Energy Efficiency Roadmap for Uganda

Making Energy Efficiency Count

SUSTAINABLE ENERGY FOR ALL

MINISTRY OF ENERGY AND MINERAL DEVELOPMENT

POWER AFRICA

A U.S. GOVERNMENT-LED PARTNERSHIP

ENERGY EFFICIENCY ROADMAP FOR UGANDA

Making Energy Efficiency Count

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ABSTRACT

Like many countries in Sub-Saharan Africa, Uganda has focused its energy sector investments largely on increasing energy access by increasing energy supply. The links between energy efficiency and energy access, the importance of energy efficiency in new energy supply, and the multiple benefits of energy efficiency for the level and quality of energy available, have been largely overlooked. Implementing energy efficiency in parallel with expanding both the electricity grid and new clean energy generation reduces electricity demand and helps optimize the power supply so that it can serve more customers reliably at minimum cost. Ensuring efficient appliances are incorporated into energy access efforts provides improved energy services to customers. Energy efficiency is an important contributor to access to modern energy.

This Energy Efficiency Roadmap for Uganda (Roadmap) is a response to the important role that electrical energy efficiency[5] can play in meeting Uganda's energy goals. Power Africa and the United Nations Sustainable Energy for All (SEforALL) initiatives collaborated with more than 24 stakeholders in Uganda to develop this document. The document estimates that if the most efficient technologies on the market were adopted, 2,224 gigawatt hours could be saved in 2030 across all sectors, representing 31% of the projected load. This translates into 341 megawatts of peak demand reductions, energy access to an additional 6 million rural customers and reduction of carbon dioxide emissions by 10.6 million tonnes in 2030. The Roadmap also finds that 91% of this technical potential is cost-effective, and 47% is achievable under conservative assumptions.

The Roadmap prioritizes recommendations for implementing energy efficiency and maximizing benefits to meet the goals and priorities established in Uganda's 2015 SEforALL Action Agenda. One important step is to create and increase demand for efficiency through long-term enabling policies and financial incentives combined with development of technical expertise in the labor force to allow for the promotion of new business models, such as energy service companies. A combination of enabling policies, financial schemes, regulations, enforcement, and skill development are needed to open the energy efficiency market.

[5] Efficiency opportunities in the transportation sector and other fuels (e.g., biomass, kerosene) are outside the Roadmap scope. Authors identify this as an area of needed focus for future research.

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ACRONYMS

AFD	Agence Française de Développement
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BCR	Benefit-cost ratio
BEE	Bureau of Energy Efficiency
BUDS-ERT	Business Uganda Development Scheme Energy for Rural Transformation
BREEAM	BRE Environmental Assessment Method
c	Cent
CADLF	Coincident after diversity load factor
CCE	Cost of conserved energy
CFL	Compact fluorescent light
CLASP	Collaborative Labeling and Appliance Standards Program
CO_2	Carbon dioxide
CREEC	Centre for Research in Energy and Energy Conservation
DC	Designated consumer
DSM	Demand-side management
EAC	East African Community
EACREEE	East African Centre for Renewable Energy and Energy Efficiency
ECBC	Energy Conservation Building Code
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Regional Centre for Renewable Energy and Energy Efficiency
EECB	Energy Efficiency and Conservation Bill
EEDSM	Energy efficiency demand-side management
EEI	Energy efficiency indicator
EERF	Energy efficiency revolving fund
EESL	Energy efficiency services limited
EETMS	Energy efficiency target monitoring system
ELI	Efficient lighting initiative
EMS	Energy management system
EPC	Energy performance certificate
ERA	Electricity Regulatory Authority
ERT	Energy for Rural Transformation
ESCO	Energy service company
ESMAP	Energy Sector Management Assistance Program
EU	European Union
EVO	Efficiency Valuation Organization
GEF	Global Environment Facility
GET FiT	Global Energy Transfer Feed-in-Tariff
GHG	Greenhouse gas
GHS	Ghanaian Cedis
GIZ	Gesellschaft für Internationale Zusammenarbeit
Global LEAP	Global Lighting and Energy Access Partnership
GOGLA	Global Off-Grid Lighting Association
GWh	Gigawatt hours
HVAC	Heating, ventilation, and air conditioning
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
IGG	Inclusive green growth
IPMVP	Internal performance measurement and verification protocol

IPP	Independent power producer
ISO	International Standards Organization
KCCA	Kampala Capital City Authority
KfW	Kreditanstalt für Wiederaufbau
kVArh	Kilo-volt amps reactive hours
kWh	Kilowatt hour
M&V	Measurement and verification
MW	Megawatt
LBNL	Lawrence Berkeley National Laboratory
LCOE	Levelized cost of electricity
LED	Light-emitting diode
LEED	Leadership in Energy & Environmental Design
LTA	Long-term agreement
M	Million
MCDA	Multi-criteria decision analysis
MEMD	Ministry of Energy and Mineral Development
MEPS	Minimum energy performance standard
MLHUD	Ministry of Lands, Housing & Urban Development
MoFPED	Ministry of Finance, Planning and Economic Development
MoLG	Ministry of Local Government
MOU	Memorandum of understanding
MTIC	Ministry of Trade, Industry, and Cooperatives
MVA	Megavolt ampere
MW	Megawatt
MWT	Ministry of Works and Transport
NPV	Net present value
O&M	Operations and maintenance
OECD	Organization for Economic Cooperation and Development
PREEEP	Promotion of Renewable Energy and Energy Efficiency Programme
PSDO	Power Sector Development Operation
PSFU	Private Sector Foundation Uganda
PSIP	Power Sector Investment Plan
QA	Quality Assurance
RAP	Regulatory Assistance Project
REA	Rural Electrification Agency
RESP	Rural Electrification Strategy Plan
Rs	Rupees
S&L	Standards and labeling
SEAD	Super-Efficient Equipment and Appliance Deployment
Shs	Shillings
SEforALL	Sustainable Energy for All
SHS	Solar home system
Sida	Swedish International Development Agency
SMEs	Small and medium enterprises
SOP	Standard offer program
SUNREF	Sustainable Use of Natural Resources and Energy Finance
T&D	Transmission and distribution
t	Tonne
tce	Tonnes carbon equivalent
TOU	Time of use
TV	Television

UCPC	Uganda Cleaner Production Center
UEB	Uganda Electricity Board
UECCC	Uganda Energy Credit Capitalization Company Limited
UEDCL	Uganda Electricity Distribution Company Limited
UEEA	Uganda Energy Efficiency Association
UEGCL	Uganda Electricity Generation Company Limited
UETCL	Uganda Electricity Transmission Company Limited
UK	United Kingdom
UMA	Uganda Manufacturing Association
UNBS	Uganda National Bureau of Standards
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNREEA	Uganda National Renewable Energy and Energy Efficiency Alliance
UNIDO	United Nations Industrial Development Organization
URA	Uganda Revenue Authority
U.S. DOE	United States Department of Energy
U.S. EPA	United States Environmental Protection Agency
USSIA	Uganda Small Scale Industries Association
WB	World Bank
WRI	World Resource Institute

1. EXECUTIVE SUMMARY

Key Findings:

- Scaling up energy efficiency investments in Uganda requires a combination of enabling policies that include regulations, enforcement, target setting, and financial schemes combined with development of technical expertise in the labor force and promotion of new business models, such as energy service companies.
- The technical potential analysis indicates that with available technology and best practice, 2,224 gigawatt hours can be saved in 2030 across all sectors, representing 31% of the forecasted load. This translates into 341 megawatts of peak demand reduction, representing 2.5 times the demand that will be supplied by the Isimba dam.
- Including energy efficiency in the national planning process could increase energy access to 6 million rural customers and reduce carbon dioxide (CO_2) emissions by 10.6M tonnes by 2030. Annual emissions reductions in 2030 represent 6% of the country's Nationally Determined Contribution pledge under the Paris 2015 United Nations Climate Change agreement.
- Approximately 91% of the technical potential is cost effective (7% discount rate), and 47% is achievable under conservative assumptions (20% discount rate and benefit-cost ratio greater than two).
- The main barriers to energy efficiency investment in Uganda consist of a lack of access to affordable capital and financing, a lack of confidence about energy efficiency investments, a lack of enabling policies, a lack of enforcement of regulations, and a lack of technical expertise.
- Based on a multi-criteria decision analysis (MCDA) tool, priority programs to implement were found to be: enacting the Energy Efficiency and Conservation Bill, prioritizing energy efficiency in integrated resource planning, developing regulations for energy audits and energy management systems for large energy users, and enforcing the existing standards and labeling (S&L) program.
- Next priority programs include: expanding the S&L program, setting industry targets, encouraging the market for efficient products, and encouraging energy efficiency in small and medium enterprises.
- Additional programs to implement include: developing training and accreditation schemes, developing building codes, recognizing champions of energy efficiency, developing financing schemes through an energy efficiency and conservation fund, encouraging development of clean industry, promoting building disclosure and benchmarking, developing government lead-by-example programs, and developing cities' and municipal councils' energy efficiency action plans.
- The implementation costs for these programs were estimated to approximate the cost to government, which is one of the MCDA tool criteria. The annual budget per recommendation ranges from US$1,000 to US$231,000, and averages US$107,000.

Uganda is experiencing economic growth and rapid urbanization, which are driving a steady increase in energy demand. Electricity demand is increasing at a rate of 8.2% annually, which translates to 125,000 new customers every year. Power generation capacity tripled over 13 years to an estimated 900 megawatts (MW) in 2015. This swift expansion has been fueled by a dynamic economy that is growing at an average annual rate of 7%, placing Uganda among the fastest-growing economies in the world.

Expanding rural access to electricity is another important factor driving demand. An estimated 74% of Uganda's population currently does not have an electricity grid connection, household solar, or diesel generator. By 2030 it is estimated that the demand of the grid-connected residential sector will have grown by more than 250% from current levels. The key driver of this increase is rural and urban electrification, which is supported by the aggressive goals of the *Ugandan Government National Development Plan* (Uganda Government NDPII, 2015).

Investment in Uganda's energy sector has focused mainly on increasing energy access by increasing supply. The links between energy efficiency and energy access, and the multiple benefits of energy efficiency for the level and quality of energy available, have been largely overlooked by many stakeholders in Uganda, including the international donor community. Energy efficiency and energy access are sometimes viewed as competing priorities for funding rather than elements that can work together to achieve the goal of providing improved access to energy services. Moreover, energy efficiency is often perceived as a short-term solution to power outages and load shedding without taking into account that it is also a source of energy for future electricity planning.

As recognized in the Sustainable Energy for All (SEforALL) objectives, energy efficiency is a core element of ending energy poverty and securing access to affordable, reliable, sustainable, and modern energy. Implementing energy efficiency in parallel with expanding both the electricity grid and new clean energy generation reduces electricity demand and helps optimize the power supply so that it can serve more customers reliably at minimum cost. Adopting efficient technology and appliances along with informed energy management practices allows rapid scaling up of energy efficiency to ease power constraints and lower utility bills for both the public and private sectors while supporting a sustainable framework for long-term energy stability.

The benefits of energy efficiency are numerous. Energy efficiency contributes to reducing power plant fuel inputs and thereby reducing costs of power generation, reducing harmful pollution, mitigating climate change, and enhancing energy security. Even more important for developing economies, energy efficiency allows deferral of costly investment in new power generation, thus contributing to reducing the cost of electricity. Energy efficiency is also a critically important component of increasing access to modern energy services. By enabling consumers to use less electricity to operate appliances and equipment, energy efficiency frees up electricity that can be used for accessing additional services. However, harnessing energy efficiency is a complex endeavor that requires first assessing the energy efficiency potential across sectors of the economy and identifying programs and policies that help remove market barriers to private investment in energy efficiency.

1.1 PURPOSE OF THE ENERGY EFFICIENCY ROADMAP FOR UGANDA

This Energy Efficiency Roadmap for Uganda (Roadmap) is a response to the important role that electric energy efficiency can play in meeting Uganda's energy goals. Power Africa and the United Nations SEforALL Initiative collaborated with more than 24 stakeholders in Uganda to develop this document. The Roadmap prioritizes recommendations for implementing energy efficiency and maximizing benefits to meet the goals and priorities established in Uganda's 2015 SEforALL Action Agenda and the SEforALL Investment Prospectus (SEforALL, 2015; 2016a). Like many countries that have joined SEforALL, Uganda developed an Action Agenda to outline milestones through 2030 for building the three main energy pillars of sustainable development: energy access, energy efficiency, and renewable energy. The Action Agenda identifies priorities and challenges, and this Roadmap provides additional detail on electrical energy efficiency opportunities along with support for designing and implementing policies and programs that will meet the SEforALL energy-saving goals. The Roadmap focuses on electrical energy efficiency; efficiency opportunities in the transportation sector and those associated with other fuels (e.g., biomass, kerosene) are outside the scope. The authors identify these as needed areas of focus for future research.

The Roadmap assesses in detail Uganda's electricity market and experience with energy efficiency programs (*Situation Assessment*), explains the potential for electrical energy savings (*Electricity Savings Potential*), and recommends actionable steps to advance energy efficiency (*Energy Efficiency Action Plan*).

1.2 SITUATION ASSESSMENT: BUILD ON SUCCESS AND ADDRESS BARRIERS TO ENERGY EFFICIENCY

Uganda has successfully evolved its power sector so that, today, power generation, transmission, and distribution have been unbundled, and roles and responsibilities are well-defined among different entities, including an independent regulating agency, the Electricity Regulatory Authority (ERA).

Recent success in attracting private investment to develop new power capacity is evident in the Bujagali hydropower plant (250 MW), which is currently meeting 49% of the country's electricity needs. Additional planned capacity includes the construction on the River Nile of the Karuma and Isimba dams (783 MW, December 2018) and Ayago dam (840 MW, 2022) to produce hydro-electricity. Moreover, Uganda launched an innovative feed-in tariff program, the Global Energy Transfer Feed-in-Tariff (GET FiT), to fast-track the development of 170 MW of smaller, renewable energy investments.

However, additional capacity comes at a hefty cost. On average, the investment cost per MW is US$2.6M. The Bujagali plant produces electricity at a cost of US$0.11 per kilowatt hour (kWh). This cost does not account for the cost of transmission and distribution to deliver electricity to end-users. Uganda's electricity household tariffs are currently US$0.18 per kWh, making energy efficiency a very attractive investment.

Despite the apparent business case for energy efficiency, a significant share of the potential to improve energy efficiency in Uganda remains untapped, and the level of investment in energy efficiency generally remains low. Barriers to energy efficiency investments are summarized in Table 1-1.

