Commissioned by the UN Secretary-General and supported by the UN Development Group

ENERGY COSTING TOOL

for use in costing MDG-based national energy needs

User Guide

Version 1.0

This **User Guide** is designed to be used in conjunction with the **Energy Costing Tool** available at:

http://www.undp.org/energy
or
http://www.unmillenniumproject.org/

This User Guide is a joint product of the United Nations Development Programme (UNDP) and the UN Millennium Project.

The United Nations Development Programme (UNDP) is the UN's global development network, advocating for change and connecting countries to knowledge, experience and resources to help people build a better life. We are on the ground in 166 countries, working with them on their own solutions to global and national development challenges. As they develop local capacity, they draw on the people of UNDP and our wide range of partners.

The **UN Millennium Project** is an independent advisory body commissioned by the UN Secretary-General to propose the best strategies for meeting the Millennium Development Goals (MDGs). The bulk of its analytical work is performed by 10 thematic task forces, each composed of scholars, policy makers, civil society leaders, and private-sector representatives.

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Overview

At the 2005 World Summit, world leaders reiterated their support for the Millennium Development Goals (MDGs) by committing to support the development and implementation of MDG-based national development strategies.

In response, the United Nations Development Programme (UNDP) is embarking on an ambitious plan to support countries in preparing long-term, results-based development strategies in line with the MDGs. At the heart of the plan is an integrated package of policy advice and technical support, known as “MDG Support Services”, aimed at strengthening countries’ capacity to achieve the MDGs. UNDP is rolling out its MDG Support Services initially in 19 countries during 2006 with the target of reaching a total of 60 countries by the end of 2007.

In recognition of the critical role that energy and the environment play in reaching the MDGs, UNDP’s Energy and the Environment Group is developing a set of tools for helping mainstream energy and environmental considerations into MDG-based national development strategies. The Energy Costing Tool is one of these tools.

The Tool is designed to be used by government planners and decision-makers as they adapt their national development strategies to meet country-specific targets for the year 2015 based on the MDGs. A crucial part of this process is MDG costing, which quantifies the specific financial and human resources needed, as well as infrastructure required, to meet the MDGs. Costing is part of a larger needs assessment process in which countries define specific interventions and outcome targets consistent with the MDGs.

Thanks to the UN Millennium Project, a number of tools for assisting governments in estimating costs for the many inter-related actions needed to achieve the MDGs already exist. However, until now there has not been a methodology available that would allow countries to estimate the amounts and types of investments in energy access required to meet their nationally tailored MDG targets. That is the gap that the Energy Costing Tool is meant to fill.

The Tool was developed by UNDP and the UN Millennium Project. It was applied and tested in Senegal, one of eight Millennium Project pilot countries, and then further refined. It is meant to be used as part of a comprehensive national planning process, in combination with other MDG costing and needs assessment tools.

Although there is no specific MDG dealing with energy, increased access to energy services is a prerequisite for meeting all eight MDGs. Expanded energy services are essential in order to meet the MDGs for reducing hunger and poverty, improving health care and educational opportunities, and addressing gender equity. However, few national Poverty Reduction Strategy Papers or other National Development Plans set explicit targets or budgets for expanding energy access and affordability. Moreover, sector-specific plans for improved health services, for example, or greater access to education, rarely take into account or plan for the associated investments in energy that are needed for additional health care and educational facilities. Therefore, this Guide emphasizes the need for an integrated, multi-sectoral approach to energy needs assessments and cost estimates.

The remainder of this Guide is split into five chapters. The first chapter provides a brief introduction to the context in which this Tool was developed. Chapters 2 and 3 outline the national decision-making process that must underpin an energy costing exercise. This process entails identifying MDG-compatible energy interventions and setting long-term energy access targets. Chapter 4 provides a detailed introduction to the Energy Costing Tool itself, including an outline of the data inputs needed, a description of the calculations performed by the Tool and instructions for adapting it to national circumstances. The fifth and last chapter is dedicated to discussing next steps.

Chapter
1

Introduction

The Energy Costing Tool was prepared as part of a broader UNDP effort to offer practical guidance to developing countries for integrating the Millennium Development Goals (MDGs) into their national poverty reduction and development plans. It was designed to support the formulation and implementation of comprehensive MDG-based national development strategies, especially for those countries where efforts to address widespread poverty are hampered by a lack of modern energy services.

At the 2005 World Summit, governments committed themselves to turning their national development plans into MDG-based strategies. This involves looking beyond yearly or short-term economic plans and budgets, and placing greater emphasis on the types of long-term policies and investments needed for reducing poverty and hunger and promoting health, education, gender equality and environmental sustainability by 2015.

One of the challenges of formulating effective MDG-based development strategies, especially in poorer countries where Poverty Reduction Strategy Papers (PRSPs) are used as the key instrument for development planning, is assessing the fiscal implications of reaching medium and long-term poverty reduction goals. A common criticism of PRSPs, for example, is that they are too often de-linked from availability of financial resources in the national budget. Few PRSPs attempt a comprehensive costing of their priority actions or use cost estimates as the basis for allocating resources for development priorities in national budgets or mid-term expenditure frameworks.

It was with this in mind that UNDP and the Millennium Project developed the Energy Costing Tool. The Tool is meant to assist countries in assessing the fiscal implications of reaching their development goals and help develop stronger linkages between policy, planning and budgeting by providing them with a methodology for estimating the costs of expanding access to basic energy services in line with medium and long-term development priorities.

In preparing the Energy Costing Tool, UNDP worked with the UN Millennium Project, which was commissioned by UN Secretary-General Kofi Annan to identify practical ways for countries to achieve the MDGs. The Project brought together a team of experts who recommended that countries adopt a bold 10-year investment framework for meeting the quantitative targets set out in the MDGs, rather than merely considering how to gradually accelerate progress towards the goals. “Instead of asking ‘How close can we get to the Goals given current financial and other constraints?’ countries should ask the question ‘Which investments and policy changes are needed to meet the Goals?’ ” (World Bank/ESMAP, UNDP and UN Millennium Project, 2005). The approach involves working backwards from the outcome targets for each MDG to identify what actions and resources are needed now to reach those outcomes by 2015.

This is particularly relevant to energy, as current approaches to energy planning by government agencies and utilities tend to focus on short-term responses to pressures for urban and industrial growth. Possibilities for expanding energy access to sparsely populated rural areas or poor urban settlements are generally considered only when specific project resources are made available, or when there has been a detailed study in a specific area demonstrating that there are enough customers able to pay for energy services. The Energy Costing Tool, however, provides a methodology for calculating the cost of the overall, long-term investments in energy access required for national development and poverty alleviation. It is meant to show national decision-makers what is needed to meet the MDGs by 2015, rather than focusing just on what can be accomplished based on current budget projections.

Using the Energy Costing Tool, governments and utilities can formulate 10-year plans that incorporate quantitative estimates of the energy requirements and costs associated with national strategies to meet the MDGs. Those numbers can then be integrated into long-term development plans, budgets and requests for financial assistance.

To better understand how to use the Energy Costing Tool, it is useful to consider, in more detail, its role within countries' efforts to move toward MDG-based national development planning, including national needs assessments.

What is an MDG-based National Development Strategy?

Turning national development plans into MDG-based strategies involves not only longer-term planning – based on targets for 2015 – but also results-oriented planning. With the promise of increased Official Development Assistance (ODA) for meeting the MDGs, governments have an opportunity to put together multi-year national budgets based on what is needed to meet the MDGs, rather than only considering shorter-term budgets based on resources they already have available. The current challenge is to get these MDG-based strategies set up and funded in the short term, with continuous resource allocations over the next 10 years, so that countries can get on track early enough to make significant progress by 2015.

For poorer countries, national planning has become primarily focused on the preparation of PRSPs, based on a process of consultations with stakeholders within the country, including civil society groups. The PRSPs are intended to formally incorporate poverty reduction measures into three- to five-year public expenditure plans adopted by governments and international donors. Given the strategic importance of the PRSPs for the countries most affected by poverty, hunger, health crises and environmental degradation, it is critical to link PRSPs with longer-term National Development Strategies to achieve the MDGs using Mid-Term Expenditure Frameworks and other budgeting mechanisms.

Because of the crucial need for energy services in poor communities, it is important to enhance the attention given to energy planning within the PRSPs and MDG processes. UNDP has therefore become increasingly involved in efforts to build greater understanding of the energy-poverty nexus and to integrate energy interventions into poverty-reduction plans and budgets.

Why is access to modern energy services important to meeting the MDGs?

Without access to an adequate quantity and quality of modern energy services, achievement of the MDGs will not be possible. In many developing countries, especially in sub-Saharan Africa and South Asia, large numbers of people still live without any access to modern energy services.

There are currently 1.6 billion people in the world, mostly in rural areas, without electricity. In addition, 2.4 billion people rely on traditional fuels – wood, dung and agricultural residues – to meet their daily heating and cooking needs. This situation has serious impacts on people's health and the condition of the natural environment. It also severely limits people's economic opportunities and ability to overcome poverty. Major changes in the energy service delivery system are needed so that expansion of energy access can become an important instrument for sustainable development.

Even though there is no MDG directly addressing energy, it is clear that reaching the Goals will require great improvements in the quality and quantity of energy services in the developing world. The Johannesburg Plan of Implementation, which was adopted at the 2002 World Summit on Sustainable Development, recognized a direct link between energy services and poverty reduction, and called for joint actions to improve access to reliable and affordable energy services "bearing in mind that access to energy facilitates the eradication of poverty."

In addition, access to energy services affects many other aspects of sustainable development, including income generation, gender equality, health care, education and environmental sustainability. The authors of the report Energy Services for the Millennium Development Goals, published in 2005 by the World Bank/ESMAP, UNDP and the UN Millennium Project, recommend that national governments "place the issue of energy services at par with other MDGs". They also recommend that countries systematically integrate their energy sector development strategies into a comprehensive MDG-based national development strategy.

What does conducting an MDG Needs Assessment entail?

In order to assist countries in developing MDG Needs Assessments, the UN Millennium Project has produced a Handbook on Preparing National Strategies to Achieve the Millennium Development Goals (http://www.unmillenniumproject.org/policy/handbook.htm). The Project has also put together a set of costing and needs assessment tools for a number of MDG-related issues, including education, gender, water and sanitation, hunger, and various health topics. http://www.unmillenniumproject.org/policy/needs03.htm

The Handbook outlines the steps involved in formulating an MDG-based National Development Strategy. The first activity is to adapt the MDGs to each country-specific situation by defining appropriate national outcome targets based on the MDGs. This will require coordinated planning across all national sectors and ministries. Once outcome targets have been set, there are four steps for conducting an overall MDG Needs Assessment, as illustrated in Figure 1:

Figure 1: Steps in an MDG Needs Assessment

1. Develop a list of interventions

2.. Specify targets for each set of interventions

3. Estimate resource needs

4. Check results

These same steps should also be followed in preparing needs assessments for specific sectors or types of investments required for achieving the MDGs, including energy. Unlike other needs assessment tools that have been developed for sectors such as education and health, the Energy Costing Tool focuses mainly on Step 3 – estimating the costs of the interventions needed to achieve the MDGs (in this case those related to energy). While Steps 1 and 2 are discussed in subsequent chapters for the purpose of providing context, this User Guide is not intended to provide concrete guidance in terms of helping to identify appropriate energy interventions or determine how to set targets. The national decision-making processes that are responsible for determining these decisions are assumed to have taken place outside or in parallel to activities related to the application of the Energy Costing Tool.

Why is costing national energy needs a necessary component of MDG planning processes?

Implementation of plans to meet the MDGs must be based on many different types of interrelated interventions, including actions to reduce hunger and poverty, promote better health care and education, and support environmental sustainability. As discussed earlier, in many countries, increased energy investments are critical for achieving goals of improved economic development, poverty reduction and expanded social services.

However, despite its cross-sectoral importance, energy is too often considered a single-sector issue, and does not receive enough attention as a development priority. One reason for this is a general unfamiliarity among practitioners and policy makers regarding the links between energy and development. Energy planning has generally been the province of specialized engineers and energy-sector experts, and is widely viewed as involving highly technical matters, such as numbers and types of electricity generators, miles of transmission lines, and facilities for importing, producing and distributing oil, gas and other fuel supplies. As a result, energy policies and interventions tend to be skewed towards a narrow set of issues – for example, focusing exclusively on electrification, without any specific regard to the needs and interests of the poor. When energy is mentioned in national MDG reports, it is usually analysed in terms of improving efficiency and reducing greenhouse gas emissions rather than as a factor in poverty-reduction programmes.

Due to the cross-cutting need for energy services, energy-planning processes can and should bring together representatives from a number of different government line ministries, economic sectors and planning perspectives. Just saying that energy requirements should be considered in other types of planning, such as health or education initiatives, does not provide decision-makers with a sufficient basis for accomplishing that. Planners in a variety of sectors need to be involved with energy experts in figuring out what energy services are needed and what it will cost to get them. This sort of cross-sectoral discussion about a country's energy needs and investment decisions provides an extremely useful opportunity for debate and coordination among different government offices, planners and stakeholders within the country. Helping facilitate this kind of policy dialogue, by providing practitioners with a relatively simple methodology for estimating the cost of energy needs related to reaching the MDGs, is the key aim of the Energy Costing Tool.

Chapter
2

Identifying interventions to expand energy access

Before calculating quantitative cost estimates, country-specific planning exercises are needed to determine what sorts of interventions are most appropriate for expanding access to modern energy services for the poor. The first step for each country committed to implementing the MDGs is to look at each of the MDG targets – e.g., halving the proportion of people whose income is less than $1 a day, or halving the proportion of people who suffer from hunger, or reducing the child mortality rate by two-thirds – to determine what types of energy services would be needed in connection with each target.

In terms of economic growth and poverty alleviation, countries need affordable and reliable access to energy for productive business and commercial activities. Increased access to energy would have the direct effect of allowing a larger proportion of the population to earn income. In terms of health care and educational goals, new schools and health facilities may be required.

In many cases, countries will have already identified specific sector-based interventions as part of their development planning and budget projections – including requirements for human resources, infrastructure and financing. For MDG purposes, these planned sectoral interventions, and additional cross-cutting actions, will need to be put together in a comprehensive policy framework and a detailed integrated plan, with a timeline that extends to 2015.

The UN Millennium Project's Handbook, *Preparing National Strategies to Achieve the Millennium Development Goals,* outlines nine areas of activity or "investment clusters" for MDG-based planning, including:

1) Rural development (increasing food supplies and income levels);

2) Urban development (promoting jobs, upgrading slums);

3) Ensuring access to health services;

4) Expanding education systems;

5) Overcoming gender inequality;

6) Improving environmental management;

7) Building national science and technology capacities;

8) Increasing cross-national cooperation and trade integration; and

9) Enhancing government management.

In addition, the Handbook points out that a comprehensive national needs assessment should include several critical areas not explicitly addressed by the MDGs, including access to energy and transportation services, because these are critical for reaching many of the MDGs.

Clearly, including energy services in an overall needs assessment is important, but it can be a challenge for planners to demonstrate clear, quantitative and causal relationships between energy services and progress towards meeting the MDGs. The Handbook, however, offers some suggestions for energy interventions that would be supportive of MDG targets.

Box 1: Suggested interventions from the UN Millennium Project's Handbook
Preparing National Strategies to Achieve the Millennium Development Goals

For rural development:

- Distribution of efficient cooking stoves
- Distribution of modern fuels for cooking and heating
- Interventions to reduce the adverse health impacts from cooking with biomass
- Interventions to increase sustainable biomass production
- Provision of diesel generators, hybrid systems, or solar home systems to schools, hospitals, clinics, community health centres and other community facilities
- Interventions to facilitate community-level access to electricity and mechanical power through support for electrification, fuel, and mechanical devices for cooperatives, small businesses and community centres
- Interventions to facilitate the use of electricity in rural communities that are not connected to the grid through low-cost technologies such as batteries and charging stations
- Extension of the electrical power grid

For urban development:

- Interventions to support the use of modern cooking fuels (such as LPG and kerosene) and modern cooking devices (such as stoves and canisters)
- Interventions to reduce the adverse health impacts from cooking with biomass
- Interventions to ensure reliable electricity and mechanical power through grid extensions, lifeline rates, etc.
- Financing mechanisms to spread out first costs of electricity connection, fuel supply and devices

Source: UN Millennium Project, 2005

Chapter 3

Setting MDG-based national energy access targets

While the choice of interventions involves an analysis of a country's energy needs and appropriate options for action, selecting targets requires decision-makers to determine how much additional access to energy can reasonably be expected to be provided by 2015.

Target-setting for energy is complicated by the fact that there is no established MDG target for access to energy services. Decisions about, for example, what proportion of people in rural areas should be provided with electricity or LPG stoves are not addressed in the agreed-upon international targets for the MDGs. Yet this is not actually so different from other MDG-related investment contexts, because even where there are specific MDG targets, every country needs to adapt and translate the goals into nationally appropriate action plans, which can be a complicated process.

An energy target-setting exercise first requires collection of a comprehensive set of data about existing conditions within the country. The starting point is to estimate current levels of access to different types of energy services – for cooking, heating and food processing, illumination and communications, commercial and business operations, transportation, and other applications essential for economic and social development – and then to consider what minimum levels of access are needed over time to support achievement of the MDGs by 2015.

In some countries there may be quite a bit of information about energy usage and availability, while in other countries accumulating the necessary data will be a major challenge.

Existing levels of energy availability – and possibilities for increasing those levels – may also vary greatly depending on population density and geographical features in different regions of the country, or between urban and rural areas. In some cases, poverty and isolation are both causes for, and effects of, lack of energy access. Setting energy access targets for meeting national MDGs differs from business-as-usual energy planning by focusing on determining what is necessary to reduce poverty, rather than focusing mainly on extending the electrical grid to the places that are close to urban and/or industrial areas – where the demand and the ability to pay is the greatest.

Political factors, however, will also come into play in defining acceptable development goals and priorities, just as the targets set for the MDGs themselves reflected political decisions about what degree of poverty alleviation could reasonably be expected by 2015 – for example, reducing by half, rather than 90 or 100 percent, the proportion of people suffering from hunger.

- There are many questions that must be asked about expanding energy access, such as:
- How many households to try to reach?
- How many schools and health facilities, existing and new?
- In what parts of the country?
- How many in urban areas?
- How many in rural areas?

In order to establish meaningful national MDG targets, experts and planners in many different sectors will need to coordinate their efforts. For example, government ministries concerned with agriculture, business, employment, health, education, water and the environment all have to consider what actions are needed to meet the targets and what types and amounts of energy services are associated with those actions.

Examples of MDG-based national energy access targets do exist. The targets suggested by **Energy Services for the Millennium Development Goals** provide one example.

Box 2: Suggested energy targets in Energy Services for the Millennium Development Goals

1) Ensure reliable access to electricity to everyone in urban and peri-urban areas;

2) Provide access to modern energy services (in the form of mechanical power and electricity) at the community level for all rural communities; and

3) Enable the use of modern fuels for 50 percent of those who currently use traditional biomass for cooking. (For others, support the use of improved stoves, adopt measures to reduce adverse health effects of cooking with traditional fuels and increase sustainable biomass production.)

Source: World Bank/ESMAP, UNDP, and UN Millennium Project, 2005

The targets mentioned above focus on a few key priorities for increasing energy access. Any particular country's own energy coverage targets can be based on these targets, or other sources, or determined independently by the country based on its own objectives, conditions, data and inputs from different sectors and ministries, or arrived at on a regional basis – as was done recently by the countries in the Economic Community of West African States (ECOWAS).

Box 3: Regional energy targets set by the Economic Community of West African States (ECOWAS)

In January 2006, the Heads of State of 15 West African countries adopted a Regional Policy on access to energy services for poverty reduction in line with achieving the MDGs. By 2015:

1) 100% of the total population will have access to modern cooking fuel or facilities.

