustainable and equitable economic growth.

Municipal energy efficiency measures can help address this challenge in two ways. First, they can improve the productivity of municipal services through reduced energy and maintenance costs. Second, they can help maintain or improve services by, for example, retrofitting street lighting. Successfully implemented, these measures create a win-win situation for both municipalities and citizens as they not only reduce the costs of vital municipal services but also enhance universal access to them while improving public health and fostering local economic activity.

The Tool for Rapid Assessment of City Energy (TRACE), first developed in 2008 by the World Bank's Energy Sector Management Assistance Program (ESMAP), is a free decision-support tool designed to help city officials quickly identify energy efficiency performance gaps and opportunities in a variety of public sectors including lighting, water and wastewater, buildings, transportation, solid waste, and power and heating. It guides its users through the process of data collection and sector prioritization—taking into account key constraints such as technical capacity and finance—to generate specific, integrated recommendations cities can use to improve and expand their energy efficiency efforts. TRACE's benchmarking function allows a city to compare its energy use against a range of peer cities and show the potential energy efficiency improvement the city may realize if it were to match the average of better-performing cities.

TRACE can help build this overall framework and initiate a process in a municipal government by using a set of standardized data to address a number of issues.

TRACE has now supported more than 80 cities' efforts to develop long-term energy efficiency strategies and investment pipelines by increasing their understanding of the cross-sectoral energy challenges, helping direct funds for dedicated energy efficiency investments, and pointing to necessary legislative adjustments; it has also improved local administrators' ability to identify, plan, and implement energy efficiency solutions across sectors.

The tool has recently undergone a major upgrade and now incorporates almost 100 built-in recommendations for energy efficiency interventions. Following requests from municipal officials for more detailed technical and financial analysis, TRACE 2.0 now provides customizable models for each selected intervention. With the help of the intervention "calculators," users can now quickly calculate the costs and benefits related to each recommendation.

As with its predecessor, TRACE 2.0 is hosted on https://esmap.org/TRACE. Both the updated tool and this manual draw upon lessons learned from the tool's deployments worldwide.

LIMITATIONS

Although the tool has been upgraded, the user should be aware that TRACE has three main limitations:

- Its calculations cannot replace thorough technical assessments and cost-benefit analyses for each intervention. Therefore, any investment will require further assessments, including a prefeasibility or feasibility study.
- The tool does not directly consider institutional and legislative requirements needed to implement the selected energy efficiency measures. Individual assessments are recommended.
- The tool's snapshot analysis does not take into consideration future changes to urbanization, such as deurbanization or rapid urbanization. For cities facing those developments, additional analyses are advisable.

ROLE AND BENEFITS OF TRACE

Prioritize Municipal Sectors with the Highest Potential for Energy Savings

Essentially, TRACE is used to identify both energy and cost savings opportunities through improving the energy efficiency of municipal service sectors. After the required data are gathered and entered, the tool assesses the energy performance of utility services, prioritizes sectors with the highest potential for energy savings, and recommends energy efficiency solutions that can be tailored to the city's needs. The city diagnostics and the energy efficiency plan can help city officials develop a long-term, sustainable local agenda and encourage the uptake of energy efficiency opportunities. Even exploring sectors where the city may have limited regulatory authority, such as private transport or residential buildings, can help officials gain a broader view of their city's potential.

Help City Officials Develop a City Energy Efficiency Plan and Other Strategies

Urban energy efficiency opportunities can be subject to different sector challenges that should be addressed (to some extent) within the city's institutional and legal structures. TRACE can help city officials draft plans to reduce energy consumption and greenhouse gases and improve the delivery of municipal services. For example, the city of Ploiesti in Romania used the TRACE city diagnostics to develop the local development strategy and the Sustainable Energy Action Plan the city had to prepare after becoming a signatory to the Covenant of Mayors, a European platform targeting the reduction of energy consumption and greenhouse gases in cities. In the Kyrgyz Republic, city officials used TRACE to develop municipal savings plans targeting public buildings and street lighting retrofits to address national electricity shortages and improve municipal service delivery.

TRACE users must bear in mind that the responsibility for actually implementing the energy efficiency measures recommended by TRACE lies with the city government, and that the implementation is influenced by a number of factors. These factors include, but are not limited to, level of interest and commitment from local authorities, available funds, the city's level of control over the given sectors, local implementing capacity, and local and national regulations. Some measures may be easier than others to execute directly from the city budget or by applying a regulatory framework, such as designing procurement guides for street lights. In other cases, the interventions may require more substantial initiatives, such as changes to national legislation.

While usually the most attractive areas for energy efficiency interventions are street lighting and public buildings, both of which are under municipal administrative and financial control, the city may choose to address other sectors that actually account for the bulk of energy use but are less amenable to local administrative leverage, such as residential and commercial buildings. For example, the city can enforce building codes or traffic restrictions.

Set Up a Database with City Indicators

Finally, TRACE can also help cities organize a database of indicators that are useful for any energy related investments. The overall goal is to eventually help city governments develop short-, medium-, or long-term energy efficiency investment plans that can be executed with funds from the local or national budget, with loans from commercial banks and/or international donors, or directly by private entities.

THE TRACE USER TEAM

TRACE is most effectively applied by energy experts with good technical skills and a deep knowledge of the municipal sectors the tool addresses. This is particularly important during the initial data- and information-collection process as well as during the final population of "intervention calculators," which require informed assumptions on the cost of equipment, potential energy savings, implementation duration, and so on.

Based on positive past experience, the team deploying the tool can consider a combination of senior and junior energy experts, as follows:

- **A senior expert** is responsible for overseeing the overall TRACE process and coordinating the TRACE deployment while providing international expertise to the municipality and junior experts. The senior expert leads and advises the municipality on the general features and requirements of urban energy diagnostics, manages the data collection process by reviewing the city background information and data collected by junior consultants, and helps aggregate and consolidate the sector data. The senior expert also plays an important role in prioritizing the municipal sectors and selects appropriate energy efficiency measures.
- **Junior experts** play an important role in collecting local data and information such as urban development strategies and relevant energy efficiency legislation, which are essential inputs for the city background report that feeds into the TRACE assessment. Their support is also critical for preparing the on-site TRACE deployment as well as data collection and compilation for key performance indicators (KPIs). Local expertise is important with regard to utility and municipal services administration as well as in identifying potential stakeholders, engaging with the city government, and organizing meetings with local stakeholders.

SUPPORT AND COMMITMENT FROM THE CITY AUTHORITY

It is important to ensure municipal "ownership" of the TRACE deployment process so the TRACE team can be assured it will have access to the necessary data and can coordinate with and interview relevant staff across departments. It is advisable to ask the municipal administration to provide an overview of the current public policies and strategies in the context of energy efficiency at the local level.

Ideally, the TRACE deployment effort should bring together experts from all relevant municipal sectors to form a cross-sectoral energy efficiency working group to discuss sector prioritization and energy efficiency recommendations. The group could comprise energy efficiency/technical experts from the city government and municipal service providers, in addition to the energy experts. For example, it could include technical personnel responsible for street lighting, solid waste, municipal buildings, public transport, urban planning, and someone from the city energy department if one exists.

Because forming such a group has proved difficult in many cities, the TRACE team should engage separately with the various stakeholders, while at the same time encouraging collaboration where possible. During the TRACE deployment, the team should establish a solid contact with a staff member from the city hall (preferably from the Energy Unit, if available) who can help organize meetings with relevant service providers and other city departments.

Finally, from the outset, it is important that the municipality takes ownership of the outcome of TRACE, and hence provides support both before and during the deployment of the tool. The process is always more successful if the city has an energy efficiency champion (such as the mayor or deputy mayor) who can engage with municipal departments and help incorporate the TRACE findings into the city strategy.

PREPARING TO DEPLOY TRACE

At the technical level, before starting the TRACE deployment, the local expert should prepare a brief overview of existing city development strategies and energy and energy efficiency action plans (if the city has any). A clearer picture of where the city is heading in the next 5–10 years can be achieved during interviews with local officials and service providers.

In some cases, the TRACE team may need two or even three visits to deploy the tool and finalize the sector prioritization along with the energy efficiency recommendations (it depends on the ease of data collection and the municipality's level of commitment). During the first visit, the team should aim to complete the data collection and conduct interviews with local stakeholders; during the second visit, they usually discuss and agree on the energy efficiency solutions. In addition, a third visit could be organized for a final meeting with the city mayor and his or her team, and/or a workshop could be held to disseminate the key findings and results of TRACE.

DATA COLLECTION

The earlier version of TRACE required comprehensive data for the main urban sectors—namely, street lighting, water and wastewater, buildings, transport (both public and private), solid waste, and power and heat—to determine energy performance at an aggregated level. The new version has added more sectors, such as buildings in residential and commercial sectors. Although these sectors are not under city control, they use a significant amount of energy and TRACE users should consider including them in the city energy balance and city diagnostic.

Users can choose from among a wide variety of KPIs when running the tool, depending on the sectors analyzed and resulting datasets needed. No matter which KPIs are chosen, however, TRACE users must ensure that they have all the data necessary to run the tool and perform the benchmarking before proceeding to Step 1 (see Part 2, "The TRACE Process"). Some of the KPIs can be collected easily and should be provided by the city government and utility companies, whereas others will require supplementary data and information. **Further guidance on data collection, including advice on conducting interviews, is provided in the appendix to this manual.**

Due to its cross-sectoral nature, urban energy efficiency data are located in several places and formats, so data collection is a time-intensive process that calls for cooperation across different departments in the city hall as well as among the city and service providers. Usually data stay with the city government and utilities. However, some information can be retrieved from public and open source documents, including local/national legislation, energy/energy efficiency plans, local development strategies, and urban development plans. For example, local development strategies should contain general information on the municipality, such as city area, length of streets, number of passengers using public transport, and annual electricity consumption in the city. This data must be reviewed and double-checked with the stakeholders. National energy strategies/plans can give an idea about energy/energy efficiency policies in the long run.

Options for Collecting TRACE Data

There are a few ways to collect the TRACE KPI data.

Data are collected before—and verified during—the implementation of TRACE

This can happen in two ways:

- This option could work assuming that the city government is aware of the purpose of TRACE and is willing to put some effort into supporting data collection. The local expert first prepares a list of KPIs with a brief explanation of each and sends this (in the form of a survey) to local service providers asking them to fill it in, prior to engaging them directly or through the city hall. The survey data should be prepared both in English and the local language. The senior consultant verifies the data and fills in any gaps during the field visit, while interviewing stakeholders from the TRACE sectors and city authorities. Interviews and site visits, for example, to municipal landfills or wastewater treatment plants, help paint a comprehensive picture of the sectors and contribute to a full understanding of particular issues and opportunities in the given public service areas.
- The senior expert usually prepares the KPI list and sends it to the junior expert, who fills in relevant data available using public documents and other open-source information. Subsequently, the data are double-checked and the remaining gaps are filled in during interviews during the TRACE deployment mission.

Data are collected during the TRACE deployment mission

If local authorities and utilities are unable to produce the required data during the deployment trip, the senior expert must gather the data from them (for instance through email) after the visit. Subsequently, the team needs to aggregate and consolidate the data to generate (a) the KPIs required for the benchmarking exercise, and (b) an energy balance for the baseline year.

Data are collected by local authorities by a designated person from the municipality

If TRACE is implemented by local authorities or by an independent local energy expert (without support from other experts), they should directly approach the utilities and relevant departments in the city administration to get data for the KPIs.

Important: During interviews with stakeholders, the TRACE team must quickly assess each stakeholder's capacity with regard to finance, human resources, policy regulation and enforcement, assets and infrastructure, and overall ability to provide accurate data. Additionally, the team should collect information on key issues and challenges for each sector and current investment plans that could influence the energy consumption balance in the future (as well as energy efficiency plans, if available). This information should be collected for each sector and introduced in Step 7 in the tool. (See "Step 7" later in this manual.) The energy efficiency investment plans should be considered later in the process because they may complement the TRACE energy efficiency recommendations.

Challenges to Data Collection

Level of administrative centralization/decentralization

The challenges to data collection are related mainly to the administrative framework of the country, powers vested in the local administration, and the available data. The data collection process can vary from country to country and even between regions in the same country. It depends also on the level of control the municipality has over utility services. If the local administration is decentralized, then cities have significant local powers. Often, most utilities are under the city authority, and they are organized under public entities of which the city council is the main or sole shareholder.

However, collection of data can be quite challenging in centralized and federal countries, where city authorities have very limited powers over most of the TRACE sectors. In this case, the counterpart is usually a government entity. For example, in the Arab Republic of Egypt, a centralized country, most utilities are managed by the central government; whereas in Mexico, a federal nation, some services, such as public transport, are managed at the state level.

Usually, the power sector is under the central government in any administrative setting.

Level of bureaucracy

The level of bureaucracy in some countries can be a barrier in gathering data in a timely manner. TRACE experts may need special permission or they may need to consult multiple agencies and departments before they can access the necessary data and information. Garnering local support may facilitate the process and reduce additional delays.

Data availability and quality

The lack of available data can pose a major challenge in any scenario. TRACE experience shows that municipalities have sometimes struggled to supply the necessary information. For example, data on energy consumption in municipal buildings have often been quite difficult to obtain. Surprisingly, although the energy bill for public schools and municipal hospitals is paid out of the local budget, the city often does not know the overall floor area of these facilities or how much energy is consumed.

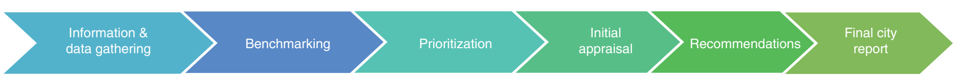
When data availability and quality are poor, an experienced team can come up with some fair estimates. TRACE users should bear in mind that to generate data for some KPIs, city officials may be asking a staff member to put together the required information, which is a task that often is not financially compensated.