Table 1-1. Barriers to Energy Efficiency in Uganda

	Barriers	Description	Remedy/Opportunity
Regulatory	**Lack of policies and regulations to enforce energy efficiency**	Processes and procedures to enforce and prioritize energy efficiency requirements have not been put in place.	Enactment of the Energy Efficiency and Conservation Bill is needed to provide the legal basis for the elaboration and enforcement of the national policy.
Regulatory	**Lack of prioritization of investment in energy efficiency**	Although energy efficiency is recognized as a resource to meet energy demand (NDPII, 2015), it is not yet prioritized in investment decisions.	▪ Integrate energy efficiency in resource planning ▪ Mandate that large energy users invest in energy efficiency ▪ Regulate products sold in the market
Informational	**Limited information and knowledge about the benefits of energy efficiency**	Those making purchasing decisions do not have information about the energy performance of technologies, and there is an inadequate awareness of the benefits of energy efficiency investment.	Develop programs to inform the private sector in investment decisions: ▪ Labeling of appliances ▪ Awareness campaigns ▪ Incentivized audits ▪ Recognition awards ▪ Best practices ▪ Training
Informational	**Inadequate technical expertise**	Expertise on energy efficiency opportunities and benefits assessments is currently inadequate.	▪ Build capacity and create certification schemes to develop an established professional community ▪ Collaborate with UNBS and ECREEE* to establish a testing facility to enforce market verification
Economic and Financial	**Lack of access to affordable capital and financing**	Uganda is among the countries with the highest cost of financing in the world. Uganda ranks 121 (out of 144 countries) by affordability of financial services. In comparison, Kenya and Rwanda rank 64 and 56, respectively (World Bank, 2015 a). Moreover, commercial banks do not have experience with financing energy efficiency projects and do not fully understand the profitability of energy efficiency loans.	▪ Provide affordable financing for energy efficiency investment ▪ Support financial intermediaries to invest in energy savings opportunities ▪ Support financing access to energy service companies ▪ Establish funding for energy efficiency investments by leveraging funding from public (government and development partners) and private stakeholders ▪ Develop guarantee fund to cover for deflationary risk

*UNBS – Uganda National Bureau of Standards; ECREEE - Economic Community of West African States Regional Centre for Renewable Energy and Energy Efficiency

Uganda has had success in implementing energy efficiency programs during the past 10 years. A compact fluorescent light (CFL) distribution program reduced power demand by 32 MW at an investment of US$0.05M per MW, which is more than 50 times cheaper than investing in a new baseload hydropower plant. The World Bank (WB)-funded Power Factor Correction Program reduced demand by 8.6 MW and helped stimulate the creation of energy efficiency consulting companies in Uganda. Recently, ERA allocated US$4.1M toward demand-side management (DSM)[6] programs and developed a DSM plan that currently includes light-emitting diode (LED) procurement and distribution, a time-of-use (TOU) tariff program, and a public awareness campaign for energy efficiency.

Two programs that have not yet been fully successful but have the potential to succeed are appliance standards and labeling (S&L) and implementation of energy audit recommendations. If enforced, appliance standards could substantially improve energy efficiency. Similarly, implementation of energy efficiency recommendations from energy audits has been limited because of lack of access to affordable financing options as well as lack of confidence in the predicted energy savings.

1.3 ELECTRICITY SAVINGS: ASSESS THE POTENTIAL

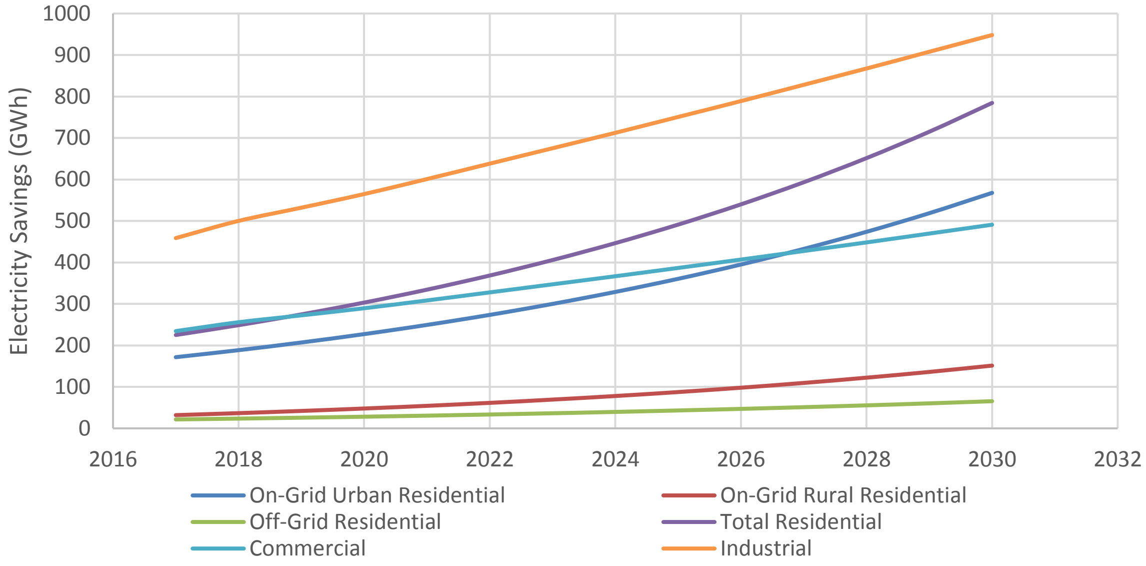
The energy efficiency opportunities recommended in this Roadmap were developed based on an assessment that started with a set of representative energy efficiency measures that are broadly suitable for application in developing world markets. These measures apply to electricity usage within the residential, commercial, and industrial sectors. As noted previously, the Roadmap focuses exclusively on electrical efficiency upgrades, so measures such as fuel switching to biomass or natural gas have not been considered. The technologies considered for this assessment were selected based on information and data gathered from research and stakeholder collaboration. Based on the energy efficiency measures considered, three levels of potential were calculated: technical, economic, and achievable economic.

The Roadmap assessment indicates a significant opportunity for energy efficiency to mitigate growing levels of electricity consumption and demand in Uganda. Considering available technology and best practice, our analysis of the estimated technical potential for savings in the year 2030 indicates that 2,224 gigawatt hours (GWh) of meter-level consumption can be saved across all sectors (see Figure 1-1), which is equivalent to 31% of the forecasted load. The consumption savings from energy efficiency also translate into peak demand savings and thus the ability to provide electricity to more consumers without the need for additional power plants. It is estimated that energy efficiency improvements can save 341 MW of on-grid meter-level peak demand and an additional 15 MW of off-grid demand. Assuming the current transmission and distribution loss rate of 22.8%, energy efficiency can offset 442 MW of generation-level demand, which is nearly 2.5 times the demand that will be supplied by the Isimba dam (183 MW). Demand projections show no sign of declining in the short term, so energy efficiency offers an opportunity to extract the maximum value from each power generation facility. In total, an estimated 10.6 million

[6] DSM refers to energy demand reductions through efficiency improvements or load shifting on the customer side of the electrical meter.

tonnes of carbon dioxide (CO_2) emissions can be avoided through the implementation of energy efficiency measures.

Figure 1-1. Electricity Consumption Technical Potential per Sector in Uganda, 2017-2030 Including Residential Subsectors

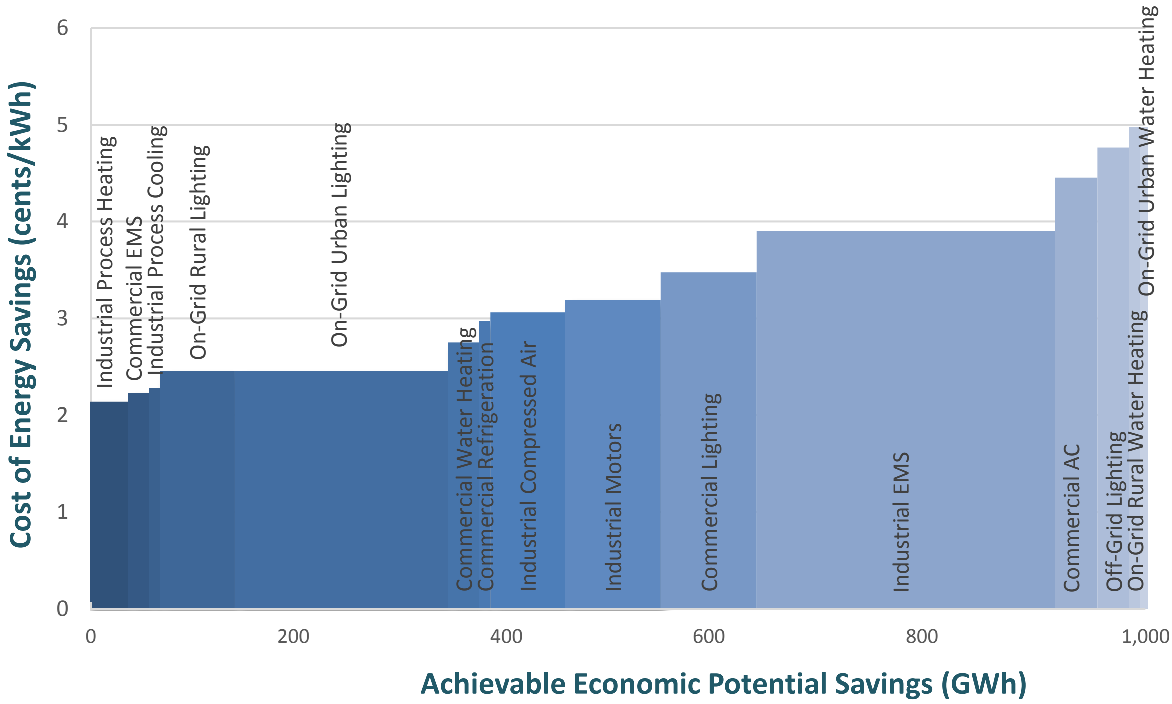


It is important to not overlook the large opportunity for energy efficiency to help manage load growth so that additional electricity capacity that is added can be used to increase access for new customers. Assuming a total electricity consumption of 1,060 kWh per year per urban customers and 369 kWh per year per on-grid rural customers (Parsons Brinckerhoff, 2011), the on-grid efficiency savings in 2030 could allow grid access through grid extension to an estimated additional 2.1M urban customers, or 6M rural customers, without the need for additional generation. In other words, including efficiency in the national planning process could mean adding 6M rural customers without the need for new generation, at a cost that is likely to be lower than the cost of building additional grid supply capacity.

Out of the 2,224 GWh of technical potential, approximately 91% is included in the economic potential (2,022 GWh), and 47% is included in the achievable economic potential (1,052 GWh, medium case). This provides strong support for the cost-effectiveness of energy efficiency improvements in Uganda and reveals a significant opportunity for energy efficiency to benefit the economy. Figure 1-2 shows a breakdown of the top opportunities, prioritized by end-user cost of conserved energy (CCE). Highly cost-effective opportunities are found in a multitude of sectors and end-uses, including on-grid residential lighting, commercial water heating, and industrial motors. The largest opportunity is the implementation of energy audits coupled with energy management systems (EMSs) in the industrial sector. The magnitude of this opportunity strongly supports the prioritization that these systems have been given in the current draft Energy Efficiency and Conservation Bill. An uncertainty analysis of the achievable economic potential indicates that even with conservative savings estimates, energy efficiency is still capable of saving 663 GWh of electricity by 2030. This equates to approximately 16% of the anticipated load growth over the next 13 years, emphasizing that, even under unfavorable estimates, energy efficiency can make a significant contribution to meeting Uganda's power needs for years to come.

Figure 1-2. Top Measures for Achievable Economic Potential, Medium Case

Prioritized by End-User Cost of Conserved Energy



1.4 ENERGY EFFICIENCY ACTION PLAN: PRIORITIZE ACTIONS

Achieving the many benefits of energy efficiency requires bundling a package of policy instruments that best address the market failures hindering energy efficiency investment. Energy efficiency opportunities tend to be distributed across all sectors of the economy and among many technologies and practices. Policy makers have three basic types of policy tools available to address barriers to energy efficiency: regulations, knowledge diffusion, and financial incentives. A combination of these tools along with targets and continuous monitoring often best accelerates energy efficiency improvement. This Roadmap builds on these basic policy tools to recommend *building blocks* for energy efficiency: energy performance standards, target setting, information diffusion, capacity building, public awareness, and financing support.

Policy and program recommendations are provided for each sector of the economy based on the situation assessment, analysis of potential savings and international best practices. Each recommendation is discussed in detail, and actionable steps are identified for optimum implementation. The actionable steps are also used to estimate the government’s cost of implementation.

Based on a multi-criteria decision analysis (MCDA), programs and policies were prioritized to form a Roadmap of energy efficiency program recommendations according to five criteria:

- Energy savings
- First cost to government
- Speed of implementation
- Prerequisite to other measures
- Multiple benefits

The resulting Roadmap is shown in Figure 1-3. The priority programs are those dictated by the Energy Efficiency and Conservation Bill because their implementation creates the basis for further initiatives by establishing the regulatory frameworks, data systems, and stakeholder relationships needed to carry out successful energy efficiency programs.

The priority cross-cutting program recommendation is enacting the Energy Efficiency and Conservation Bill. Integrating energy efficiency into resource planning constitutes the next priority because this will ensure that energy efficiency opportunities are considered in future investment decisions, on an equal basis with supply options. The S&L program is the next cross-cutting priority recommendation. This program is at an advanced stage of development and only lacks the enforcement necessary to make it very impactful. Moreover, S&L are prerequisite to many additional programs that require equipment energy performance identification. The final cross-cutting priority is the creation of an Energy Efficiency and Conservation Fund, which is critical to supporting energy efficiency incentives and investments by Ugandan businesses; the fund requires substantial resources to be developed.

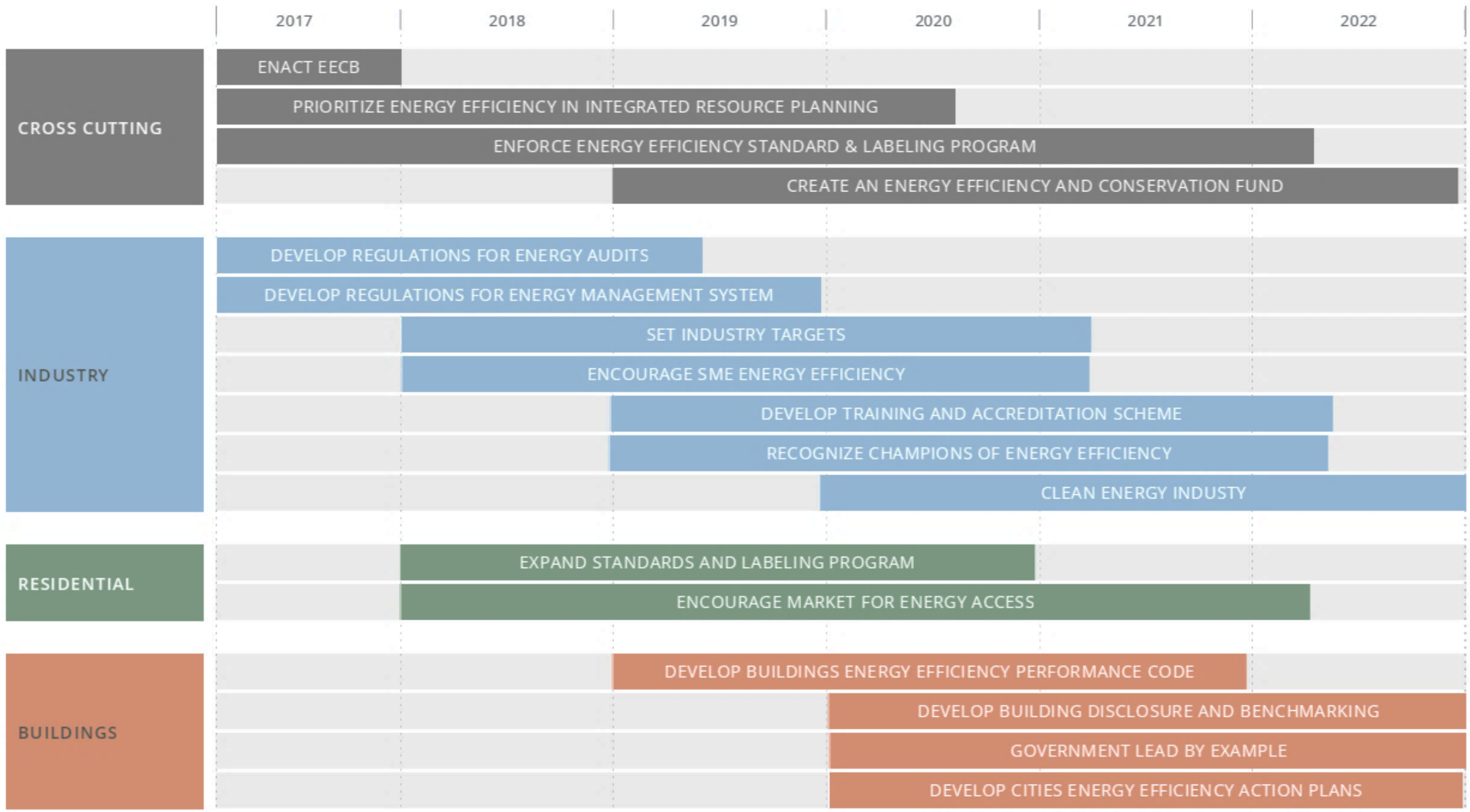
Industrial energy efficiency is a priority because of the significant potential for energy savings and the high concentration of actors in this sector. The progression of program implementation recommended in this sector recognizes that auditing and energy management are foundation steps to drive investment toward energy efficiency improvements. Setting energy efficiency targets comes next, to galvanize industry toward more aggressive efficiency strategies. Programs targeting small and medium enterprises (SMEs) expand the outreach to smaller industries and increase their awareness of and capacity to undertake energy efficiency investments. Recognition of energy efficiency champions and expanding workforce trainings follow next in the order of priority for this sector.