2) At least 60% of people living in rural areas will have access to productive energy services in villages, in particular motive power to boost the productivity of economic activities.

3) 66% of the population will have access to an individual electricity supply, or:

   a. 100% of urban and peri-urban areas

   b. 36% of rural populations; and

   c. 60% of the rural population will live in localities with

      (i) modernised basic social services (healthcare, drinking water, communication, lighting, etc.)

      (ii) access to lighting, audiovisual and telecommunications, and

      (iii) coverage of isolated populations with decentralised approaches.

Source: ECOWAS and UEMOA, 2006

The regional energy targets set by ECOWAS build on the goals for electrification adopted in 2002 by the New Partnership for African Development (NEPAD). They also reflect the sector priorities defined by the Forum of Energy Ministers for Africa (FEMA) at the 2005 Millennium Summit, which were: modern cooking fuels; energy for productive purposes; and energy services for community infrastructure, such as for refrigeration and lighting.

Chapter 4

Using the Energy Costing Tool to estimate the costs of meeting national energy needs

After establishing a country's MDG-based national energy needs, the next step is to estimate the costs of the interventions required to meet those needs. The remaining portion of this chapter explains how to use the Energy Costing Tool to estimate these costs.

A. Energy Costing Tool basics

Purpose, scope and limitations

The Energy Costing Tool is an Excel-based model designed to assist countries in estimating the costs of increasing access to energy services to support the achievement of the MDGs. Some of the more important energy services that energy and energy appliances provide include illumination, refrigeration, communication, transportation, cooking, space heating, and mechanical power.

The Tool covers the following three categories of services as part of its analysis:

1) Improved cooking systems (i.e., modern fuels, sustainable biomass and improved cook stoves);

2) Electricity for lighting, information and communication technologies, and appliances

3) Mechanical power for agro/food processing, water pumping, enterprises and other productive uses.

The Tool's calculations are based on inputs provided by the country: nationally selected interventions and targets; data collected on population and current coverage rates; technologies that are readily available within a particular country; and unit costs of those technologies.

It is important to understand that the purpose of the Tool is to produce rough estimates of energy costs that, along with a financing analysis, can be used to prepare budgets and MDG-based investment planning. It is designed to provide a flexible framework and an easily replicable methodology that different countries can use to estimate the energy expenditures needed for meeting their MDG-based objectives.

The Energy Costing Tool is not a comprehensive investment model for a country's entire energy sector. Instead, the Tool estimates only the costs of meeting a minimum set of energy needs deemed essential to achieve the MDGs. It does not cover large-scale interventions to increase a country's generating capacity (see Box 4), or to provide energy needs for transportation and industry, or to meet household demands above a minimum level.

Box 4: Generation capacity

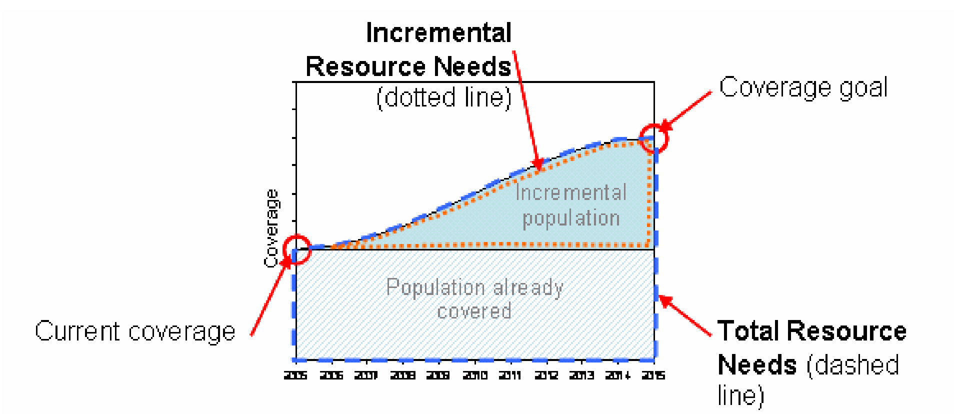
One of the more important limitations of the Tool is that it does not assess the need for or the cost of large-scale centralized infrastructure associated with increasing generation capacity. While the Tool keeps track of the increased need for electricity, and even the cost of providing it, it does not compare those needs with a country's existing generation capacity or make any attempt to estimate the cost of adding infrastructure, which might be required to produce additional electricity. That type of calculation is left to government planners to conduct outside of – or in conjunction with – this costing analysis.

It is important to point out that the Energy Costing Tool is not a financial model. Since the Tool is based on an MDG needs assessment approach, it does not try to identify sources of financing for the interventions needed, such as customer fees, government budgets or outside investments. This means that it does not take into account the amount consumers in a particular area would be willing or able to pay for energy services, or what funding sources might be available for providing energy access to unserved households and communities. Supplementary analysis will be needed to determine the financing framework for MDG investments in energy services, within the context of national development budgets and the investment frameworks of public and private energy providers.

In addition to the limitations outlined above, the structure of the Tool incorporates certain assumptions and strategies that the user should be aware of at the outset.

- First, in keeping with the MDG needs-assessment methodology, the Tool calculates total as opposed to incremental resource needs. This means that recurrent costs accrue based on the total stock of consumers in a given period (existing and new consumers), while capital costs accrue based just on new consumers. If the user chooses to do so, he/she can calculate just incremental resource needs by changing the default setting on Worksheet 1 (see page 22).

Figure 2: Total versus Incremental Resource Needs



- Second, the Tool assumes that urban areas are already served by some sort of electricity grid, and that the capital costs associated with electrifying urban areas include only the last connection cost for additional households and community institutions, such as schools and health clinics.

- Thirdly, if a community is targeted for rural electrification *and* for mechanical power interventions, the mechanical power technology selected will depend upon the kind of electrification system chosen for that type of community. Additional information about this assumption is detailed in the description of Worksheet 13 (see page 43).

- Another assumption has to do with changes in coverage levels over time. The model assumes that for each intervention, a household or community within the target population receives the same intervention, regardless of when they are reached during the period in question. For example, if 100% of communities are targeted for rural electrification over a 10-year period, a community that remains unreached until year 9 is not assumed to receive any interim technology solution (such as an alternate, less-expensive off-grid technology).

- Lastly, a few remarks are warranted about how the Tool deals with questions of whether or not grid extension is feasible for particular communities or areas of the country. As a static, spreadsheet-based model, the Tool is not able to map out or dynamically model a gradually expanding grid extension plan for a country. Instead, it provides a worksheet for estimating which areas of a country might be 'grid feasible'. This is discussed in more detail in the description of Worksheet 7 (see page 31).

Data requirements

The energy model requires users to supply a number of data inputs and 'parameters'. These inputs fall into five basic categories:

1) **Interventions and technology options** describe the types of infrastructure and services deemed necessary for MDG-compatible levels of energy access, as well as the range of available technologies for each type of service.

2) **Categories of settlement** are used to sort the different kinds of settlements in which people live (e.g., the capital city, other urban areas, or different types of rural settlements), and the ways these different settlements are spread out within the various administrative units in the country (districts, provinces, etc.). This information will require basic national census information, as well as information such as whether people in rural areas live in dense clusters of communities or are widely scattered. This information is important for determining whether or not particular areas should be considered 'grid feasible', since distances between communities and households are important factors in determining the costs involved in grid electrification. Information about a country's categories of settlement (and their grid feasibility) may be able to be supplied by experts familiar with the different administrative units in the country. However, if that is not possible, then Worksheet 7 provides a useful tool for estimating how much of the country qualifies as 'grid feasible'.

3) **Population and current access figures** are needed to establish basic population parameters. Required inputs include: population and household size for each settlement category; numbers of education, health and community institutions in each settlement category; and current coverage rates for each energy service. This information is typically found in national population censuses, administrative data from various agencies and statistical databases. Alternately, the user can estimate some of these inputs by using simple ratios, for example, by assuming that there are X number of educational institutions per community.

4) **Targets and minimum needs inputs** describe the 10-year goals for coverage for each type of intervention, as well as minimum MDG-compatible consumption levels (such as kilograms of

LPG per household per year). As discussed in previous sections, these targets will be determined by a combination of political and practical national decision-making processes.

5) **Unit costs** describe the cost of a single intervention. Some examples include the cost of an improved biomass cookstove, the cost of a solar home system, or the cost of a diesel engine. Where possible, marginal costs should be used (as opposed to average unit costs). This information can be derived from a number of sources, including past procurement contracts or current market rates. To provide for changes in costs over time – to reflect potential price changes for inputs like oil or wages – the Tool allows the user to input unit costs on an annual basis, starting from the current year to the target year. The Tool also allows the user to change currencies to facilitate cross-country comparisons.

For a more detailed list of data requirements, please refer to the Data Collection Checklist attached as Appendix A.

In addition to these basic data inputs, the user is also asked to provide several “expert” judgements regarding rural electrification technologies in areas not currently served, including the scope for grid extension in each settlement category, as discussed above, and choices of the best off-grid technologies based on cost comparisons.

Each of the input sheets and expert judgement areas are described in more detail below.

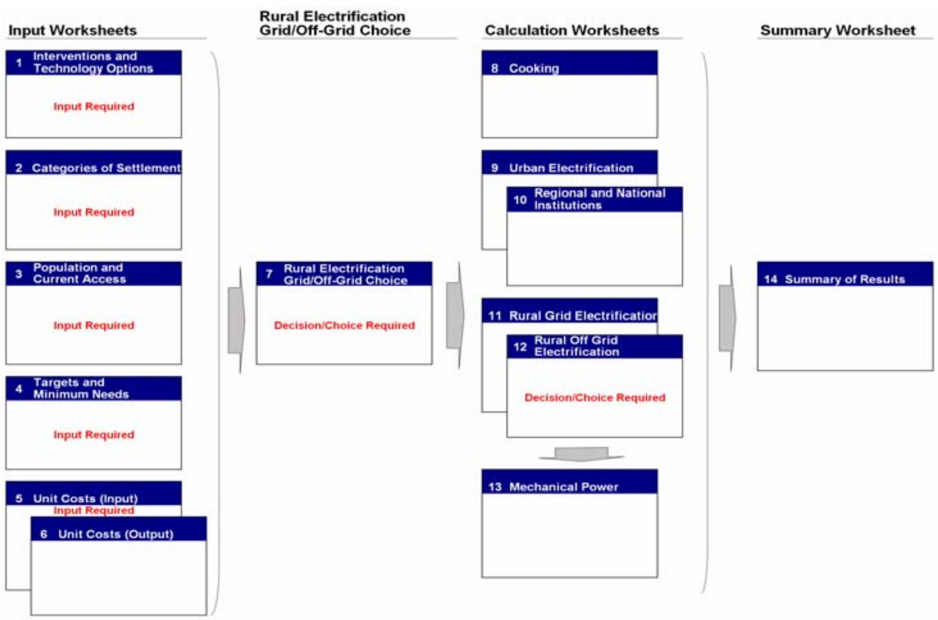
B. Using the Energy Costing Tool

Structure

The overall structure of the worksheets that make up the Tool is shown below:

Figure 3: Model architecture of the Energy Costing Tool

Based on data and policy inputs from users and a few basic decisions regarding rural electrification technologies, the Energy Costing Tool performs a series of basic calculations and generates estimates of necessary resources.



- *Input worksheets* contain information supplied by the user, including required country data and coverage targets. The input sheets include:

  1) Interventions and Technology Options

  2) Categories of Settlement

  3) Population and Current Access

  4) Targets and Minimum Needs

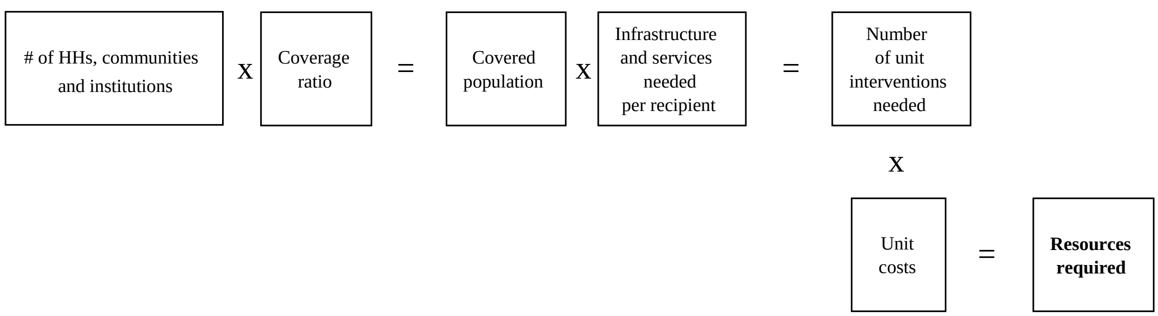
  5) Unit Costs (Input)

  6) Unit Costs (Output)

- The interim sheet '7. Rural Electrification-Grid/Off-Grid Choice' requires the user to make some basic decisions about the scope for grid extension, which will then feed into subsequent calculation sheets.

- *Calculation worksheets* take the data and coverage target inputs and perform basic multiplication and summation calculations to arrive at aggregate resource requirements. With the exception of sheet '12. Rural Off Grid Electrification' – which requires the user to make some basic decisions about which decentralized electricity technologies to cost – none of the calculation sheets require input from the user. The basic methodology for calculating the cost of delivering selected energy services can be described by the following formula:

Figure 4: Methodology for calculating Resource Requirements



The calculation sheets include:

8) Improved Cooking Systems

9) Urban Electrification

10) Regional and National Institutions

11) Rural Grid Electrification

12) Rural Off-Grid Electrification

13) Mechanical Power

The *Summary* sheet takes subtotals from each calculation sheet and organizes them into tables that provide information on total and per capita resource requirements needed for each energy service per year. It also provides 10-year totals and averages, as well as breakdowns by urban/rural settlements and by expenditure type (capital, fuel/electricity purchase and other recurrent costs).

The cells in the model are shaded different colors depending upon the kind of information they contain:

Yellow cells contain inputs from the user that require some sort of prior policy decision. Country-specific choices on interventions and technologies, targets, and minimum needs entries are all contained in yellow cells.

Green cells contain inputs from the user that can be gathered from existing data sources. Entry cells for geographic, demographic and current coverage entries, as well as unit costs, are coded green.

Grey cells contain information from input sheets, that is automatically entered into calculation sheets. When data is changed on an input sheet, grey cells will automatically update.

White cells contain information that is calculated based on user inputs. For example, when the model multiplies coverage rates and target population to calculate yearly covered population numbers, the results are shown in white cells.

Figure 5: Format key for cells

INPUT	Policy Decision Parameters (i.e. Interventions and Technology Decisions, Targets and Minimum Needs)
INPUT	Collected Data (i.e. Geographic, Demographic, Coverage Data; Unit Costs)
OUTPUT	Linked to Input Sheets
OUTPUT	Calculated Cells

Level of analysis

As mentioned earlier, the Tool is designed to cost interventions under three broad categories of energy services: (1) cooking/heating; (2) electrification; and (3) mechanical power. For each category, the level of analysis differs.

For example, in cooking/heating the level of analysis is assumed to be the household. As a result, all costs associated with cooking refer to interventions made at the household level.

In the case of electrification, there are two different levels of analysis: the household level and the community or village level (more specifically, the public institutions such as schools, health clinics and markets that are located within a community or village). In urban and peri-urban areas, the level of analysis is just the household, as it is assumed that most urban institutions such as schools and hospitals already have access to some minimum level of electricity (where this assumption does not hold true, the user can choose to analyze the costs of electrifying urban and peri-urban institutions). For rural areas, the level of analysis begins at the community/village level, as the electrification of local schools, health clinics, markets and other public institutions usually provides a node from which other users can be electrified. Depending on whether or not rural household electrification is a priority, the user can also analyze the additional costs of providing electricity at the household level.

Box 5: What constitutes a community?

While the definition of a community is likely to vary from one country or region to another, for the purposes of this Tool, a community is considered to be any grouping of people who share common public institutions such as schools, health clinics and markets, and are close enough to one another geographically to justify analyzing their energy service options jointly. In most cases, community size will vary between 500 and 5,000 inhabitants, but this will ultimately depend on the country or region under consideration. An upper boundary for what differentiates a rural community from an urban area is required, as the two are analyzed separately in the Tool.

For mechanical power, interventions are assumed to take place only at the community/village level – and only within rural areas – as people living in urban and peri-urban areas are assumed to already have access to some minimum level of mechanical power. What this means is that interventions associated with mechanical power (i.e., like installing an engine for agro-processing or a water pump) are analyzed – at least in terms of cost – as a single intervention per community/village, rather than per household. The amount and type of mechanical power needed per community, on the other hand, will remain a function of community size (i.e., number of households) and need.

C. The Worksheets

Input Sheets

The figures entered into Input worksheets must be supplied by the user. As outlined in the Data Requirements section above, factual information will be based on data collected from national sources and information from different sectors and regions. Inputs on selected interventions, technology options and coverage targets will be determined based on a combination of political and practical national decision-making processes.

Each input sheet is described in more detail in this section.

Worksheet 1. Interventions and Technology Options

Improved cooking systems

Beneficiary	Intervention	Technology Options	Notes
Households	Improved Fuels	Kerosene	
		LPG	
Households	Sustainable Production of Biomass	Sustainable Biomass	
Households	Improved Cookstoves	Improved Biomass Stoves	

Urban and peri-urban electrification

Beneficiary	Intervention	Technology Options	
Household and Institutions	Electricity	Grid	

Rural electrification and mechanical power

Beneficiary	Intervention		Technology Options		Notes
Communities and Households	Electricity		Electrification	Corresponding Mechanical Power Technology (includes additional infrastructure/equipment as needed)	
		GRID:	Grid	→ Grid (given community connection)	
		OFF-GRID:	PV	+ Mini Grid (Diesel)/MFP	this must be the same as for non-e
			Mini Grid (Non-diesel)	→ Mini Grid (Non-diesel) - equipment only	
			Mini Grid (Diesel)/MFP	→ Mini Grid (Diesel)/MFP - equipment only	
			FOR NON-ELECTRIFIED COMMUNITIES	→ Mini Grid (Diesel)/MFP	

To calculate total resource need enter "1", otherwise leave blank: 1 *default value = 1*

On this worksheet, the user lists selected types of energy access interventions and technology options for the different types of beneficiaries (households, institutions and communities) and suggested categories of energy services – e.g., improved cooking systems, urban and peri-urban electrification, rural electrification, and mechanical power.

For example, preferred technology options for improved cooking systems could include the use of cleaner fuels, such as kerosene and LPG. For those who would not be likely to obtain access to those cleaner fuels within the target period, other options to consider are sustainable biomass production and improved stoves for using traditional biomass fuels.

The technology choice for electricity access in urban areas would most often be the grid, but in rural areas where grid extension may not be affordable, other technology options could include diesel mini-grids or electrical power from available renewable energy sources, such as wind, solar, small hydropower and modern biomass generators.

As mentioned above, the Tool asks the user to specify a corresponding mechanical power technology for each rural electrification option. This ensures that the Tool estimates the costs of a coordinated package of electricity and mechanical power interventions, and avoids double counting of stand-alone systems.

At the bottom of the sheet, the user has the ability to choose whether to calculate total resource needs or incremental needs. As mentioned earlier, total resource needs include costs for both new and existing consumers. Incremental resource needs, on the other hand, just include costs associated with new consumers. In line with the needs-assessment methodology, the Tool is set to calculate total resource needs as its default (the value "1" should appear in the corresponding cell). This can be changed, if the user chooses to do so, by leaving the corresponding cell blank, in which case only incremental resource needs will be calculated.