The Importance of Data on Energy Spending

Of particular importance is the data on sector energy spending that users will need to complete Step 4. Examples include the cost of energy (gas or electricity) used to operate public transport or the overall cost of fuel used to produce heat. In some cases, if energy spending cannot be provided upfront by the sector stakeholders, additional calculations will be necessary to estimate energy consumption and related cost. For example, to calculate the annual cost of fuel for public transport, the user needs to know the amount of fuel used over a one-year period and the cost per liter (or per kWh for trams, trolley-buses, and so on). If this information is not available, however, estimates can be based on additional information such as the number of public buses, liters of gasoline consumed per 100 kilometers, kilometers run daily, and so on.

ESTIMATED TIMELINE FOR TRACE DEPLOYMENT

There is no standard timeline for deploying the tool. The overall time needed depends on several factors: who is in charge, the level of local government commitment and interest, data availability and quality, and so on. That said, the overall process, including drafting the city report, generally takes three to six months. If TRACE is implemented by local authorities, it is up to them to decide on the timeframe for data collection and the 12-step TRACE process outlined in Part 2 of this manual ("The TRACE Process"):



Following are two suggestions on how the process might unfold:

- **If the data survey is sent in advance,** the first round of data collection may take a few weeks to two months, depending on the size of the city, the degree of administrative decentralization, data availability, and the depth of the desired output. In this case, the TRACE deployment could last a week to 10 days or so, and should focus on double-checking the data, filling in missing information, conducting interviews with local service providers, and performing site visits. For example, in small cities in the Kyrgyz Republic with populations of about 50,000, the data were produced in about two weeks. If city officials are familiar with the purpose of the TRACE and if they receive, fill out, and return the data survey before the visit to the municipality, then the visit can focus on getting a comprehensive understanding of the TRACE sectors and energy savings opportunities, rather than on clarifying data issues.
- **If the data are collected during the TRACE visit with senior experts,** the initial process—gathering information and conducting interviews and field visits—generally takes a couple of weeks per city, depending on data availability. For example, in Romania, where TRACE was deployed in seven cities, the bulk of the data were collected from interviews with stakeholders during the TRACE visits, whereas only limited data were gathered before the trip and verified during the deployment of the tool. The TRACE teams spent up to two weeks in each city to review previously

available information, gather data, conduct interviews for each sector, and visit utility sites.

TRACE deployments in Europe and Central Asia—particularly in the Kyrgyz Republic, Romania, and Ukraine—have yielded useful lessons in this regard. Access to data is granted more quickly and smoothly in small cities where local administration is decentralized and the city government holds a great amount of control over municipal services. Also in small cities, local authorities and service providers usually have a good working relationship, and data collection can be facilitated by personal connections. In deploying TRACE in Mexico, it was important to prioritize short-term projects that could be implemented within a mayor's singular three-year term.

Finally, it works better when only one city staff member is responsible for each of the TRACE sectors (for example, street lighting), when there is only one provider for each municipal service, and when a city hall official with strong relationships in the relevant sectors takes on the role of energy efficiency champion, helping to coordinate from the city's side.

TRACE OUTPUTS

The TRACE tool helps users carry out a municipal energy efficiency assessment by organizing the collection and processing of KPI data. It does not by itself generate a "report" suitable for submission to policy makers. However, the tool comes with a Document Library containing, inter alia, a sample final "City Report" that illustrates the potential scope of a TRACE assignment—including a comprehensive analysis (based on selected high-priority sectors), as well as a project pipeline and project profiles.

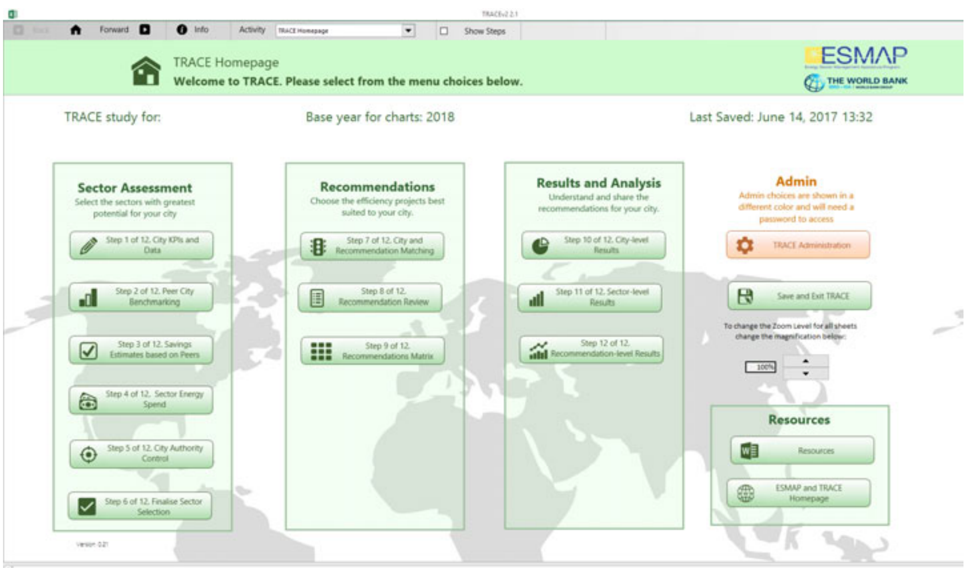
The final report is shared and discussed with city officials to see what energy efficiency measures might be feasibly implemented. The main findings and energy efficiency recommendations can then be presented in a workshop with the participation of the city managers, technical staff from the local government, public service providers, energy experts, and other relevant stakeholders.

2 | THE TRACE PROCESS

The Tool for Rapid Assessment of City Energy (TRACE) is an Excel-based application. It is accessible, following registration, on the ESMAP website at https://esmap.org/TRACE. The tool asks users to carry out 12 steps that are divided into three stages, as follows:

- Sector Assessment (Steps 1–6)—Data collection, energy performance benchmarking, and prioritization of sectors with the highest potential savings
- Recommendations (Steps 7–9)—Selection and fine-tuning of energy efficiency recommendations for the sectors identified in the previous stage
- Results and Analysis (Steps 10–12)—Assessment of selected measures for energy efficiency planning and investments

The TRACE home page reflects this division:



GETTING STARTED

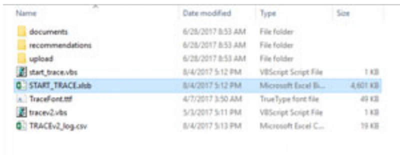
Before using TRACE, users must have two things:

- **A clear understanding of all key performance indicators (KPIs) required for the sectors they wish to address.** Definitions are available by clicking on the respective KPI; users are further able to specify which KPIs are “key” to their desired diagnostics.
- **The data required.** Some of the KPIs will be automatically calculated, whereas some need to be extracted from other data previously made available.

Further guidance on data collection for these KPIs, including advice on conducting interviews, is provided in the appendix.

STARTING TRACE

1 | To begin using TRACE, open the mail Excel file by double-clicking the file named **"START_TRACE.xlsb."**



2 | At the top of the Excel window, be sure to specify "Enable Content" to allow the built-in macros to run.

3 | To go to Step 1, click "Step 1 of 12. City KPIs and Data" :

4 | From Step 1 onward, either click the "forward" icon at the top Forward or use the "Activity" menu Activity. The home page is always available by clicking "Home" at the top of the window.

SAVING WORK

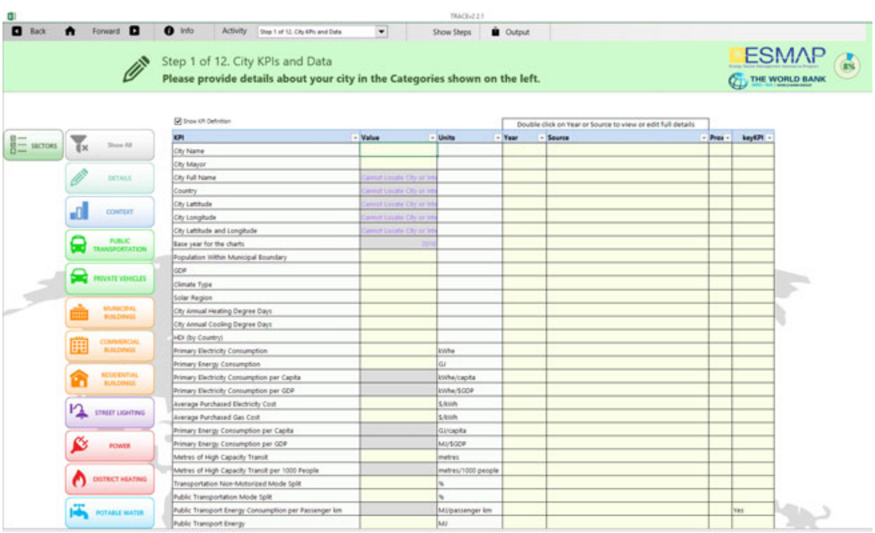
At the end of every work session, users should save their work by clicking the "Home" button to go back to the Home page; then click "Save and Exit" .

Those who desire added security may save a new file for each working session. To do this, after opening TRACE, choose File > Save As and choose a new filename that includes the date. Then, at the end of the session, save and close the file as with a standard Excel file.

RESOURCES AND SUPPORT

- The **TRACE Documents Library** is accessible from the Home page by clicking "Resources" . It currently contains nine documents, including a template for a city report and samples of a final city report, TRACE presentation, and energy services company (ESCO) business plan.

STEP 1. CITY KPIs AND DATA



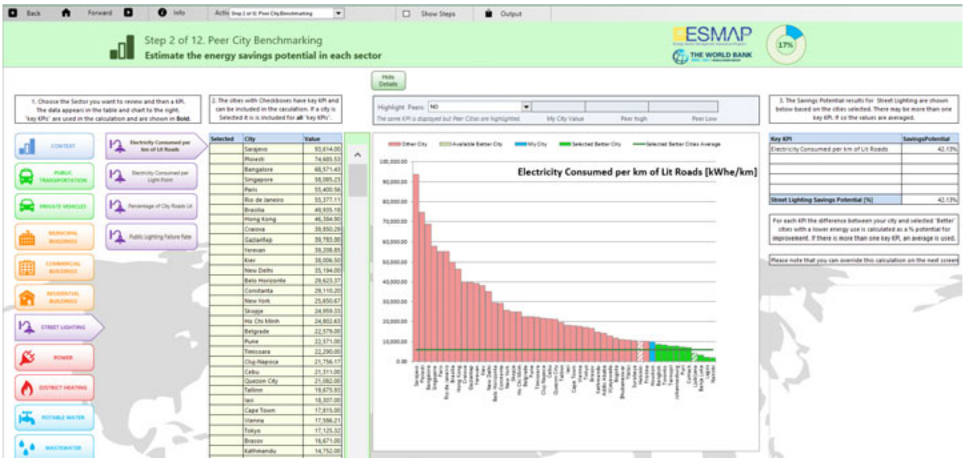
In Step 1, users enter city KPI data that will be used later in the process. Users should use the green "SECTORS" button on the upper left (a separate window pops up) to deselect those sectors that are not relevant to them, such as Public Transportation or Residential Buildings.

By contrast, users who wish to address all KPIs at once may click "Show All"  to reveal all possible KPIs.

Some general rules:

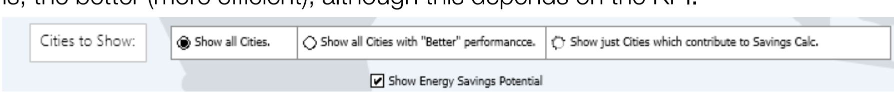
- It is important, especially for new TRACE users, to check (or tick) the "Show Step" box at the top of each step. Doing so reveals explanations and details for each step.
- Users may also check the box marked "show KPI definition" at the top of the table. Clicking any KPI cell then yields a brief explanation.
- Users enter data in the yellow boxes, after which the related grey boxes will automatically calculate the KPIs. If some data are missing and the KPI is not automatically calculated, the user must calculate it using the raw data and enter it manually. In some cases, KPIs expressed as a percentage should be filled in as decimals. (For example, 0.45 is 45 percent, 1 is 100 percent.)
- If available, all data should be from the same year for a more accurate assessment.
- The source of information must be mentioned, as well as the link to the respective document/website, if available. If data were obtained through expert estimates, this should be specified.
- Users can select the KPIs most relevant to their diagnostics by choosing either "yes" or "no" in the "keyKPI" column.
- "Context" button: When indicating the city's level of development (in the "Value" column), the user should consult the Human Development Index available at http://hdr.undp.org/en/content/human-development-index-hdi. Although this shows data at the country level only, the same data may be applied to the city in question.
- Heating and Cooling Degree Days:
    - Users can refer to the free calculator available at http://www.degreedays.net.
    - The user should select the city or weather station ID.
    - The base temperature selected should be 20°C for heating and 26°C for cooling.
    - Proxy data: If reliable data are not available, the user should enter estimates based on data for similar cities.
- If some city-level data are unavailable—for example, primary energy consumption—users may wish to enter an estimate based on data for national consumption figures. Energy and climate data for most countries are available at http://www.tsp-data-portal.org.
- Useful data on solar photovoltaic generation are available from the World Bank's Global Solar Atlas at http://globalsolaratlas.info.

STEP 2. PEER CITY BENCHMARKING



Step 2 allows users to compare their municipality's performance (with regard to specific KPIs) to that of its peers worldwide. This benchmarking exercise is not designed to yield precise analyses or solutions. Rather, it uses easy-to-grasp graphic illustrations to show where the city ranks in comparison to its peers and indicates areas for potential improvement.