Residential efficiency programs will be largely centered on uptake of efficient products enabled through the S&L program. Uganda has a unique opportunity to promote energy efficiency to newly grid-connected households as well as to off-grid communities, enhancing the off-grid sector at large. The well-documented benefits of energy efficiency for off-grid users can be achieved through accelerating the growth of Uganda's nascent off-grid appliance market, often in partnership with solar home system (SHS) companies.

The long lives of buildings create a strong impetus for improving building efficiency; building energy codes implemented today will reap benefits for the next 50 years or more. In this light, building efficiency codes are the first step. Building disclosure and benchmarking complement and advance building efficiency through mandatory energy performance reporting, target setting, and incentives. The government has an opportunity to lead by example by making smart investment in energy efficiency to reduce its energy bills and at the same time helping to develop new business models, such as energy service companies (ESCOs). Municipal leadership is the final priority program because of the great impact that city policies can have on a city's building stock, particularly the facilities owned by the municipality, but also because city policies play an important role in the implementation of building codes.

The intent of the Roadmap is that it be used to drive and track progress on each action in the short, medium, and long term in Uganda. The Ugandan Ministry of Energy and Mineral Development (MEMD) is the lead implementer of this action Roadmap, but support from key stakeholders is needed to design and implement these recommendations, and from international development organizations to optimize results.

Figure 1-3. Energy Efficiency Roadmap for Uganda



1.5 CONCLUSION: MAKING ENERGY EFFICIENCY COUNT REQUIRES LEADERSHIP

Improving energy efficiency is highly cost effective, but many barriers prevent residential, commercial, and industrial customers from investing in efficient appliances, buildings, motors, and processes. Important steps for Uganda to take to realize the full potential and benefits of energy efficiency investments include establishing enabling policies and financial incentives and developing technical expertise in the labor market to allow for promoting new business models, such as ESCOs. Uganda will benefit from developing and implementing new policies to overcome these barriers and to integrate energy efficiency into future energy resource planning.

MEMD has a key role to play in leading implementation of Uganda's energy efficiency action plans. Leadership is essential to motivate actions and communicate vision and purpose. Part of the leadership commitment is setting goals and monitoring progress to focus efforts and optimize resources. Regular data collection and program impact evaluation are necessary to support continuous energy efficiency implementation. MEMD can use the energy-saving potential of 185 MW from the achievable economic potential as an initial energy-savings goal for implementing the recommendations of the Energy Efficiency Roadmap.

MEMD also has an important role to play in leading others to consensus by reaffirming to all actors the critical role that improved energy efficiency can play in addressing energy reliability, energy access, and Uganda's environmental and economic objectives. The international development community should support MEMD's efforts, share experiences in successfully raising the level of energy efficiency in their own countries, as well as through investments in other countries, and committing to energy efficiency as a resource and economic growth tool in Uganda.

2. INTRODUCTION

Energy efficiency plays a central role in the development of sustainable energy and increased access to electricity. For households and businesses consuming energy from the grid, energy efficiency strategies can lower electricity bills, directly paying back investments in efficient equipment and building materials and freeing up income to spend on health, education, or new business investments. For households and businesses consuming energy from a solar home system (SHS) or micro-grid, energy-efficient appliances maximize the energy services provided by these systems so that each kilowatt hour (kWh) goes further. For utilities struggling to meet the power demands of a growing population and expanding economy, energy efficiency can be viewed as a near-term, low-cost strategy to add "generation" to the grid, meeting consumers' needs by delivering less electricity than would be required to power less-efficient buildings and equipment. For governments and international development agencies looking to expand energy access, energy efficiency strategies enable consumers to meet their energy needs using less electricity than would be required to serve less-efficient end-uses, optimizing consumer investment and providing access to better quality energy services.

This Energy Efficiency Roadmap for Uganda (Roadmap) delineates the important roles that energy efficiency can play in meeting Uganda's energy goals by assessing the energy efficiency potential across all sectors of the economy and by identifying programs and policies that contribute to removing market barriers that hinder private investment in energy efficiency.

Power Africa and the United Nations Sustainable Energy for All (SEforALL) Initiative collaborated with more than 24 stakeholders in Uganda to develop this Roadmap. Power Africa is a U.S.-led initiative to double electricity access in Sub-Saharan Africa by leveraging effective partnerships that link public- and private-sector goals and resources, and connect investors and entrepreneurs to business opportunities in Africa. Power Africa's ambitious goals are to add 30,000 megawatts (MW) of new power and 60 million (m) new household and business connections by 2030. SEforALL was launched in September 2011 by United Nations Secretary-General Ban Ki-Moon to increase universal access to sustainable energy. This initiative also operates through partnerships among governments, businesses, and civil society. SEforALL is working towards the following three objectives for 2030:

- Ensure universal access to modern energy services
- Double the global rate of improvement in energy efficiency
- Double the share of renewable energy in the global energy mix

Energy efficiency clearly has an important role to play in helping these initiatives achieve their goals to increase access to sustainable energy by providing a least-cost energy resource that has multiple economic, environmental, health, and social benefits.

2.1 OBJECTIVE

In support of SEforALL, Uganda developed an Action Agenda outlining milestones through 2030 for reaching the three main SEforALL objectives (SEforALL, 2015). The Action Agenda recognizes the challenges of doubling the rate of energy efficiency and recommends building on analyses of energy efficiency savings potential by sector (household, commercial, industrial, and buildings). The Action Agenda identifies the following main gaps for scaling up energy efficiency:

- Incomplete regulatory framework
- Insufficient public awareness
- Insufficient baseline data
- Inadequate financing mechanisms
- Inadequate technical capacity

The objective of the Roadmap is to complement the Action Agenda by providing greater detail on electricity energy efficiency opportunities and detailed support for designing and implementing policies and programs that will achieve the SEforALL energy savings goals. The Roadmap is focused on electric energy efficiency opportunities. Efficiency opportunities in the transportation sector and those associated with other fuels (e.g., biomass, kerosene) are outside the Roadmap scope. The authors identify this as an area of needed focus for future research.

2.2 APPROACH/METHODOLOGY

Just as transmission lines are the infrastructure for power grids, data and analytic methods are the infrastructure for market deployment of efficiency at scale. The energy efficiency opportunities included in the Roadmap were developed through an assessment that began with a set of representative energy efficiency measures that are broadly suitable to developing country markets. These measures apply to the residential, commercial, and industrial sectors. Technologies with the greatest opportunity to reduce energy demand in Uganda were identified by gathering the following information:

1. **Customer and building characterization by sector.** This includes the number of customers by sector, subsector, and rate class; new construction growth rates (historical and projected); and building system characteristics and efficiencies.
2. **Energy end-use disaggregation for each sector and subsector**.
3. **Planning assumptions**. Planning assumptions include utility retail rates for all rate classes, discount rate for economic analysis, and line losses.
4. **Market data on energy efficient technologies**. An example of these market data is the availability of compact fluorescent lights (CFLs) in Kampala.
5. **Appliance and technology market saturation surveys**. An example of market saturation data is the percentage of homes that currently have high-efficiency appliances.
6. **Information on current or past energy efficiency or demand response programs**. This information includes implemented energy efficiency technologies, incentive levels or financing mechanisms, past participation, and other program performance

data. The success and impact of energy efficiency and demand response programs provide valuable insight into the feasibility of new programs.

7. **Research or feasibility studies on energy efficiency technologies.**
8. **Cost of energy-efficient and standard technologies**. This includes equipment, materials, and appliance costs.
9. **Electricity consumption and demand forecasts.**

For energy efficiency policies and programs, recommendations are based on an analysis of the barriers to energy efficiency in Uganda and analysis of the potential energy savings and information gathered from international best practices. Each recommendation is discussed in detail, and actionable steps are identified to provide a path to optimum implementation. MCDA was used to prioritize programs according to the following six criteria:

- Energy savings
- First cost to government
- Speed of implementation
- Prerequisite to other measures
- Multiple benefits

The Roadmap that has resulted from the above analyses provides a framework that the Ministry of Energy and Mineral Development (MEMD) can use to pursue Uganda's energy efficiency goals. To optimize results, key stakeholders, including international development organizations, should support MEMD in implementing the actions detailed. The schedules laid out in the Roadmap are based on the experience and benefits as described for each activity but can be adjusted to fit priorities and resources in Uganda.

2.3 ROADMAP OUTPUTS & BENEFITS

The Energy Efficiency Roadmap has three main components: it assesses in detail Uganda's electricity market, (*Situation Assessment*), explains the potential for electricity savings (*Electricity Savings Potential*), and describes actionable steps to advance energy efficiency (*Energy Efficiency Action Plan*).

The *Situation Assessment* section describes the needs and conditions of the Ugandan energy efficiency market as it existed in 2016. That section reviews Uganda's power sector and assesses the legal and institutional frameworks that govern the sector and mandate energy efficiency programs. The section also describes energy efficiency program implementation by local stakeholders, international donors, and multi-lateral organizations, including an assessment of the current financing resources available to develop energy efficiency programs. This portion of the text describes existing collaboration on efficiency and energy access as well as Kampala-specific activities. The *Situation Assessment* closes with a description of the main barriers to development of energy efficiency in Uganda.

The *Electricity Savings Potential* section estimates the technical, economic, and achievable economic potentials for consumption and demand from energy efficiency improvements. The technical potential quantifies the savings possible through energy efficiency if the most efficient technologies on the market were adopted without any limitations on costs or logistics. The economic and achievable economic potentials are each subsets of the technical potential, with restrictions placed on measure cost-effectiveness. For the economic potential, improvements are required to be cost-effective for the end-user under a general societal discount rate. Under the achievable economic potential, the improvements must have a benefit-cost ratio of two for the end-user, as calculated with a stringent discount rate reflective of in-country interest rates. In addition to consumption and demand savings, non-energy benefits such as electricity access through efficiency and emissions reductions are discussed for each potential.

The Roadmap concludes with the *Energy Efficiency Action Plan*. The plan describes the actions needed to advance energy efficiency in Uganda based on the situation assessment and the estimated electrical energy-savings potential. Policies, programs, and capacities needed to advance progress toward achieving Uganda's energy efficiency potential are described for each economic sector. Included are stakeholder action items, opportunities for joint efficiency and energy access, and Kampala-specific activities. In addition to identifying specific action steps, the Roadmap provides a timeline that can be used to set goals and milestones.

3. SITUATION ASSESSMENT

3.1 POPULATION

According to Uganda's 2014 census, the country's population of 34.8M inhabitants increased by 3% annually from 2002 to 2014 (UBOS, 2014). The household size of approximately 4.7 persons has remained constant over the past four decades. Table 3-1 shows Uganda National Bureau of Statistics (UNBS)-estimated population trends for 2015, 2020, and 2025 and the SEforALL Investment Prospectus estimate for 2030.

Table 3-1. Uganda's Projected Population Trend 2015-2030

Year	2015	2020	2025	2030
Population (in M)	35.8	40.4	46.7	56.2
Number of households	7,617,021	8,595,745	9,936,170	11,956,636

Source: UNBS; SEforALL Investment Prospectus, 2016a.

Uganda has experienced significant poverty reduction during the past two decades, with the number of households living under the poverty level ($1.25 per person per pay day) reduced from 56.4% in 1992/93 to 19.7% in 2012/13 (MFPED, 2014). Thus, Uganda has met the first Millennium Development Challenge target of halving poverty by 2015.

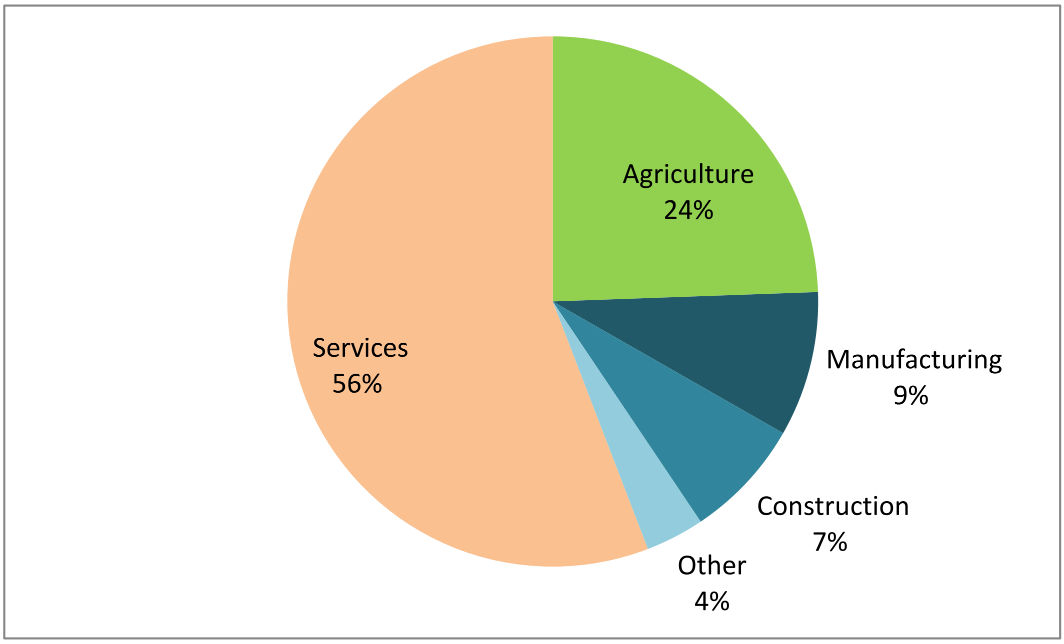
The process of urbanization is just beginning. According to the 2014 National Population and Housing Census, 18% of Ugandans live in urban areas, with approximately one-third living in the city of Kampala. The urban population is projected to double by 2040, which will mean significant population growth in cities.