Worksheet 2. Categories of Settlement

RURAL

Categories of Rural Settlement:

Type	Description	Criteria Community size (e.g. "0-500 inhabitants")
Type A (rural)	Rural	>1000
Type B (rural)	Rural	500-1000
Type C (rural)	Rural	<500

Separating Data Units into "Types"

Rural Administrative or Geographic Unit	Rural population in unit (current)	Geographic Area (sq. km)--excl urban areas	Avg Density--Current (calculated)	Number of Communties (i.e. villages)	% of Communities in: Type A (rural)	Type B (rural)	Type C (rural)	0
Matam	279,135	24,845	11.2	279	0%	50%	50%	0%
Diourbel	513,801	4,335	118.5	514	100%	0%	0%	0%
Thies	783,987	6,670	117.5	784	100%	0%	0%	0%
Ziquinchor	355,499	7,352	48.4	355	100%	0%	0%	0%
Fatick	680,621	8,478	80.3	681	100%	0%	0%	0%
Kaolack	798,654	15,488	51.6	799	100%	0%	0%	0%
Kolda	816,232	21,112	38.7	816	100%	0%	0%	0%
Louqa	670,773	29,412	22.8	671	0%	50%	50%	0%
Saint-Louis	481,302	19,241	25.0	481	0%	50%	50%	0%
Tambacounda	599,181	59,543	10.1	599	0%	50%	50%	0%
Other	267,722	2,259	118.5	268	66%	0%	34%	0%
			-					
			-					
			-					
			-					

URBAN

Categories of Urban Settlement:

Type	Type Description (e.g. "Capital City", "other urban")
Type E (urban)	Dakar
Type F (urban)	Other Urban

Urban Area	Population in each (current)	Type (user decides)
Dakar	2,167,120	Dakar
Secondary Cities	80,177	Other Urban
Other Urban	2,318,742	Other Urban

Summary by type

	Current Population
Type E (urban)	2,167,120
Type F (urban)	2,398,919

Type of Institution Served	Current # of this type
District Hospital	10
Central Government Office	1

One of the most difficult challenges of costing is to determine which electrification and mechanical power technologies should be used and therefore costed. Appropriate technology choices and costs vary with the size, density and distance between rural communities. The Energy Costing Tool provides a framework for the user to determine the best technologies for a particular type of community by dividing the country into different "categories of settlement". Once settlement categories are defined, all population data, targets and unit costs are entered separately by category.

The categories of settlement worksheet has separate divisions for urban and rural areas and for regional and national institutions.

Rural areas

The first task for the user is to define the different categories of rural settlement into which the country's communities will be divided. The categorisation of rural areas is determined by the user, and should reflect major differences in settlement patterns (i.e., village size, density, etc.) that will significantly affect the cost structure for energy interventions (particularly in electricity and mechanical power). Furthermore, because the rest of the input pages allow for separate inputs by settlement category, the user should define categories for which disaggregated data may be available. Once the categories are defined, the worksheet allows the user to enter the percentage of communities in each administrative unit that fall into each category.

Lines 6 through 13 below provide a sample framework for determining rural settlement categories.

	C	D	E
6	**Categories of Rural Settlement:**		
7	**Type**	**Description**	**Criteria**
8			Community size
9			(e.g. "0-500 inhabitants")
10	Type A (rural)	Rural	>1000
11	Type B (rural)	Rural	500-1000
12	Type C (rural)	Rural	<500
13			

In the sample, Column “C” lists the generic name for each type of settlement. There is space to enter up to four different rural settlement categories. In Columns D and E, the user is asked to define the different categories chosen. For example, in the table above, 3 categories are listed, based on average community size. In accordance with the color coding, these inputs are in *yellow*, as they are policy/analytical decisions rather than data inputs.

Once rural settlement categories are defined, the Tool allows users to input the percentages of different rural administrative units (i.e., districts, provinces, etc.) that fall into the different settlement categories. Rows 16 through 33 allow the user to enter information for up to 14 administrative units. For each administrative unit, the user specifies the rural population (the population of any urban areas in the unit should be excluded), the geographic area of the unit (again excluding urban areas), the total number of communities and the percentage of each unit’s communities that fall into each category. Because these are straight data inputs, the cells are shaded *green*.

16	Separating Data Units into "Types"					% of Communities in:			
17									
18	**Rural Administrative or Geographic Unit**	**Rural population in unit (current)**	**Geographic Area (sq. km)--excl urban areas**	**Avg Density--Current** (calculated)	**Number of Communties** (i.e. villages)	**Type A (rural)**	**Type B (rural)**	**Type C (rural)**	**0**
19	Matam	279,135	24,845	11.2	279	0%	50%	50%	0%
20	Diourbel	513,801	4,335	118.5	514	100%	0%	0%	0%
21	Thies	783,987	6,670	117.5	784	100%	0%	0%	0%
22	Ziquinchor	355,499	7,352	48.4	355	100%	0%	0%	0%
23	Fatick	680,621	8,478	80.3	681	100%	0%	0%	0%
24	Kaolack	798,654	15,488	51.6	799	100%	0%	0%	0%
25	Kolda	816,232	21,112	38.7	816	100%	0%	0%	0%
26	Louqa	670,773	29,412	22.8	671	0%	50%	50%	0%
27	Saint-Louis	481,302	19,241	25.0	481	0%	50%	50%	0%
28	Tambacounda	599,181	59,543	10.1	599	0%	50%	50%	0%
29	Other	267,722	2,259	118.5	268	66%	0%	34%	0%
30				-					
31				-					
32				-					
33				-					

Urban areas

In rows 38 through 42 of the sample, the Tool allows the user to define 2 categories of urban settlements. For example, the Senegal analysis defined a separate category for the capital city (usually the largest and most densely populated, and likely to have the most grid-based electrical service) and another grouping for other cities.

38	Categories of Urban Settlement:	
39	Type	Type Description
40		(e.g. "Capital City", "other urban")
41	Type E (urban)	Dakar
42	Type F (urban)	Other Urban

In rows 44 through 49, the user enters population information for specified types of urban areas (there is space for up to 5) and specifies which of the two settlement categories they fall into. In this example, Dakar falls into Type E “Capital City”. Secondary cities along with peri-urban areas located just outside of Dakar are grouped into Type F “Other Urban”.

44	Urban Area	Population in each (current)	Type (user decides)
45	Dakar	2,167,120	Dakar
46	Secondary Cities	80,177	Other Urban
47	Other Urban	2,318,742	Other Urban
48			
49			

Based on these inputs, the Tool aggregates the population in each category of urban settlement.

Summary by type

	Current Population
Type E (urban)	2,167,120
Type F (urban)	2,398,919

Regional and national institutions

Information is also entered on this worksheet concerning regional and national institutions. Since major public institutions (such as hospitals, universities, etc.) are likely to be spread out unevenly throughout the country, they are treated separately in the model. These are defined by the user and listed in rows 55 through 60, along with the current number of each type of institution.

Worksheet 3. Population and Current Access

This worksheet requires the user to provide information about current population figures, household size and existing institutions for each category of settlement (according to the categorisation undertaken on the previous worksheet).

The rural institutions that are assumed to be covered are health and education facilities and markets or community centres, as well as any "other" institutions. Ideally, the user would have accurate information on the number of each type of institution in each settlement category. If this data is not available, users might wish to estimate the number of institutions based on population parameters (e.g., one school for every 4,000 inhabitants).

Populations and demographics can be expected to change over time, so for purposes of formulating a long-term plan, an attempt needs to be made to take these changes into account.

For each category of settlement, the user is then asked to estimate current access to cooking systems, electrification and mechanical power.

			Current	Year 1	Year 2	Year 3
22	RURAL		Current	Year 1	Year 2	Year 3
23	*Profile*		Type A (rural)			
24	Populatior	population growth rate	2.40%			
25	Population		4,125,490	4,224,502	4,325,890	4,429,712
26	HH Characteristics					
27	Average HH size		9.6	9.6	9.6	9.6
28	Biomass Use Per HH/Year (tons)--For Cooking Only					
29	Institutions (NOT INCLUDING REGIONAL/NATIONAL INSTITUTION)					
30	# of Health Institutions		6,876	7,041	7,210	7,383
31	# of Educational Institutions		6,876	7,041	7,210	7,383
32	# of Markets/Community Centers		6,876	7,041	7,210	7,383
33	# of Other Institutions		6,876	7,041	7,210	7,383
34	*Access (Current access as % of EACH TYPE)*					
35	Cooking Systems					
36	% of HH with Access to:					
37	Kerosene		0.0%			
38	LPG		30.0%			
39	Total % of HH with Access to Improved Fue		30.0%			
40	% of HH with Access to:					
41	Sustainable Biomass		0.0%			
42	% of HH with Access to:					
43	Improved Biomass Stoves		0.0%			

Current percentages of the population with access to grid and off-grid electricity should be entered separately, as both are dealt with (i.e., costed) differently.

A separate section lists national and regional institutions, allowing the user to input expected changes in the number of each type of institution over time. For urban households and for regional and national institutions, the "current" column is automatically filled with the information from the "Categories of Settlement" worksheet.

Worksheet 4. Targets and Minimum Needs

After defining the percentage of people in each category of settlement who currently have access to energy services, the “Targets and Minimum Needs” worksheet asks the user to enter projected percentage levels of coverage needed over the course of the next 10 years to meet the national MDG targets. Current coverage is entered automatically based on inputs on the previous sheet. The sheet also calculates weighted averages for all types in rural and urban areas.

115	**Rural Electrification**	**Current**	**Year 10**
116	*Coverage*		
117	Communities	**Type A (rural)**	
118	% Communities of each Type Electrified	43%	100%
119			
120	Rural Community Coverage (Weighted Average	38%	91%
121			
122	Households	**Type A (rural)**	
123	% HH electrified of each Type	26%	60%
124			
125	Rural HH Penetration Rate	60%	60%
126			
127	Rural HH Coverage (Weighted Average)	23%	55%
128			
129	Rural HH Pentration Rate (Weighted Average)	60%	60%
130			
131	*Minimum Needs (Annual)*	**Type A (rural)**	
132	kWh/yr for Local-level Health Institutions	1117.8	
133	kWh/yr for Educational Institutions	100.74	
134	kWh/yr for Markets/Community Centers	100.74	
135	kWh/yr for Other Institutions	0	
136			
137			
138	Connections per HH (always 1)	1	
139	Lifeline/minimum kWh amount per hh/yr	83.95	

Setting yearly projected percentage levels for each energy service requires the user to make decisions about how quickly energy access is expected to be ramped up in order to meet the target level set for 2015. Although a linear projection is built in the model as a default, the user is free to manually adjust the yearly coverage rates as needed, as long as they are increasing and use the current and target years as beginning and end points.

This sheet also asks users to define minimum consumption levels for each type of energy service. For example, in rows 132 through 139, the user enters the minimum amount of electricity needed for each type of public institution, along with the amount of electricity deemed sufficient to satisfy basic household needs such as lighting.

Worksheet 5. Unit Costs (Input)

This sheet asks users to enter the unit costs for each intervention according to the different types of costs associated with it. The costs for different technology options include both capital costs for acquiring new equipment and recurrent costs such as for fuel and maintenance expenses, as well as institutional capacity costs (see Box 6). If costs that are not explicitly included in the Tool (such as depreciation or replacement costs) are deemed significant enough to warrant counting them (as might be the case when it comes to replacing cookstoves), it is recommended that they either be annualised and included under maintenance costs or inserted as a new line item under the appropriate type of cost.

Box 6: Institutional capacity costs

The term 'institutional capacity cost' refers to the cost of building the institutional and human capacities required to scale up service delivery. This includes training, awareness building, advocacy and any other costs associated with expanding programmes in line with increasing service delivery. In some cases, these costs may already be included in a previously accounted for cost (i.e., an electricity tariff). In these cases, it may not be necessary to include a separate cost for institutional capacity building. However, care should be taken in deciding when not to analyse institutional capacity costs separately, as such costs are not always recoverable by public utilities or energy providers.

Unlike capital and recurrent costs, which typically scale by the incremental number of interventions made (i.e., number of stoves distributed per year) and the total amount of energy used (i.e., LPG consumed by year), respectively, institutional capacity costs can be incurred in a number of different ways throughout the lifetime of a programme. Examples include onetime costs for setting up offices, incremental costs for promotion, and cumulative costs for training. As modelling these different types of costs would complicate the use of the Tool, users are asked to annualise institutional capacity costs and enter them on an incremental basis; that is, as a function of how many units of a particular intervention are delivered per year.

For example, under 'improved cooking systems', users are asked to enter the capital cost for kerosene stoves, per-litre kerosene fuel costs at the port or terminal, and per-litre transportation and distribution costs, as well as institutional capacity costs per household served.

4	Input Currency	USD			
5		Current	Year 1	Year 2	Year 3
6	**RURAL**	**Type A (rural)**			
7	**Improved cooking systems**				
8	Kerosene				
9	Capital (i.e. stove)				
10	Cost Per HH	16.7	16.7	16.7	16.7
11	Fuel				
12	Per liter				
13	Fuel Costs at Port/Terminal	0.7	0.7	0.7	0.7
14	Transport and distrib.				
15	Institutional Capacity				
16	Cost per HH				
17					

For off-grid rural electrification technologies, users are asked to provide per-community, per-institution and per-household costs, divided into capital costs and several categories of recurrent costs.

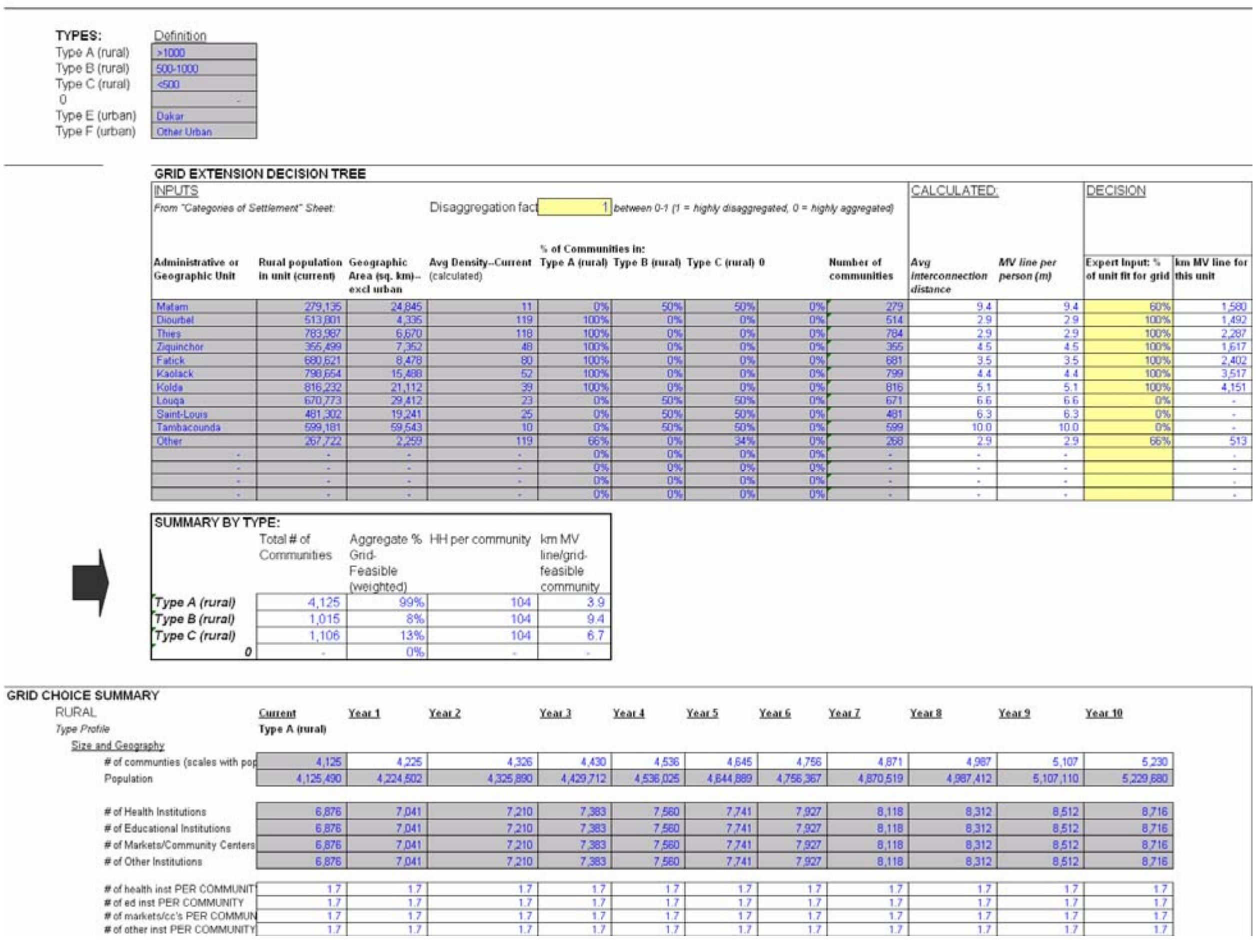
124	Tech Mini Grid (Non-diesel)				
125	Institutions	Current	Year 1	Year 2	Year 3
126	Capital				
127	Initial Capital Cost per community	50,000	50,000	50,000	50,000
128	Last Connection Cost (per institution)	445	445	445	445
129	Recurrent				
130	System Maintenance Cost				
131	per node/yr	2,000	2,000	2,000	2,000
132	Recurrent (Supply) Costs				
133	cost per kWh				
134	Billing/Collection Cost				
135	per node/yr				
136	Institutional Capacity Cost				
137	per node/yr	5,000	5,000	5,000	5,000
138					
139	Households				
140	Initial Capital Cost (i.e. Last Connection Cost)				
141	Per HH	400	400	400	400
142	System Maintenance Cost				
143	Per HH/yr	80	80	80	80
144	Lifeline Tariffs (for minimum consumption)				
145	Lifeline/minimum kWh amount per hh/yr	84			
146	cost per kWh	0.1	0.1	0.1	0.1
147	Per HH	8	8	8	8
148	Billing/Collection Cost				
149	Per HH/yr				
150	Institutional Capacity Cost				
151	Per HH/yr	50	50	50	50

For costing purposes, it is vital to obtain location-specific information, since fuel prices and availability, electricity-generating capacities, and costs of different types of technologies will vary from place to place. These costs could be verified through interviews with local utilities, ministries and other agencies/organizations that have participated in previous project development. The Tool enables users to enter separate costs by year, if prices are expected to change (for example, to reflect anticipated economies of scale).

Worksheet 6. Unit Costs (Output)

Once all unit costs have been entered in the Unit Costs (Input) worksheet, the user is asked to enter – at the top of the following unit cost worksheet titled “Unit Costs (Output)” – the currency in which all subsequent calculations will be performed. The worksheet also asks the user to enter the exchange rate between the currency the unit costs were entered in and the desired currency in which the Tool’s outputs will be reported. If the two are the same, all the user must do is enter in the same currency in both the input and output fields and enter the value “1” as the exchange rate.