- **Selection of KPIs:**
  - Given the large number of benchmarks available, users should focus on a small set of KPIs targeting the most critical areas and sectors—especially energy-related KPIs such as "heat consumption per square meter" and "energy density to produce one cubic meter of water."
  - For each municipal sector, users can choose a specific KPI from the sectors (in the menu at left) to generate a graph depicting the city's position relative to its peers. The drop-down menu allows users to compare peer cities in terms of climate type, population, Human Development Index, primary energy consumption per unit of gross domestic product, and so on.
- **Selection of peer cities:**
  - At the bottom of the screen, users can choose to compare their city to (a) all cities, (b) only those cities with better performance (that is, those that contribute to better savings), or (c) only cities that contribute to the savings calculation. The user's city (called simply "your city") will appear in blue and peer cities in pink. If peer-city bars are striped rather than solid, their data are based on estimates. Better-performing cities appear in green. Usually the closer to the right side of the graph the user's city is, the better (more efficient), although this depends on the KPI.



  - Users may want to benchmark their city against only those cities that best suit the desired analysis.
- **Potential energy savings.** The comparison with "better performing" peer cities indicates the sector's theoretical potential for energy savings. An overview of the savings potential for the sector appears on the right side of the screen, with specific

figures for all relevant KPIs. For each KPI, the difference between the user's city and the selected "better" cities (that is, those with a lower energy consumption) is calculated as a potential percentage for improvement; if there is more than one KPI, then the average of the respective KPIs is used.

STEP 3. SAVINGS ESTIMATES BASED ON PEERS

Step 3 is the first of three steps necessary to fully prioritize the desired sectors. The sector prioritization is based on three key variables:

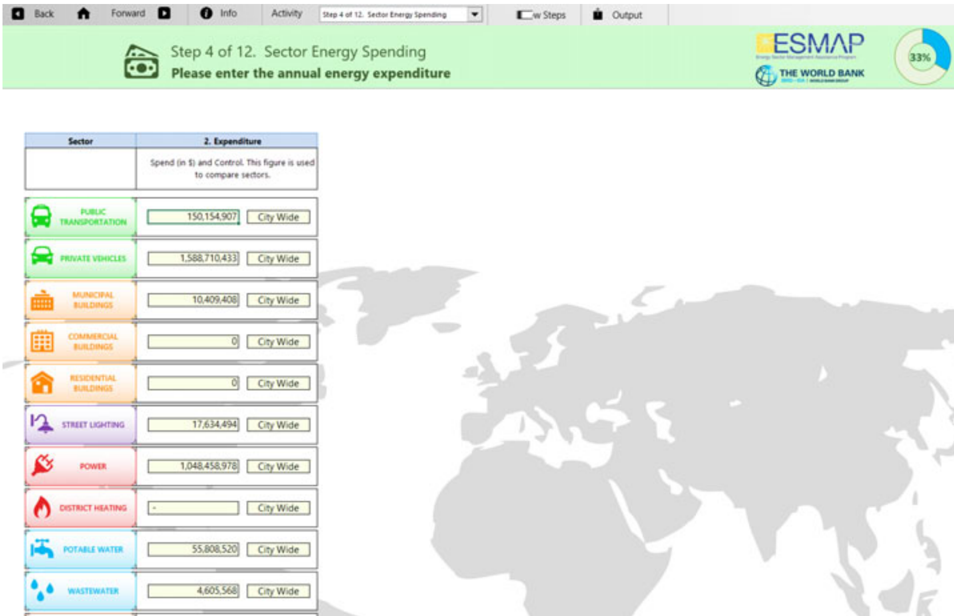
- City authority control
- Sectoral energy spending
- Peer energy-savings estimates

In Step 3, the TRACE sectors are prioritized based on highest potentials for energy and energy-cost savings. By this time, based on the data collection process and discussions with city managers and relevant service providers, the TRACE user should have an idea about the city's engagement level and what potential savings could be achieved.

Prioritization of sectors starts by calculating the energy savings estimates for each sector. When the Step 3 window is opened, all sectors show standard values based on peer-city values in the left column. While these values can hint some potential savings, each city has specific features that impact savings. Hence, this requires careful analysis (through in-depth interviews, site visits, etc.) to approximate some fair savings estimates.

Some of the values for the three aforementioned variables are preset values and will need to be reviewed and overridden based on information obtained during on-site visits, interviews with experts, and services providers. These values can be adjusted based on the circumstances specific to the city and each sector. Users can easily override each value simply by entering a new value in the “override” box. Then the new value will be used for the energy savings assessment.

STEP 4. SECTORAL ENERGY SPENDING



Step 4 allows TRACE users to calculate the cost of the energy their city uses to operate the chosen sectors. Users must (a) enter figures (in U.S. dollars) on annual energy expenditure for each sector and (b) specify the responsible entity for the sector. (“City authority” refers to municipal budget-related expenditures, whereas “city-wide” can also include private expenditures.)

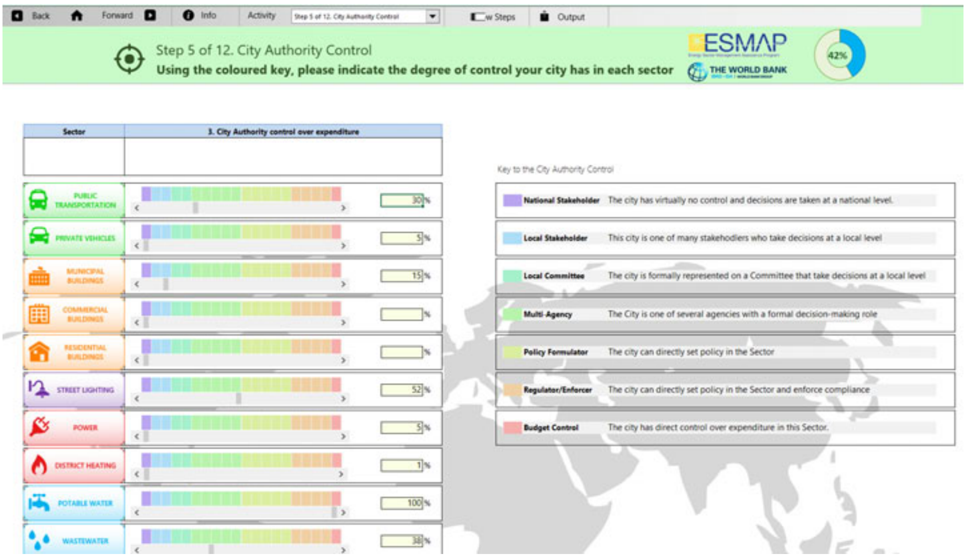
TRACE then compares this with its global dataset to identify those areas with the largest savings potential. The following list shows examples of costs for each of the city sectors:

- Public Transport—cost of fuel (gasoline/gas/electricity) used to operate public transport in the city
- Private Sector—cost of fuel (gasoline/gas) used to operate the private vehicle fleet in the city
- Municipal Buildings—cost of electricity/heat used
- Commercial Buildings—cost of electricity/heat used
- Residential Buildings—cost of electricity/heat used
- Street Lighting—cost of electricity used to light the streets in the city
- Power—cost of electricity used in the city
- District Heating—cost of fuel used to produce heat

- Potable Water—cost of electricity used to produce and distribute potable water
- Wastewater—cost of electricity used to treat wastewater
- Solid Waste—cost of energy used to collect, transport, and treat solid waste

As mentioned, users should ensure that information on energy spending is available upfront, before entering the KPI data in Step 1. For those sectors not being considered, the value introduced should be 0 (zero). Also, the responsible entity for the sector—city authority or city-wide—can be chosen via the drop-down menu.

STEP 5. CITY AUTHORITY CONTROL



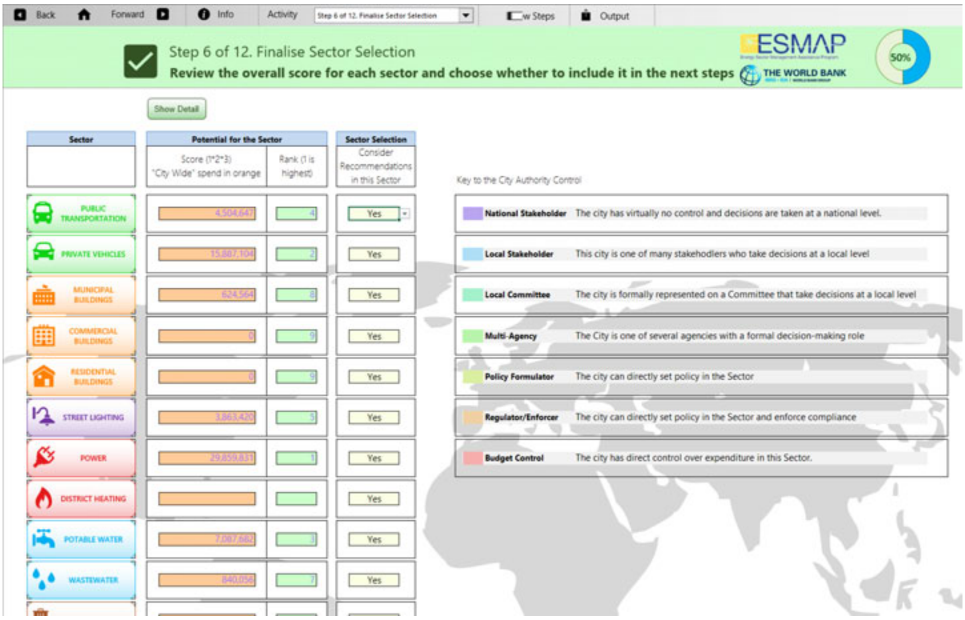
Step 5 is about determining the level of control the city has over each of the TRACE sectors. This is an important factor not only for the shaping of relevant legislation, but also for the design of sector investments, including those related to energy efficiency. The local government's level of control can determine its priorities for each of the municipal sectors.

TRACE automatically suggests the degree of control based on common levels seen worldwide. However, experienced TRACE users are encouraged to override the TRACE values if they believe the level of city influence to be smaller or larger—an opinion that should be based on a field assessment and interviews with local authorities and stakeholders.

TRACE can assess the level of control of the city authority based on criteria such as whether the city is a shareholder in the sector utility, whether it has some regulatory power over the sector, and whether it has leverage over the service area through dedicated programs and incentives.

The user should not enter any data into the last sector on the page, "City Management."

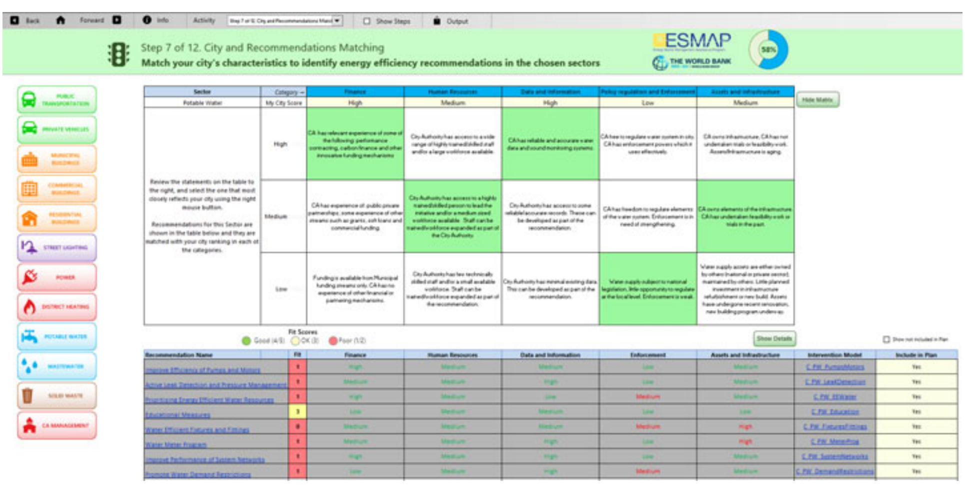
STEP 6. FINALIZE SECTOR SELECTION



Step 6 completes the sector prioritization process by aggregating the results from Steps 3, 4, and 5—savings estimates, sectoral energy spending, and city authority control—and calculating an overall score for each sector for which data were entered in Step 1. (These appear in the left column on the screen.) Sectors are ranked in descending order: the higher the rank, the higher the chance to consider recommendations for the respective sector.

Choosing "yes" or "no" in a drop-down menu in the last column allows users to pick which sector recommendations will be considered for the city diagnostics. The sectors that are excluded will be removed in the next steps.

STEP 7. CITY AND RECOMMENDATION MATRIX



In Step 7, the user can match built-in sets of energy efficiency recommendations to the city's needs and capacities for each of the sectors selected in Step 6. TRACE suggests potential energy efficiency recommendations in five areas: finance, human resources, data and information, policy regulation and enforcement, and assets and infrastructure. These five areas give an indication of the city's readiness for various energy efficiency measures.

The questions required to fill in the answers should be asked during interviews with stakeholders from each sector (see "Data Collection" in Part 1; also see the appendix for advice on stakeholder interviews). The user should be able to explain each score so the interlocutors can choose the one that best reflects the reality.