3.2 ECONOMIC ACTIVITY

In the late 1980s, Uganda became one of the first Sub-Saharan African countries to liberalize its economy and introduce pro-market reforms. Uganda's economy experienced a sustained period of high growth from 1987 to 2010, with gross domestic product (GDP) growth averaging 7% per year during the 1990s and 2000s. This places Uganda among the 15 fastest-growing economies in the world (WB, 2016a). The World Bank (WB) forecasts growth of 6.8% in FY17/18 and an upward trajectory into the medium term.

The services sector is the largest source of value added in the country, accounting for 53% of all economic activities (Figure 3-1). During FY 2015/16, the services sector grew by 6.6%, with the bulk of this growth driven by activity in the information and technology subsectors. The largest subsectors contributing to economic activity are trade (24%), information and communication (17%), education (11%), and real estate activities (9%) (UBOS, 2016). In the manufacturing sector, the largest subsectors are processed food (40%); drinks and tobacco (20%); chemicals, paint, soap, & foam products (10%); metal products (8%); and bricks & cement (8%).

Figure 3-1. Gross Domestic Product by Economic Activity, 2015-2016



Source: UBOS, 2016

3.3 ELECTRICITY SECTOR IN UGANDA

3.3.1 POWER SECTOR STRUCTURE

Uganda was the first African country to unbundle generation, transmission, and distribution into separate utilities and to offer private concessions for power generation and distribution (WB, 2016b). In 1999, the Electricity Act unbundled the Uganda Electricity Board (UEB) into three units:

- Uganda Electricity Generation Company Limited (UEGCL) – generation
- Uganda Electricity Transmission Company Limited (UETCL) – transmission and sole electricity buyer
- Uganda Electricity Distribution Company Limited (UEDCL) – distribution

Generation and distribution assets were subsequently transferred to concessions through a competitive bidding process. Among the private concessions is UMEME Ltd., which was assigned the main distribution role for the grid. UMEME Ltd. distributes 95% of all electricity in the country.

Another important outcome of the 1999 Electricity Act was the creation of the Electricity Regulatory Authority (ERA). ERA's main role is to be the "guardian" and facilitator of the least-cost path for future resource development. ERA is also charged with ensuring the reliability and affordability of the power sector to meet the country's growing electricity demand, expanding geographic coverage of the power grid, and improving the quality of supply.

MEMD is composed of three entities: Energy Resources Development, the Petroleum Directorate, and the Geological Survey Mines Directorate. Energy Resources Development is responsible for the energy sector and is made up of the Electric Power Department, Renewable Energy Department, and Energy Efficiency and Conservation Department, which is mandated to promote efficient utilization and conservation of energy in all sectors of Uganda's economy. See Appendix 1 for an organigram of the current structure of Uganda's power sector.

3.3.2 DEMAND

Uganda's electricity demand has grown at an annual average of 8.2% since 2008, with peak demand in 2014 reaching 550 MW in May (ERA, 2015b) against an installed generation capacity of 825 MW.

Electricity access in Uganda, defined as access to grid services, is estimated at approximately 15% nationally, which translates to 55% in urban areas and 7% in rural areas (UBOS, 2013). However, if SHSs and diesel generators are considered, electricity access is closer to 20% in rural areas, and the national electrification access rate is about 26% (SEforALL, 2015).

The total number of electricity grid customers is growing very rapidly, from 501,754 in 2012 to 872,836 in 2015, an average annual growth rate of 20% with an average of 125,000 additional customers per year (SEforALL, 2015).

Uganda's national average electricity consumption remains one of the lowest in the world, 72 kWh per capita in 2015, compared to an average 536 kWh per capita on the African continent and an average 3,688 kWh per capita in South Africa. One of the main reasons for the low consumption is the Uganda's low electrification rate. The average electricity consumption of new customers is 2,875 kWh.

These very low rates of electricity consumption and the growing economic activity in the country position Uganda as a very high energy growth potential country.

The Ugandan government national development plan targets bringing grid access to 30% of the population by 2020 and 80% by 2040, with a goal of increasing per-capita electricity consumption to 578 kWh by 2020 and 3,668 kWh by 2040. This means grid power generation capacity needs to increase from 825 MW in 2012 to 2,500 MW by 2020, and to 41,738 MW by 2040 (Uganda Government NDPII, 2015).

Under the 2012 Rural Electrification Strategy and Plan, the Rural Electrification Agency (REA) is expected to support grid expansion and densification to meet its goal of adding 1.28M new connections while providing 140,000 additional off-grid services by 2022. These new customers will benefit from using efficient appliances and lighting to provide superior energy services with lower energy demand than would be possible with inefficient equipment. By increasing the energy services a consumer can obtain from 1 kWh, energy efficiency contributes to providing reliable energy access at the lowest possible cost. For households and businesses consuming energy from the power grid, energy efficiency lowers utility costs, freeing up income that can be used for health, education, new business investments or increased energy services. For off-grid households, super-efficient off-grid appliances enable consumers to purchase smaller (and therefore less expensive) solar photovoltaic panels, lowering the costs of energy service by as much as 50% (Phadke et al., 2015). Efficient off-grid appliances also present a large commercial opportunity: a 2016 study projected that, with the right support, the global market for off-grid televisions, fans, and refrigerators could be as large as $4.7 billion per year by 2020 (Global LEAP, 2016).

3.3.3 SUPPLY

Uganda's installed power generation capacity has increased significantly during the past decade, from about 300 MW in 2002 to 895.5 MW in 2015, of which 695 MW is from hydropower, 136 MW is from petroleum-based thermal generation, and 64.5 MW is from biomass co-generation (ERA, 2014). The biomass co-generation comes from a 50-MW plant owned by Kakira Sugar Ltd. and a 14.5-MW plant owned by Kinyara Sugar Works Ltd. See Appendix 3 for more detail.

After a series of load-shedding events in 2011, which resulted from a prolonged drought that affected hydroelectric production, Uganda has recently successfully attracted private investment in new capacity. The recent Bujagali hydropower plant, at the time of completion, is the largest private investment built by an independent power producer (IPP) in Africa.

Uganda's currently commissioned power plants to meet fast-growing electricity demand are shown in Table 3-2.

Table 3-2. Additional Planned Capacity

UECTL-commissioned power plants	Planned Capacity	Completion date	Total Investment Cost	Average Investment Cost
Karuma Hydro Power dam	600 MW	2019	US$1.688 billion	US$2.8M per MW
Isimba Hydro Power dam	183 MW	2019	US$567.7M	US$3.0M per MW
Ayago Hydro power	840 MW	2022	US$1.97 billion	US$2.3M per MW

Source: Kyokunzire, 2016; Wesonga and Mugerwa, 2015; Uganda Government NDPII, 2015.

In addition, Uganda launched an innovative feed-in tariff program in 2013 to fast-track 157 MW of small-scale renewable energy generation projects. The GET FiT program was initiated by Kreditanstalt für Wideraufbau (KfW) with support from four donor agencies (Government of Norway, Government of United Kingdom [UK], Germany, and the European Union [EU]) with a total commitment of €94.5M (US$104M).[7] About 90% of this funding is expected to be paid as a premium to renewable energy produced. The remainder of the funding is split between technical assistance (2%) at the beginning of the project and implementation (9%). The premium provided is 1.4 US cents(c)/kWh for hydropower, 1 US c/kWh for biomass, and 0.5 US c/kWh for bagasse over 20 years. However, the total support is front-loaded, with disbursement of these funds through the first five years of operation. The GET FiT portfolio currently contains 17 projects -- 14 hydro, 1 biomass, and 2 solar photovoltaic -- distributed across five of the 10 Ugandan sub-regions (GET FiT, 2015).

[7] Using an exchange rate of US$1.11 for 1 euro (6/24/2016)

Uganda has also a rapidly growing market for solar home systems, which is served by the private sector. Estimated national sales are approximately 10,000 SHSs per year, for residential as well as productive (largely water pumping) and social uses (hospitals and schools) (SEforALL, 2015).

Energy efficiency can complement the above capacity-adding efforts by ensuring that the power supply is maximized in the most affordable way. Energy efficiency expands the level of energy services that additional electricity supply brings to the grid and lowers the cost of electricity supply. Efficiency is not only the most economical resource available, it can also be quickly implemented to help meet growing electricity demand. This builds flexibility into the system and helps smooth the gap between demand growth and the time needed for development of new power generation.

3.3.4 TRANSMISSION AND DISTRIBUTION

Uganda has made significant progress in addressing transmission and distribution (T&D) losses that affect the overall efficiency of power delivery. T&D losses were reduced from 38% in 2005 to 25% in 2014. However, these losses are still significant compared to levels in other countries and to international standards. For example, T&D losses are about 6% on average in Organization for Economic Cooperation and Development (OECD) countries, 8% in South Africa, and 13% on average on the African continent as a whole (IEA, 2016a).

A 2011 study by ERA estimated that the 30% T&D losses in 2010 were due equally to technical inefficiencies in the system and to commercial losses, the latter consisting mainly of power theft and billing anomalies (ERA, 2011). Today, T&D losses are approximately 22.8%, with transmission losses representing approximately 3.6% of technical losses and distribution losses approximately 19.2%. The greatest reduction in commercial losses has come from installation of pre-paid meters for 30% of UMEME customers and for all new customers. The bill collection rate reached 99.1% in 2014 (UMEME, 2015). Reducing commercial losses (or non-technical losses) is critical to ensure the financial viability of the utility company. According to UMEME estimates, distribution technical losses are about 13%, and commercial losses are about 6.2% (Anyanzwa, 2015). UMEME’s target, set in collaboration with ERA, is to achieve 14.7% distribution losses by 2018.

3.3.5 TARIFFS

ERA sets retail tariffs based on generation, transmission, and distribution company revenue requirements as defined in license agreements, and on the basic principle that the electric power sector should be financially viable. Tariffs have been adjusted several times, including a major increase of 48% in January 2012 when the Ugandan government approved a transition to cost-reflective tariffs.

Today, Uganda’s electricity tariffs (Table 3-3) are comparable to tariffs in OECD countries. For example, household tariffs are slightly lower than the average tariff in the EU (0.20 US$/kWh) but significantly higher than in the U.S. (0.13 US$/kWh). Industrial tariffs are lower than those in Europe (0.16 US$/kWh) but higher than those in the U.S. (0.7 US$/kWh) (IEA, 2016a).

Table 3-3. Base Tariffs per Kilowatt Hour Consumption, 2016 (ERA, 2015b)

	Domestic	Commercial	Medium Industrial	Large Industrial	Streetlights
Uganda Shillings (Shs)	651	587	544.9	369.4	628.4
U.S. dollars[8]	0.18	0.16	0.15	0.10	0.17

Time-of-Use Tariff

ERA has implemented an incentive-based regulatory regime for industrial and commercial consumers that offers lower tariffs during off-peak periods (23:00–05:00h) and proportionately higher tariffs during peak periods (18:00–23:00 h). In 2015, ERA increased the weighting factor for the time-of-use (TOU) tariff during the peak period from 110 to 120 shillings (Shs), and in 2016 to Shs 130 (Okoboi and Mawejje, 2016) after the load profile of industrial consumers did not significantly change in response to the first increase in 2015. The 2015 load profile is available in Appendix 4.

Power Factor Charge and Reward

ERA implemented a charge of Shs 40 per kilo-volt amps reactive hours (kVArh) per month and a reward of Shs 20 per kVArh per month to incentivize medium and large industrial consumers to correct for power factor and ensure efficient power utilization; see Section 3.5 for more detail. In 2015, UMEME charged Shs 3,243M (US$0.98M) and issued rewards totaling Shs 3,599M (US$1.08M), for a negative balance of Shs 355M (US$106,834). The difference is compensated in electricity price setting. In its 2016 tariff application to ERA, UMEME stated that the reactive power tariff is an impactful initiative to support demand side management (DSM) and requested that the charge be maintained as part of the tariff structure to influence efficient energy utilization by large consumers (ERA, 2015b).

3.3.6 DEMAND-SIDE MANAGEMENT

Recognizing that energy efficiency has multiple benefits -- saving electricity costs, improving supply reliability, reducing peak demand, and deferring the need for additional generation capacity -- ERA has allocated US$4.1M toward DSM and developed a DSM plan that includes the following (ERA, 2014):

- Procurement and distribution of light-emitting diodes (LEDs) to replace high-energy-consumption incandescent bulbs currently used by domestic consumers. Distribution of an initial batch of 420,000 LEDs to consumers began in January 2015.
- The TOU scheme described above that encourages commercial and industrial consumers to shift consumption from peak periods (evenings) to off-peak and shoulder periods (day and late night).
- An awareness campaign to educate consumers about efficient energy use, that includes dissemination of informational booklets titled “How to Reduce Your Electricity Bill.”

[8] Exchange rate of US$2.8 for Shs 1000.

3.4 INSTITUTIONAL AND LEGAL FRAMEWORK

3.4.1 POLICY AND LEGAL FRAMEWORK FOR ENERGY EFFICIENCY IN UGANDA

MEMD is responsible for formulating energy policy and oversees the electric power subsector's operations. MEMD is the lead implementer of the Energy Efficiency Action Roadmap. Key stakeholders should support MEMD in implementing the actions detailed. This includes international development organizations that can support MEMD in optimizing results.

Table 3-4 summarizes the major policies that govern the power sector and mandate energy efficiency programs in Uganda. The principles of one of the major policies, the Energy Efficiency and Conservation Bill, were approved by the Cabinet in January 2016. The draft bill is being prepared for submission to Parliament for approval.

Table 3-4. Major Policies Governing Uganda's Power Sector and Energy Efficiency Programs

Year	Policy/Legislation
1999	The **Electricity Act of 1999** was developed to enhance efficiency through privatization and liberalization of the electricity sector and to provide for an independent regulator, ERA. One of the major results of the Act's implementation has been the unbundling of the former Uganda Electricity Board. The Act also established the Rural Electrification Fund. The Act has been reviewed and is awaiting presentation to Parliament.
2002	The **Energy Policy for Uganda** is the framework policy for the country's entire energy sector. This policy states that the government's goals in managing the energy sector are "to meet the energy needs of Uganda's population for social and economic development in an environmentally sustainable manner." Promoting efficient utilization of energy resources is one of the activities that the government plans to pursue to meet this goal.
2007	The **Renewable Energy Policy** is a concretization of the **Energy Policy for Uganda** commitment, setting out the government's policy vision, goals, principles, and objectives for promoting sustainable utilization of renewable energy in Uganda.
2009	The **Draft Energy Efficiency Strategy for 2010-2020** was developed to establish efficiency programs for each economic sector (households and institutions, industry and commerce, transport, and power transmission and distribution) through five main types of intervention (1) awareness and information, (2) training and education, (3) research and development, (4) financing and incentives, and (5) legislation and framework (GIZ, 2009). The Energy Efficiency and Conservation Bill must be enacted for the Energy Efficiency Strategy to be implemented.
2014	Creation of the **Energy Efficiency and Conservation Department** in MEMD
2016	The **draft Energy Efficiency and Conservation Bill** awaits submission to Parliament. The Bill provides the legal, institutional, and regulatory framework for elaborating and enforcing the national policy targeting efficient energy use and reduction in waste of limited energy resources. The draft includes three regulations: ▪ Establishment of minimum energy performance standards (MEPS) for equipment (refrigerators, air conditioners, motors, lighting) ▪ Requirement of energy management systems (EMSs) for large industries ▪ Requirement of energy audits for large industries

3.4.2 ROLES AND CAPACITIES OF ENTITIES ASSOCIATED WITH ENERGY EFFICIENCY IMPLEMENTATION

Table 3-5, Table 3-6, Table 3-7, and Table 3-8 briefly describe the roles and experiences of government institutions, international donor agencies, non-governmental agencies, and private entities, respectively that are supporting energy efficiency in Uganda.