Worksheet 7. Rural Electrification — Grid/Off-Grid Choice



TYPES:	Definition
Type A (rural)	>1000
Type B (rural)	500-1000
Type C (rural)	<500
0	-
Type E (urban)	Dakar
Type F (urban)	Other Urban

GRID EXTENSION DECISION TREE

INPUTS

From "Categories of Settlement" Sheet: Disaggregation fact 1 between 0-1 (1 = highly disaggregated, 0 = highly aggregated)

CALCULATED: DECISION

Administrative or Geographic Unit	Rural population in unit (current)	Geographic Area (sq. km)--excl urban	Avg Density--Current (calculated)	% of Communities in: Type A (rural)	Type B (rural)	Type C (rural)	0	Number of communities	Avg interconnection distance	MV line per person (m)	Expert Input: % of unit fit for grid	km MV line for this unit
Matam	279,135	24,845	11	0%	50%	50%	0%	279	9.4	9.4	60%	1,580
Diourbel	513,801	4,335	119	100%	0%	0%	0%	514	2.9	2.9	100%	1,492
Thies	783,987	6,670	118	100%	0%	0%	0%	784	2.9	2.9	100%	2,287
Ziguinchor	355,499	7,352	48	100%	0%	0%	0%	355	4.5	4.5	100%	1,617
Fatick	680,621	8,478	80	100%	0%	0%	0%	681	3.5	3.5	100%	2,402
Kaolack	798,654	15,488	52	100%	0%	0%	0%	799	4.4	4.4	100%	3,517
Kolda	816,232	21,112	39	100%	0%	0%	0%	816	5.1	5.1	100%	4,151
Louga	670,773	29,412	23	0%	50%	50%	0%	671	6.6	6.6	0%	-
Saint-Louis	481,302	19,241	25	0%	50%	50%	0%	481	6.3	6.3	0%	-
Tambacounda	599,181	59,543	10	0%	50%	50%	0%	599	10.0	10.0	0%	-
Other	267,722	2,259	119	66%	0%	34%	0%	268	2.9	2.9	66%	513
-	-	-	-	0%	0%	0%	0%	-	-	-		-
-	-	-	-	0%	0%	0%	0%	-	-	-		-
-	-	-	-	0%	0%	0%	0%	-	-	-		-
-	-	-	-	0%	0%	0%	0%	-	-	-		-

SUMMARY BY TYPE:

	Total # of Communities	Aggregate % Grid-Feasible (weighted)	HH per community	km MV line/grid-feasible community
Type A (rural)	4,125	99%	104	3.9
Type B (rural)	1,015	8%	104	9.4
Type C (rural)	1,106	13%	104	6.7
0	-	0%	-	-

GRID CHOICE SUMMARY

RURAL

Type Profile: Type A (rural)

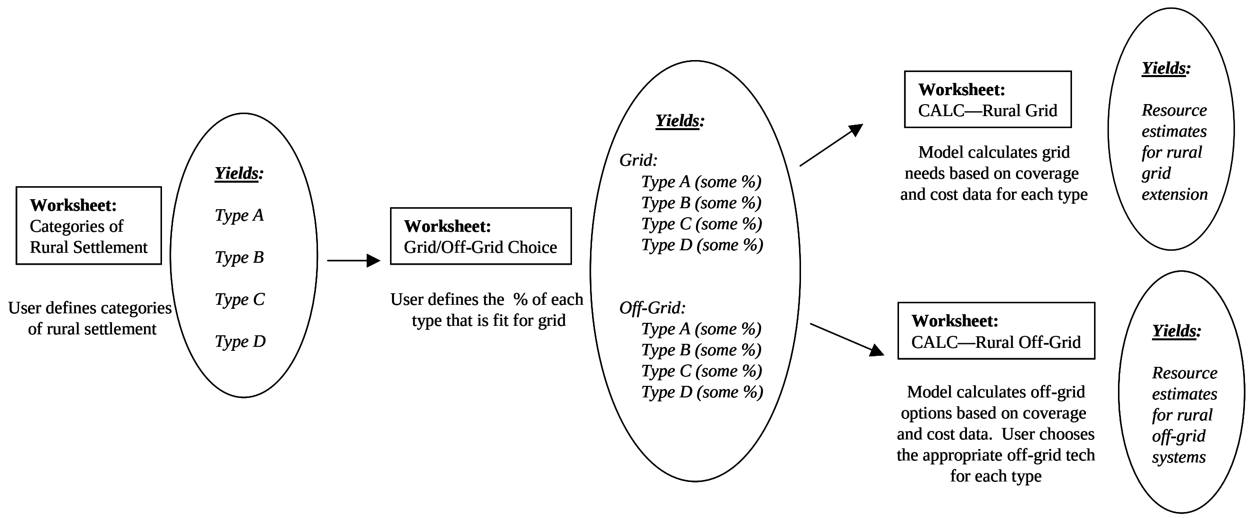
Size and Geography

	Current	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
# of communties (scales with pop	4,125	4,225	4,326	4,430	4,536	4,645	4,756	4,871	4,987	5,107	5,230
Population	4,125,490	4,224,502	4,325,890	4,429,712	4,536,025	4,644,889	4,756,367	4,870,519	4,987,412	5,107,110	5,229,680
# of Health Institutions	6,876	7,041	7,210	7,383	7,560	7,741	7,927	8,118	8,312	8,512	8,716
# of Educational Institutions	6,876	7,041	7,210	7,383	7,560	7,741	7,927	8,118	8,312	8,512	8,716
# of Markets/Community Centers	6,876	7,041	7,210	7,383	7,560	7,741	7,927	8,118	8,312	8,512	8,716
# of Other Institutions	6,876	7,041	7,210	7,383	7,560	7,741	7,927	8,118	8,312	8,512	8,716
# of health inst PER COMMUNIT	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
# of ed inst PER COMMUNITY	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
# of markets/cc's PER COMMUN	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
# of other inst PER COMMUNITY	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7

To allow users to specify appropriate rural electrification technologies, the Tool contains a special worksheet for determining the communities to which the national grid should be extended, and the communities for which off-grid systems would be most appropriate. After this sheet is completed, the Tool feeds this information into two separate calculation sheets for rural electrification (grid and off-grid).

The diagram below illustrates how this sheet feeds into the calculation sheets for rural electrification.

Figure 6. Grid and Off-Grid Electrification



The Grid/Off-Grid choice worksheet provides a framework for users to enter expert judgements on which areas are "grid feasible". The two calculation sheets are described in more detail below.

This worksheet automatically enters the information on population, density, community type and number of communities from the Categories of Settlement worksheet, as such data is useful in determining grid feasibility. Using a geographic disaggregation factor supplied by the user (see Box 7), the sheet then calculates the average interconnection distance between communities and the amount of medium voltage transmission wire needed per person within each administrative unit, assuming all communities are to be electrified by the national grid. This provides a framework in which experts can then, in the "expert input" column, enter what percentage of a particular administrative unit is 'grid feasible'.

16	GRID EXTENSION DECISION TREE												
17	INPUTS									CALCULATED:		DECISION	
18	*From "Categories of Settlement" Sheet:*			Disaggregation fact	1	*between 0-1 (1 = highly disaggregated, 0 = highly aggregated)*							
19													
20													
21					% of Communities in:								
22	**Administrative or Geographic Unit**	**Rural population in unit (current)**	**Geographic Area (sq. km)--excl urban**	**Avg Density--Current** (calculated)	**Type A (rural)**	**Type B (rural)**	**Type C (rural)**	**0**	**Number of communities**	***Avg interconnection distance***	***MV line per person (m)***	**Expert Input: % of unit fit for grid**	**km MV line for this unit**
23	Matam	279,135	24,845	11	0%	50%	50%	0%	279	9.4	9.4	60%	1,580
24	Diourbel	513,801	4,335	119	100%	0%	0%	0%	514	2.9	2.9	100%	1,492
25	Thies	783,987	6,670	118	100%	0%	0%	0%	784	2.9	2.9	100%	2,287
26	Ziquinchor	355,499	7,352	48	100%	0%	0%	0%	355	4.5	4.5	100%	1,617
27	Fatick	680,621	8,478	80	100%	0%	0%	0%	681	3.5	3.5	100%	2,402
28	Kaolack	798,654	15,488	52	100%	0%	0%	0%	799	4.4	4.4	100%	3,517
29	Kolda	816,232	21,112	39	100%	0%	0%	0%	816	5.1	5.1	100%	4,151
30	Louqa	670,773	29,412	23	0%	50%	50%	0%	671	6.6	6.6	0%	-
31	Saint-Louis	481,302	19,241	25	0%	50%	50%	0%	481	6.3	6.3	0%	-
32	Tambacounda	599,181	59,543	10	0%	50%	50%	0%	599	10.0	10.0	0%	-
33	Other	267,722	2,259	119	66%	0%	34%	0%	268	2.9	2.9	66%	513
34	-	-	-	-	0%	0%	0%	0%	-	-	-		-
35	-	-	-	-	0%	0%	0%	0%	-	-	-		-
36	-	-	-	-	0%	0%	0%	0%	-	-	-		-
37	-	-	-	-	0%	0%	0%	0%	-	-	-		-

Box 7: Estimating grid feasibility using 'MV Line per Person' as a guide

Determining where the grid would provide the most cost-effective solution for electrifying communities and households – as compared with other alternatives such as solar PV, micro hydro power, mini-grids, etc. – can be a complicated process, one that relies on a number of factors, including geography, population density and costs. It is also a process that is beyond the scope of this Tool. In lieu of performing such a complex analysis, the Tool provides users with an estimation of how much medium-voltage (MV) transmission line would be required per person, assuming that all communities are to be electrified by the grid. This correlates well with grid feasibility as medium-voltage line represents the bulk of the cost of extending a grid. The usefulness of this estimation is that, when combined with data about costs, it allows users to compare the costs of grid extension with decentralized systems on a per capita basis. For example, if through some additional analysis the user determined that the maximum length of MV line per capita above which a stand-alone system would be a cheaper solution is 6 meters, the user could then compare the actual MV line required (as computed in the Tool) with this threshold to make a judgement about the cost effectiveness of extending the grid. Even without cost data, the length of MV line required per person provides users with a relative ranking of which administrative units would be more likely to be grid feasible. The lower the value (i.e., the less line required per person), the more likely the grid would be the cost-effective solution. The higher the value (i.e., the more line required per person), the less likely the grid would be the cost-effective solution, as other alternatives such as PV and mini-grids would become more competitive. Ultimately, however, it is up to the user to decide the percentage of each administrative unit's communities for which the grid would provide the most cost-effective solution for electrification.

Based on this unit-by-unit information, the model calculates the weighted percentage of each settlement category that is "grid-feasible". If it is more appropriate to make a grid/off-grid determination by settlement type rather than by administrative unit, a percentage can be entered directly in the "Aggregate % Grid-feasible" column. This will automatically feed into the rest of the model. The model also calculates the number of households served per community and the kilometres of medium-voltage (MV) line needed per grid-feasible community – the key parameter in determining the cost of grid extension.

	SUMMARY BY TYPE:	Total # of Communities	Aggregate % Grid-Feasible (weighted)	HH per community	km MV line/grid-feasible community
39					
40					
41	*Type A (rural)*	4,125	99%	104	3.9
42	*Type B (rural)*	1,015	8%	104	9.4
43	*Type C (rural)*	1,106	13%	104	6.7
44	*0*	-	0%	-	-

In the remaining rows of this sheet, there is a summary of grid needs for each category of settlement, based on the aggregate percentages calculated above.

It is important to note that this estimation is *separate from* the question of coverage targets – this worksheet simply establishes what percentage of communities *could* feasibly be covered by a national grid. Once this determination is made, coverage rates are applied to rural communities for the different technology options.

Calculation Worksheets

As the data in the General Inputs worksheets is inserted, it is automatically inserted in the appropriate Calculation Worksheets. There is a separate worksheet for each type of energy service – cooking systems, rural electrification, mechanical power and urban electrification – and within each worksheet the calculations are broken down by each category of settlement. Based on these inputs, the calculations sheets perform simple multiplication and addition to arrive at resource estimates. With the exception of the calculation sheet for rural off-grid systems (which requires the user to choose between technologies), no additional input is needed from the user to operate the calculation sheets.

The basic methodology for calculating the cost of delivering selected energy services can be described in the following formula, presented earlier in Figure 2:

[# of HHs, communities and institutions] x [Coverage ratio] = [Covered population] x [Infrastructure and services needed per recipient] = [Number of unit interventions needed]

x [Unit costs] = [**Resources required**]

Each calculation is performed for each year, by settlement category. The yearly scale-up of services is determined by changes in population and coverage targets for each year.

For example, we can look at the first rows of the urban electrification sheet set out below. Here, you can see how inputs on yearly "Type E" urban population (row 9), household coverage (row 12), and household size (row 14) are used to calculate the total, incremental and cumulative number of households electrified (rows 15 thru 17). According to the color-coding system of the model, all automatic entries from input sheets are shaded grey. All subsequent calculations appear in white.

5		Current	Year 1	Year 2	Year 3
6	**Urban**				
7	*Coverage*	Type E (urban)			
8	Population	10,812,946	11,072,457	11,338,196	11,610,313
9	Urban Population	2,167,120	2,219,131	2,272,390	2,326,928
10					
11	Households				
12	HH Coverage	71%	74%	77%	80%
13	Covered Population	1,538,655	1,639,938	1,745,196	1,854,561
14	Average HH Size (Urban)	8	8	8	8
15	# of HH Connected	205,154	218,658	232,693	247,275
16	Incremental HH Connected		13,504	14,034	14,582
17	cum		13,504	27,539	42,121

Next, we can see that the calculation sheet aggregates the unit costs entered on the input sheets, calculating a per-household urban electrification cost:

		Current	Year 1	Year 2	Year 3
46	*Unit Costs*				
47	*Per HH*	Type E (urban)			
48	Initial Capital Cost	419.0	419.0	419.0	419.0
49	System Maintenance Cost	44.2	44.2	44.2	44.2
50	Lifeline Tariffs (for minimum consumption)	7.8	7.8	7.8	7.8
51	Billing/Collection Cost	0.0	0.0	0.0	0.0
52	Institutional Capacity Cost	0.0	0.0	0.0	0.0
53	Total Per HH Costs		470.9	470.9	470.9

Then the calculation sheet brings together the coverage and cost calculations to calculate total yearly costs by settlement type. Capital costs are applied to incrementally added households, while all recurrent costs (for the exception of capacity building costs – see Box 6) are applied to the total number of households electrified.

		Current	Year 1	Year 2	Year 3
89	*Total Costs*				
90	*Households*	Type E (urban)			
91	Initial Capital Cost (by increment)		5,657,963	5,880,035	6,109,508
92	System Maintenance Cost (by total)		9,656,747	10,276,556	10,920,553
93	Lifeline Tariffs (by total)		1,697,965	1,806,947	1,920,182
94	Billing/Collection Cost (by total)		-	-	-
95	Institutional Capacity Cost (by increment)		-	-	-
96	Total HH Costs		17,012,674	17,963,538	18,950,244

Worksheet 8. Improved Cooking Systems

	Current	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Rural											
General Characteristics	Type A (rural)										
Population covered by this Type	4,125,490	4,224,502	4,325,890	4,429,712	4,536,025	4,644,889	4,756,367	4,870,519	4,987,412	5,107,110	5,229,680
Average HH size in this Type	10	10	10	10	10	10	10	10	10	10	10
# of Households this Type	429,739	440,052	450,614	461,428	472,503	483,843	495,455	507,346	519,522	531,991	544,758
Coverage											
% of HH With Access to Improved Fuels	30%	34%	37%	41%	44%	48%	51%	55%	58%	62%	65%
Of Which											
Kerosene	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
LPG	30%	34%	37%	41%	44%	48%	51%	55%	58%	62%	65%
# of HH w/ Kerosene											
Total	-	-	-	-	-	-	-	-	-	-	-
Incremental		-	-	-	-	-	-	-	-	-	-
Cumulative		-	-	-	-	-	-	-	-	-	-
# of HH w/ LPG											
Total	128,922	147,418	166,727	186,878	207,901	229,825	252,682	276,503	301,323	327,174	354,093
Incremental		18,496	19,309	20,151	21,023	21,924	22,857	23,821	24,819	25,851	26,919
Cumulative		18,496	37,805	57,957	78,980	100,904	123,760	147,582	172,401	198,253	225,171
% of HH w/ Sustainable Biomass	0%	4%	7%	11%	14%	10%	21%	25%	20%	32%	35%
# of HH w/ Sustainable Biomass											
Total	-	15,402	31,543	48,450	66,150	84,672	104,046	124,300	145,466	167,577	190,665
Incremental		15,402	16,141	16,907	17,700	18,522	19,373	20,254	21,166	22,111	23,088
Cumulative		15,402	31,543	48,450	66,150	84,672	104,046	124,300	145,466	167,577	190,665
% of HH w/ Improved Biomass Stoves	0%	4%	7%	11%	14%	18%	21%	25%	28%	32%	35%
# of HH w/ Improved Biomass Stoves											
Total	-	15,402	31,543	48,450	66,150	84,672	104,046	124,300	145,466	167,577	190,665
Incremental		15,402	16,141	16,907	17,700	18,522	19,373	20,254	21,166	22,111	23,088
Cumulative		15,402	31,543	48,450	66,150	84,672	104,046	124,300	145,466	167,577	190,665
Miniumum Per HH Consumption											
Kerosene	200	liter									
LPG	177.7683465	kg									
Calculations											
Kerosene											
Capital (i.e. stove)											
Cost Per HH	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7
Total Capital Cost (incremental)		-	-	-	-	-	-	-	-	-	-
Fuel											
Cost Per Unit (i.e. liter, kg, etc)											
Fuel Costs at Port/Terminal	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7

Using the inputs for population, targets, minimum needs and unit costs, this worksheet calculates the overall costs of (a) projected capital investments in equipment, (b) estimated supplies of kerosene and LPG, and (c) increases needed in sustainable production of biomass and improved stove technologies.

The results for each settlement category are shown first, and then aggregated into national totals.

Worksheet 9. Urban Electrification

	Current	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Urban											
Coverage	Type E (urban)										
Population	10,812,946	11,072,457	11,338,196	11,610,313	11,888,960	12,174,295	12,466,478	12,765,674	13,072,060	13,385,779	13,707,038
Urban Population	2,167,120	2,219,131	2,272,390	2,326,928	2,382,774	2,439,961	2,498,520	2,558,484	2,619,888	2,682,765	2,747,152
Households											
HH Coverage	71%	74%	77%	80%	83%	86%	88%	91%	94%	97%	100%
Covered Population	1,538,655	1,639,938	1,745,196	1,854,561	1,968,171	2,086,166	2,208,691	2,335,896	2,467,934	2,604,965	2,747,152
Average HH Size (Urban)	8	8	8	8	8	8	8	8	8	8	8
# of HH Connected	205,154	218,658	232,693	247,275	262,423	278,156	294,492	311,453	329,058	347,329	366,287
Incremental HH Connected		13,504	14,034	14,582	15,148	15,733	16,337	16,961	17,605	18,271	18,958
cum		13,504	27,539	42,121	57,269	73,001	89,338	106,299	123,904	142,175	161,133
Institutions											
Local-level Health Institutions											
# of Health Instutions	-	-	-	-	-	-	-	-	-	-	-
Health Institutions Coverage	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
# of Health Instutions Covered	-	-	-	-	-	-	-	-	-	-	-
Incremental Health Inst Covered		-	-	-	-	-	-	-	-	-	-
cum		-	-	-	-	-	-	-	-	-	-
Educational Institutions											
# of Educational Instutions	-	-	-	-	-	-	-	-	-	-	-
Educational Institutions Coverage	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
# of Educational Instutions Covered	-	-	-	-	-	-	-	-	-	-	-
Incremental Educational Inst Covered		-	-	-	-	-	-	-	-	-	-
cum		-	-	-	-	-	-	-	-	-	-
Other Instutions											
# of Other Instutions	-	-	-	-	-	-	-	-	-	-	-
Other Institutions Coverage	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
# of Other Instutions Covered	-	-	-	-	-	-	-	-	-	-	-
Incremental Other Inst Covered		-	-	-	-	-	-	-	-	-	-
cum		-	-	-	-	-	-	-	-	-	-
Minumum Urban Consumption											
Households	Type E (urban)										
Lifeline/minimum kWh amount per hh/yr	84										
Instutions											
kWh/yr for Local-level Health Institutions	0										
kWh/yr for Educational Institutions	0										
kWh/yr for OtherInstitutions	0										
Peak kW For Local-level Health Institutions	0										
Peak kW For Ed Institutions	0										
Peak kW For Other Institutions	0										
Unit Costs	Current	Year 1	Year 2	Year 3							
Per HH	Type E (urban)										
Initial Capital Cost	419.0	419.0	419.0	419.0	419.0	419.0	419.0	419.0	419.0	419.0	419.0
System Maintenance Cost	44.2	44.2	44.2	44.2	44.2	44.2	44.2	44.2	44.2	44.2	44.2
Lifeline Tariffs (for minimum consumption)	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
Billing/Collection Cost	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Institutional Capacity Cost	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Per HH Costs		470.9	470.9	470.9	470.9	470.9	470.9	470.9	470.9	470.9	470.9

As mentioned above, the Tool assumes that grid electrification will be appropriate in all urban areas. Thus, this sheet performs simple calculations to arrive at the total cost of connecting urban households and institutions to the national grid.