- On the left side, the user can select each of the prioritized sectors to display the corresponding energy efficiency recommendations to match against the five category capacities.
- For each sector, a matrix with city capacities will appear—low, medium, or high capacity for each of the five areas. The user can choose the appropriate box by clicking it, which is then reflected in the lower recommendations table. Upon selection of all capacities, each recommendation will display a score under the "Fit" column, indicating the readiness for this specific recommendation. A low score does not necessarily mean that the recommendation cannot be selected; rather, it suggests that other measures need to be put in place to increase the city's readiness for this solution. A good score of 4 or 5 will be shown in green, while a poor score of 1 or 2 will be in yellow.
- A table showing recommendations and scores appears at the bottom of the page for each sector. The intervention model can be kept or removed by choosing "yes" or "no" in the "Include in Plan" column. The user can keep in the plan only those recommendations for which the intervention model has been completed. In Step 8, the user can review whether the recommendations should be kept in the plan.
- **Important:** By clicking on the name of the intervention model, the user is directed to a detailed description of the model that includes **two "calculators": L1 and L2.** (The calculator is also available in the next step, Step 8.) Both the L1 and L2 calculators require data from the TRACE user and differ in terms of level of detail. While the L1 calculator is simpler and hence faster to complete, the L2 calculator needs more detailed input data. It is up to the user to choose which calculator to use, or indeed whether both are applicable. Hence, she or he can (a) introduce in L1 the results of the user's energy efficiency calculations, (b) use the L2 calculator, or (c) enter only "0" and move on (the intervention model can be revisited later). Users should be sure to complete all fields.

Intervention Model
C_PW_PumpsMotors
C_PW_LeaKDetection

Below is an example of how the intervention model works using L1 and L2 calculators. The example uses the Street Lights Audit and Upgrading Program for two cities, where 100,000 street lights were retrofitted. The following variables are used: cost of electricity of $0.10/kWh, CO_2 conversion factor as 0.0005 tCO_2/per kWh, cost of LED fixture of $400, and annual budget project available (CAPEX) of $4.5 million.

The following table shows a breakdown before the energy efficiency measure was implemented:

Breakdown	Wattage	Number of Street Lights	Total kW	Total kWh	Annual Replacement Budget ($)
LED 10%	120	10,000	1,200	5,160,000	133,333
HPS 10%	300	10,000	3,000	12,900,000	400,000
Metal halide 10%	400	10,000	4,000	17,200,000	444,444
Mercury vapor 70%	500	70,000	35,000	150,500,000	2,333,333
100%		100,000	43,200	185,760,000	3,311,111

Note: HPS = high pressure sodium; kW = kilowatts; kWh = kilowatt-hours; LED = light-emitting diode.

L1 calculator—Investments of $500,000 per year could save some 6 million kWh (the equivalent of 300,000 kg of CO_2), which translates into $1 million and 3 percent in energy savings. The implementation period is five years, with a simple payback period of half (0.5) a year.

L2 calculator—This calculator also considers more detailed technical data (see below), such as hours of operation and mean replacement time, and will give the user a more fine-tuned result. If the city invests $24 million, it could save 104,160,000 kWh. This could result in $10,416,000 in energy cost savings per year, with 53 percent energy savings and 52,000 kg of CO_2 savings annually. $1.2 million in operation-related cost annually can be avoided. The implementation period for this intervention is five years, with the simple payback of 2.3 years

The following tables show a breakdown of energy and cost savings after implementation:

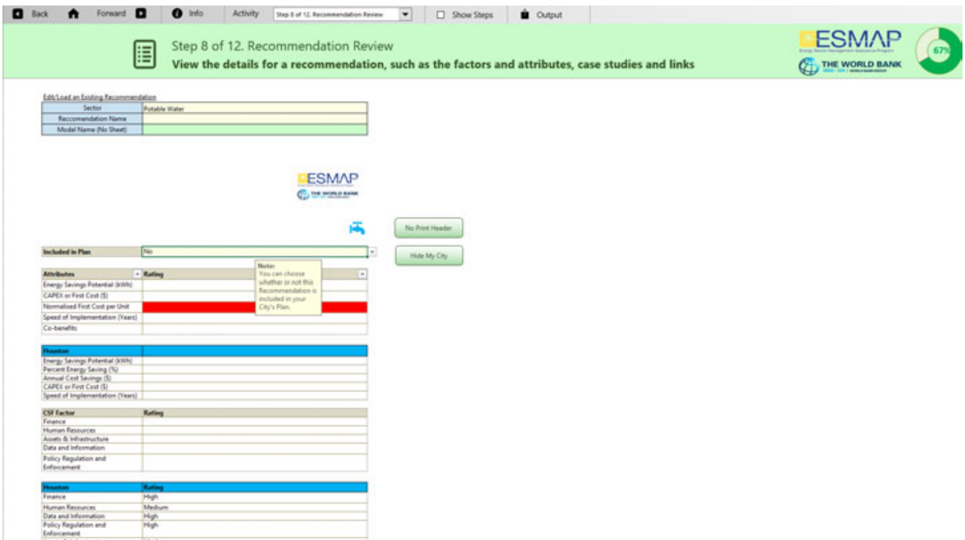
Breakdown	Wattage	Number of Street Lights	Total kW	Total kWh	Annual Replacement Budget ($)	CAPEX ($)
LED 70%	120	70,000	8,400	33,600,000	933,333	24,000,000
HPS 10%	300	10,000	3,000	12,000,000	400,000	
Metal halide10%	400	10,000	4,000	16,000,000	444,444	
Mercury vapor 10%	500	10,000	5,000	20,000,000	333,333	
100%		100,000	20,400	81,600,000	2,111,111	24,000,000

Note: CAPEX = capital expenditure; HPS = high pressure sodium; kW = kilowatts; kWh = kilowatt-hours; LED = light-emitting diode.

Technical Data (use defaults or adjust as necessary)					
Minimum (hours)	Maximum (hours)	Average (hours)	Mean Replacement Time (years)	Bulb Replacement Cost ($)	Budget ($/year)
50,000	100,000	75,000	19	250	13
15,000	25,000	20,000	5	200	40
16,000	20,000	18,000	5	200	44
18,000	30,000	24,000	6	200	33

Important: Users must choose "Complete" from the drop-down menu at the bottom of the page.

STEP 8. RECOMMENDATIONS REVIEW

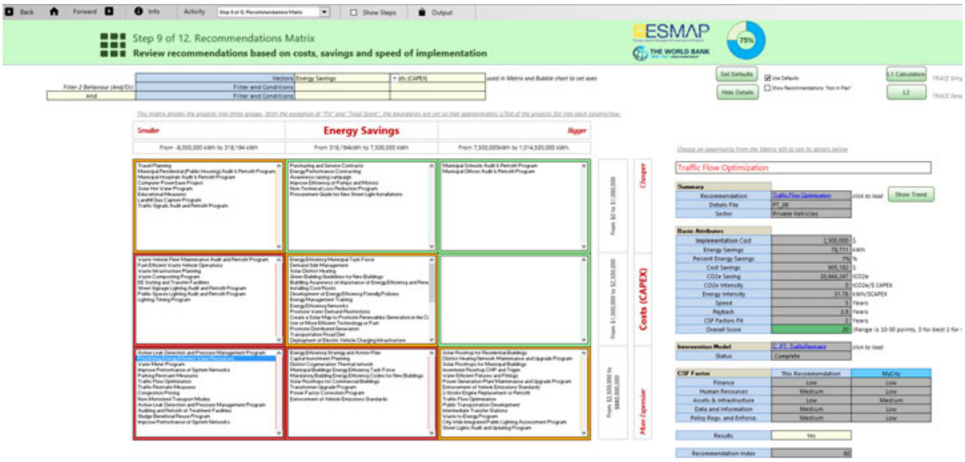


Once the L1 and/or L2 calculator has been used for a given energy efficiency measure, the user can move on to Step 8 to see a detailed description of the measure (including recommendations), implementation models, and links to a few case studies.

Both the sector and recommendation must be selected from the drop-down menus located on the top of the page. The model will display the name used for the recommendation in the tool/sheet. Below, the user should enter information on energy savings potential, initial capital cost, normalized first cost per unit, speed of implementation (in years), and co-benefits (if any). This information should come from the user/energy expert, based on data inventory collected from the city and her or his technical knowledge—for example, the cost of a LED bulb, or potential savings considering existing or new infrastructure. (Please note: only after choosing the recommendation and completing the calculation will full details about the intervention be given.)

At the top of the page, the user can decide whether to keep the recommendation in the plan.

STEP 9. RECOMMENDATIONS MATRIX—REVIEW AND REFINE RECOMMENDATIONS



From Step 9 onward, TRACE can refine a "matrix" of recommendations and show the recommendations at the city and sector levels. Step 9 is essential and is especially useful for presentations. Steps 10–12 are especially useful for more advanced users.

From the drop-down box located at the top of the Step 9 page, the user should choose the categories for the x and y vectors:

	Vectors	Energy Savings	Costs (CAPEX)
Filter 2 Behaviour (And/Or)	Filter and Conditions		
And	Filter and Conditions		

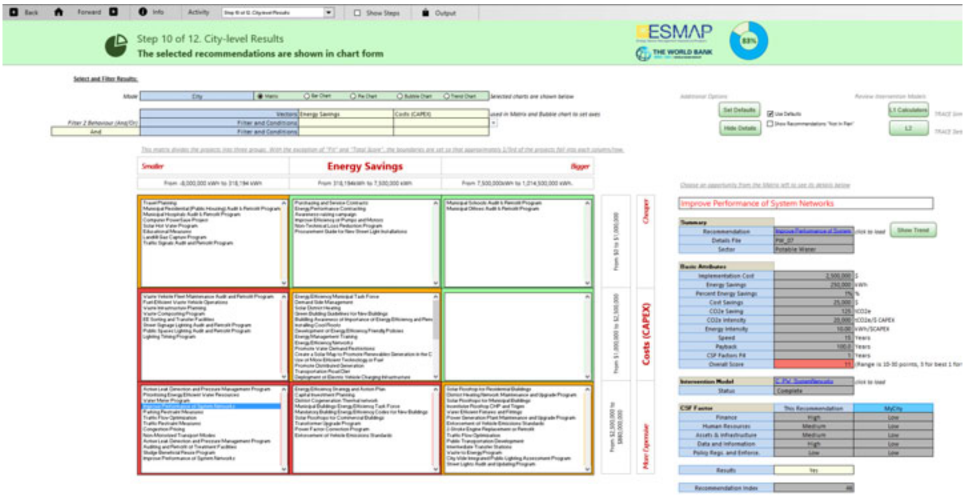
In the second and third columns, the user can choose from a number of variables such as energy savings, cost savings, saving percentage, cost (CAPEX), energy intensity, and payback. In the next row, the criteria must be selected, and then figures/maximum values for the criteria selected must be entered. For example, if the "Speed" (of the implementation) were selected in the matrix category, and "Payback period year (Min)" were selected in the next row, then the user must introduce the minimum number of years allowed for the payback period. The selection for the recommendation matrix can be done by sector as well, so the user can determine what sector recommendations would be a better fit, based on the given criteria.

Subsequently, the matrix will divide the projects into three groups for the filtered selections, indicating the boundaries between smaller and bigger amounts/figures for the respective selections. The matrix will show the smaller numbers on the left side and the greater number on the right side. For example, the matrix for the Street Lighting sector based on CAPEX, indicates that the Street Lighting Audit and Retrofit Program for Houston has a large energy savings potential (between 7.5 million and 104 million kWh in energy savings) because it is placed on the right side of the matrix and in the range of the more expensive interventions ($24 million).

Once the user clicks the recommendation in the matrix, the details will pop up on the right side of the screen, where the main information about the implementation model is provided, such as implementation cost, energy savings, payback period, and speed of implementation. Here the user has a chance to review or remove the calculations made using the L1/L2 calculators in Step 8.

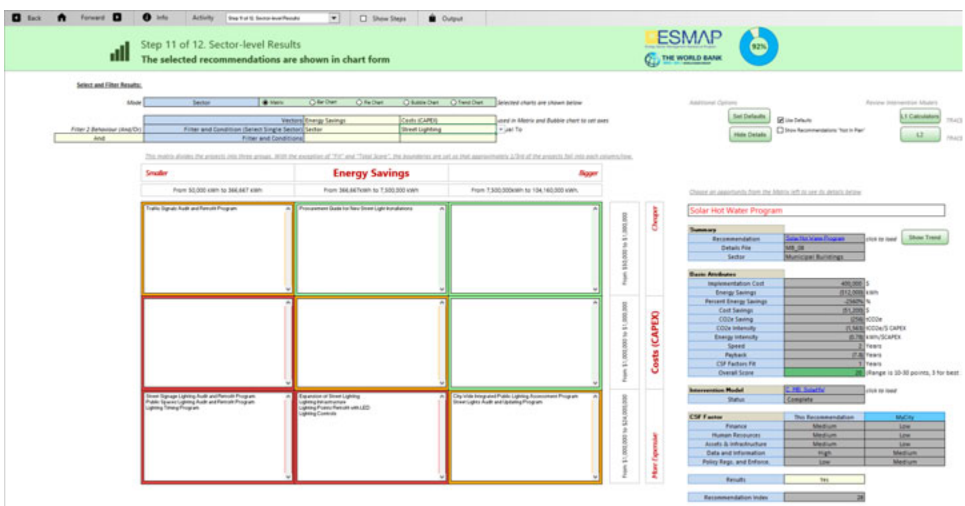
The last action in Step 9 is about deciding whether to include each recommendation in the final results. For each recommendation, click “yes” or “no” in the “Recommendation included in the results” line, located at the bottom of the page.