Table 3-5. Government Agencies Supporting Energy Efficiency in Uganda

Government Agency	Description	Energy Efficiency Activity
Ministry of Energy and Mineral Development (MEMD)	MEMD's mandate is to establish, promote development of, strategically manage, and safeguard the rational and sustainable exploitation and utilization of energy and mineral resources for social and economic development. MEMD is responsible for formulating energy policy and oversees the electric power subsector's operations.	The Energy Efficiency and Conservation Department began operating in financial year 2014/2015. Key Energy Efficiency and Conservation Department functions are to develop strategies and programs to improve energy efficiency and conservation (EEC).
Electricity Regulatory Authority (ERA)	ERA is the independent electricity-sector regulator. Its main function is to regulate generation, transmission, distribution, sale, export, and import of electricity.	Promoting energy efficiency and DSM is included in ERA's 9 Strategic Objectives for 2014 to 2023 (ERA, STRATEGIC PLAN 2014/15 – 2023/24). ERA has developed a *Demand-Side Management Plan*, as described in Section 3.3.6 Demand-Side Management.
Uganda National Bureau of Standards (UNBS)	UNBS is a statutory body under the Ministry of Trade, Industry, and Co-operatives, established in 1989. UNBS's mandate is to formulate, promote, and enforce standards.	UNBS issued five MEPS in 2012 for lighting, refrigerators, freezers, motors, and air conditioners. No regulation exists to enforce these MEPS, so they have not been implemented.
Rural Electrification Agency (REA)	REA is a semi-autonomous governmental agency mandated to facilitate the government's goal of achieving a rural electrification rate of at least 22% by the year 2022, as specified by the Rural Electrification Strategy and Plan (RESP) 2013-2022 (MEMD, 2012) (1.28M on-grid and 140,000 off-grid new connections).	RESP does not mention energy efficiency or DSM, and no major program has been developed for implementing energy efficiency as part of rural electrification.
Uganda Energy Credit Capitalization Company Limited (UECCC)	UECCC is a government-owned company launched in 2011 with initial capital of US$6.6M. UECCC has a mandate to promote financial solutions for developing the electricity sector (Office of the Auditor General, 2015).	UECCC has provided financial and technical support for small-scale renewable energy development through dedicated lines of credit at concessional rates (WB, 2015a). There is no major focus on energy efficiency in UECCC's activities at this point.
Kampala Capital City Authority (KCCA)	KCCA is the local government in Kampala. Expertise France has been working with KCCA on a Climate Change Action Plan. KCCA is committed to leading by example, implementing energy efficiency measures in public buildings, street lighting, waste management, and renewable energy.	The Climate Change Action Plan suggests requiring renewable energy or energy efficiency measures for building permits. The plan also proposes development of city "eco guidelines" that set high environmental standards and include energy and climate elements for public construction and renovations.[9]

[9] KCCA is also committed to improving biomass stove and vehicle efficiency, but these topics are beyond the scope of this report's focus on electricity.

Table 3-6. Donor Agencies Supporting Energy Efficiency in Uganda

Donor Agency	Description	Energy Efficiency Activity
World Bank (WB)	WB's portfolio of active projects in Uganda represents a commitment of US$2.1 billion. One of the flagship projects, **Energy for Rural Transformation (ERT)**, is entering its third phase with a budget of US$168M. This project aims to increase electricity access in rural areas of Uganda. WB also supported the Power Sector Development Operations (PSDO) project from 2007-2012. This project had a component on energy efficiency and DSM.	▪ **ERT II**: ERT II implemented a program to improve power factors in the industrial sector and energy audits in public and commercial buildings. ▪ **ERT III:** US$1M is intended for developing a Quality Assurance framework for developing an off-grid solar products market. This includes awareness and standards programs for improving the energy performance of products. ▪ **PSDO (2007-2012):** This project supported energy efficiency investments in public institutions.
Gesellschaft für Internationale Zusammenarbeit (GIZ)	GIZ supports the German government in achieving its objectives for international cooperation on sustainable development. GIZ has been the only donor agency to provide a comprehensive, sustained energy efficiency program in Uganda. The **Promotion of Renewable Energy and Energy Efficiency Programme (PREEEP)** works under MEMD to promote energy efficiency. The 3-year PREEEP Phase III concluded in January 2017, and a new 2-year phase started in February 2017.	Past **PREEEP activities** include energy audits, training of local energy auditors, and technical assistance to MEMD. See *Section **3.5.1 Past and Current Experience in Energy Efficiency*** for more information. **Preliminary activity plans for 2017 and 2018** include: ▪ Conduct baseline study for 30 companies ▪ Conduct 4 EMS training workshops in 4 regions ▪ Conduct detailed energy audits for 10 companies ▪ Conduct 5-day certification training for 20 energy auditors ▪ Monitor and evaluate the implementation of energy efficient measures in industries
Agence Française de Développement (AFD)	AFD is the French development agency. In April 2016, AFD launched **SUNREF** (Sustainable Use of Natural Resources and Energy Finance) in Uganda. SUNREF combines technical assistance, a credit line, and a guarantee fund to assist local banks in assessments and lending for renewable energy and energy efficiency investment projects. SUNREF programs have been developed in Mauritius, South Africa, Kenya and are currently being launched in East and West Africa.	The program has been particularly successful in Kenya. The credit line for 8 projects totals US$37M and prompted a total investment of US$55M in renewable energy. Project implementation is by the Kenya Association of Manufacturers and UMA. In Uganda, SUNREF is currently working with local bank to provide financing with interest as low as 11% per annum.

Donor Agency	Description	Energy Efficiency Activity
European Union (EU)	The EU provides technical assistance to Uganda's **SEforALL Secretariat**, which has resulted in several key publications: (1) SEforALL Action Agenda in 2015, (2) Gap analysis for three pilot districts (Kaabong, Kasese, and Jinja), (3) SEforALL Investment Prospectus and two future publications, (4) SEforALL Communication Strategy, and (5) SEforALL Database and Monitoring tool.	The EU's efficiency activities are embedded in the SEforALL Secretariat's activities.
Kreditanstalt für Wiederaufbau (KfW)	KfW is Germany's government-owned development bank. KfW has developed the Get-FiT program, which fast-tracks private investment in small-scale renewable energy.	KfW has not developed any energy efficiency projects in Uganda. However, efficiency is a topic of interest to KfW, which has long experience in providing financing for energy efficiency upgrades in Europe and other regions of the world.
Swedish International Development Agency (Sida)	Sida is the Swedish aid agency. One of Sida's major programs offers attendance at training programs designed to build capacity of low- and middle-income countries on specific topics.	Uganda policy makers from MEMD benefited from a training program, *Efficient Energy Use and Planning*, offered by Sida from 2010 to 2015 (SIDA, 2015).
Royal Embassy of Norway	The Royal Embassy of Norway has an aid program for Uganda with a clean energy development component, which focuses mainly on renewable energy development.	The embassy has a project with UETCL and REA to reduce power losses and is interested in considering additional support in the area of energy efficiency.
United States Agency for International Development (USAID)	USAID is the United States development agency. In Uganda, USAID focuses its energy-sector activities on agriculture, energy access, and economic growth.	No major program has been designed on energy efficiency. USAID Uganda is implementing activities under Power Africa and is supporting the development of this Roadmap.
United Nations Development Programme (UNDP)	UNDP has a new UNDP has a new Uganda country program running from 2015 to 2020. One of the elements is Inclusive Green Growth (IGG), which is designed to contribute to sustainable and inclusive economic development (UNDP, 2015).	No major program has been designed on energy efficiency. UNDP has supported the SWITCH Africa Green (SAG) project through which the Uganda Cleaner Production Center is conducting energy audits in small and medium enterprises.

Table 3-7. Non-Governmental Organizations Supporting Energy Efficiency in Uganda

NGO	Description	Energy Efficiency Activity
Private Sector Foundation Uganda (PSFU)	PSFU is an association representing the private sector. It is composed of 185 business associations, corporate bodies, and public-sector agencies. PSFU serves as a focal point for private-sector advocacy and capacity building and maintains a positive dialogue with the government on behalf of the private sector. PSFU is managing the Business Uganda Development Scheme Energy for Rural Transformation (BUDS-ERT).	PSFU has implemented several energy efficiency activities: ▪ Energy audits and work with UMEME to develop the list of large energy users; the focus was on raising awareness raising and interest in the ESCO market. ▪ Power-factor improvement. See Section 3.3.5 for Power Factor Charge and Reward
Uganda Manufacturing Association (UMA)	UMA is the manufacturing association of Uganda. UMA's members include nearly 750 small, medium, and large enterprises from both the private and public sectors. Its mission is to advocate and lobby for a conducive business environment for its members (including addressing local, tax fiscal, and other issues).	UMA has developed an energy efficiency strategy (UMA, 2016) that includes the following objectives: ▪ Establishing an energy management center ▪ Creating networks ▪ Conducting an awareness campaign ▪ Training users of energy management and providers of energy audits ▪ Providing implementation assistance ▪ Developing a policy framework
Uganda Cleaner Production Center (UCPC)	UCPC was created in 2001 by the United Nations International Development Organization (UNIDO) and is now an independent center that operates under the Uganda Ministry of Trade Industry and Cooperatives. The center promotes resource efficient and clean production. UCPC is the implementing agency for SAG, which is a United Nations Environment Programme (UNEP)-funded project to promote a shift to sustainable consumption and production practices and patterns.	A component of SAG focuses on DSM for micro-, small- and medium-scale industries, in collaboration with the Uganda Small Scale Industries Association (USSIA) and Uganda Investment Authority. More than 100 companies have benefited from the program, whose main activities include awareness campaigns, networking, and benchmarking.
Uganda National Renewable Energy and Energy Efficiency Alliance (UNREEA)	UNREEA is an alliance of several business associations, industry, consultants, and academics that focus on energy efficiency and sustainability. It was formed in August 2014 with the assistance of the GIZ PREEEP program, to consolidate the associations' position and leadership.	Among UNREEA's members is the Uganda Energy Efficiency Association (UEEA) of energy efficiency and sustainability professionals. UEEA's mission is to foster provision of quality energy efficiency services; and enhance research, innovation, and knowledge transfer related to energy efficiency.
Centre for Research in Energy and Energy Conservation (CREEC), Makerere University	CREEC is a not-for-profit organization for research, training, consulting, and testing in the College of Engineering Design Art and Technology at Makerere University. The East African Community secretariat (EAC) designated CREEC as the Centre of Excellence for EACREEE (East Africa Centre for Renewable Energy and Energy Efficiency). EACREEE was launched in June 2016 and will guide interventions in renewable energy and energy efficiency in the region.	CREEC signed a Memorandum of Understanding (MOU) with PSFU to train certified energy managers to conduct audits and verify the energy savings accrued from the installation of energy efficient equipment in industries under Energy for Rural Transformation II (ERT II).

Table 3-8. Private Companies Supporting Energy Efficiency in Uganda*

Private Sector	Description	Energy Efficiency Activity
UMEME	UMEME Co. Ltd. is the largest power distributor in Uganda, distributing 97% of electricity in the country. In 2012, UMEME became a listed company on the Uganda Securities Exchange.	In 2012, UMEME launched an energy efficiency campaign called "Save Power, Save Money" to educate its customers about responsible energy usage.
AOT Consulting	AOT Consulting company's core business is energy efficiency.	AOT has conducted seven of the 15 energy audits for MEMD with GIZ funding. AOT is also working with Ecofys on developing the green growth strategy for Uganda supported by UNDP.
Luster Technologies	Luster Technologies was founded in March 2014 and focuses on major industrial and commercial energy users, performing energy audits, and helping companies realize the potential savings.	Luster Technologies is developing a new business model called "LED PAYS," in which clients invest in energy savings by replacing existing lighting with LED technologies at no upfront cost. The cost is derived from the resulting energy savings.
Electrical Controls and Switchgear Ltd	Electrical Controls and Switchgear Ltd. designs and manufactures engineering solutions for manufacturing industries and commercial buildings.	The company conducted audits for PFSU in the ERT II program.
International Energy Technik Ltd. (IET)	IET is an East Africa-based electrical engineering company that sells and installs electrical equipment such as stabilizers and power correction systems.	IET supplied and installed energy efficient equipment under the PSDO project.
ABB	ABB is an international engineering and electrical equipment manufacturing company with an office in Kampala. ABB sells and installs stabilizers, power correction systems, and transformers.	ABB provides energy efficiency solutions to industries and utilities.
Energy Monitoring Ltd.	Energy Monitoring Ltd. provides energy monitoring solutions and conducts energy audits.	Energy Monitoring Ltd. has conducted energy audits and supplied energy monitoring equipment for industries such as Coca-Cola in Uganda.
NegaWatt Ltd.	NegaWatt Ltd. is an energy efficiency consulting firm that sells and installs energy monitoring and energy management systems in buildings and industries.	NegaWatt Ltd. conducts energy audits and implements energy-saving projects.

* This table is not an exhaustive list as new companies continue to enter the Ugandan market.

3.4.3 REGIONAL CONSIDERATIONS

Uganda is part of the East African Community (EAC), an intergovernmental organization composed of six countries in the African Great Lakes region: Burundi, Kenya, Rwanda, South Sudan, Tanzania, and Uganda.

At the 9th EAC Sectoral Council on Energy meeting on April 21, 2014 in Nairobi, Kenya, the East African Centre for Renewable Energy and Energy Efficiency (EACREEE) was established, and the College of Engineering Design Art and Technology of the University of Makerere in Uganda was designated as the new Centre of Excellence for EACREEE. In 2016, EAC and the United Nations Industrial Development Organization (UNIDO) prepared a project document that describes EACREE's work plan. Work plan activities related to energy efficiency include enhancing appliance and building efficiency as well as clean production and energy management in industries, and reducing T&D losses (EAC, 2016).

3.5 ENERGY EFFICIENCY PROGRAM IMPLEMENTATION

3.5.1 PAST AND CURRENT EXPERIENCE IN ENERGY EFFICIENCY

Several energy efficiency efforts since the early 2000's have achieved various levels of success in Uganda. A successful CFL distribution program by UMEME reduced power demand by 32 MW with a budget of only US$1.6M. This represents an investment of US$0.05M per MW avoided, which is more than 50 times less expensive than investing in a hydropower plant. Another very successful project was the WB-funded Power Factor Correction Program, which reduced industrial power demand by 8.6 MW and helped stimulate the creation of ESCOs in Uganda.

Two programs with potential that has not yet been realized are appliance S&L and energy audits. MEMD, with support from GIZ, prepared energy efficiency standards for five domestic appliances (lighting, refrigerators, freezers, motors, air conditioners). These standards could result in substantial energy efficiency improvements; however, compliance is voluntary, and there is no implementation capacity or procedure to make the standards mandatory unless the draft Energy Efficiency and Conservation Bill is enacted. A number of energy audits were carried out but failed to stimulate investment activities because of lack of access to affordable financing options as well as a lack of confidence in the energy savings. As a result, the number of projects implemented in response to the audits has been limited.

Table 3-9 summarizes the major energy efficiency programs in Uganda to date and gives a brief overview of their scope and the successes / barriers faced. Each program is described in detail in the text following the table.