In addition, this sheet calculates the yearly number of new connections by recipient, as well as a yearly summary of total kilowatt-hours needed to meet minimum urban consumption and access targets.

Worksheet 10. Regional and National Institutions

This worksheet combines inputs already entered in the corresponding input pages and estimates the number of the regional and national institutions for which energy services will need to be provided, and the minimum MDG-compatible consumption levels for those institutions.

Since major regional and national institutions are likely to already have basic access, but are also likely to require investment in fuels and electricity as well as upkeep, only recurrent costs are calculated.

Worksheet 11. Rural Grid Electrification

	Current	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
General Inputs											
Rural											
General Characteristics	**Type A (rural)**										
# of Grid-Feasible communities of this type	4,065	4,163	4,263	4,365	4,470	4,577	4,687	4,800	4,915	5,033	5,154
Population in Grid-feasible zones in this Type	4,065,414	4,162,984	4,262,895	4,365,205	4,469,970	4,577,249	4,687,103	4,799,593	4,914,783	5,032,738	5,153,524
Average HH size in this Type	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
# of Local-level Health Institutions in this Type	6,776	6,938	7,105	7,275	7,450	7,629	7,812	7,999	8,191	8,388	8,589
# of Educational Institutions in this Type	6,776	6,938	7,105	7,275	7,450	7,629	7,812	7,999	8,191	8,388	8,589
# of Markets/Community Centers in this Type	6,776	6,938	7,105	7,275	7,450	7,629	7,812	7,999	8,191	8,388	8,589
# of Other Institutions in this Type	6,776	6,938	7,105	7,275	7,450	7,629	7,812	7,999	8,191	8,388	8,589
# of Households this Type	423,481	433,644	444,052	454,709	465,622	476,797	488,240	499,958	511,957	524,244	536,825
Coverage and Needs											
Coverage											
Coverage of this Type communities	43%	49%	54%	60%	66%	72%	77%	83%	89%	94%	100%
Total communities Covered	1,774	2,053	2,346	2,649	2,967	3,299	3,644	4,005	4,380	4,772	5,179
Incremental communities Covered		279	292	304	318	331	346	360	376	391	408
cum		279	571	875	1193	1525	1870	2231	2606	2998	3405
Coverage of HH in this Type	26%	29%	33%	36%	40%	43%	46%	50%	53%	57%	60%
Total this Type HH Covered	111,732	129,118	147,276	166,232	186,013	206,650	228,170	250,606	273,988	298,349	323,722
Incremental this Type HH Covered		17,386	18,158	18,956	19,782	20,636	21,521	22,436	23,382	24,361	25,373
cum		17,386	35544	54500	74281	94918	116438	138874	162256	186617	211990
Institutional Breakdown											
Total Local-level Health Institutions Cove	2957	3,422	3,908	4,416	4,945	5,498	6,074	6,674	7,301	7,953	8,632
Incremental Health Institutions Covered		465	486	507	530	552	576	601	626	652	679
cum		465	951	1459	1989	2541	3117	3718	4344	4996	5676
Total Educational Institutions Covered	2,957	3,422	3,908	4,416	4,945	5,498	6,074	6,674	7,301	7,953	8,632
Incremental Educational Institutions Covered		465	486	507	530	552	576	601	626	652	679
cum		465	951	1459	1989	2541	3117	3718	4344	4996	5676
Total Markets/Community Centers Cove	2,957	3,422	3,908	4,416	4,945	5,498	6,074	6,674	7,301	7,953	8,632
Incremental Markets/Community Centers Covered		465	486	507	530	552	576	601	626	652	679
cum		465	951	1459	1989	2541	3117	3718	4344	4996	5676
Total Other Institutions Covered	2,957	3,422	3,908	4,416	4,945	5,498	6,074	6,674	7,301	7,953	8,632
Incremental Other Institutions Covered		465	486	507	530	552	576	601	626	652	679
cum		465	951	1459	1989	2541	3117	3718	4344	4996	5676
Consumption Needs											
kWh/yr for Local-level Health Institutions	1117.8										
kWh/yr for Educational Institutions	100.74										
kWh/yr for Markets/Community Centers	100.74										
kWh/yr for OtherInstitutions	0										
Institutions Per Community											
Health	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Educational	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Markets/Community Centers	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Other Institutions	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7

This worksheet estimates the costs of meeting rural energy coverage targets in those areas where grid connection has been determined the most appropriate technology.

Unlike urban grid calculations, rural grid electrification is assumed to require the extension of medium-voltage lines to targeted rural communities. Thus, costs depend heavily on the length of MV line needed to connect each community, in addition to the last-connection cost for each community connection. The rural grid calculation page brings together the information computed in the Grid/Off-Grid Choice sheet with the unit costs entered per household and per kilometer of grid extension.

		Current	Year 1	Year 2	Year 3
65	Institutions				
66	Capital				
67	Per community				
68	MV line				
69	km MV line/community	3.9	3.9	3.9	3.9
70	cost per km	11,000	11,000	11,000	11,000
71	Cost for MV line/community		42,764	42,764	42,764
72					
73	Transformers	7,611	7,611	7,611	7,611
74	Last Connection Cost per institutio	445	445	445	445
75	Last Connection Cost per comm		2,967	2,967	2,967
76	Total Initial Capital Cost per comm		53,342	53,342	53,342
77					
78	TOTAL this Type GRID CAPITAL COST (by increme		14,895,600	15,556,877	16,241,316
79					
80	Recurrent				
81	System Maintenance Cost				
82	Per node/yr	2,146	2,146	2,146	2,146
83	Total System Maintenance Cos		4,406,180	5,032,044	5,685,443
84	Recurrent (Supply) Costs				
85	kWh per community	2,199	2,199	2,199	2,199
86	cost per kWh	0.1	0.1	0.1	0.1
87	Total Recurrent (Supply) Costs		417,600	476,916	538,843
88	Billing/Collection Cost				

The Tool provides a detailed breakdown of grid extension costs for the different categories of consumers – including capital outlays for lines and transformers, as well as system maintenance costs, recurrent supply costs, billing and collection costs, and institutional capacity costs. It will also produce a summary of consumption requirements for minimum MDG needs by rural grid consumers.

Worksheet 12. Rural Off-Grid Electrification: Cost Comparison and Technology Choice

The rural off-grid calculation worksheet is the only calculation worksheet for which additional user inputs are needed. The rural off-grid calculations sheet allows users to compare the costs of different off-grid technologies for each settlement category, and then choose the most appropriate technology option.

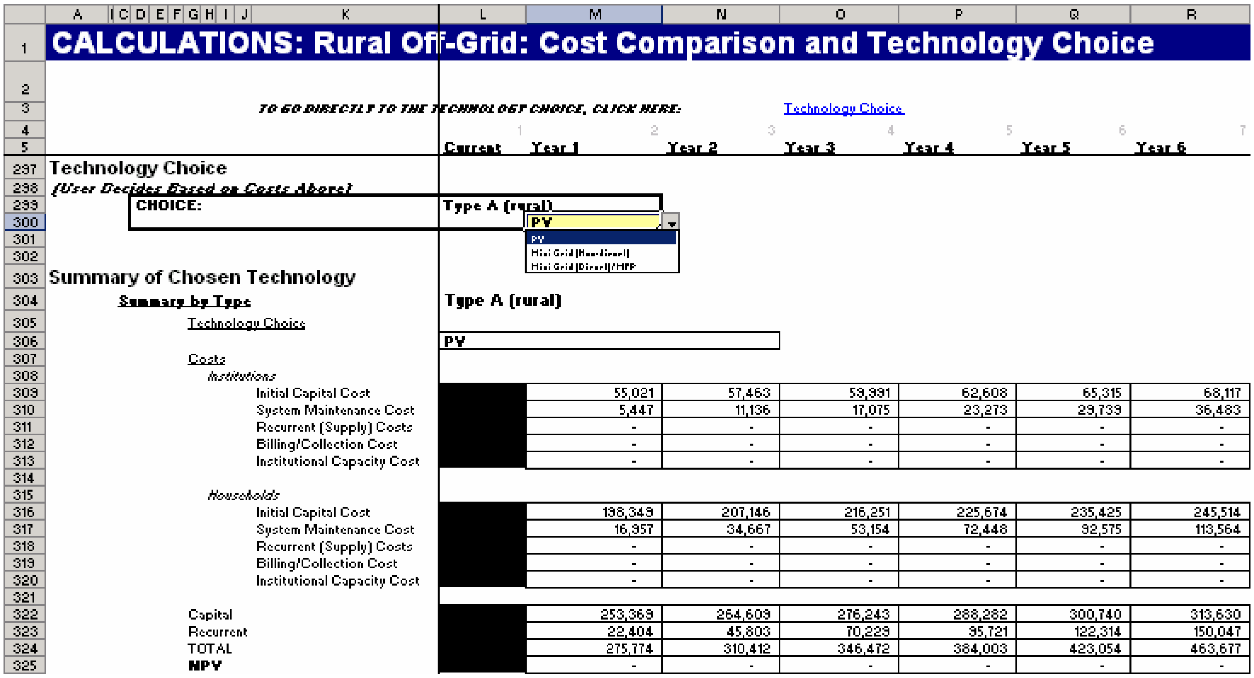
First, the worksheet calculates the costs of each off-grid option using the same methodology as in other calculation pages. After these calculations are performed, however, the model requires that the user choose one of the available technologies for each settlement category.

In rows 233 through 295, the worksheet summarizes the capital, recurrent, and total cost of each technology option (see excerpt below).

Comparison Summary

Row			Current	Year 1	Year 2	Year 3
233			**Type A (rural)**			
234	PV		PV			
235	Detailed Summary					
236	*Institutions*					
237	Initial Capital Cost			55,021	57,463	59,991
238	System Maintenance Cost			5,447	11,136	17,075
239	Recurrent (Supply) Costs			-	-	-
240	Billing/Collection Cost			-	-	-
241	Institutional Capacity Cost			-	-	-
242						
243	*Households*					
244	Initial Capital Cost			198,349	207,146	216,251
245	System Maintenance Cost			16,957	34,667	53,154
246	Recurrent (Supply) Costs			-	-	-
247	Billing/Collection Cost			-	-	-
248	Institutional Capacity Cost			-	-	-
249						
250	Capital			253,369	264,609	276,243
251	Recurrent			22,404	45,803	70,229
252	TOTAL			**275,774**	**310,412**	**346,472**
253	**NPV**	**$3,347,203.92**				
254						
255	Mini Grid (Non-diesel)		Mini Grid (Non-diesel)			
256	Costs					
257	*Institutions*					
258	Initial Capital Cost			218,570	228,273	238,316
259	System Maintenance Cost			8,253	16,873	25,871
260	Recurrent (Supply) Costs			-	-	-

In row 300, there is a drop-down menu of available technologies for each settlement category. When the user clicks the chosen technology for each settlement category, the Tool automatically draws down the costs of that technology and feeds them into the results.



CALCULATIONS: Rural Off-Grid: Cost Comparison and Technology Choice

TO GO DIRECTLY TO THE TECHNOLOGY CHOICE, CLICK HERE: Technology Choice

Technology Choice

(User Decides Based on Costs Above)

CHOICE: Type A (rural) — PV (PV / Mini Grid (Hour-diesel) / Mini Grid (Diesel)/MHP)

Summary of Chosen Technology

Summary by Type — Type A (rural)

Technology Choice: PV

	Current	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Costs							
Institutions							
Initial Capital Cost		55,021	57,463	59,991	62,608	65,315	68,117
System Maintenance Cost		5,447	11,136	17,075	23,273	29,739	36,483
Recurrent (Supply) Costs		-	-	-	-	-	-
Billing/Collection Cost		-	-	-	-	-	-
Institutional Capacity Cost		-	-	-	-	-	-
Households							
Initial Capital Cost		198,349	207,146	216,251	225,674	235,425	245,514
System Maintenance Cost		16,957	34,667	53,154	72,448	92,575	113,564
Recurrent (Supply) Costs		-	-	-	-	-	-
Billing/Collection Cost		-	-	-	-	-	-
Institutional Capacity Cost		-	-	-	-	-	-
Capital		253,369	264,609	276,243	288,282	300,740	313,630
Recurrent		22,404	45,803	70,229	95,721	122,314	150,047
TOTAL		275,774	310,412	346,472	384,003	423,054	463,677
NPV		-	-	-	-	-	-

Worksheet 13. Mechanical Power

	Current	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
General Inputs											
Rural											
Coverage Targets	Type A (rural)										
Total # of communities (this type)	4,125	4,225	4,326	4,430	4,536	4,645	4,756	4,871	4,987	5,107	5,230
Total Population (this type)	4,125,490	4,224,502	4,325,890	4,429,712	4,536,025	4,644,889	4,756,367	4,870,519	4,987,412	5,107,110	5,229,680
HH Per Community	104										
% Coverage Mechanical Power	43%	49%	54%	60%	66%	72%	77%	83%	89%	94%	100%
Total communities with Mechanical Power	1,774	2,057	2,353	2,662	2,985	3,321	3,672	4,038	4,419	4,816	5,230
Incremental communities with Mechanical Power		283	296	309	322	336	351	366	381	397	414
cum		283	579	888	1,211	1,547	1,898	2,264	2,645	3,042	3,456
Electrified communities (from Rural Electrification Calculations)											
Grid											
Total Grid-Connected communities (from CALC–	1,774	2,053	2,345	2,649	2,967	3,299	3,644	4,005	4,380	4,772	5,179
Incremental Grid-Connected communities (from (	-	279	292	304	318	331	346	360	376	391	408
Off-Grid											
Total Off-Grid communities (from CALC--Grid she	-	4	8	13	18	23	28	33	39	44	50
Incremental Off-Grid communities (from CALC--G	-	4	4	4	5	5	5	5	6	6	6
Mechanical Power Connections by Grid/Off-Grid Type											
Grid											
Total	1,774	2,053	2,345	2,649	2,967	3,299	3,644	4,005	4,380	4,772	5,179
Incremental		279	292	304	318	331	346	360	376	391	408
cum		279	571	875	1,193	1,525	1,870	2,231	2,606	2,998	3,405
Off-Grid											
Total	-	4	8	13	18	23	28	33	39	44	50
Incremental		4	4	4	5	5	5	5	6	6	6
cum		4	8	13	18	23	28	33	39	44	50
Non-electrified (targeted for Mech Power)											
Total	-	-	-	-	0	0.0	-	-	-	-	-
Incremental		-	-	-	0	-	(0)	-	-	-	-
cum		-	-	-	0	0	-	-	-	-	-

For Grid Connected nodes

Mechanical Power

Consumption per community	Consumption per community/year			Peak Per Community/Year		Fuel Cost/community/year	
Technology	per HH served	Per Community/yr	Units	Per HH served	Per Community/yr	per HH served	Per Community/yr
Grid (given community connection)	47	4,896	kWh	5.5	572.9166667	7.8	815

Cost Calculations	Current	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital											
per community/yr	25556	25556	25556	25556	25556	25556	25556	25556	25556	25556	25556
Total Capital Costs (by increment)		7,136,264	7,453,073	7,780,977	8,120,328	8,471,486	8,834,823	9,210,719	9,599,570	10,001,781	10,417,768
System Maintenance Cost											
per community/yr	185	185	185	185	185	185	185	185	185	185	185
Total System Maintenance Cost (by tota		379,843	433,797	490,124	548,908	610,235	674,191	740,869	810,361	882,765	958,181

As discussed above, this Tool links mechanical power technologies to the chosen rural electrification technology. That is, *if* a community is targeted for rural electrification and for mechanical power interventions, the mechanical power technology will depend upon the kind of electrification system chosen for that type of community.

The Mechanical Power worksheet therefore splits targeted rural communities into three categories, based on previous inputs and technology choices:

1) Communities targeted for mechanical power that are also targeted for grid extension;

2) Communities targeted for mechanical power that are targeted for off-grid systems; and

3) Communities targeted for mechanical power that are *not* targeted for electrification over the period.

For each subset of targeted communities, the worksheet performs calculations based on the technology choices the user has specified for each electrification technology.

For example, in the case of Senegal, the Tool specifies that communities targeted for grid electrification will also have access to mechanical power through the grid. Thus, for these communities the Tool calculates the additional capital and recurrent costs of meeting mechanical power needs through the grid (based on unit costs entered in the input pages).

For Grid Connected nodes

39	***Mechanical Power***				
40	Consumption per community	Consumption per community/year			
41	Technology	per HH served	Per Community/yr	Units	
42	Grid (given community connection)	47	4,896	kWh	
43					
44	Cost Calculations	Current	Year 1	Year 2	Year 3
45	Capital				
46	per community/yr	25556	25556	25556	25556
47	Total Capital Costs (by increment)		7,136,264	7,453,073	7,780,977
48	System Maintenance Cost				
49	per community/yr	185	185	185	185
50	Total System Maintenance Cost (by tota		379,843	433,797	490,124
51	Recurrent (Supply) Costs				
52	Cost per community	815	815	815	815
53	Total Recurrent (Supply) Costs (by total)		1,673,684	1,911,417	2,159,611
54	Billing/Collection Cost				
55	per community/yr	0	0	0	0
56	Total Billing/Collection Cost (by total)		-	-	-
57	Institutional Capacity Cost				
58	per community/yr	185	185	185	185
59	Total Institutional Capacity Cost (by incr		51,660	53,954	56,328
60					
61	TOTAL Mech Power for Grid communities		**9,241,452**	**9,852,241**	**10,487,040**

Worksheet 14. Summary Sheet

This sheet shows coverage levels and total national costs for all the different categories of energy service: improved cooking systems, rural and urban electrification and mechanical power.

The totals are also shown on a per capita basis to allow for comparisons between resource needs for energy and other sectoral priorities within a country, and comparisons between countries in terms of energy investments per capita.

By expanding the grouped rows on the left, users can also view summaries by an urban/rural breakdown, and by expenditure type (to expand the rows, click the "+" signs in the left margin of the sheet).

COVERAGE	Current	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Target
Cooking Systems											
Improved Fuels	**49%**	51%	53%	56%	58%	60%	63%	65%	68%	70%	**72%**
Improved Biomass Stoves	**4%**	7%	9%	11%	14%	16%	18%	21%	23%	25%	**28%**
Sustainable Production of Bi	**2%**	4%	7%	9%	12%	15%	17%	20%	23%	25%	**28%**
Electricity											
Urban Households	**71%**	74%	77%	80%	83%	86%	88%	91%	94%	97%	**100%**
Rural Communities	**38%**	44%	49%	54%	59%	65%	70%	75%	81%	86%	**91%**
Rural Households	**23%**	26%	29%	33%	36%	39%	42%	45%	48%	52%	**55%**
Mechanical Power											
Rural Communities	**38%**	45%	51%	57%	63%	69%	75%	82%	88%	94%	**100%**

COSTS	Current	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total (10 years)
TOTALS												
By Service												
Cooking Systems	[redacted]	128,030,877	141,825,010	156,207,516	171,198,691	186,819,467	203,091,429	220,036,838	237,678,645	256,040,519	275,146,859	1,976,075,850
Electricity		80,346,827	86,092,767	92,068,133	98,280,629	104,738,194	111,449,015	118,421,526	125,664,424	133,186,672	140,997,507	1,091,245,694
Mechanical Power		13,282,625	14,365,650	15,492,651	16,665,114	17,884,572	19,152,607	20,470,847	21,840,972	23,264,713	24,743,853	187,163,604
Grand Total		**221,660,328**	**242,283,427**	**263,768,300**	**286,144,434**	**309,442,234**	**333,693,051**	**358,929,211**	**385,184,042**	**412,491,904**	**440,888,219**	**3,254,485,148**
By Urban/Rural												
Urban	[redacted]	121,134,026	126,576,892	132,211,243	138,043,135	144,078,803	150,324,671	156,787,351	163,473,652	170,390,587	177,545,373	*1,480,565,733*
Rural		100,526,302	115,706,534	131,557,057	148,101,299	165,363,430	183,368,380	202,141,860	221,710,390	242,101,317	263,342,846	*1,773,919,415*
Regional/National Institutions		-	-	-	-	-	-	-	-	-	-	-
By Expenditure Type												
Capital	[redacted]	53,015,165	55,315,326	57,695,368	60,157,771	62,705,146	65,340,145	68,065,506	70,884,047	73,798,673	76,812,372	*643,789,509*
Fuel/Electricity Purchase		120,040,559	128,060,289	136,396,045	145,058,375	154,058,156	163,406,594	173,115,242	183,196,004	193,661,150	204,523,324	*1,601,515,737*
Other Recurrent		48,604,605	58,907,812	69,676,897	80,928,287	92,678,931	104,946,312	117,748,464	131,103,991	145,032,080	159,552,523	*1,009,179,902*

The additional "Graphs" worksheet gives graphic representations of these summary results.