STEP 10. CITY-LEVEL RESULTS



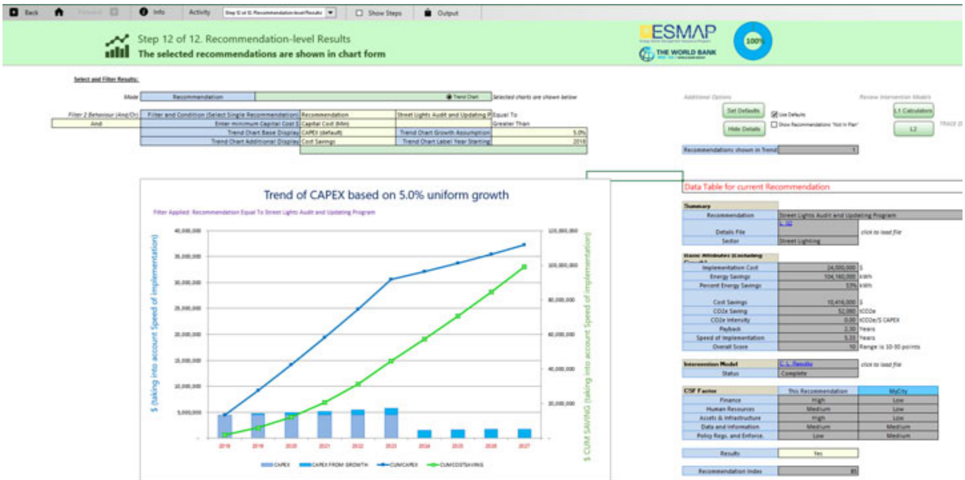
Step 10 shows the results for the recommendations at the city level. The same methodology for selection criteria and process should apply as in Step 9.

STEP 11. SECTOR-LEVEL RESULTS



In this step, the user can see the matrix of recommendations at the sector level. Similar methods of selection and criteria apply as in Steps 9 and 10.

STEP 12. RECOMMENDATION-LEVEL RESULTS



Finally, in Step 12 TRACE predicts how each recommendation will perform during the implementation period. The charts are shown starting from zero for the first year of implementation.

The user must choose from a drop-down list of selection criteria at the top of the page. For example, as the screenshot above shows, in the first row ("Filter and Condition") "Recommendation" has been chosen; in the second column the recommendation, "Street Lights Audit and Updating Program" has been selected. In the next row, "Capital cost (Min)" has been selected, and then the value must be introduced. Outputs of every step in TRACE can be generated for different formats through the button at the top of the tool.

3 | BEYOND TRACE: PLANNING INVESTMENTS

Finally, TRACE not only provides municipalities with a tool for sector assessment and prioritization, but can also constitute a base for planning energy efficiency investments. The city report, populated with TRACE data and recommendations, enables the municipality to act on the most feasible recommendations in a structured manner that should allow it to improve its overall performance while eventually saving money.

The results from TRACE can lay the foundation for energy efficiency plans, and can also be used as inputs for prefeasibility studies for some of the energy efficiency solutions. The list of energy efficiency recommendations can help develop an investment pipeline for the city, as TRACE offers preliminary information on initial costs, energy cost savings, implementation timeline, and so on that gives city managers a sense of what interventions are suitable for a given context.

In addition to suggesting specific energy efficiency investments, TRACE provides a set of noninvestment measures that can help the city manage service delivery and reduce energy spending in sectors under its control or influence. These measures aim to strengthen implementation capacity (such as energy inventory or monitoring and evaluation of program results) and develop institutional structures (such as the energy management department) and financial delivery mechanisms (such as energy performance contracting), in addition to providing support for investment development (such as energy audits). These measures are also useful for preparing a sustainable city energy efficiency plan.

Any energy efficiency action plan that the city may want to prepare will require solid data and information about the energy performance of public utility service areas. Because TRACE is based on a number of energy KPIs and a sector analysis, the tool gives planners most of the material they need for the plan—including energy data and performance indicators for utilities, such as water or electricity losses. This helps city governments develop short-, medium-, and long-term energy efficiency investment plans. The financial savings achieved from implementing the energy efficiency plans may be used to invest in expansion or improvements to services, either in the same sector or in other sectors with urgent needs, such as education and social services.

The energy efficiency investment plan could include not only the solutions identified by TRACE, but also other interventions derived from the city's particular needs and best practices. This energy efficiency plan should suggest to the city managers how much money they will need to implement each energy efficiency recommendation and the savings that could result. The energy efficiency plan can outline the project lifespan, payback period, achievable results, and energy efficiency per investment. For example, TRACE implementation in Ternopil, Ukraine, indicated that retrofitting and thermal insulation of 46 schools and kindergartens (with a total area of 140,000 square meters) would require approximately $11.1 million. The intervention would result in annual primary energy savings of 15.5 GWh, which accounts for about 60 percent of baseline energy consumption. The project lifecycle would be about 20 years, with a payback period of 18 years and an internal rate of return of 10 percent. Overall, electricity savings per dollar of investment would average 1.4 kWh/US$/year.

Also, TRACE can be a good basis for identifying the appropriate delivery models for implementing the energy efficiency solutions. Most cities have limited budgets, and the funds available are never enough to undertake such investments, so municipalities must identify additional funding sources. The TRACE output can point to sustainable mechanisms for municipal energy efficiency financing, in addition to options for funding energy efficiency projects in the public sector. Previous experience shows that investments in energy efficiency can be executed in different ways—either by setting up an energy efficiency revolving fund that uses initial payback monies to fund future investments, or by establishing an energy services company (ESCO) that funds energy efficiency improvements and retrofits through the energy savings.

Finally, once the city has embraced the energy efficiency recommendations with the highest potential for energy savings, the municipal government could undertake a prefeasibility study. Further information and examples of how to develop investment pipelines and prefeasibility studies as well as financing mechanisms can be found in the document library as well as on the TRACE website.

APPENDIX: BRIEF GUIDE TO COLLECTING DATA AND CONDUCTING INTERVIEWS FOR TRACE

This appendix is intended to serve as a guide to collecting key performance indicator (KPI) data for the various TRACE sectors and conducting interviews with relevant stakeholders. For each sector, it suggests a set of questions and issues to be discussed with relevant stakeholders, then advises how best to conduct interviews with city authorities and private/public providers of public utility services. These questions should be helpful not only in determining how the sector is organized and obtaining the data necessary to implement the tool, but also in preparing the customized city report, especially the sector analysis/diagnostic part.

The second section of each sector tackles each KPI by defining it, showing how it should be calculated, and suggesting sources for relevant data.

PUBLIC LIGHTING

Questions and Issues to Be Discussed with Relevant Stakeholders

Preliminary

- Clarify from the beginning (a) what entity (public or private) is responsible for the public lighting sector in the city and (b) what authority is responsible for paying the energy bill to operate the system.
- If the system is operated by a private entity under a concession agreement, find out the overall value and duration of the contract (ideally, obtain a copy of the contract). Also, determine the ownership structure of the public lighting infrastructure, that is, who owns the city's lighting poles, ballasts, luminaires, transformers, and so on (the city itself or the national/federal government)? If the sector is managed by a private entity under a concession agreement, identify the role of the local/national authority in supervising/monitoring the sector.

Other

- Lighting technology used—Determine the types of lamps used (high-pressure sodium vapor, low-pressure sodium, metal halide, LED) and, if possible, the number of lamps in each category. Are there inefficient mercury lamps? Find out about the types of poles, including number of lamps per pole.
- Distance between lighting poles—What is the average distance (in meters) between lighting poles? The distance may vary considerably from neighborhood to neighborhood.
- Street lighting coverage—Are there neighborhoods without coverage or with poor lighting? If possible, get an idea of how many people live in these neighborhoods and about safety-related issues there.
- Average hours of operation—What are the average daily hours of operation (for example, 5 P.M.–7 A.M.)?
- Dimming—Is there a lighting timing/dimming program that can dim light intensity during prescribed periods, such as at night when traffic and road activity diminishes?
- Investments and upgrades—Determine the extent of recent public lighting system investments and upgrade programs, if any. Has the system undergone modernization

or rehabilitation recently? When was the public lighting network upgraded and when were the lamps last replaced?

- Overall annual electricity consumption and related expenditure—In addition to the energy used to operate the public lighting network, the energy bill usually covers building lighting, holiday lighting (such as Christmas decorations), and operation of fountains. However, all street lighting services are usually included in one bill without a breakdown.
- Annual maintenance costs—If possible, determine the overall street lighting system maintenance costs per year.
- Maintenance entity—Is the city government involved in maintaining the public lighting network? In some cities, maintenance is not carried out by an operator or concessionaire; for example, it could be a public entity under the city government.
- Public lighting pricing—Determine the average electricity rates for street lighting (in local currency/kWh). Is there more than one tariff? Some cities have two tariffs for public lighting, for daytime and nighttime; nighttime is less expensive.

Public Lighting (PL) KPIs

KPI: PL1—Electricity Consumed per Kilometer of Lit Roads (kWh/km)	
Definition	The amount of electricity consumed per kilometer of lit roads within the municipal boundary.
Methodology/ Calculation	Divide electricity consumption of the public lighting sector into kilowatt-hour by length of illuminated roads in kilometers within the municipal boundary.
Example	In Ho Chi Minh City, Vietnam, the total length of lit roads was 3,800 km and the annual electricity consumption of public lighting was 94,250,000 kWh in 2011.[a] Thus the electricity consumed per kilometer of lit roads is 94,250,000 kWh divided by 3,800 km, which is 24,803 kWh/km.
Key Sources	Electricity consumption for public lighting: The mayor's office, city energy office, lighting maintenance department, engineering department, utilities, or budget office. Length of lit roads: The city hall, department of transportation, or central office of statistics.
TRACE Database	Primary and secondary online sources were used to obtain the electricity consumption and length of lit roads. Some of the primary data were collected directly from the cities. In cities where the primary data were not available, cities' annual statistical yearbooks or surveys were used as major data sources. Additionally, information from city/national standards or targets, international best practices or lessons learned, and other research reports were used in some cities. Where city-level data were not available (as was the case in three cities), country-level statistics were used. An assumption was made for several highly developed cities (such as Paris, Singapore, and Tokyo), assuming that all city roads were lit.

a. UNDP, "Vietnamese Cities Embrace Energy Efficient Public Lighting."

KPI: PL2—City Roads Lit (%)	
Definition	The percentage of city roads that are lit.
Methodology/ Calculation	Divide the length (in kilometers) of city roads that are lit by the total length of roads in the city.
Example	In Brasov, Romania, as of 2014, the length of lit roads was 487 km, while the total length of the city road network was 551 km. Therefore, the percentage of lit city roads is 88.4%.[a]
Key Sources	The department of transportation, planning department, or central/city statistics office.
TRACE Database	Primary or secondary online sources were used for calculations when the length of lit roads was not collected directly from cities. Most of the data came from cities' annual statistical yearbooks or surveys. Siemens Green City Index was used to estimate the total length of road networks in many cities. For some specific cities, data from city/national standards or targets and best practices or lessons learned from governmental or nongovernmental organizations such as UN-Habitat and Japan International Cooperation Agency (JICA) were used. A major assumption made for several highly developed cities, such as Paris, Singapore, and Tokyo, was that the city roads are 100% lit.

a. TRACE Implementation in Brasov in 2013.

KPI: PL3—Electricity Consumed per Light Point (kWh/Point)	
Definition	The amount of electricity consumed per public light point within the municipal boundary.
Methodology/ Calculation	Divide the electricity consumption with regard to public lighting (in kilowatt-hours) by the number of lighting points in the city.
Example	In Tbilisi, Georgia, the annual electricity consumption in the street lighting sector in 2012 was 46,800,000 kWh, with some 92,560 lighting points in the city. Thus, the overall electricity consumed in the sector is 46,800,000 kWh divided by 92,560, which is 506 kWh/lighting point.[a]
Key Sources	The energy, maintenance, or budget office.
TRACE Database	Primary or secondary online sources were used for calculations when data were not collected directly from cities. Cities' annual statistical yearbooks or surveys were the major data sources. For some cities, data from utility reports, city's emission inventories, and standards or targets at city, state, or national level were used. Country-level data from the "en.lighten initiative" of the Global Environment Facility (GEF) were also used where no better data source was available.[b]

a. 2013 ESMAP TRACE Implementation in Tbilisi.

b. United Nations Environment Programme (UNEP)–Global Environment Facility (GEF) en.lighten initiative (www.enlighten-initiative.org).

KPI: PL4—Failed Public Lights (%)	
Definition	The percentage of public lights that are not working due to outage or other technical and maintenance related issues in a one year period.
Methodology/ Calculation	Divide the number of public lights that are not working annually by the total number of street lights in the city.
Example	In Buenos Aires, Argentina, about 150,000 public lights are not working annually, out of a total of 700,000 lights in the city; hence, the failure rate is about 21%.[a]
Key Sources	The public lighting maintenance or engineering office.
TRACE Database	Primary or secondary online sources were used for calculations when data were not collected directly from cities. Data, targets, and standards from city government's website, best practices and lessons learned from governmental or nongovernmental organizations, and news articles were investigated during the data collection process.

a. SAP Insider, "How Buenos Aires Citizens Are Benefiting from a New SAP Platform."

BUILDINGS

Questions and Issues to Be Discussed with Relevant Stakeholders

The following discussion addresses three types of buildings: municipal, commercial, and residential.

Municipal Buildings

Municipal buildings are buildings that are owned and managed by the city government and for which local authorities are responsible for the energy bills (electricity, heat). This category usually includes educational facilities (including kindergartens, primary and secondary schools, high schools, vocational schools, and public universities), municipal hospitals and medical facilities, cultural centers and facilities (such as opera house, theater), social assistance centers, (local) public administration buildings, and so on.

Preliminary

- Clarify from the beginning the authority who is responsible for municipal buildings in the city, and who pays the energy bills for such buildings.
- Find out if the city government has an office that keeps track of floor area, energy consumption, renovation of public buildings, and so on and if there is a dedicated energy office that monitors energy consumption in all these buildings. Most cities do not have such an office, and gathering data on public building energy performance is often difficult. In some cases, estimates were used based on a sample per type of building: one hospital, one school, one public office, and so on.