Table 3-9. Past and Current Energy Efficiency Program Experience in Uganda

Program	Year	Description	Implementing Entity	Funding Entity	Result
CFL distribution	2007	Distributed CFLs to households	UMEME CREEC	ERA	32-MW demand reduction Budget: $1.6M
Installation of energy efficient equipment in public institutions	2007-2012	Investments in energy-efficient equipment in in public institutions	MEMD	WB PSDO	10 GWh energy savings; difficult monitoring and evaluation of project success
Industrial Energy audits	2009-ongoing	Subsidized audits for commercial and industrial consumers	MEMD PFSU CREEC	GIZ	Expected investment in energy efficiency not realized due to lack of access to financing
Efficiency standards & labeling	2009-ongoing	Standards for lighting, air conditioning, refrigerators, motors	MEMD UNBS	GIZ WB	Standards not implemented due to lack of regulation
Power factor correction	2011-2014	Covered 50% of the investment cost	PFSU CREEC	WB ERT2	8.6 MW demand reduction; helped stimulate ESCO creation
Solar water heaters	2011-2014	Covered 50% of the investment cost	PFSU	WB	3.9 MW of peak load avoided at cost of approximately US$1M (~US$0.26M per MW avoided).
Awareness	2014-ongoing	Energy week; regional sustainable energy campaigns	MEMD	MEMD ESKOM	Annual awareness campaign, quarterly regional awareness campaigns
Energy management training	2015	Training workshop	MEMD UMA	GIZ	Transfer of knowledge about energy management systems to energy managers
City leadership	2015-ongoing	Climate Change Strategy	KCCA	AFD	Strategic plan for future action on efficiency in Kampala
Awards	To de developed	Corporate Social Responsibility Award	UMA	GIZ	Demonstration of benefits of energy efficiency

CFL Distribution

Following severe electricity shortages in 2007, the government procured 800,000 CFLs for UMEME to distribute to consumers in various parts of the country. Consumers were given three free CFLs in exchange for removal of three incandescent bulbs.

UMEME conducted a competitive tender in July 2006 to select a supplier for 800,000 CFLs. To ensure that only high-quality lamps would be supplied, the tender document included technical specifications based on the International Finance Corporation (IFC)/Global Environment Facility (GEF) Efficient Lighting Initiative (ELI) Voluntary Technical Specifications for Compact Fluorescent Lamps (as revised July 10, 2002).

According to the Energy Sector Management Assistance Program (ESMAP) (2009), the winning bidder in this bulk procurement offered a unit price of US$1.07 per lamp. This compared favorably with the CFL market price at that time, which ranged from US$3.90 to $4.50. CREEC, in collaboration with Development Consultants International, monitored, verified, and evaluated the program. Table 3-10 shows the cost of the CFL program.

Table 3-10. CFL Program Cost

Item	Cost (US$)
Procurement of 800,000 CFLs	982,695
Distribution of CFLs	240,000
Awareness Campaigns	96,000
Monitoring, Verification, & Evaluation	46,000
Development of CFL Standards	10,000
CFL testing equipment	250,000
Total cost of the program	**1,624,951**

Source: Isingoma, 2008

Key benefits:

- Demand was reduced by approximately 32 MW.
- Consumers who installed CFLs saw considerable energy bill reductions.
- Carbon dioxide (CO_2) emissions were reduced as a result of avoided use of diesel generators during peak periods.
- Electricity cost was reduced (MW saved vs. MW generated); program cost of US$1.62M provided 32 MW compared to the cost of US$17M required annually to operate a diesel plant to provide 30 MW for four hours during peak demand.
- Program triggered demand for CFLs, bringing down their price and offering quality products.

Following this success, ERA allocated US$4.1M toward its DSM program, which includes procurement and distribution of LEDs to replace high-energy-consumption incandescent bulbs. The initial batch of 420,000 LEDs was distributed to consumers starting in January 2015.

Audits

Energy audits have been performed for more than 50 high-energy-consuming industries and commercial facilities in Uganda under different projects:

- Under the **2007-2011 WB PSDO** program, energy audits were conducted in publicly owned facilities, including hospitals, schools and colleges, buildings, universities, KCCA street lighting, and National Water and Sewerage corporation facilities (WB, 2012a). Following completion of these energy audits, MEMD procured the energy-efficient equipment recommended in the audits and installed it in public institutions in Uganda. It is estimated that these interventions reduced energy consumption by about 10 GWh. However, monitoring and evaluating the project success was a challenge (WB, 2012a).
- **GIZ PREEEP and MEMD** commissioned energy audits of 26 high-energy-consuming industries from September 2014 to March 2015 to establish a current energy consumption baseline in different industrial subsectors and to sensitize industry managers to energy management. GIZ PREEEP (2015) provides a baseline survey summarizing results from these audits. One of the main findings is the "low intake of energy audits and energy management in industries." The number of energy efficiency measures implemented subsequent to the audits in the private sector has been limited. Discussions with local consultants indicate that only three out of the 15 companies that AOT Consulting audited for MEMD under GIZ have implemented energy efficiency measures.

To stimulate a higher level of investment in energy efficiency, MEMD has developed a regulation to require large energy users, referred to as designated consumers (DCs), to appoint an energy manager to conduct regular energy audits and report progress on implementation of energy efficiency measures to the ministry. However, this regulation, which is part of the draft Energy Efficiency and Conservation Bill, has not yet been approved.

Standards and Labeling

MEMD and UNBS developed and issued five MEPS in 2012 (lighting, refrigerators, freezers, motors, air conditioners), but, as noted earlier, these standards have not been implemented in the absence of regulations for enforcement. The regulation to enforce these standards is included in the draft Energy Efficiency and Conservation Bill that has not been enacted.
Enforcement could be part of Pre-Export Verification of Conformity, an international inspection and verification program adopted in Uganda. This program checks compliance against technical regulations and standards.

MEMD and UNBS have also developed a guide to assist importers and the business community dealing with the five appliances to understand the MEPS. The guide contains parameters related to energy consumption, to which the appliances imported to Uganda must conform.

Testing capacity is only available for lighting in Uganda. A test bench was procured with funding from WB under the Energy for Rural Transformation (ERT) II program, to test the quality of products sold on the Ugandan market.

UNBS has a five-year revision period, so the MEPS issued in 2012 will be up for review in 2017. The standards should be updated at that time to reflect the current state of the market. To complement the MEPS, MEMD is working with UNBS on developing a voluntary energy efficiency label for lighting, refrigerators, and air conditioners.

Power Factor Correction Program

Power quality is a major source of electricity waste in Uganda. Between 2007 and 2011, MEMD conducted a series of energy audits showing that some large electricity users have a power factor as low as 0.5, which represents a 51% energy loss. With installation of power-factor correction equipment, this can be mitigated to 5% or less (Okadokoi, 2016).

In 2011, PSFU implemented a program to incentivize industry to correct power factors under the WB ERT II project. The program included free audits and offered 59% cost sharing of the investment to correct power factor.

CREEC was in charge of verifying the estimated energy savings. As of 2014, 21 manufacturing companies had benefited from the program, with a total saving of 8.04 megavolts ampere (MVA) of demand, equivalent to 8.4 MW of electricity.

Key benefits:

- In industries where power factor correction equipment has been installed, the power factor increased from an average of 0.68 to 0.95, an improvement of 40%.
- This program allowed for the creation of companies that perform energy audits and efficiency upgrades.
- As noted in the Power Sector section *0. Power Factor Charge and Reward*, ERA has implemented an incentive-based tariff structure to penalize companies with low power factors and reward those with high power factors.

Solar Water Heaters

PSFU implemented a program with WB ERT I funding to install solar water heaters in hotels, guest houses, and lodges (300 units); homes (366 units); and institutions (e.g., schools, hospitals) (245 units). In total, 911 water heater systems were installed, representing 2,866 square meters of solar collector area. This program offered a cost-share of 50% for purchase and installation of the solar water heater.

The program saved 3.9 MW of peak load for a total cost of about US$1M or US$0.26M per MW avoided (ERA, 2014). This compares very positively against the cost of new power plant construction; for example, the 188 MW Isimba hydropower project is estimated to cost

US$3.1M per MW, more than 10 times the cost of the MW of avoided consumption under the water heater program[10] (Wesonga and Mugerwa, 2015).

Awareness Campaign

The largest event to raise awareness and educate the public on the benefits of using energy-efficient technologies is Energy Week, which takes place annually. This is a platform for large public announcements, such as LED distribution, and for exhibiting and demonstrating technologies. In 2014, Energy Week attracted 74 companies during five days of exhibitions. One-third were solar companies, another third were biomass companies, and the rest were energy efficiency companies, ESCOs, liquefied petroleum gas companies, government agencies, and financing institutions.

Eskom Uganda Limited is also sponsoring regional exhibitions and roadshows promoting efficiency and renewable energy. The first three-day Sustainable Energy Campaign was held in Jinja in December 2015 and the next was held in Mbarara in June 2016. The next Sustainable Energy Campaign planned will be in Eastern Uganda in the Spring of 2017

Training

Local energy auditors were involved in theoretical and practical energy management trainings conducted by the German consulting firm GFA in 2015 as part of the **GIZ PREEEP and MEMD** energy efficiency improvements for high-energy-consuming companies. Trainings were given for the first seven facilities, after which trained local consultants conducted the remaining energy audits under the supervision of GFA consultants.

Energy management training workshops organized by GIZ and MEMD were also carried out with UMA in November 2015 in Kampala. Representatives of 20 companies participated. Other energy management training workshops are planned in 2016, with the Uganda Manufacturers Association (UMA), for companies in Jinja and Fort Portal.

GIZ worked with MEMD to develop a process to certify energy auditors who completed the training course with the ministry. 18 out of the 50 who participated have already received the “Certified Energy Manager” designation. This process is envisioned to be carried out yearly to increase the technical expertise in the sector. GIZ is also planning to monitor and evaluate the implementation of recommendations for 15 companies where energy audits have been carried out.

City Leadership

The Kampala Capital City Authority (KCCA) is leading by example and playing a key local role in integrating climate change and energy issues in its public policies. In 2015, with funding from AFD and the French Global Environment Facility, KCCA conducted energy audits for a selection of the buildings that it owns or manages. Following up on the results of these audits, KCCA has piloted energy efficiency measures including occupancy sensors, lighting timers for corridors, and sensor-controlled outdoor lights.

[10] The whole project is estimated to have cost US$567.7M (Shs 1.7 trillion).

The city has developed a Climate Change Action Strategy with the goal of simultaneously addressing adaptation to climate change and mitigation of greenhouse gas (GHG) emissions through direct and indirect activities. Recommended actions under the Climate Change Action Strategy include supporting energy efficiency in the building sector through the city's authority in the fields of construction and renovation. The plan also proposes development of city "eco guidelines" that set high environmental standards and include energy and climate elements for public construction and renovations.

Activities leading up to the Paris climate talks in 2015 included an official roadmap launch, a city festival, and a stakeholders' dialogue at Makerere University. A climate change video and presentations were available on the KCCA website. The action strategy includes sector-specific electricity consumption forecasts with breakdowns by end-use.

Awards

No award recognizing significant action in energy efficiency exists yet in Uganda. However, two projects to institutionalize an energy efficiency award have taken form:

- GIZ 2016 is supporting an initiative from UMA to expand the scope of corporate social responsibility awards and include an award for energy management.
- The Energy Efficiency Strategy (2009) recommends that the government create a National Energy Efficiency Award to raise public awareness of energy efficiency. The recognition would be annual or bi-annual for enterprises, hotels, businesses, etc. that have notably improved energy use.

3.5.2 FINANCING OF ENERGY EFFICIENCY

Three main sources of funding can be leveraged to save energy: international public, domestic public, and private.

The majority of the energy efficiency projects implemented so far in Uganda have been funded by international grants from donors. The German government, through GIZ, has provided the most durable and comprehensive programmatic support to MEMD to develop its energy efficiency strategy. WB has provided more targeted support of specific opportunities to increase energy efficiency. As reviewed in the previous section, other international donors have contributed periodically to promote energy efficiency. More recently, the AFD program SUNREF has opened credit lines to improve financial access locally and provide technical support for increasing the rate of investment. However, the risk of currency deflation remains a barrier for local banks who would rather avoid loans in dollars because of the instability of the Uganda Shilling and the risk of loss revenue in the case of currency deflation over time. Domestically, the two main budget allocations for promoting energy efficiency are the national government allocation to MEMD for Energy Efficiency and Conservation Department activities (which include developing, administering, and monitoring regulations) and the budget raised by ERA through the electricity tariff.

Private sector funding for energy efficiency is limited at this time in Uganda because of the many barriers are outlined in the next subsection. However, there is a growing interest in expanding the development of ESCOs.

3.5.3 ISSUES AND CHALLENGES IN SITUATION ASSESSMENT

The barriers summarized in Table 3-11 and described below are among the reasons for the low level of investment in energy efficiency in Uganda.

Table 3-11. Barriers to Energy Efficiency in Uganda

	Barriers	Description	Remedy/opportunity
Regulatory	**Lack of policies and regulations to enforce energy efficiency**	Processes and procedures to enforce and prioritize energy efficiency requirements have not been put in place.	Enactment of the Energy Efficiency and Conservation Bill is needed to provide the legal basis for the elaboration and enforcement of the national policy.
	Lack of prioritization of investment in energy efficiency	Although energy efficiency is recognized as a resource to meet energy demand (NDPII, 2015), it is not yet prioritized in investment decisions.	▪ Integrate energy efficiency in resource planning ▪ Mandate that large energy users invest in energy efficiency ▪ Regulate products sold in the market
Informational	**Limited information and knowledge about the benefits of energy efficiency**	Those making purchasing decisions do not have information about the energy performance of technologies, and there is an inadequate awareness of the benefits of energy efficiency investment.	Develop programs to inform the private sector in investment decisions: ▪ Labeling of appliances ▪ Awareness campaigns ▪ Incentivized audits ▪ Recognition awards ▪ Best practices ▪ Training
	Inadequate technical expertise	Expertise on energy efficiency opportunities and benefits assessments is currently inadequate.	▪ Build capacity and create certification schemes to develop an established professional community ▪ Collaborate with UNBS* and ECREEE* to establish a testing facility to enforce market verification
Economic and Financial	**Lack of access to affordable capital and financing**	Uganda is among the countries with the highest cost of financing in the world. Uganda ranks 121 (out of 144 countries) by affordability of financial services. In comparison, Kenya and Rwanda rank 64 and 56, respectively (World Bank, 2015 a). Moreover, commercial banks do not have experience with financing energy efficiency projects and do not fully understand the profitability of energy efficiency loans.	▪ Provide affordable financing for energy efficiency investment ▪ Support financial intermediaries to invest in energy savings opportunities ▪ Support financing access to energy service companies ▪ Establish funding for energy efficiency investments by leveraging funding from public (government and development partners) and private stakeholders ▪ Develop guarantee fund to cover for deflationary risk

*UNBS – Uganda National Bureau of Standards; ECREEE - Economic Community of West African States Regional Centre for Renewable Energy and Energy Efficiency

4. ELECTRICITY SAVINGS POTENTIAL

This section estimates the technical and economic potential for electrical energy savings and peak-demand reduction from implementation of energy efficiency improvements in Uganda. The potentials are assessed from 2017-2030 and consider efficiency improvements for grid-connected industrial, commercial, urban residential, and rural residential customers as well as off-grid residential customers. The technical potential quantifies the maximum technologically feasible savings from energy efficiency measures without regard for market barriers or cost-effectiveness. In contrast, the economic potential estimates the savings that are cost-effective to implement, with the cost-effectiveness evaluated from the standpoint of the end-user. Two types of cost-effective potential are calculated. The first is a societal cost-effective potential, which assumes a discount rate of 7% for benefits of energy efficiency. The second is an achievable cost-effective potential, which assumes a discount rate of 20%, reflecting the interest rates available for financing energy efficiency measures across Sub-Saharan African countries. For the achievable potential, an uncertainty analysis is also performed to provide upper and lower bounds for the energy savings potential estimate.