D. Adapting the Tool

The Energy Costing Tool is designed to be generally applicable to a broad range of countries and systems, but countries may wish to adapt it further to reflect local circumstances. Here, we discuss three adaptations that countries may wish to make to the model: dropping interventions, changing interventions and adding interventions.

Dropping interventions

In some cases, countries may decide not to use one or more of the interventions built into the model. For example, a country may decide that some of the demand-side interventions are not needed. There are many ways to reflect this in the model, but the easiest is to zero out coverage and costs. To do this, users enter zeros for all coverage targets associated with the intervention. This will eliminate the intervention from resource estimates. For example, in the Senegal study, it was determined that kerosene interventions were not needed.

6	**Improved cooking systems**				
7	*Coverage*				
8	**% of HH with Access to Improved Fuels**				
9	Rural Coverage	**Type A (rural)**			
10		Current	Year 1	Year 2	Year 3
11	% HH of each Type Covered	30%	34%	37%	41%
12	*Of Which*				
13	Kerosene	0%	0%	0%	0%
14	LPG	30%	34%	37%	41%
19					
20	Rural Coverage (Weighted Average)	30%	34%	37%	41%
21	*Of Which*				
22	Kerosene	0%	0%	0%	0%
23	LPG	30%	34%	37%	41%

By simply entering "0" every year for coverage targets, the Senegal model eliminated kerosene from its calculations.

Changing interventions

To modify an intervention by changing it to a different kind of intervention, users should go to the "Interventions and Technologies" page and change the name of the intervention. If the costing methodology for the intervention remains the same as the one it is replacing, then changing the names of the cells in the "Interventions" page should be sufficient. Otherwise, the user will need to ensure that appropriate costing fields and formulas are entered for the new intervention.

Adding interventions

There are many ways to add interventions to the model, and advanced users should find it relatively easy to add rows and link them throughout the model to the relevant worksheets. The simplest, most modular and most intuitive way to add an intervention to the model is to add a worksheet to the model to account for all of the new interventions.

Users should enter any new population data, coverage targets and unit costs associated with the new intervention. The new worksheet should follow the same general methodology as the rest of the model, scaling up coverage targets and multiplying them by unit costs to derive resource estimates. Once resource estimates have been calculated, formulas on the Summary page should be updated to include them. In particular, the formulas for capital, recurrent and total costs in each area should be revised to include the capital, recurrent, and total costs of the new interventions.

E. Checking results and trouble-shooting

Once results have been derived from the Energy Costing Tool, how can the user tell whether the results are realistic?

One way is to check the totals obtained by using the Tool against results for other countries by comparing the per capita costs. The UN Millennium Project Handbook Preparing National Strategies to Achieve the Millennium Development Goals provides some illustrative per capita dollar figures for investment needs, including for energy that can be used for comparisons.

Other ways to check results include examining the path of per capita expenditures over a 10-year period and running internal checks on cost drivers:

- **Path of per capita expenditures**. One way to check for major errors is to study the 10-year path of per capita expenditures. If there are any unusual spikes or troughs, or other patterns, users may need to reexamine scale-up paths and other formulas on calculations pages.

- **Internal checks on cost drivers.** Another way to assess results is to analyze the major drivers of total resource needs. Cross-country comparisons suggest that costs for improved fuels will contribute between 40 percent and 50 percent of total cost estimates. Primarily due to this, cooking systems typically make up 50 percent to 60 percent of total costs. If there are large variances in one or more of these costs, the user may wish to re-examine some of the unit costs, the outcome/coverage targets, or input quantity ratios and compare them to international standards to identify the source of variance.

Trouble-shooting

During the course of the costing exercise, users may also encounter a number of modeling issues and problems. Here, we discuss some of the most common problems and identify simple tools that may help resolve them.

1) **Unrealistically high or low resource estimates**

After comparing results with comparable estimates, the user may find that the model has produced unrealistically high or low values. A bit of detective work will be in order, moving from general to specific issues.

- Are any of the cost drivers significantly higher or lower than cross-country benchmarks?
- Are there any large spikes or troughs in the pattern of resource needs? (This might indicate a typographical error in a single year's entry).
- Are all of the coverage and input quantity ratio targets accurate?
- Are the unit costs reasonable?
- Are recurrent and capital costs calculated correctly? (If the calculations are mixed up, or based incorrectly on incremental vs. cumulative figures, results may be unrealistically high or low)
- Are results highly sensitive to small changes in variables? If so, users should be very careful in interpreting results.

2) **#VALUE**

If the phrase “#VALUE” appears in a cell, the problem is most likely that the user has entered an inappropriate value for the variable, e.g., text in a cell that accepts only numbers. If inappropriate values are entered into cells that are used to calculate values in other cells, all the dependent cells will also display the #VALUE symbol. If confronted with this problem, the user should click on a cell where the #VALUE symbol is displayed and go to the “Tools” menu, select “Auditing,” and click on “Trace Precedents”. By following the arrows backward to the cell with the original error, the user should be able to identify and correct the problem.

3) **#REF**

If the phrase “#REF” appears, a link has been broken, most likely by deleting a precedent cell. If the #REF symbol has just appeared, go to the “Edit” menu and select “Undo,” which may bring back the deleted cell and solve the problem. If this does not help, select a cell where the #REF symbol appears and try to assess what cell might have been deleted or moved. If, for example, the cell is the sum of various infrastructure costs and there is one #REF symbol in the summation formula, it is likely that the missing cell is also an infrastructure entry. Going through this process may help the user identify and rectify the problem.

Many #REF problems can be avoided by following two simple rules. First, before deleting any cell, select it and use the Auditing function (under the “Tools” menu) to “Trace dependents.” If there are any dependents, make sure that their formulas are appropriately modified before deleting the cell.

Second, when moving cells or rows from place to place, always CUT (from the “Edit” menu) and then PASTE (also from the “Edit” menu). Never “COPY” and paste. Cutting and pasting updates all of the links; copying and pasting does not.

4) **#DIV/0!**

The “#DIV/0” symbol means that a formula involves division where the denominator is zero, yielding an undefined result. When this occurs, examine the formula and check the precedent cells to ensure that the values are correct. More often than not, the “#DIV/0” symbol appears when an entry has been accidentally deleted and used as the denominator in a quotient formula, yielding this readily resolvable problem.

Chapter
5

Conclusion and next steps

This Guide has been prepared to introduce and facilitate use of the Energy Costing Tool as part of strategic planning and budgeting processes that will bring countries closer to achieving the MDGs. Those Goals were adopted in 2000, with a target date of 2015, so there is an urgent need for action. By making the proper types of long-term investments now, governments and institutions can make it possible to meet the Goals, and bring much-needed relief to the many people around the world currently suffering from hunger, extreme hunger, lack of education and health care and social inequities.

At the 2005 World Summit, world leaders reiterated their support for the MDGs by committing to support the development and implementation of MDG-based national development strategies, and acknowledged that energy is a fundamental element of such actions. This acknowledgement was founded on the understanding that without increased access to modern energy services for the poor, the MDGs are unlikely to be met.

Although the focus of this Guide and the Tool is on costing MDG-based national energy needs, UNDP and the UN Millennium Project view this effort as just one aspect of a larger, coordinated effort to focus attention on practical steps that must be taken to move discussions about the MDGs beyond the level of wishful thinking. Within countries, broad-based inputs from civil society groups and the private sector are needed, as well as effective government action, to establish achievable long-term development priorities and targets. Once that process has begun, the Energy Costing Tool, and other similar tools for other sectors, can be used to help arrive at an estimate of the country's actual budgetary needs in connection with the MDGs.

Realistic costing information can provide a bridge that will move policy and planning wish lists past the financial constraints that stand in the way of coordinated development initiatives – by providing a framework for combined pro-poor investments from a variety of sources, including businesses, communities, civil society groups and international donors, as well as national governments.

The Energy Costing Tool has already been applied and tested in West Africa, and is ready to be offered to other countries as a useful tool for integrating energy investments into medium and long-term fiscal planning. It is hoped that the Tool will prove to be an effective vehicle for helping governments and planners move toward the incorporation of MDG-based budgeting. As it is more widely applied, we expect, however, that additional adaptations and improvements will be developed, and the Tool can be modified and updated in response to further testing and feedback from users.

References and additional reading

Columbia University and UNDP Energy Workshop, “Energy Services to Meet the MDGs: Cost Estimates for Senegal”, May 2006

Economic Community of West African States (ECOWAS) and West African Economic and Monetary Union (UEMOA), “White Paper for a Regional Policy: Geared towards increasing access to energy services for rural and periurban populations in order to achieve the Millennium Development Goals”, January 2006

UN Millennium Project, Preparing National Strategies to Achieve the Millennium Development Goals: A Handbook, October 2005

UNDP, “Integrated Package of Services to Support MDG-Based National Development Strategies”, December 2005

UNDP, “Making Sense of MDG Costing”, August 2004

World Bank/ESMAP, UNDP and UN Millennium Project, Energy Services for the Millennium Development Goals, 2005

Appendix A: Data collection checklist

Socio-Demographic Data					
		Typical	This data is needed for…		
Type of Data	**Definition**	**Unit**	**Rural/Urban**	**Current/Planned**	**Priority**
Population Data					
Rural population	Rural population of each administrative unit (i.e., district) within the country	capita	rural	current	high
Urban population	Population of all major urban and peri-urban areas	capita	urban	current	high
Population growth rate	Projected population growth rate or estimate of rural and urban populations over time	percent	rural & urban	na	medium
Geographic Data					
Size of administrative units	Geographic area of each administrative unit (excluding urban areas)	km2	rural	na	low
Demographic Data					
Distribution of community/village size by administrative unit	Number of communities/villages of different size per administrative unit	villages	rural & urban	current	high
Household size	Average household size	capita	rural & urban	current & planned	high
Number of educational institutions	Number of educational institutions (i.e., local schools), as measured either as a total for each rural/urban area or as an average per rural community/village	school	rural & urban	current & planned	high
Number of health institutions	Number of health institutions (i.e., health clinics), as measured either as a total for each rural/urban area or as an average per rural community/village	health clinic	rural & urban	current & planned	high
Number of markets/community centers	Number of markets or community centers, as measured either as a total for each rural/urban area or as an average per rural community/village	community center	rural & urban	current & planned	high
Number of ‘other’ institutions	Number of ‘other’ institutions to be analyzed, as measured either as a total for each rural/urban area or as an average per rural community/village	other	rural & urban	current & planned	high

Energy Access Data						
Type of Data		Definition	Typical Unit	This data is needed for… Rural / Urban	Current / Planned	Priority
Cooking/Heating Data						
	% of households with access to modern fuels	Percentage of households using LPG or kerosene as their primary cooking/heating fuel	percent	rural & urban	current & planned	high
	% of households with access to sustainable production of biomass	Percentage of households using biomass, which is produced sustainably (either through agroforestry, woodlots, community forests, etc.)	percent	rural & urban	current & planned	medium
	% of households with access to improved biomass cookstoves	Percentage of households using one or more improved biomass cookstoves	percent	rural & urban	current & planned	medium
Electrification Data						
	% of communities electrified	Percentage of communities/villages that are electrified, either from the national electricity grid or stand-alone systems	percent	rural	current	high
	% of households electrified	Percentage of households that are electrified, either from the national electricity grid or stand-alone systems	percent	rural & urban	current & planned	high
	% of urban educational institutions electrified	Percentage of urban educational institutions (i.e., local schools) that are electrified	percent	urban	current & planned	medium
	% of urban health institutions electrified	Percentage of urban health institutions (i.e., health clinics) that are electrified	percent	urban	current & planned	medium
	% of urban markets/community centers electrified	Percentage of urban markets or community centers that are electrified	percent	urban	current & planned	medium
	% of 'other' urban institutions electrified	Percentage of 'other' urban institutions that are electrified	percent	urban	current & planned	medium
Motive Power						
	% of rural communities/villages with access to motive power	Percentage of communities/villages that have access to motive power for agroprocessing, water pumping, etc.	percent	rural	current & planned	high

Energy Needs Data						
Type of Data		**Definition**	**Typical Unit**	**This data is needed for… Rural / Urban**	**Current / Planned**	**Priority**
Cooking/Heating Data						
	Minimum consumption of modern fuels per household per year	Minimum amount of LPG or kerosene needed per household per year to meet cooking/heating needs	liters/year or kgs/year	rural & urban	current	high
Electrification Data						
	Minimum lifeline consumption of electricity per household per year	Minimum amount of electricity needed per household per year	kWh/year	rural & urban	current	high
	Electricity consumption per educational institution per year	Average amount of electricity needed per year to satisfy a school's basic power needs (i.e., lighting, computers, etc.)	kWh/year	rural & urban	current	high
	Electricity consumption per health institution per year	Average amount of electricity needed per year to satisfy a health clinic's basic power needs (i.e., lighting, refrigeration, etc.)	kWh/year	rural & urban	current	high
	Electricity consumption per market/community center per year	Average amount of electricity needed per year to satisfy a market/community center's basic power needs (i.e., lighting, etc.)	kWh/year	rural & urban	current	high
	Electricity consumption per ‘other’ institution per year	Average amount of electricity needed per year to satisfy other community power needs	kWh/year	rural & urban	current	medium
Motive Power						
	Minimum consumption of electricity for motive power per rural household per year	Minimum amount of electricity needed for motive power per rural household per year given access to the national electricity grid	kWh/year	rural	current & planned	high
	Minimum consumption of fuel for motive power per rural household per year	Minimum amount of fuel (i.e., diesel) needed for motive power per rural household per year given access to an engine	liters/year	rural	current & planned	high

Unit Cost Data						
Type of Data	**Definition**	**Typical Unit**	**This data is needed for… Rural / Urban**	**Current / Future**	**Priority**
Cooking/Heating Data					
Capital cost of modern fuel cooking device	Capital cost of a typical modern fuel cooking stove (for both kerosene & LPG)	$/unit	rural & urban	current & future	high
Recurrent (supply) cost of modern fuel	Cost of modern fuel supply, measured at different nodes within the supply chain (i.e., port, transportation, etc.)	$/liter or $/kg	rural & urban	current & future	high
Other recurrent costs for modern fuel supply	Cost of any other recurrent activities associated with the supply of modern fuels (i.e., institutional, etc.)	$/household	rural & urban	current & future	high
Capital cost of sustainable production of biomass	Capital cost associated with the sustainable production of biomass	$/household	rural & urban	current & future	high
Recurrent (supply) cost of sustainable production of biomass	Recurrent cost associated with the sustainable production of biomass	$/household	rural & urban	current & future	high
Other recurrent costs for sustainable production of biomass	Cost of any other recurrent activities associated with the sustainable production of biomass	$/household	rural & urban	current & future	high
Capital cost of improved biomass cookstove	Capital cost of a typical improved biomass cookstove	$/unit or $/household	rural & urban	current & future	high
Recurrent (supply) cost of improved biomass cookstove	Recurrent cost associated with improved biomass cookstove	$/household	rural & urban	current & future	high
Other recurrent costs for improved biomass cookstove	Cost of any other recurrent activities associated with improved biomass cookstove	$/household	rural & urban	current & future	high
Electrification Data					
Capital cost of medium-voltage electricity line	Average capital cost associated with extending 1 km of medium-voltage electricity line	$/km	rural	current & future	high
Capital cost of a transformer	Cost of transformers for different kW needs	$/unit or $/village	rural	current & future	high
Last connection cost for institutions	Capital cost associated with connecting an institution to the local electricity distribution line (i.e., wiring, bulbs, etc.)	$/village or $/institution	rural & urban	current & future	high
Recurrent (supply) cost of electricity for institutions (given a connection to the grid)	Electricity tariff for institutions	$/kWh	rural & urban	current & future	high
Other recurrent costs for electrifying institutions	Cost of any other recurrent activities associated with electrifying an institution (i.e., O&M, billing, institutional, etc.)	$/village or $/institution	rural & urban	current & future	medium

	Last connection cost for households	Capital cost associated with connecting a household to the local electricity distribution line (i.e., wiring, bulbs, etc.)	$/household	rural & urban	current & future	high
	Recurrent (supply) cost of electricity for households (given a connection to the grid)	Lifeline electricity tariff for households	$/kWh	rural & urban	current & future	high
	Other recurrent costs for electrifying households	Cost of any other recurrent activities associated with electrifying a household (i.e., O&M, billing, institutional, etc.)	$/household	rural & urban	current & future	medium
	Capital cost of alternative technology for electrifying institutions	Capital cost of any alternative technologies for electrifying institutions (i.e., PV, mini-grid, etc.)	$/unit or $/institution	rural & urban	current & future	high
	Recurrent (supply) cost of electricity from alternative technology	Recurrent (supply) cost of electricity from alternative technology	$/kWh	rural & urban	current & future	high
	Other recurrent costs of electricity from alternative technology	Cost of any other recurrent activities associated with alternative technology (i.e., O&M, billing, institutional, etc.)	$/village or $/institution	rural & urban	current & future	high
	Capital cost of alternative technology for electrifying households	Capital cost of any alternative technologies for electrifying households (i.e., PV, mini-grid, etc.)	$/unit or $/household	rural & urban	current & future	high
	Recurrent (supply) cost of electricity from alternative technology	Recurrent (supply) cost of electricity from alternative technology	$/kWh	rural & urban	current & future	high
	Other recurrent costs of electricity from alternative technology	Cost of any other recurrent activities associated with alternative technology (i.e., O&M, billing, institutional, etc.)	$/household	rural & urban	current & future	high
Motive Power						
	Capital cost for motive power (given a connection to the grid)	Capital cost for providing motive power given a connection to the grid (i.e., equipment)	$/unit or $/village	rural	current & future	high
	Other recurrent costs of motive power (given a connection to the grid)	Cost of any other recurrent activities associated with providing motive power (i.e., O&M, billing, institutional, etc.)	$/village	rural	current & future	high
	Capital cost for motive power (given an alternative technology)	Capital cost for providing motive power by an alternative technology (i.e., MFP)	$/unit or $/village	rural	current & future	high
	Other recurrent costs of motive power (given an alternative technology)	Cost of any other recurrent activities associated with providing motive power by an alternative technology (i.e., O&M, billing, institutional, etc.)	$/village	rural	current & future	high

APPENDIX B: Senegal Country Case Study (in PowerPoint format)

See following page.