Other

- Are building codes in place and what do they require?
- How many municipal buildings are in the city? How many schools, hospitals, public offices, cultural centers (if possible to determine)?
- Are these buildings new or old facilities? Are they in good shape? Do they require rehabilitation or renovation?
- Was rehabilitation or renovation performed in recent years?

- What cooling system is in place—such as fans, air conditioning (centralized or split units)?
- What heating system is in place—such as district heating, individual heating units, or stove?
- Do these buildings have photovoltaic (PV) solar rooftops? Are other renewable energy systems available?
- Are these buildings thermally insulated? Are they equipped with double-glazed windows and efficient lighting systems, such as light-emitting diodes (LEDs)?
- What is the total floor area of municipal buildings (square meters)?
- What is the total annual energy consumption (power and heat)?
- What is the annual energy bill (electricity, heat, etc.)?

Commercial Buildings

Commercial buildings are facilities that are used for commercial purposes, including office buildings, retail buildings (such as malls, stores), and warehouses. In some cities, there are mixed buildings with both residential and commercial functions. In this case, such buildings should be considered as residential.

- What is the total number of commercial buildings?
- What types of buildings are there? If possible, break this down into office buildings, malls, and so on.
- Are most of these buildings new or old?
- Do they have solar PV rooftops?
- Are the buildings thermally insulated and/or equipped with double-glazed windows and efficient lighting systems?
- What cooling system is in place—such as fans, air conditioning (AC) systems (centralized or split units)?
- What heating system is in place—such as centralized heating from the district heating plant, individual heating units, stoves?
- Are there any mixed-use buildings—that is, used for both commercial and residential purposes?
- What is the annual heat and electricity related expenditure?
- What is the total floor area of commercial buildings (square meters)?
- What is the total annual energy consumption (power and heat)?

Residential Buildings

Residential buildings are buildings where most of the floor area is used for dwelling purposes.

- How many residential buildings are in the city?
- Are these buildings in good or poor shape?
- Have they been renovated or rehabilitated?
- Do these buildings have solar PV rooftops?
- Are these buildings thermally insulated and equipped with double-glazed windows and efficient lighting systems, such as compact fluorescent lamps (CFLs) or LEDs?

- What is the number of households in the city (if possible)?
- What cooling and heating systems are in place—centralized heating, centralized AC, split units, and so on?
- What is the total floor area of residential buildings (square meters)?
- What is the total annual energy consumption (power and heat)?
- What is the annual energy bill (electricity, heat, etc.)?

Municipal Building (MB) KPIs

KPI: MB1—Municipal Buildings Electricity Consumption (kWh/m^2)	
Definition	Electricity consumed per floor area of municipal buildings. (Note: definition of municipal buildings may vary from city to city.)
Methodology/ Calculation	Divide the overall electricity consumption for municipal buildings (in kilowatt-hours) by the total floor area of municipal buildings (in square meters).
Example	The municipal buildings in Sarajevo, Bosnia and Herzegovina, had a floor area of 894,441 square meters, which used 30,196,345 kWh of electricity in 2012.[a] The electricity consumption per floor area is 34 kWh/m^2.
Key Sources	The building maintenance and management office, energy office, utilities, and city budget departments.
TRACE Database	Primary or secondary online sources were used for calculations when the data were not collected directly from cities. Most of the electricity consumption data came from cities' annual statistical yearbook or databases. Some cities had this data published in their energy plans, reports, or greenhouse gas emissions inventories. The floor area of municipal buildings is included in some cities' master plans.

a. 2012 ESMAP TRACE Implementation in Sarajevo.

KPI: MB2—Municipal Buildings Heat Consumption (kWh/m^2)	
Definition	Energy per floor area of municipal buildings consumed for heating purposes.
Methodology/ Calculation	Divide the municipal buildings' total energy consumption for heating (in kilowatt-hour equivalent) by the total floor area of municipal buildings (in square meters).
Example	In 2013, the city of Kamianets-Podilskyi, Ukraine, used 19,757,778 kWh of energy to heat its municipal buildings, which had a floor area of 181,970 square meters. Therefore, the heat consumption per floor area is 109 kWh/m^2.
Key Sources	The building maintenance and management office, energy office, utilities, and city budget departments.
TRACE Database	Primary or secondary online sources were used to calculate the heat consumption per floor area. Some energy consumption and floor areas data came from cities' energy plans or utilities' assessment reports. Heat consumption data were only available in limited regions where district heating was used in cold climates.

KPI: MB3—Municipal Buildings Energy Spending as a Percentage of Municipal Budget	
Definition	Annual expenditure on energy for the public buildings, as a percentage of the city budget for a fiscal year.
Methodology/ Calculation	Divide the city's annual expenditure on energy for public buildings by the city budget, using the currency the city has reported.
Example	New York City spent $858,058,056 on the energy for its municipal buildings in 2013. The total budget of New York City was $75,026,906,545 in 2015.[a] Therefore, the percentage of the municipal buildings' energy spending from the city budget was 1.14%.
Key Sources	The building maintenance and management office, energy office, utilities, and city budget offices.
TRACE Database	Primary or secondary online sources were used for calculations when the energy spending and budget were not collected directly from cities. Some cities published the data in the annual reports of its finance and revenue department.

a. The City of New York Executive Budget, Fiscal Year 2016.

Residential Building (RB) KPIs

KPI: RB1—Residential Buildings Electricity Consumption (kWh/m²)	
Definition	Electricity consumed per floor area in residential buildings.
Methodology/ Calculation	Divide the electricity consumption for residential buildings (in kilowatt-hours) by the total floor area of residential buildings (in square meters).
Example	The residential buildings in Guangzhou, China, have a floor area of 223,221,700 square meters, and used 14,139,510,000 kWh of electricity in 2014.[a] Therefore, electricity consumption per floor area is 63 kWh/m^2.
Key Sources	The central statistics office, census data, energy office, utilities, electricity distribution companies, urban planning, city planner, and demographer. Also, by performing a quick sampling of buildings during the World Bank's missions.
TRACE Database	Primary or secondary online sources were used for calculations when the data were not directly collected from cities. Most of the electricity consumption data came from cities' annual statistical yearbook or databases. Some cities had this data published in their energy plans, reports, or greenhouse gas emissions inventories. When city-level data were not available, country-level electricity consumption data from the World Energy Council, UN Statistics Division Energy Statistics Database, or other country reports were used.[b, c, d] The floor area of residential buildings was sometimes included in cities' master plans or housing sector profiles. Country-level floor area of several European countries was from the ENTRANZE Project. When no better data source is available, the total floor areas were estimated based on the regional floor area per capita data from a research paper by Professor L. D. Danny Harvey from the University of Toronto and city population.[e]

a. Guangzhou Statistical Yearbook 2014.

b. World Energy Council, Average Electricity Consumption per Electrified Household, 2014.

c. UN Energy Statistics Database 2015.

d. ENTRANZE Project.

e. L. D. Danny Harvey et al., Construction of a Global Disaggregated Dataset of Building Energy Use and Floor Area in 2010, *2015.*

KPI: RB2—Residential Household Buildings Electricity Consumption (kWh/Household)	
Definition	Residential electricity consumption per household.
Methodology/ Calculation	Divide the electricity consumption for residential buildings (in kilowatt-hours) by the number of households in a city.
Example	In Beijing, China, the electricity consumption of the residential sector in 2014 was 13,933,000,000 kWh, and the number of residential households was 4,961,000.[a] Therefore, the electricity consumption per household is 2,809 kWh/m².
Key Sources	The central statistics office, census data, energy office, utilities, electricity distribution companies, urban planning, city planner, and demographer.
TRACE Database	Primary or secondary online sources were used for calculations when the data were not directly collected from cities. Most of the electricity consumption data came from cities' annual statistical yearbook or databases. Some cities had this data published in their energy plans, reports, or greenhouse gas emissions inventories. When city-level data were not available, country-level electricity consumption data from the World Energy Council, UN Statistics Division Energy Statistics Database, or other country reports were used.[b, c] The number of households was from city's and country's annual statistical yearbook.

a. Beijing Statistical Yearbook 2014.

b. World Energy Council, Average Electricity Consumption per Electrified Household.

c. Energy Statistics Database.

KPI: RB3—Residential Buildings Heat Consumption (kWh/m²)	
Definition	Energy per floor area in residential buildings used for heating purposes.
Methodology/ Calculation	Divide residential buildings' total energy consumption for heating (in kilowatt-hour equivalent) by the total floor area of residential buildings (in square meters).
Example	Households in Tallinn, Estonia, used 2,325,000,000 kWh of energy to heat their homes. The residential sector has a floor area of 38,440,262 m².[a] Therefore, the heat consumption per floor area is 60.5 kWh/m².
Key Sources	Central statistics office, census data, energy office, utilities, electricity distribution companies, urban planning, city planner, and demographer.
TRACE Database	Primary or secondary online sources were used to calculate the heat consumption per floor area. Some energy consumption and floor areas data came from cities' energy plans or utilities' assessment reports. Heat consumption data were available only in regions with cold climates where district heating is required.

a. Energy Efficiency Action Plan for Tallinn, http://www.tallinn.ee/g4128s55841

KPI: RB4—Residential Buildings Energy Spending as a Percentage of Residential/Household Expenditure	
Definition	Percentage of a household's annual total budget spent on energy.
Methodology/ Calculation	Divide household's average annual expenditure on energy by the total household expenditure in a year, using the currency that the city reported.
Example	On average, a household in Colombo, Sri Lanka, spent 3,549 rupees on energy in 2013, while the average household expenditure was 63,030 rupees.[a] The percentage of residential buildings energy spending of the household was 5.63%.
Key Sources	The cities' poverty studies, statistics office, or a quick sampling of some residents during the World Bank's missions.
TRACE 2.0 Database	Primary or secondary online sources were used for calculations when the energy spending and total expenditure were not collected directly from cities. Some cities published the data in their statistical yearbook. When city-level data were not available, country-level data from the World Bank's report *Expenditure of Low-Income Households on Energy* (2010) were used for several cities.

a. Household Income and Expenditure Survey, 2012–13.

Commercial Building (CB) KPIs

KPI: CB1—Commercial Buildings Electricity Consumption (kWh/m²)	
Definition	Electricity consumption per floor area of commercial buildings.
Methodology/ Calculation	Divide the electricity consumption for commercial buildings (in kilowatt-hours) by the total floor area of commercial buildings (in square meters).
Example	In 2014, New Delhi, India, the commercial building sector had a floor area of 28,244,800 square meters and consumed 6,786,000,000 kWh of electricity. Therefore, electricity consumption per floor area was 240 kWh/m².
Key Sources	This data were typically obtained from the central statistics office, census data, energy office, utilities, electricity distribution companies, urban planning office, city planner, and demographer. The floor area data sometimes came from real estate companies or the business promotion department of the city.
TRACE 2.0 Database	Primary or secondary online sources were used for calculations when the data were not collected directly from cities. Most of the electricity consumption data came from cities' annual statistical yearbook or databases. Some cities had this data published in their energy plans, reports, or greenhouse gas emissions inventories. When city-level data were not available, country-level electricity consumption data from the Eurostat Energy Balance Sheets, UN Statistics Division Energy Statistics Database, or other country reports were used.[a, b] The floor area of commercial buildings was sometimes included in cities' master plans or housing sector profiles. The country-level floor areas of several European countries were available from the ENTRANZE Project.[c] When no better data source was available, building floor areas were estimated using regional floor area per capita from a research paper by Professor L. D. Danny Harvey from the University of Toronto.[d]

a. Eurostat, Eurostat Energy balance sheets, 2014.

b. UN Energy Statistics Database, 2015.

c. ENTRANZE Project, www.entranze.eu

d. L. D. Danny Harvey et al., Construction of a Global Disaggregated Dataset of Building Energy Use and Floor Area in 2010, *2015.*

KPI: CB3—Commercial Buildings Heat Consumption (kWh/m²)	
Definition	Energy consumed for heating purposes per floor area of commercial buildings.
Methodology/ Calculation	Divide residential buildings' total energy consumption for heating (in kilowatt-hour equivalent) by the total floor area of commercial buildings (in square meters).
Example	The commercial sector in Beijing, China, used 22,723,159,200 kWh of energy to heat the buildings. The floor area of commercial buildings is 292,660,000 m². Thus, the heat consumption per square meter is 77.64 kWh/m².
Key Sources	The central statistics office, census data, energy office, utilities, electricity distribution companies, urban planning, city planner, and demographer. Data related to floor area may also from real estate companies or the business promotion department of the city.
TRACE Database	Primary or secondary online sources were used to calculate the heat consumption per floor area. Some energy consumption and floor areas data came from cities' energy plans or assessment reports. Heat consumption data were only available in limited regions where district heating was used in cold climates.

TRANSPORT

Questions and Issues to Be Discussed with Relevant Stakeholders

Preliminary

Clarify from the beginning who is in charge of public transport in the city and who the operators are (public or private entities). If there are private operators, explain the institutional (legal) arrangement between the companies and the local government (for example, concession).

Other

- Split between different transport modes—public transport, cars, nonmotorized, etc.
- Means of public transport in the city—buses, trams, metro, etc.
- Public transport expenditure—total liters of diesel/gasoline used for public transport
- Average price of fuel (per liter)
- Total cost of fuel used to operate public transport in the city (for example, 100,000 liters × 10 pesos per liter = 1,000,000 pesos)
- Number of buses in use and types—large, standard, minibuses, etc.
- Total standing and seating capacity of vehicles—per each category of bus, if possible
- Number of kilometers a vehicle runs daily—per each category of vehicles, if possible
- Does the city have green/clean energy buses, such as compressed natural gas (CNG) vehicles?
- The approximate occupancy ratio (expressed as a percentage) for each category of vehicle (for example, 50 percent means the bus is half full)
- Overall standard fleet classification—whether vehicles are equipped with European standard emissions engines Euro 2/3/4, or above Euro 4
- Age of the public transport fleet—average age of vehicles (for example, 20 years old)
- The condition of the bus fleet—new or old, good or poor, well maintained or upgraded?
- Are buses equipped with GPS? Does the city have a system to monitor public transport vehicles while in traffic?
- How many bus routes operate in the city?