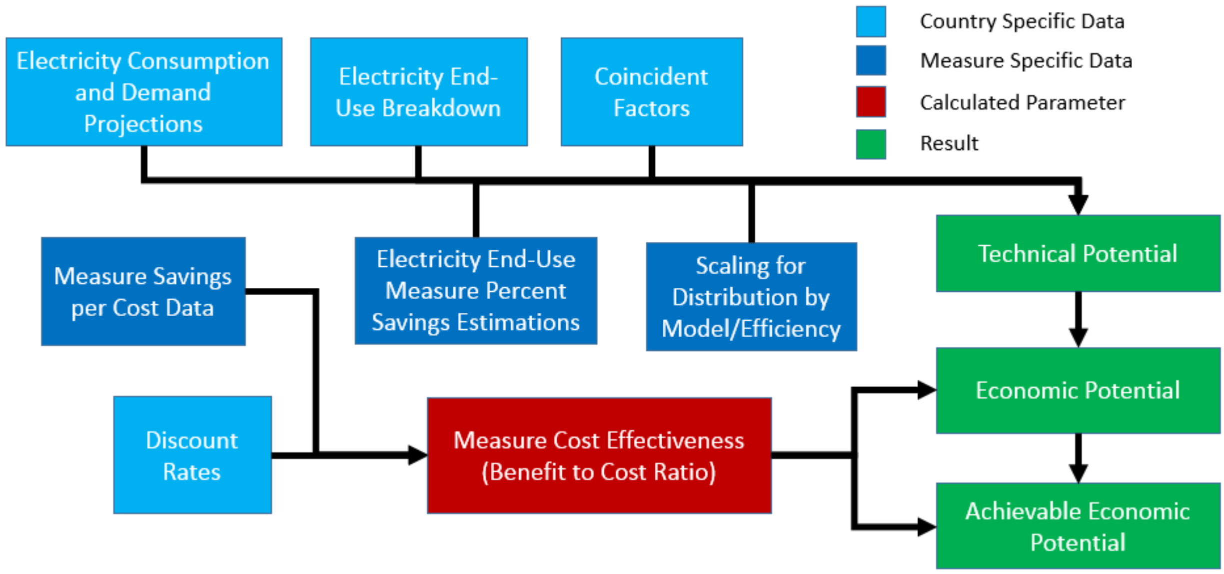
4.1 METHODOLOGY AND DATA

4.1.1 TECHNICAL, ECONOMIC, AND ACHIEVABLE ECONOMIC POTENTIAL FRAMEWORK

A top-down approach is used based on electricity consumption and demand projections to estimate technical, economic, and achievable economic potentials. The framework for this approach is illustrated in Figure 4-1. In this approach, the total electricity consumption for each sector is broken down by end-use, based on relative end-use electricity-consumption percentages. The total sector demand is also broken down by the end-use percentages; however, these percentages are corrected by coincident factors estimating the peak-demand contribution relative to non-peak electricity consumption. The technical potential for each end-use is then calculated by examining the impact of different measures on each end-use, such as solar water heaters for the residential water heating end-use. The impact is estimated using savings percentage estimations along with scaling factors for the relative applicability of the measure to the end-use. The primary data used in estimating technical potential are discussed in detail in the subsections below.

The economic and achievable economic potentials are each calculated from the technical potential by removing measures that are not cost-effective for the end-user. The cost-effectiveness for the end-user is assessed over the entire measure lifetime, and the only difference between the economic and achievable economic potentials is the discount rate assumed for the time value of money. For the economic potential, a societal discount rate of 7% is assumed whereas for the achievable economic potential, a discount rate of 20% is assumed, which, as noted above, reflects the interest rates available for financing energy efficiency in Sub-Saharan Africa. The uncertainty analysis for the achievable economic potential estimates a minimum and maximum percentage of energy savings for each of the measures examined. The uncertainty in energy savings stems primarily from the uncertainty in the baseline for each measure examined. This is the result of an absence of statistical data on measure efficiency levels, e.g., a breakdown of the percentage of homes that use cathode-ray tube versus liquid crystal display TVs.

Figure 4-1. Framework for Calculating Energy Efficiency Technical, Economic, and Achievable Economic Potentials



4.1.2 ENERGY AND DEMAND PROJECTIONS

All of the energy efficiency potentials are calculated using a top-down approach. Because the timeline of the savings potential is 2017 through 2030, the first step in quantifying this potential is to formulate projections of energy consumption and demand. The projections for the energy consumption of the commercial and industrial sectors are calculated based on the historical consumption values reported by ERA (2015a), the projections in the Uganda Power Sector Investment Plan (PSIP) (Parsons Brinckerhoff, 2011), and a breakdown of 2015 consumption, by customer, from UMEME (UMEME, 2016). Because the large industrial, medium industrial, and commercial tariff classes are broken down by voltage-level demands rather than actual customer type classification, the customer list from UMEME is used to determine how tariff classifications should be mapped to the customer type classifications assessed in this report. Table 4-1 shows the breakdown of energy consumption into the two customer types for each of the applicable tariff classes.

The PSIP projections encompass four scenarios: low, base, high, and Vision 2035. A comparison of ERA's reported historical energy consumption data to the PSIP projections reveals that, for both the large industrial and commercial tariff classes, the base-case projections have proven to be far more accurate than either the low or high scenarios. This is illustrated in Figure 4-2 for the commercial tariff class and Figure 4-3 for the large industrial class. In addition, through a comparison of the ERA-reported consumption values in Table 4-2, it is evident that the cumulative growth rates for the large industrial and medium industrial sectors for the period 2010-2015 are within 5% of each other (59% for medium industrial and 64% for large industrial). Further examination of the base-case projections reveals that the growth rates for the commercial, medium industrial, and large industrial tariff classes are nearly equivalent from 2017-2030. Therefore, the base-case growth rates are used to formulate the energy consumption projections for the analysis in this report for both the industrial and commercial sectors.

Table 4-1. Percentage of Consumption per Customer Type for Each Tariff Class

		Tariff Class		
		Large Industrial	Medium Industrial	Commercial
Customer Type	Industrial	86%	18%	7%
	Commercial	14%	17%	20%

Figure 4-2. Commercial Tariff Electricity Consumption, PSIP Forecast and Actual

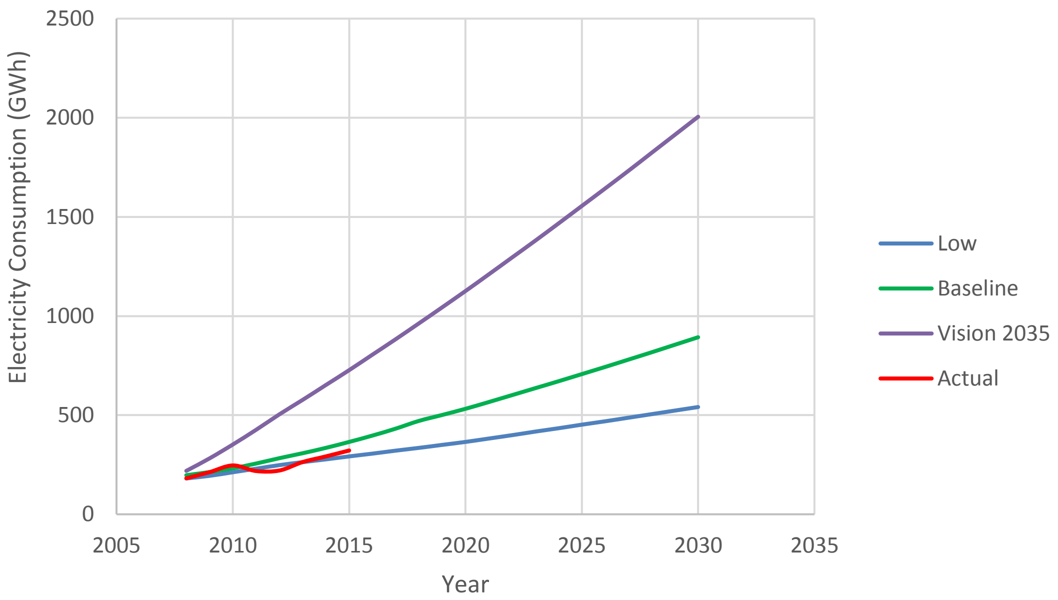


Figure 4-3. Large Industrial Tariff Electricity Consumption, PSIP Forecast and Actual

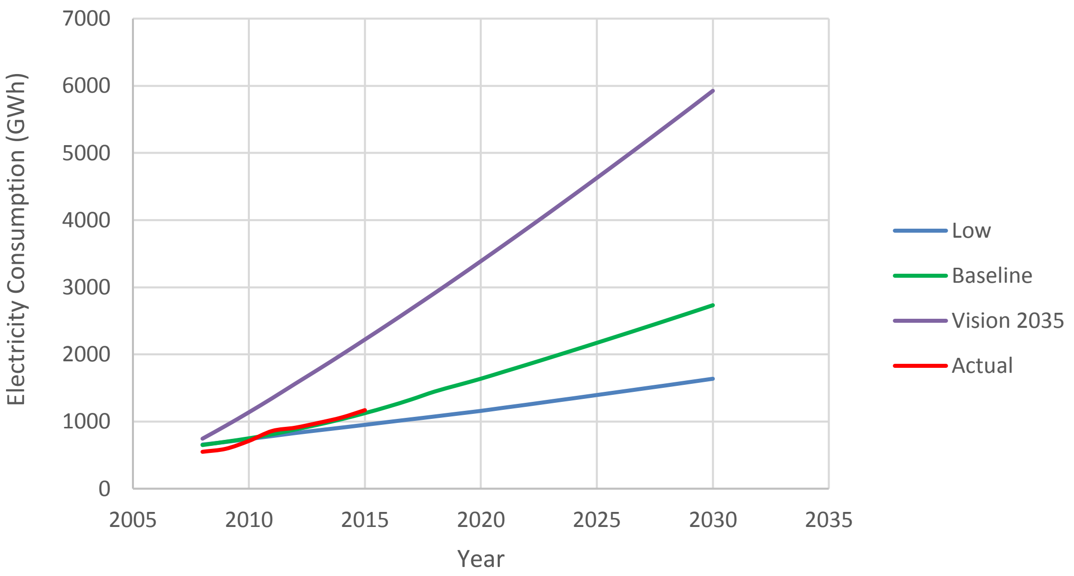


Table 4-2. Electricity Sales Statistics from ERA, 2008 - 2015

Year	Commercial (GWh)	Medium Industrial (GWh)	Large Industrial (GWh)
2008	181	223	549
2009	213	232	594
2010	246	256	711
2011	218	260	859
2012	221	342	909
2013	263	379	980
2014	292	391	1,060
2015	322	408	1,170

While the PSIP growth rates are utilized for the commercial and industrial sectors, growth in the residential sectors is not calculated in this way because this sector is broken down into three subsectors: on-grid urban, on-grid rural and off-grid rural. Growth of the on-grid urban and rural residential sectors is calculated based on the number of planned new connections outlined in Uganda's SEforALL Action Agenda (SEforALL 2015). Approximately 2.5M additional on-grid connections are planned from 2017-2030, 53% of which will be urban. Because this Roadmap is being released prior to the release of Uganda's off-grid master plan, similar data are not available for the off-grid residential sector. Therefore, the projections for the off-grid residential sector are calculated from international reports on the growth of the solar industry in Sub-Saharan Africa. A growth rate of 6% is assumed for off-grid connections, based on reviewing historical growth in electrification from reports by the Global Lighting and Energy Access Partnership (Global LEAP) and Global Off-Grid Lighting Association (GOGLA) (Global LEAP, 2016; GOGLA, 2016). Additional assumptions for calculating on-grid urban, on-grid rural, and off-grid residential projections are presented in Appendix 5.

The resulting projections for each of the five sectors are shown in Figure 4-4. This plot shows that the industrial sector is anticipated to continue to be the most influential sector for energy consumption. However, because of increased electrification as well as higher consumption per household, domestic sector consumption is projected to grow faster than commercial sector consumption so that by 2030 the total consumption of the residential sector is 60% larger than the projected commercial consumption. The data in Figure 4-4 are also presented for select years in Table 4-3.

Figure 4-4. Electricity Consumption Projections for Energy Efficiency Potential Calculations, 2016 – 2030

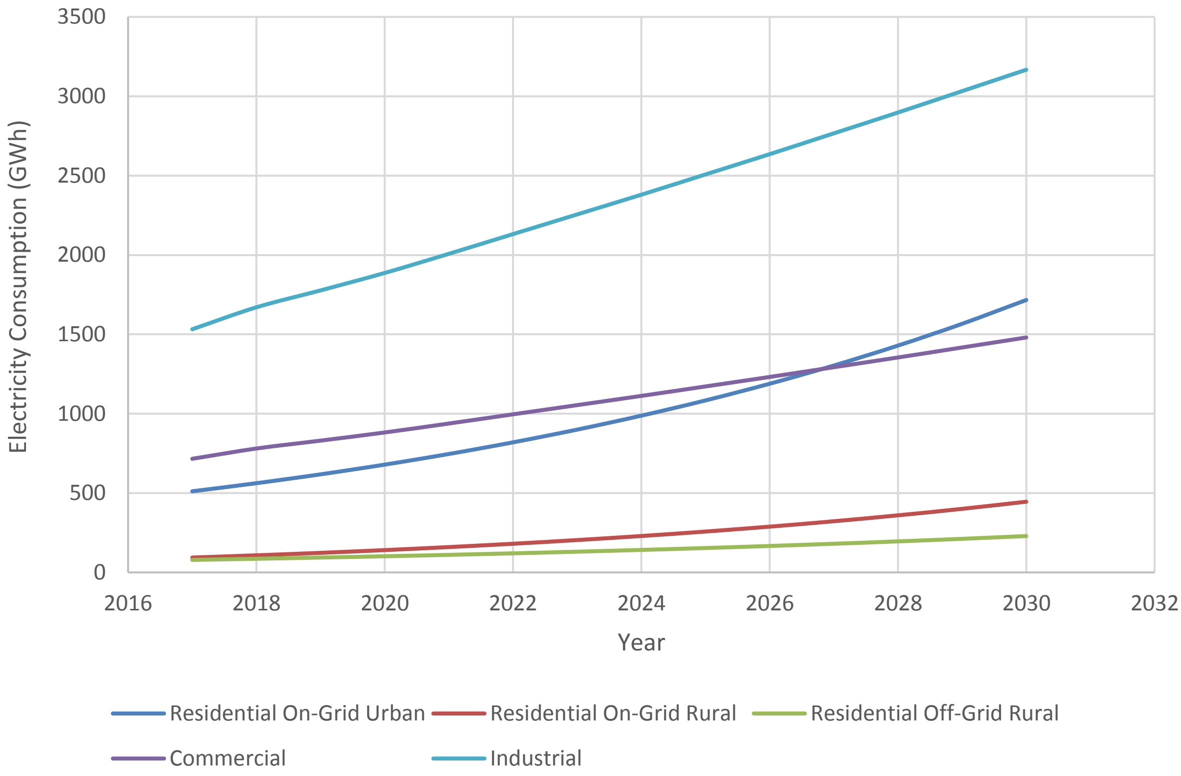


Table 4-3. Electricity Consumption Projections (GWh) for 2017, 2020, 2025, and 2030