An Application of the Energy Costing Tool in Senegal

Jointly Sponsored by:

Sustainable Energy Programme
Bureau for Development Policy, UNDP

Regional Energy/Poverty Programme
Regional Bureau for Africa, UNDP

UN Millennium Project

Columbia University

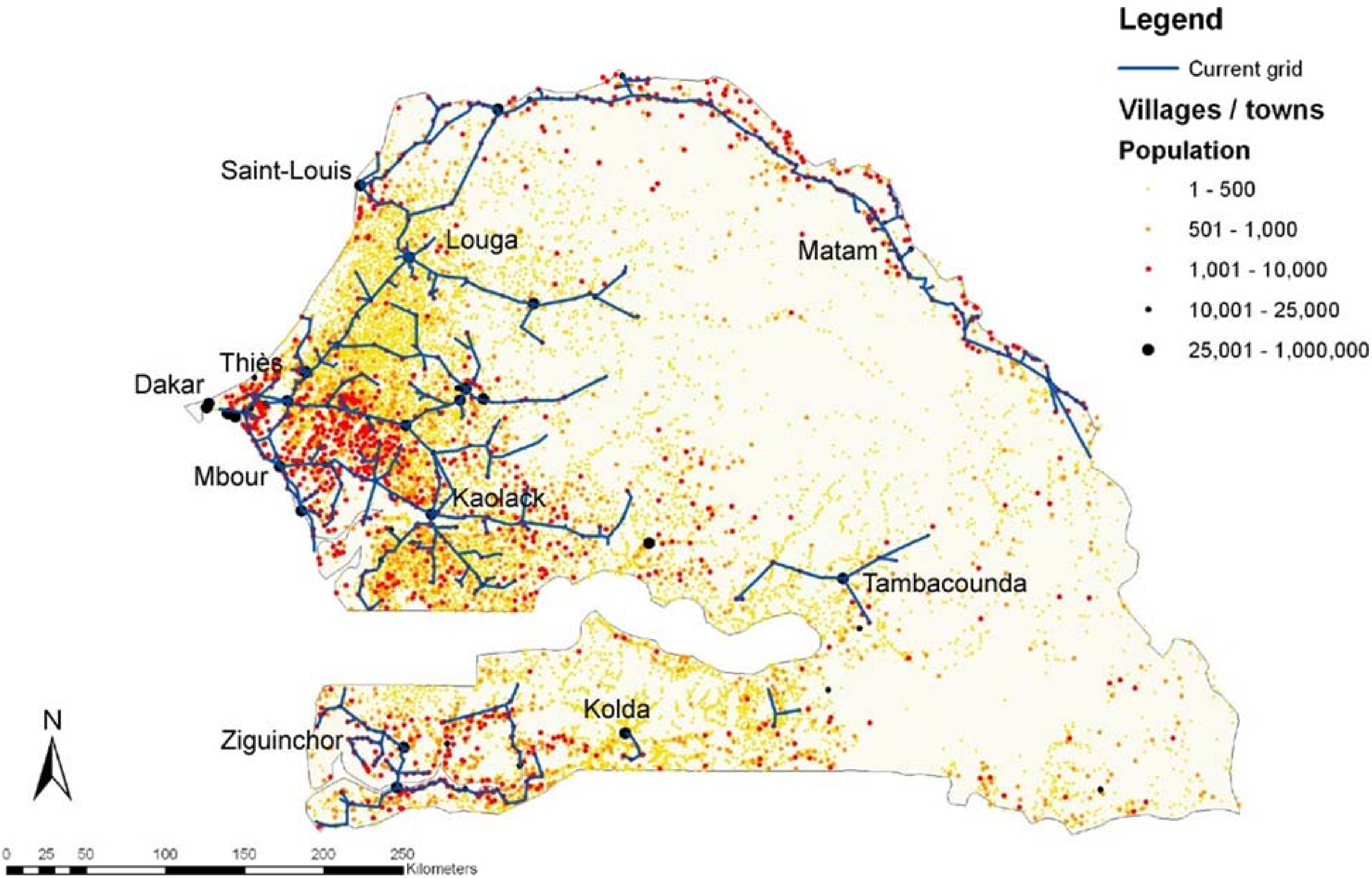
Contents

Objectives

- Estimate outlays needed to deliver energy services necessary to achieve the MDGs
  - Focus on needs-assessment across three service lines
    - Modern cooking systems
    - Electricity
    - Mechanical power for agro- and water processing
  - Calculate incremental as opposed to total resource needs

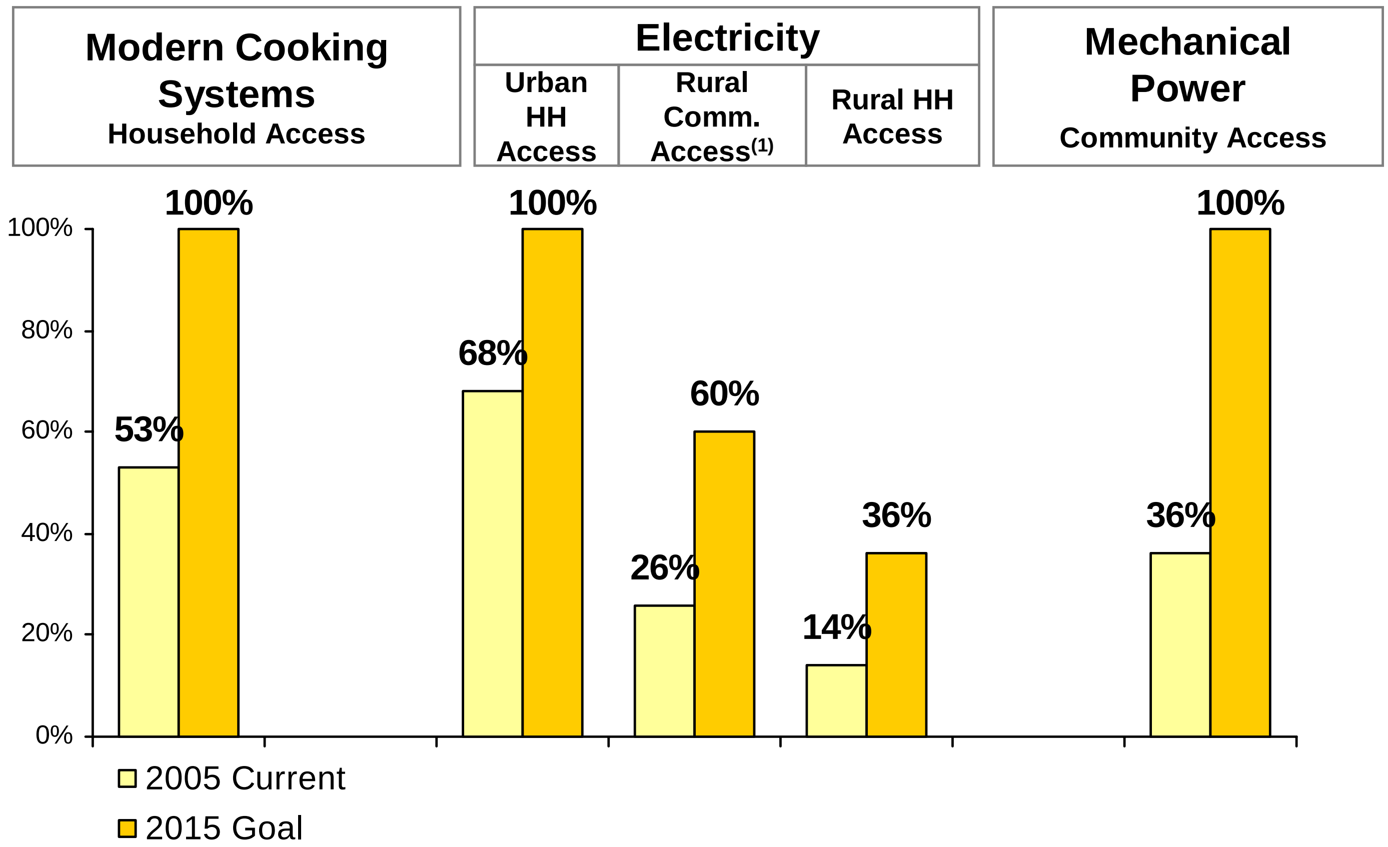
    !! Important: this differs from the Tool !!
- Apply methodology in a **country-specific** setting
  - As one of the first 8 countries chosen by the UNDP and the Millennium Development Project for a pilot needs assessment study, Senegal was used as a case study

Senegal- Population and Electricity Grid



Current Situation and Goals in Senegal

Current Access to Energy Services in 2005 and Goals for 2015

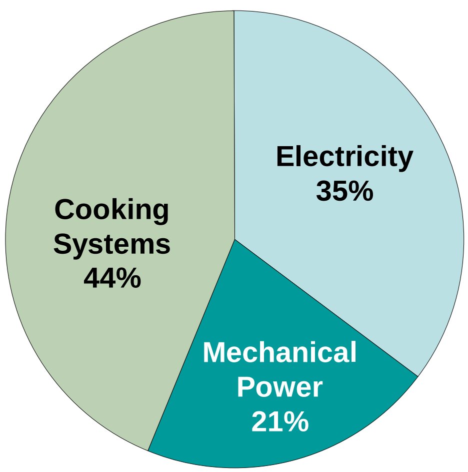


Note: (1) Community access is the percentage of households living in communities with electrified basic social services; with a 60% community access rate in Senegal, 100% of the population will live within 5km of an electrified community.

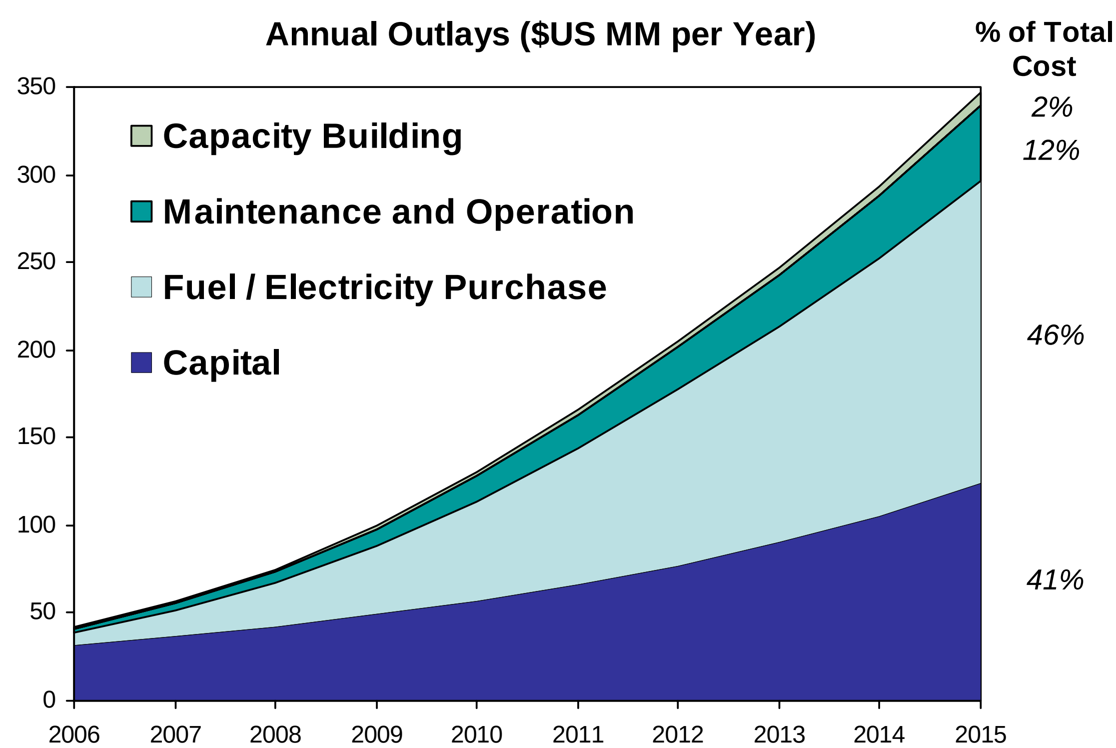
Energy Services Outlays for Senegal (I)

Total Outlay = $1.7 billion over 10 years

Total Outlay by Energy Service

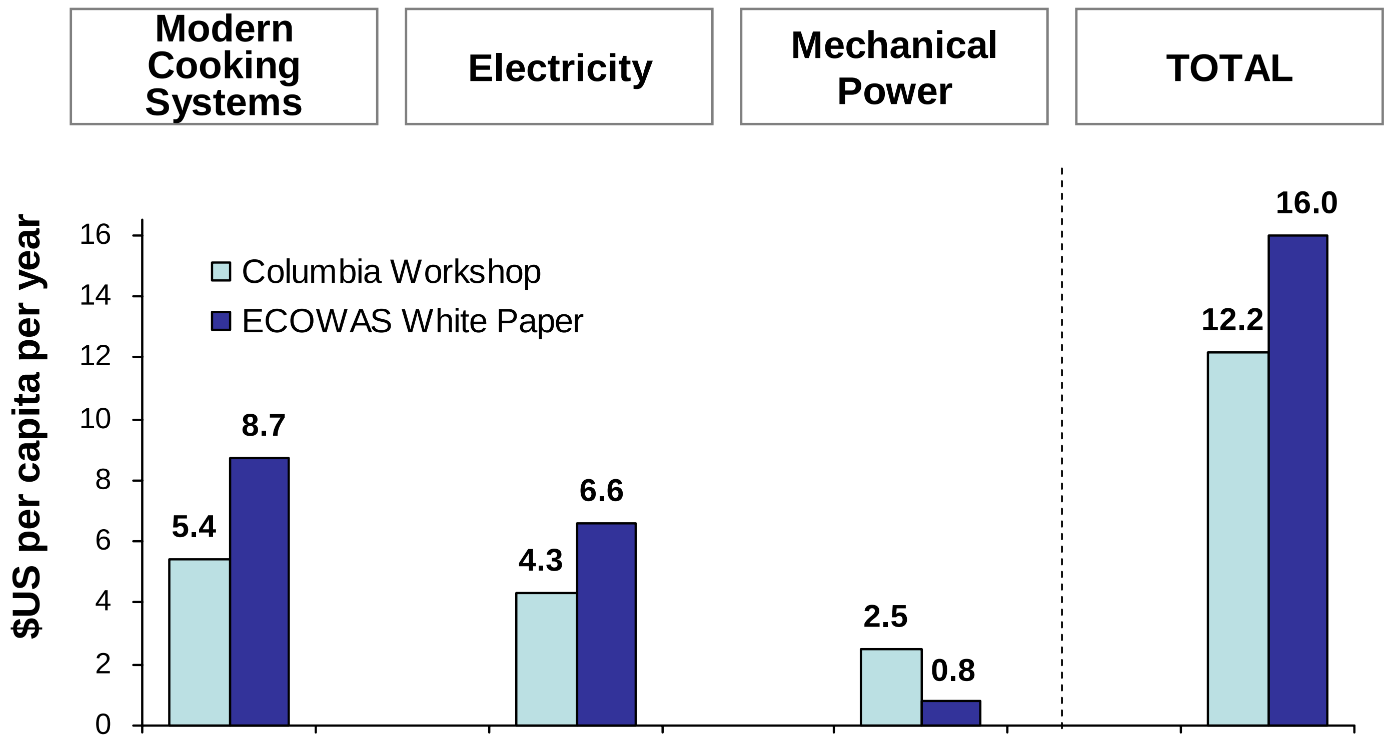


Annual Outlays ($US MM per Year)



Energy Services Outlays for Senegal (II)

$12 Annual per capita costs per year[(1)] in Senegal



Per capita costs are calculated on the basis of total estimated population in 2015

Methodology (I)

Preliminary Research → **Field Study** → **Analysis**

Preliminary Research

- Data gathering
- Understanding linkages between MDGs energy
  - Determining technology options

Field Study

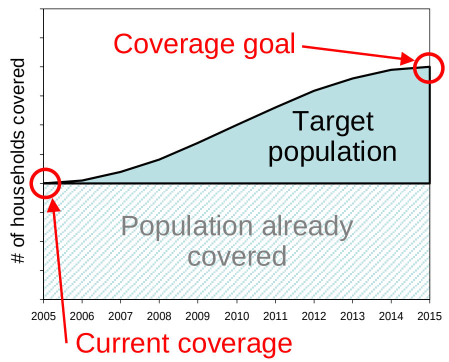
- Interviews in three communities
- Collected unit level costs
- Determined existing coverage levels
- Assessed community and HH needs

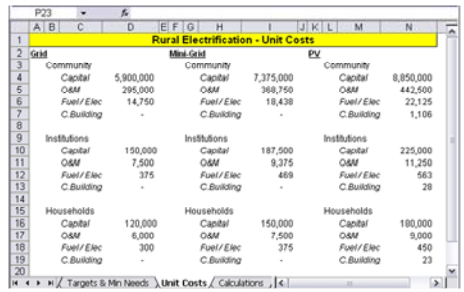
Analysis

- Identified target population
- Determined cost effective technology
  - Community size/density
- Determined scale up strategy
- Calculated total outlays by year to 2015

Methodology (II)

Target population	X	Unit costs	=	Total outlays

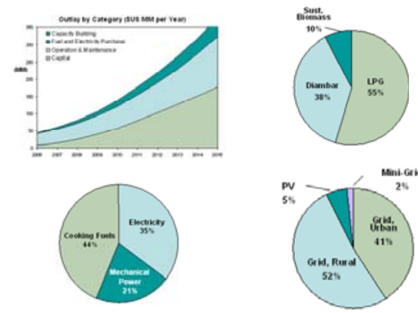




Rural Electrification - Unit Costs

Grid		Mini-Grid		PV	
Community		Community		Community	
Capital	5,900,000	Capital	7,375,000	Capital	8,850,000
O&M	295,000	O&M	368,750	O&M	442,500
Fuel / Elec	14,750	Fuel / Elec	18,438	Fuel / Elec	22,125
C.Building	-	C.Building	-	C.Building	1,106
Institutions		Institutions		Institutions	
Capital	150,000	Capital	187,500	Capital	225,000
O&M	7,500	O&M	9,375	O&M	11,250
Fuel / Elec	375	Fuel / Elec	469	Fuel / Elec	563
C.Building	-	C.Building	-	C.Building	28
Households		Households		Households	
Capital	120,000	Capital	150,000	Capital	180,000
O&M	6,000	O&M	7,500	O&M	9,000
Fuel / Elec	300	Fuel / Elec	375	Fuel / Elec	450
C.Building	-	C.Building	-	C.Building	23

Targets & Min Needs | Unit Costs | Calculations



- **Target population** = Total pop. covered – Pop. already covered

- Unit cost breakdown:
  – Service
  Cooking fuel, electricity, mech. power
  – Technology
  LPG, charcoal, sustainable biomass - Grid, mini grid, PV
  – Delivery point
  Community, institution, household
  – Cost category
  Capital, O&M, fuel/electricity purchase, capacity building

- Outlays computed as a function of:
  – Year
  – Service
  – Technology
  – Cost category
  – Rural / Urban

Assumptions and Limitations

- **Assumptions**
  - Calculates incremental as opposed to total resource needs !! Important: this differs from the Tool !!
  - Costs are the sum of undiscounted outlays
  - Assumes stable fuel prices over time
  - Supporting infrastructure required to deliver technologies was assumed to be available

- **Analysis does not consider**
  - Funding sources for the proposed plan
  - Topography
  - Benefits from the use of more efficient technologies
  - Institutional costs to develop national training programs