- Does the city have a high-transit capacity system (metro, bus/rapid transit, tram)? If so, what is the length of the infrastructure (for example, 50 kilometers of metro lines serving 50 stops)?
- Is there e-ticketing?
- Do bus stops have the proper infrastructure?
- Can passengers find out real-time information about bus schedules? Are bus stops equipped with electronic screens that display such information?
- Tariff of ticket/per trip—Are there discounts for students, retirees, and others?
- Are there dedicated bus lanes? If so, how many?
- Does the city have a dedicated bike network? If so, are bike lanes interconnected and also connected to the public transport system?
- Is there a bike-sharing program? Are there docking stations where people can rent bicycles? If so, what are the tariffs per bike (hourly, daily, etc.)?
- Does the city have a good pedestrian network (car-free streets)?
- Does the city have an integrated public transport system?
- How many private vehicles are registered in the city? Describe the fleet (old, new, etc.).
- Hours of congestion in the city—what are typically the peak hours in the city?
- Is there a congestion price enforced? (For example, in London, people who drive their cars to the downtown area must pay a fee.)
- Are there enough parking facilities in the city? Is underground parking available? What is the parking fee? Can users pay for parking by phone or use e-ticketing for public transport?
- Are there are park-and-ride facilities (on the outskirts of the city) where people can leave their cars and take public transport?
- Are there flyovers or ring roads in the city?
- Is the city equipped with an adequate stock of traffic lights and traffic signals?
- Does the city have adequate traffic management in place?
- How many vehicles are in the municipal fleet—cars used by the local public offices for which the city government pays the fuel related bills (for example, cars that belong to the city hall or police cars, if any).

Public Transport (T) KPIs

KPI: T1—Public Transport Energy Consumption (MJ/Passenger km)	
Definition	Energy consumption per passenger kilometer of public transport.
Methodology/ Calculation	Divide the total energy consumption (in megajoules) by the total passenger distance travelled by public transit (in kilometers). The passenger distance is usually calculated by multiplying the number of unlinked passenger trips by the average length of the trips.
Example	In Iasi, Romania, the total energy consumption of public transport is 166,718,976 MJ, while the public transportation passenger kilometers are 843,600,000 km.[a] Thus, energy consumption per passenger kilometer of public transport is 0.20 MJ/passenger km.
Key Sources	The passenger kilometers data are usually provided by the city's transportation department, while the energy public transport consumption is available from the local transport company/operator or the fuel distribution company. Usually, a couple companies supply all public vehicle fuels in the city. It is assumed that gasoline is sold mainly to vehicles.
TRACE Database	Most data come from previous TRACE implementations.

a. TRACE Implementation in Iasi in 2013.

KPI: T2—Meters of High Capacity Transit per 1,000 People (m/1,000 People)	
Definition	Length of high-capacity transit network (tram, metro, bus/rapid transit) in the city per 1,000 people.
Methodology/ Calculation	Divide the total length of high-capacity transit (in meters) by total population (in thousands). High-capacity transit generally enjoys exclusive rights regarding supporting infrastructure and services—such as dedicated lanes, queue jumps, or transit signal priority—that can substantially improve the speed, capacity, and frequency of the system.
Example	In Johannesburg, South Africa, in 2010 the length of the public transport network was 128 kilometers, and the total population was 3.5 million.[a] Therefore, meters of high-capacity transit were 36.6 m/1,000 people.
Key Sources	The department of transportation, planning department, transport company/ companies, or central statistics office.
TRACE Database	Primary or secondary online sources were used for calculations when the length of the high-capacity transit network was not collected directly from cities. Most of the data came from cities' annual statistical yearbooks or surveys. The Siemens Green City Index was used to estimate the length of high-capacity transit in many cities. The EMTA Barometer of Public Transport was also examined for European cities during the data collection process.

KPI: T3—Nonmotorized Transportation Mode Split (%)	
Definition	Percentage of passenger journeys or trips by the main mode of nonmotorized transport, namely walking and cycling.
Methodology/ Calculation	Divide the number of trips by walking or cycling by the total number of in-land passenger transport trips.
Example	The percentage of passenger trips by walking and cycling in Bogota was 33% as of 2015.[a]
Key Sources	The department of transportation, planning department, technical department from the city hall, or central statistics office.
TRACE Database	Primary or secondary online sources were used when the data were not collected directly from cities. The European Platform on Mobility Management (EPOMM) Modal Split Tool, UN Habitat's "State of Urban Passenger Transport," and the paper, "Research on Practical Approach for Urban Transport Planning" by the Japan International Cooperation Agency (JICA) are the main data sources.[b, c] In some specific cities, data from household surveys or city development plans were used.

a. 2015 ESMAP TRACE Implementation in Bogota.

b. EPOMM, Modal Split Tool, 2015.

c. JICA, The Research on Practical Approach for Urban Transport Planning, *2011.*

KPI: T4—Public Transportation Mode Split (%)	
Definition	Percentage of passenger journeys or trips by public transport, such as buses or trolleybuses, subway, railroad, ferry boat, etc. Usually, taxis are not considered as public transport.
Methodology/ Calculation	Divide the number of trips performed by public transport by the total number of in-land passenger transport trips.
Example	The percentage of passenger journeys or trips by public transport in Belgrade is 24.96%.
Key Sources	This figure should be provided by department of transportation, local transport operator, planning department, or central statistics office.
TRACE Database	Primary or secondary online sources were used when the data were not collected directly from cities. The European Platform on Mobility Management (EPOMM) Modal Split Tool, the Japan International Cooperation Agency (JICA)'s research paper, and the report *Passenger Transport Mode Shares in World Cities* (by the Land Transport Authority of Singapore) are the main data sources.[a, b, c] In some cities, data from household surveys or city development plans were used.

a. EPOMM, Modal Split Tool, 2015.

b. JICA, The Research on Practical Approach for Urban Transport Planning, *2011.*

c. Land Transport Authority (LTA), Singapore, Passenger Transport Mode Shares in World Cities, *2014.*

KPI: T5—Private Transport Energy Consumption (MJ/Passenger km)	
Definition	The energy consumption per kilometer travelled by private transport.
Methodology/ Calculation	Divide the total energy consumption (in megajoules) by the total distance travelled in private vehicles (in kilometers).
Example	In Timisoara, Romania, total energy consumption of private transport was 1,145,178,711 MJ in 2012, while the kilometers vehicles travelled was 597,456,538 km.[a] Thus, energy consumption per passenger kilometer of public transport was 0.2 MJ/passenger km.
Key Sources	Data on passenger distance travelled (in kilometers) are often provided by the city's transportation department, and the energy public transport consumed usually comes from the fuel distribution company. Typically, a couple companies supply all vehicle fuels to the city. It was assumed that gasoline sold in the city was used mainly for vehicles.
TRACE Database	Most data were available from the current version of TRACE.

a. Implementation of TRACE in Timisoara in 2013.

KPI: T6—Congestion (Hours Wasted/Spent in Traffic Congestion)	
Definition	Average number of hours people spend waiting in traffic congestion per year.
Methodology/ Calculation	Not applicable.
Example	In Rio de Janeiro, Brazil, people wasted an average of 99 hours per year in traffic jams.
Key Sources	The department of transportation sometimes collects this data.
TRACE Database	Where the data were not available directly from cities, the INRIX Traffic Scorecard and TomTom Congestion Index were used as the main data sources.

KPI: T7—Meters of Bicycle Lanes per 1,000 People (m/1,000 People)	
Definition	Length of bicycle lanes network per 1,000 people in the city.
Methodology/ Calculation	Divide the total length of dedicated bicycle lanes (in meters) by the total population (in thousands).
Example	In Ljubljana, Slovenia, the total length of bicycle lanes was 128.0 kilometers and the total population was 273,000 in 2015. Therefore, there are 469 m of bike lanes/1,000 people.
Key Sources	The departments of transport and planning often collect this data.
TRACE Database	Primary or secondary online sources were used for calculations when the data were not collected directly from cities. Information from city/national standards or targets, international best practices or lessons learned, news articles, and other research reports were investigated during the data collection process.

POWER AND DISTRICT HEATING

Questions and Issues to Be Discussed with Relevant Stakeholders

- How many apartments in the city are connected to the district heating network?
- How many heating plants are in the city? Are they running on coal or natural gas? Is there a cogeneration plant (combined heat and power)?
- What is the status of the network—old or new; was it rehabilitated or insulated? Are pipes insulated to prevent hot water leaks?
- What is the total amount (in gigacalories, or Gcal) produced annually?
- What is the cost of production of heat per year (that is, the operational budget used to run the district heating plant)?
- What is the amount of heat distributed/sold to the residential/commercial/public sector?
- Energy prices (per Gcal)—are tariffs subsidized for some consumer groups? (For example, in Romania energy prices for the population are usually subsidized by the local government.)
- Is revenue collection timely—that is, do people pay their heating bills on time?
- Are apartments equipped with meters? Do they have radiator control valves that can turn the heat on and off? Can users regulate the temperature?
- Have there been disconnections from the centralized heating system in the city? (In East European countries, many people switched from district heating systems to individual natural gas/electric-based heating micro-units.)
- What is the number of residential/commercial/public electricity customers?

Power and District Heating (PH) KPIs

KPI: PH1—Total Distribution Loss (%)	
Definition	Percentage of total electricity loss in the distribution system in the city.
Methodology/ Calculation	Divide the difference between the amount of electricity delivered to the distribution system (through the transmission network) and the amount of electricity delivered to the costumers (through the distribution network) by the amount of electricity delivered to the distribution system.
Example	In Bogotá, Colombia, the amount of electricity produced in 2012 was 13,994,690,000 kWh and total transmission and distribution (T&D) losses were 1,357,484,930 kWh. The total distribution loss was 1,357,484,930 kWh divided by 13,994,690,000 kWh, which was 9.7%.
Key Sources	Usually from the utilities or by consulting the utilities' annual reports and websites.
TRACE Database	Primary and secondary online sources were used to obtain the percentage of total distribution loss. Some of the primary data were collected directly from the power utilities. When the primary data were not available, utilities' reports were used as major data sources. If data solely on distribution loss were not available, TRACE implementation data (which also comprises transmission loss, at the city level) were used. If municipal-level or utility-level data were not available, national-level data (EIA) databases were also used.

KPI: PH2—Technical Distribution Loss (%)	
Definition	Percentage of technical electricity loss in the distribution system in the city.
Methodology/ Calculation	This KPI was not calculated. Percentage values were obtained from the relevant sources. The utility is only able to calculate its total distribution loss (please refer to KPI: PH1). Utilities can estimate their technical losses according to technical characteristics of their distribution networks.
Example	Not applicable.
Key Sources	Utility companies or their reports and websites.
TRACE Database	Secondary online sources were used to obtain the percentage of technical distribution loss. Some of the information was collected directly from the power utilities, their reports, and websites. Thus, some of the data are at the utility level. If data solely on distribution loss were not available, then the TRACE implementation data (which also comprises transmission loss, at the city level) were used.

KPI: PH3—Nontechnical Distribution Loss (%)	
Definition	Percentage of nontechnical (or commercial) electricity loss in the distribution system in the city.
Methodology/ Calculation	This KPI was not calculated. Percentage values were obtained from the sources. The utility is only able to calculate its total distribution loss (please refer to KPI: PH1). Utilities can estimate their nontechnical distribution losses by subtracting the percentage of technical distribution loss from the percentage of its total distribution loss.
Example	Not applicable.
Key Sources	The utility company, reports available, and their website.
TRACE Database	Secondary online sources were used to obtain the percentage of nontechnical distribution loss. Some of the information was collected directly from the power utilities, their reports, and websites. Thus, some of the data were at the utility level. If data solely on distribution loss were not available, TRACE implementation data (which also comprises transmission loss, at the city level) were used.

KPI: PH4—Solar Generation (kWh/Capita)	
Definition	Solar electricity generation per capita in the city.
Methodology/ Calculation	Divide solar electricity produced by the population in the municipal boundary, if data at the city level are available.
Example	In India, solar electricity generation was 2.099 (billion kWh) and the population was 1,236,686,732 in 2012. Thus, solar electricity generated by the population was 2.099 billion divided by 1,236,686,732, which equals 1.69 kWh/capita.
Key Sources	Usually, information about solar electricity generation is available at the national level, so population refers to the national population.
TRACE Database	Secondary online sources were used to obtain solar electricity generation and population; EIA was the primary source for solar electricity generation data, and the World Bank database was used for data on population.

WATER AND WASTEWATER

Questions and Issues to Be Discussed with Relevant Stakeholders

Preliminary

Clarify from the beginning who is the water/wastewater operator in the city.

Other

- Water sources—overground (rivers) and/or underground (wells)
- Does water come from upstream rivers and have a gravity-flow delivery system (in which case it requires less energy for water pumping)?
- Length of water network (potable water)—kilometers of water pipes in the city
- Water coverage—the percentage of city residents that are connected to the water network
- Length of sewage network in the city (kilometers)
- Total number of water pumps (if possible)
- Overall pumping capacity—overall installed capacity of water pumps; find out the break-down of pump types, if possible
- Pumping system maintenance cost—amount the water company spends annually on maintenance services for water pumps
- Water treatment plants—the number and type of potable-water treatment facilities in the city and the percentage of the wastewater that is treated
- Wastewater treatment plants—the number of wastewater treatment facilities in the city
- Are wastewater treatment facilities equipped with digesters to produce biogas? If so, is the energy produced used to operate the facility?
- Is a Supervisory Control and Data Acquisition (SCADA) system in place to monitor water connections and identify in real time possible issues/leakages that may occur in the network?