Cost Categories Analyzed

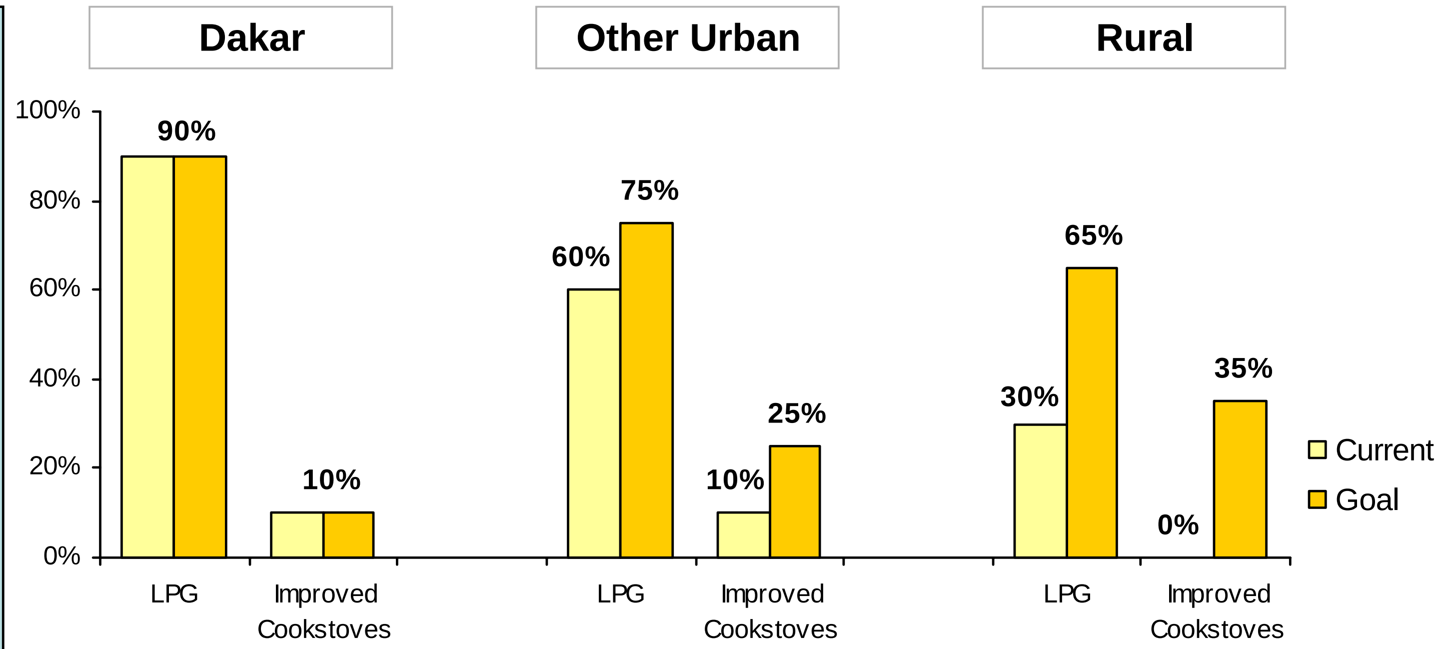
- **Capital equipment**
  - Including replacement where necessary
- **Fuel / electricity purchase**
  - All fuel costs
  - Grid electricity costs ($0.09/kWh, includes generation and HV transportation costs)
- **Operation and maintenance costs**
  - Includes billing costs
- **Capacity costs**
  - Promotional programs for Diambar stoves
  - Technical training on the use of machinery

Contents

Cooking Systems (I)

Current Situation / Goals

Coverage



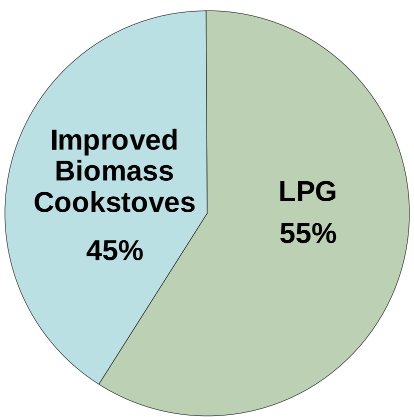
Technology Choices and Limitations

- Increase consumption of modern fuels to 76% of energy needs
- The increase in access will be achieved by implementing LPG cook systems and improved biomass cookstoves in equal proportions

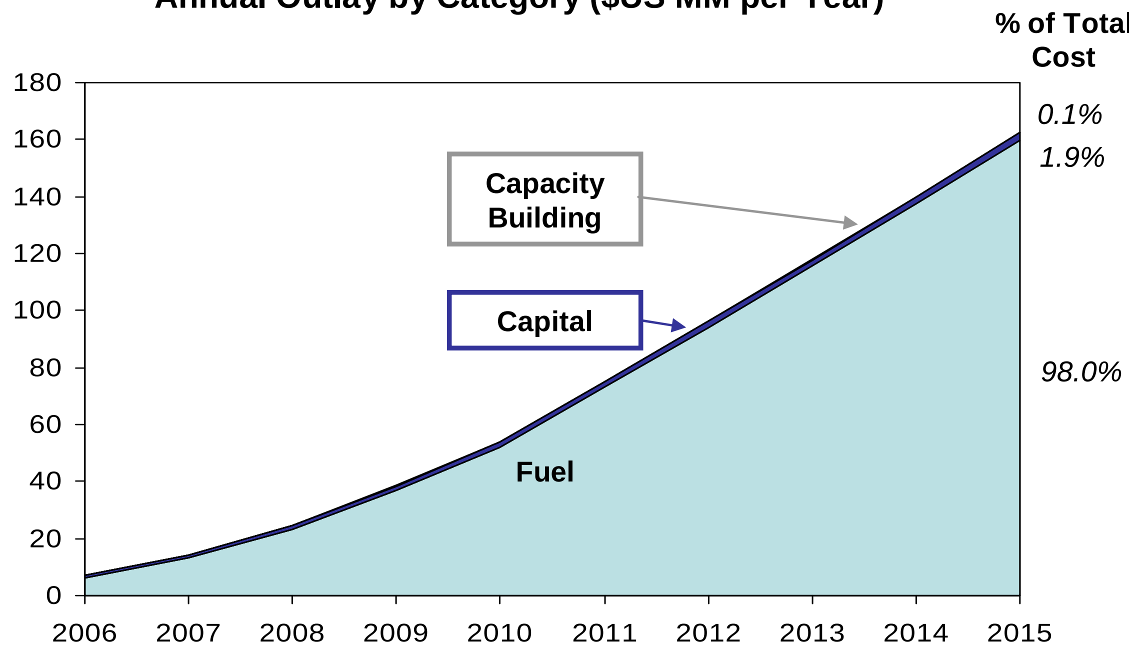
Cooking Systems (II)
Access Technology and Outlay Breakdown

Total Outlay = $730 million over 10 years

Total Outlay by Technology



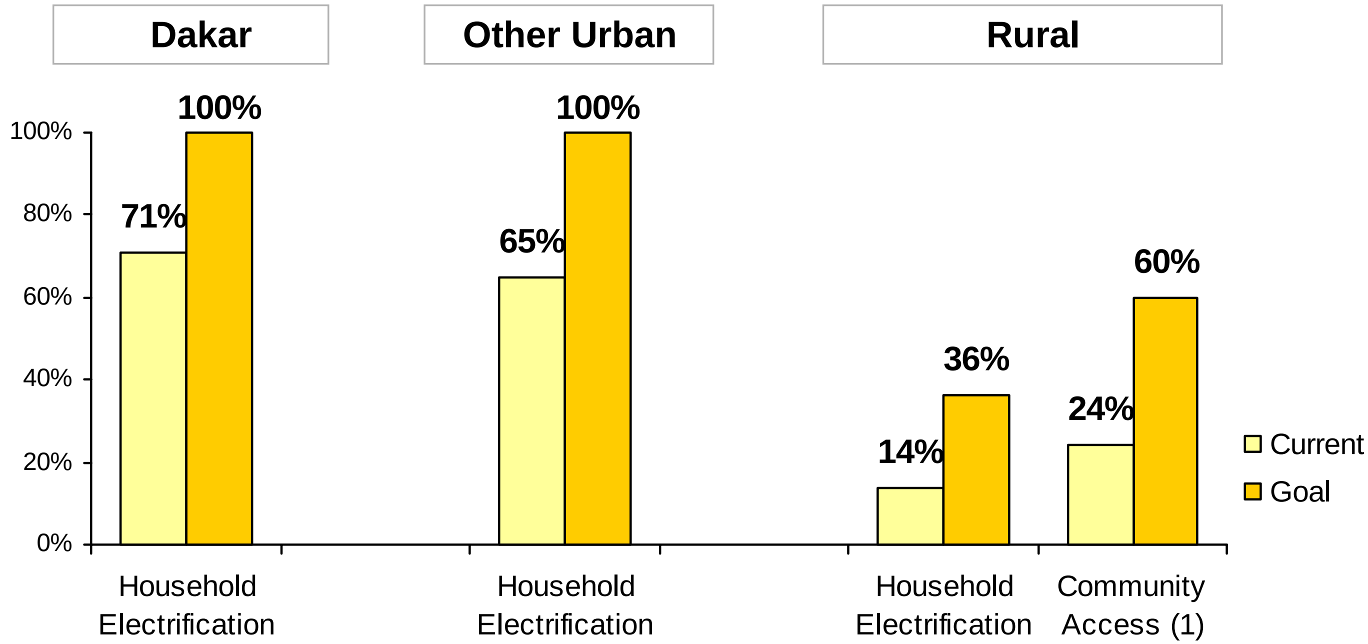
Annual Outlay by Category ($US MM per Year)



Electricity (I)

Current Situation / Goals

Coverage



Technology Choices and Limitations

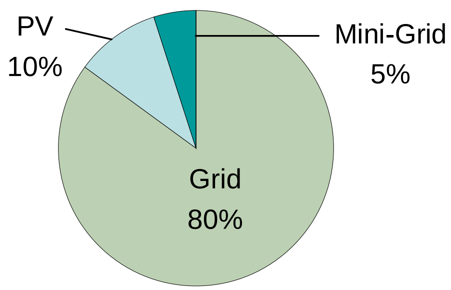
- Three technologies were chosen
  - Grid, diesel mini-grid and photovoltaic systems
- Increases in access will be accomplished by extending the national grid in areas where it is the most cost-effective solution, and implementing stand-alone systems elsewhere

Note: (1) Community access is the percentage of households living in communities with electrified basic social services. With a 60% community access rate in Senegal, 100% of the rural population will live within 5km of an electrified community.

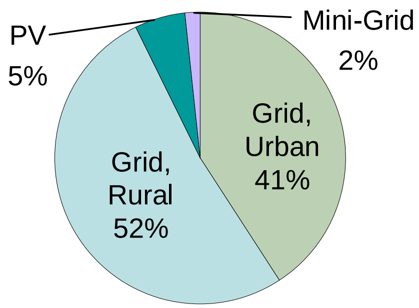
Electricity (II)
Access Technology and Outlay Breakdown

Total Outlay = $588 million over 10 years

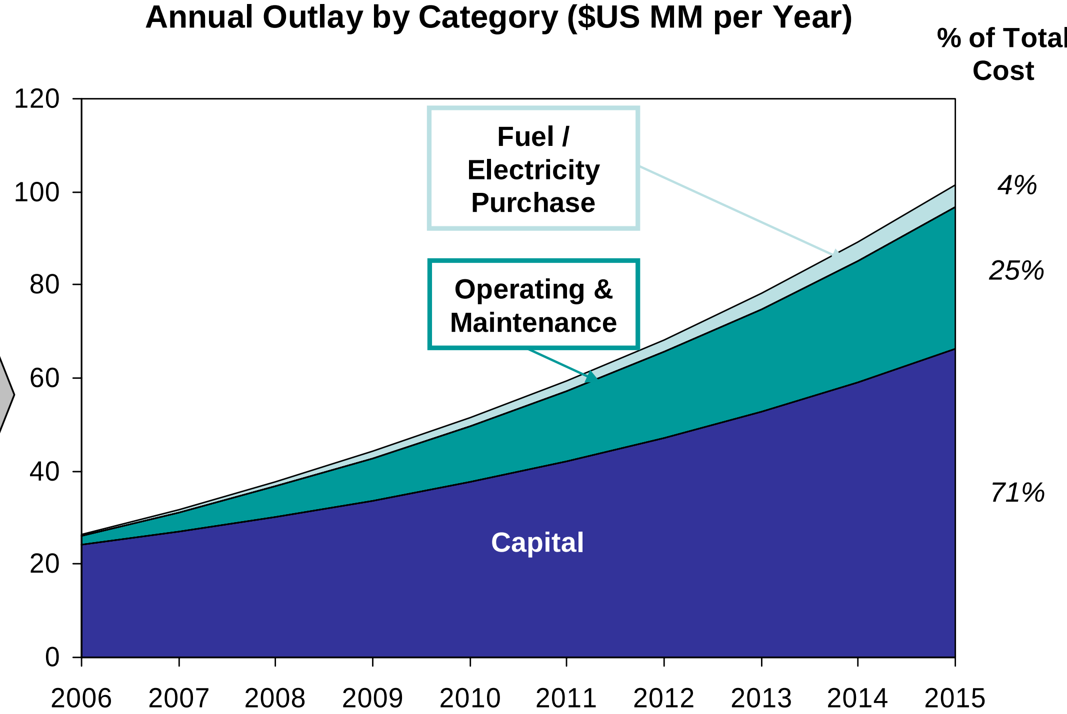
Rural Community Access by Technology



Total Outlay by Technology



Annual Outlay by Category ($US MM per Year)

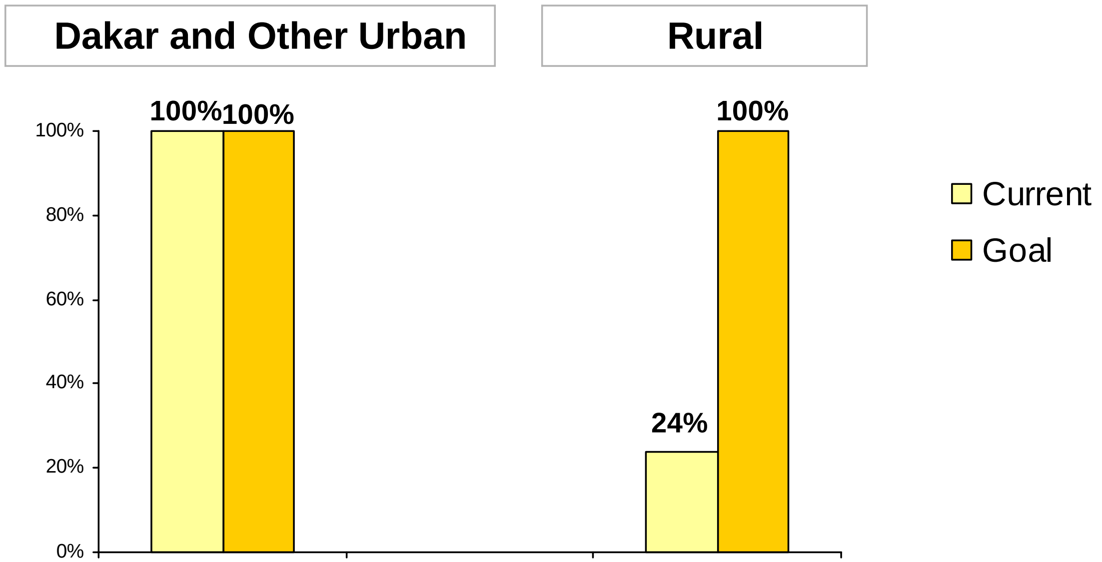


Note: An outlay of $588 million for an increase of the electrified population of 4.5 million people implies a cost of **$130** to electrify one person. IEA estimate for Africa is **$400** per capita, where large-scale transportation, generation and capacity costs (not included in this workshop) represent roughly $200.

Mechanical Power (I)

Current Situation / Goals

Coverage

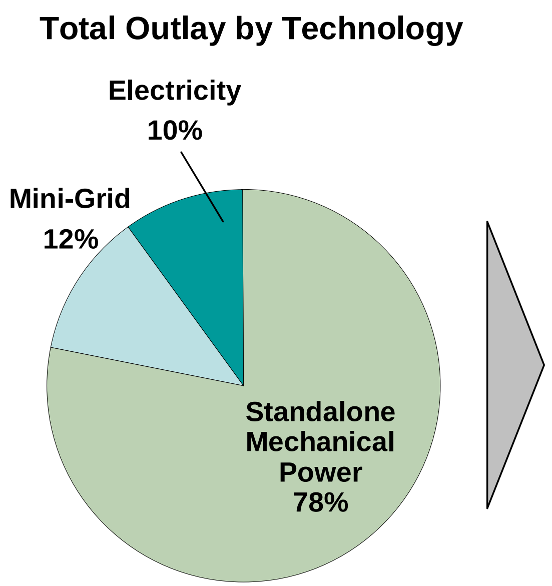


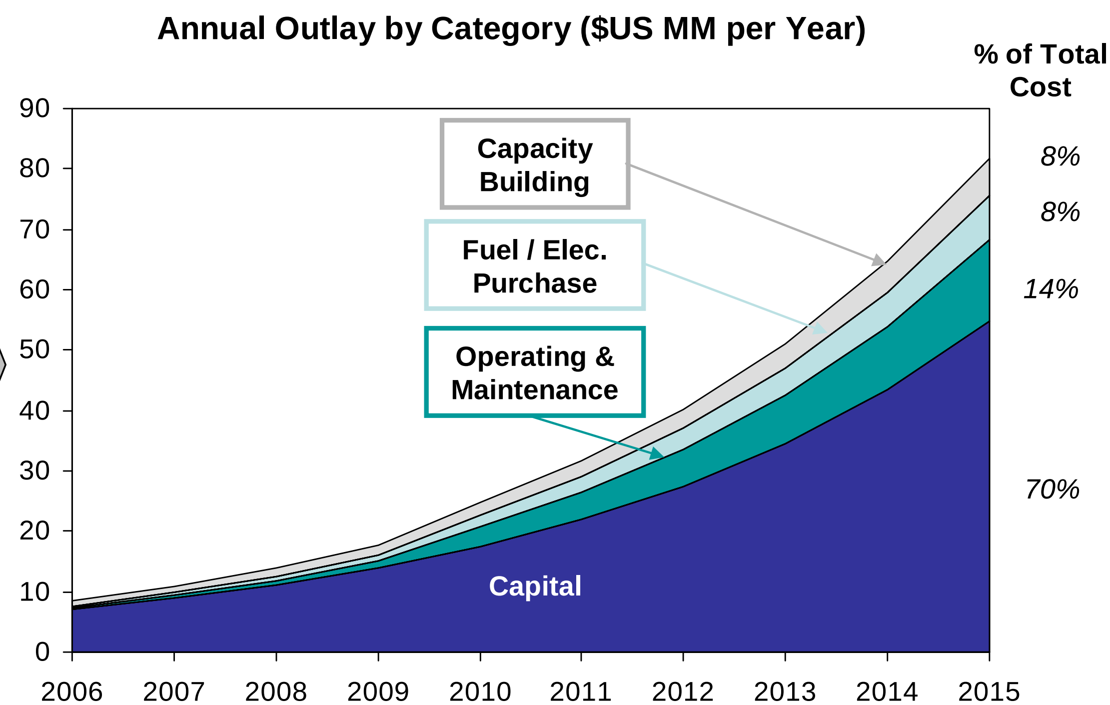
Minimum Needs, Technology Choices and Limitations

- All communities provided with mechanized agro-processing
- 100L of water per person for potable, animal and garden use
- Assumes all communities with grid access have mechanical power access
- Diesel Engine/Multi-Functional Platform: each module serves 500-1500 people
- Water processing includes only above ground technology

Mechanical Power (II)
Access Technology and Outlay Breakdown

Total Outlay = $345 million over 10 years





Contents

- Introduction
  - Objectives
  - Current Situation and Goals in Senegal
  - General Results
  - Overall Methodology
- Service Specific Results
  - Cooking Systems
  - Electricity
  - Mechanical Power
- **Conclusion**

How much will it Cost?

Increasing energy access in Senegal to meet the MDGs will cost an additional ***$1.7 billion*** *over ten years*

- **Access levels**
  - From 58% to 100% access to Cooking Systems
  - From 68% to 100% individual household access to electricity in urban areas
  - From 26% to 60%(1) community access to electricity in rural areas
  - From 14% to 36% household access to electricity in rural areas
  - From 36% to 100% access to mechanical power for agro and water processing
- The methodology is a **general tool** that can be used by other countries
  - Accuracy of results is highly dependent on the quality of population data available

Note: (1) Community access is the percentage of households living in communities with electrified basic social services.
With a 60% community access rate in Senegal, 100% of the population will live within 5km of an electrified community.