Water and Wastewater (WW) KPIs

KPI: WW1—Water Consumption (L/Capita/Day)	
Definition	Water consumption per capita per day in the city.
Methodology/ Calculation	Divide the amount of water consumed in liters by the population and by 365 days in a given year in the city.
Example	In Rio de Janeiro, Brazil, the water consumption in 2013 was 704,077 liters, and the city population was reported as 6,429,923.[a, b] Therefore, water consumption per capita per day was 704,077 divided by 6,429,923 divided by 365 days, which equals 300 liters/capita/day.
Key Sources	Bureau of statistics, utilities, water surveys, and database.
TRACE Database	Primary and secondary online sources were used to obtain the amount of water consumed per capita per day. Some of the primary data were collected directly from the water utilities or bureau of statistics. When the primary data were not available, utilities' reports or surveys were used as major data sources. Most data were from IBNET database,[c] Siemens Green City Index, Open Data for Cities (World Council on City Data), and TRACE implementation data.

a. 2013 Diagnosis of water and wastewater services.

b. 2010 census.

c. The International Benchmarking Network for Water and Sanitation Utilities (IBNET).

KPI: WW2—Energy Density of Potable Water Production (kWhe/m^3)	
Definition	Electricity consumed for water production per cubic meter of water in the city.
Methodology/ Calculation	Divide the amount of electricity consumed to produce water by the amount of water produced in the city.
Example	In Brasilia, the total energy consumed by the local utility to operate the water sector in 2013 was 232,223,000 kWh, and 255,958,000 cubic meters of water was produced.[a] Therefore, the energy density of potable water operation is 232,223,000 divided by 255,958,000, which equals 0.91 kWhe per m^3.
Key Sources	Bureau of statistics, utilities, TRACE database, and other water surveys and database.[b]
TRACE Database	Primary and secondary online sources were used to obtain the energy density of potable water production. Some of the primary data were collected directly from the water utilities or bureau of statistics. When the primary data were not available, utilities' reports or surveys were used as major data sources. Most data come from IBNET database[c] and TRACE implementation data.

a. 2013 Diagnosis of Water and Wastewater Services.

b. 2012 ESMAP TRACE Implementation.

c. The International Benchmarking Network for Water and Sanitation Utilities (IBNET).

KPI: WW3—Nonrevenue Water (%)	
Definition	This is the percentage of water produced but not billed in the city.
Methodology/ Calculation	Divide the difference between the amount of water produced and the amount of water billed by total water produced.
Example	In Nairobi, Kenya, the amount of water produced in 2013 was 179,058,047 m^3 and the amount of water sold was 105,515,577 m^3. Thus, the percentage of nonrevenue water is 179,058,047 minus 105,515,577 divided by 105,515,577, which equals 41%.
Key Sources	Bureau of statistics, utilities, TRACE database, and other water surveys and database.
TRACE Database	Primary and secondary online sources were used to obtain the energy density of potable water production. Some of the primary data were collected directly from the water utilities or bureau of statistics. When the primary data were not available, surveys were used as major data sources. Most data were from International Benchmarking Network for Water and Sanitation Utilities (IBNET), Siemens Green City Index, Open Data for Cities (World Council on City Data), and TRACE implementation data.

KPI: WW4—Energy Cost of Water Treatment (Potable and Wastewater) as a Percentage of the Total Water Utility Operating Budget	
Definition	Electricity cost of water production and wastewater treatment as a percentage of total operating cost in the city.
Methodology/ Calculation	Divide the electricity cost for water production and wastewater treatment by the total operating cost for water production and wastewater treatment in the city.
Example	In São Paulo, Brazil, electricity cost for water production and wastewater treatment was R$207,260,368 in 2013, and total operational expenditure was R$2,401,835,953. Therefore, the energy cost of water treatment in 2013 was 207,260,368 divided by 2,401,835,953, which equals 9%.
Key Sources	Bureau of statistics, utilities, TRACE database, and other water surveys and databases.[a]
TRACE Database	Primary and secondary online sources were used to obtain the energy density of potable water production. Some of the primary data were collected directly from the water utilities or bureau of statistics. When the primary data were not available, surveys were used as major data sources. Most data are from International Benchmarking Network for Water and Sanitation Utilities (IBNET) database and from TRACE implementation data.

a. ESMAP TRACE Implementations.

KPI: WW5—Energy Density of Wastewater Treatment (kWhe/m^3)	
Definition	Electricity consumed for wastewater treatment in the city.
Methodology/ Calculation	Divide the amount of electricity consumed to treat wastewater by the amount of wastewater treated in the city.
Example	In Craiova, Romania, the total energy consumed by the local utility to treat wastewater in 2013 was 3,941,669 kWhe, and 34,490,000 cubic meters of wastewater was treated.[a] Thus, the energy density of wastewater treatment was 3,941,669 divided by 34,490,000, which equals 0.11 kWhe per cubic meter.
Key Sources	Bureau of statistics, utilities, TRACE database and other water surveys and databases.
TRACE Database	Most data are available from TRACE implementation.

a. 2013 TRACE Implementation in Craiova.

KPI: WW6—Population with Access to Potable Water (%)	
Definition	Percentage of the population with access to potable water in the city.
Methodology/ Calculation	Divide the population with access to potable water in the city by total population in the city.
Example	In 2013, in Belo Horizonte, Brazil, the population with access to potable water was 2,479,165 and total population was 2,479,165.[a] Thus, the percentage of population with access to clean water equals 100%.
Key Sources	National bureau of statistics, utilities, the TRACE database, and other water surveys and databases.[b]
TRACE Database	Primary and secondary online sources were used to obtain the percentage of population with access to potable water production. Some of the primary data were collected directly from the water utilities or bureau of statistics. When the primary data were not available, surveys were used as major data sources. Most data were from the International Benchmarking Network for Water and Sanitation Utilities (IBNET), Siemens Green City Index, Open Data for Cities (World Council on City Data), and the TRACE implementation database.

a. 2013 Diagnosis of water and wastewater services.
b. ESMAP TRACE Implementations.

SOLID WASTE

Issues and Questions to Be Discussed with Relevant Stakeholders

Preliminary

Clarify from the beginning who is in charge of solid waste collection and management—including transportation to the landfill, recycling, and so on. Find out if the company responsible for waste collection also manages the landfill.

Other

- If possible, break down the waste by type—for example, the amount/percentage of waste collected from the residential sector, economic agents/commercial, and public areas
- Type of waste management—amount of waste that goes to the landfill and compost stations or is recycled. Is there construction and demolition waste; if so, are there adequate disposal facilities?

- Number of waste trucks used for solid waste collection and management activities (collection of waste, transportation to the landfill)
- Are garbage trucks equipped with advanced European standard greenhouse gas emissions engines (Euro 4, 5, etc.)?
- Are the waste vehicles equipped with GPS?
- Does the city have a proper selective collection system? Is selective collection available in the residential/commercial sector?
- Are there public trash bins where people can separate organic waste from recycling waste?
- Is an informal collection system in place?
- What is the monthly tariff city residents pay for solid waste collection services?
- How many waste companies operate in the city?
- How far is the landfill from the city center (in kilometers)?
- Are there any transfer/sorting/compost stations?
- Is the landfill the property of the city government or is it privately owned?
- Is the landfill operated by a concessionaire (in which case the landfill is owned by the city government and operated by a private entity)? What is the length (in years) of the concession agreement?
- What is the area of the landfill (in square kilometers)? What is the capacity of the landfill; that is, how many tons of waste can be deposited during the entire lifespan of the facility (for example, 500 million tons)?
- Ask for a brief description of the landfill that includes the total number of cells, number of cells currently in use, number of cells that are full, and the overall lifespan of the facility.
- Is the landfill equipped with a leachate treatment plant?
- Does the landfill have the capacity to transform waste into energy by capturing biogas?
- What is the tipping fee at the landfill? That is, what is the waste collection fee operators must pay (per ton) to dump waste at the landfill?

Solid Waste (SW) KPIs

KPI: SW1—Waste per Capita (kg/Capita)	
Definition	The amount of municipal solid waste generated annually per capita.
Methodology/ Calculation	Divide the amount of municipal solid waste generated annually by the city's total population.
Example	In Belgrade, Serbia, the amount of municipal solid waste generated in 2012 was 1,801,000 kg per day and the city population was 1,576,124. Thus, waste per capita equals 1,801,000 times 365 divided by 1,576,124, which equals 417 kg/capita.
Key Sources	Municipal waste management plans, bureau of statistics, and other waste-related surveys and databases.
TRACE Database	Primary and secondary online sources were used to obtain the amount of waste generated per capita. Some of the primary data were collected directly from municipalities and the local bureau of statistics. When the primary data were not available, surveys were used as major data sources. Most data were from municipal waste management plans, Siemens Green City Index, Open Data for Cities (World Council on City Data), and TRACE implementation data. For some cities, state- or national-level data were used.

KPI: SW2—Capture of Solid Waste (%)	
Definition	Percentage of municipal solid waste collected in the city.
Methodology/ Calculation	Divide the amount of municipal solid waste collected by total solid waste generated in the city.
Example	In Iasi, Romania, the amount of municipal solid waste generated in 2012 was 156,193,099 kg and the amount captured was 153,897,060 kg.[a] Thus, capture of solid waste in Iasi equals 153,897,060 divided by 156,193,099, or 99%.
Key Sources	Municipal/regional waste management plans, bureau of statistics, and other waste reports, surveys, and databases.
TRACE Database	Primary and secondary sources were used to obtain the percentage capture of solid waste. Some of the primary data were collected directly from the local bureau of statistics. When the primary data were not available, surveys and reports were used as major data sources. Most data were from municipal waste management plans, the Siemens Green City Index, Open Data for Cities (World Council on City Data), and TRACE. For some cities, state- or national-level data were used.

a. 2013 TRACE Implementation in Iasi.

KPI: SW3—Solid Waste Recycled (%)	
Definition	The percentage of municipal solid waste recycled in the city.
Methodology/ Calculation	Divide the amount of municipal solid waste recycled by total solid waste generated in the city.
Example	In Nairobi, Kenya, the amount of municipal solid waste generated in 2013 was 2,500,000 kg per day, while the amount of municipal solid waste recycled was 240,000 kg per day.[a] Thus, the percentage of solid waste recycled equals 240,000 divided by 2,500,000, or 10%.
Key Sources	Municipal waste management plans, solid waste operator, bureau of statistics, other waste reports, surveys, and databases.
TRACE Database	Primary and secondary sources were used to obtain the percentage of recycled waste. Some of the primary data were collected directly from the local bureau of statistics. When the primary data were not available, surveys and reports were used as major data sources. Most data were from municipal waste management plans, Siemens Green City Index, Open Data for Cities (World Council on City Data), and TRACE implementation data. For some cities, state- or national-level data were used.

a. 2013 ESMAP TRACE Implementation in Nairobi.

KPI: SW4—Solid Waste That Goes to Landfill (%)	
Definition	Percentage of municipal solid waste generated in the city that goes into landfills.
Methodology/ Calculation	Divide the amount of municipal solid waste that goes into landfills by the total amount of solid waste generated in the city.
Example	In Brasov, Romania, the amount of municipal solid waste generated within the city boundary was 79,320,450 kg and the amount of municipal solid waste that was dumped in the landfill was 63,834,100 kg per day.[a] Thus, percentage of solid waste disposed at the landfill equals 63,834,100 divided by 79,320,450, or 80%.
Key Sources	Municipal/regional waste management plans, solid waste operator, bureau of statistics, and other waste reports, surveys and databases.
TRACE Database	Primary and secondary sources were used to obtain the percentage of waste that goes to landfill. When the primary data were not available, surveys and reports were used as major data sources. Most data were from municipal waste management plans, Siemens Green City Index, Open Data for Cities (World Council on City Data), and TRACE implementation data. For some cities, national-level data were used from sources such as UN HABITAT.[b]

a. 2013 TRACE Implementation in Brasov.
b. 2012 UN Habitat —The State of Arab Cities.

KPI: SW5—Energy Generated from Waste (MJ/Ton)	
Definition	Amount of energy generated from municipal solid waste.
Methodology/ Calculation	Divide the amount of energy generated from waste by total solid waste generated in the city.
Example	In the metropolitan area of Durban, South Africa, the amount of electricity generated from waste in 2010 was 77,000 MWh in the Bisasar Road landfill and 8,213 MWh in the Mariannhill landfill.[a] The amount of waste generated was 1,800,000 tons.[b] Thus, the amount of energy generated from waste equals 77,000 plus 8,213 times 3,600 divided by 1,800,000, or 170 MJ per ton.
Key Sources	Municipal/regional waste management plans, solid waste operator, bureau of statistics, and other waste reports, surveys, and databases.
TRACE Database	Primary and secondary sources were used to obtain the amount of energy generated from waste. When the primary data were not available, surveys and reports were used as major data sources. Municipal-level data on energy generated from waste were also obtained from the Clean Development Mechanisms projects.[c] Most data are at the national level: data on energy generated from waste were obtained from the Energy Information Administration (EIA).

a. 2010 Clean Development Mechanism Project—UN Convention on Climate Change.
b. 2010 Project Summary Document—Energy Information Administration.
c. UN Framework on Climate Change.

ABBREVIATIONS

GWh	gigawatt-hours
km	kilometer
KPI	key performance indicator
kWh	kilowatt-hour
kWhe	kilowatt-hour equivalent
LED	light-emitting diode
m	meter
m^2	square meter
m^3	cubic meter
MJ	megajoule

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