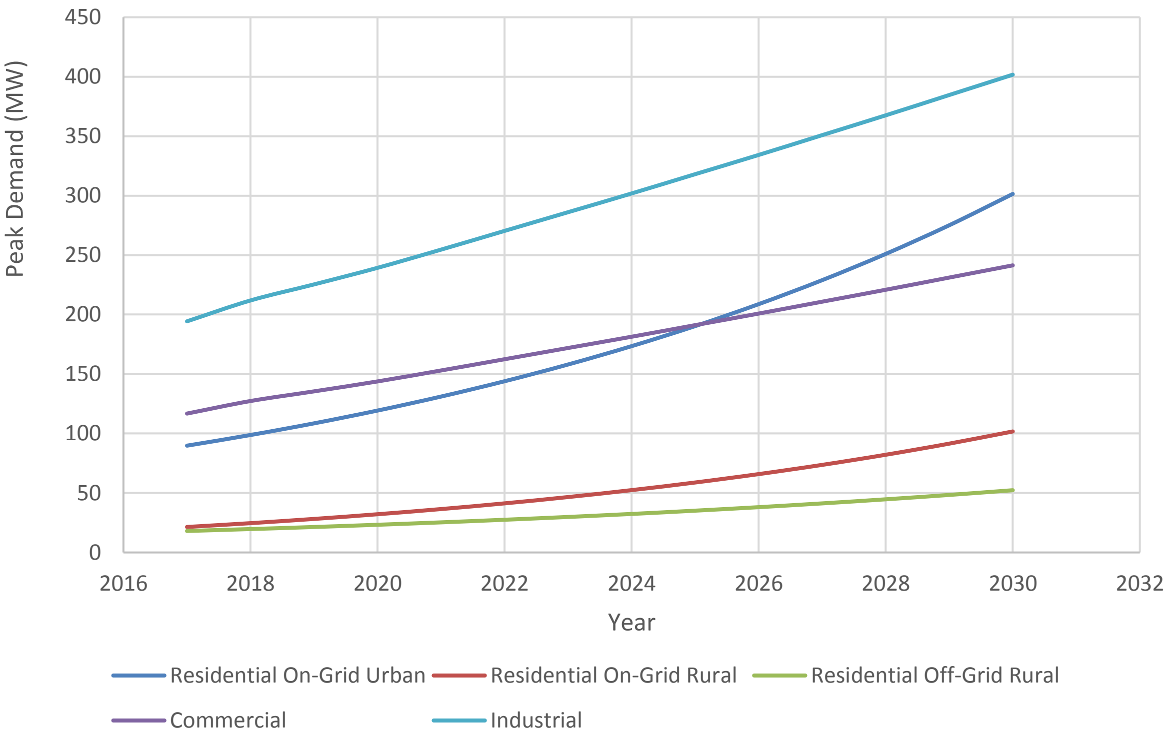
Sector	2017	2020	2025	2030
Residential On-Grid Urban	511	679	1,084	1,716
Residential On-Grid Rural	94	141	258	446
Residential Off-Grid Rural	79	102	154	229
Residential Total	*684*	*922*	*1,495*	*2,391*
Commercial	716	882	1,172	1,480
Industrial	1,532	1,887	2,507	3,167
Total	**2,932**	**3,691**	**5,174**	**7,038**

To project electricity demand based on anticipated consumption figures, the analysis leverages the coincident after diversity load factors (CADLFs) method from the PSIP (Parsons Brinckerhoff, 2011). In this method, a sector's annual consumption is spread evenly over the hours within a year and divided by the appropriate CADLF to estimate the sector's peak demand prior to T&D losses. Table 4-4 shows the PSIP CADLFs for each sector. As expected based on Uganda's evening peak, the CADLFs indicate that residential consumption has the largest proportional impact on peak demand. Figure 4-5 shows the projections for peak demand per sector based on this method. Although total on-grid residential consumption is anticipated to be much less than total industrial consumption in 2030 (2,162 GWh on-grid residential, 3,167 GWh industrial), on-grid residential peak demand in the same year is anticipated to be slightly larger than industrial peak demand (403 MW on-grid domestic, 402 MW industrial). As previously mentioned, domestic sector growth will outpace industrial sector growth, so the domestic sector is projected to have a greater influence on system peak demand in each year.

Table 4-4. Coincident After Diversity Load Factors (CADLFs) from PSIP

Sector	CADLF (%)
Domestic high consumption (on-grid urban)	65
Domestic low consumption (on- and off-grid rural)	50
Large industrial	90
Medium industrial	80
Commercial	70

Figure 4-5. On-Grid Electricity Peak Demand Projections, 2016 - 2030



4.1.3 END-USE BREAKDOWN

Two distinct methods are used to calculate the sector end-use breakdowns. For the commercial and industrial sectors, the building/facility stock for each sector is broken down using customer data from UMEME (UMEME, 2016). The total sector end-use breakdown is calculated by aggregating the end-use breakdowns for each of the building/facility types within the sector. The building/facility level end-use breakdowns for the commercial sector are predominantly estimated from Ugandan energy audit reports provided by MEMD; where data are missing, regional and international data are used to fill in the gaps. And for the industrial sector, the building/facility level end-use breakdowns are estimated from MECS (Manufacturing Energy Consumption Survey) data modified for Uganda (US DOE, 2010). In contrast to the approach for the commercial and industrial sectors, end-use breakdowns for the residential sectors are calculated using a bottom-up model of average household energy consumption. For the residential sectors, the main data sources are a household electricity consumption survey (GTZ, 2008), a market technology survey (GIZ, 2014), the 2014-15 Uganda Malaria Indicator Survey (UBOS & ICF International, 2015), and the draft Energy Efficiency Strategy for Uganda (GIZ, 2009). Data from these and several other sources are used to create a model of average household energy consumption by estimating average power consumption for each appliance within the household, along with penetration of each type of appliance in Ugandan households that have access to electricity and the average number of hours during which the appliance is used per day.

For the commercial and residential sectors, the end-use breakdowns are modeled as dynamic during the analysis period, to allow for increasing usage and penetration of air conditioning, water heating, and other energy-consuming appliances in these sectors. This is done by calculating end-use breakdowns for 2017 and 2030 and assuming a linear transition between the two.

The 2030 electricity consumption end-use breakdowns calculated for on-grid urban residential, on-grid rural residential, and off-grid residential are shown in Figure 4-6, Figure 4-7, and Figure 4-8, respectively. For all of the residential sectors, lighting is the largest end-use (25% for urban on-grid, 34% for rural on-grid, and 51% for off-grid). This is expected because it is assumed that all homes with electricity use electric lighting, and high-wattage appliances such as water heaters and air conditioners have much lower penetration. The second most influential end-uses are refrigeration in both on-grid sectors (24% urban and 21% rural), and TVs in the off-grid sector (18%). In all sectors, the same three end-uses (lighting, TVs, and refrigerators) account for at least 59% of an average household's electricity consumption, revealing that a large amount of electricity consumption could be reduced by focusing on very few end-uses.

Figure 4-6. Electricity Consumption End-Use Breakdown 2030 – On-Grid Urban Residential

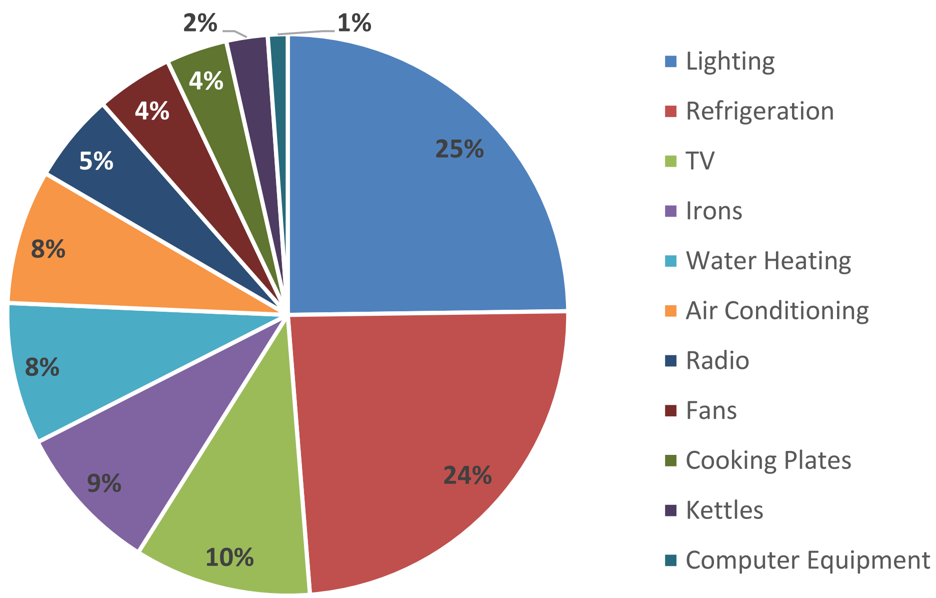


Figure 4-7. Electricity Consumption End-Use Breakdown 2030 – On-Grid Rural Residential

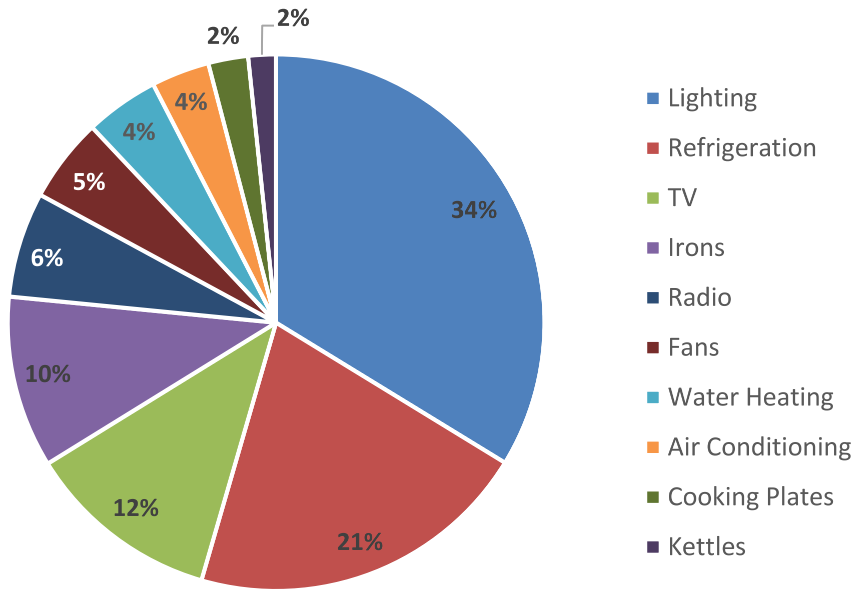
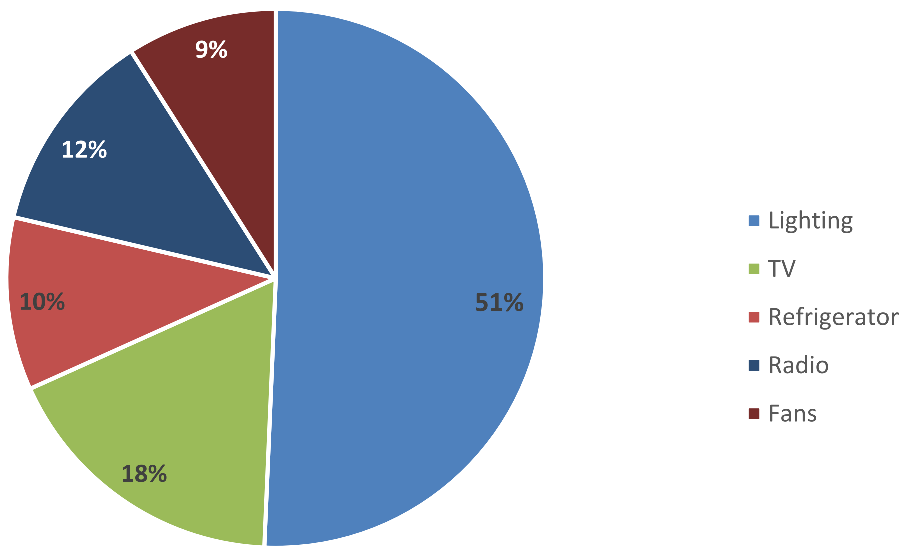


Figure 4-8. Electricity Consumption End-Use Breakdown 2030 – Off-Grid Residential



The 2030 end-use consumption breakdowns for the commercial and industrial sectors are shown in Figure 4-9 and Figure 4-10, respectively. As in the residential sectors, lighting is the most influential end-use in the commercial sector (30%). However, this is the extent of the similarity between residential and commercial breakdowns because in the commercial sector air conditioning and computer equipment play a much more influential role than in any of the residential sectors. Because only an estimated 41% of energy consumed by the commercial-sector building stock is represented in the data provided by UMEME, and the sample is biased toward customers that consume the most energy in each tariff class, there is significant room for error in this breakdown of building/facility type. This margin of error also applies to the industrial sector results but to a lesser extent because an estimated 77% of industrial sector energy consumption is represented in the UMEME data.

For the industrial sector, the sample is also biased towards the larger energy-consuming customers. Figure 4-10 shows that unlike all other sectors, in the industrial sector lighting is not an influential end-use, representing only 5% of total electricity consumption. The dominant end-use in the industrial sector is motors. This end-use includes the consumption for all drives that are not related to heating, ventilation, and air conditioning (HVAC). Air compressors are the only major motor end-use that is called out separately. They represent approximately 6% of total energy consumption. The dominant influence of motor electricity consumption fits with international expectations; motors consume approximately 69% of electricity in industry globally (Waide & Brunner, 2011).

Figure 4-9. Electricity Consumption End-Use Breakdown 2030 – Commercial

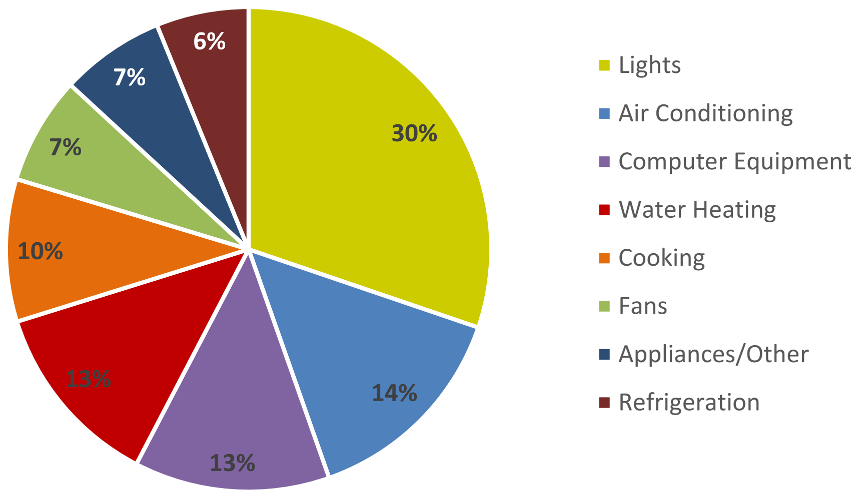
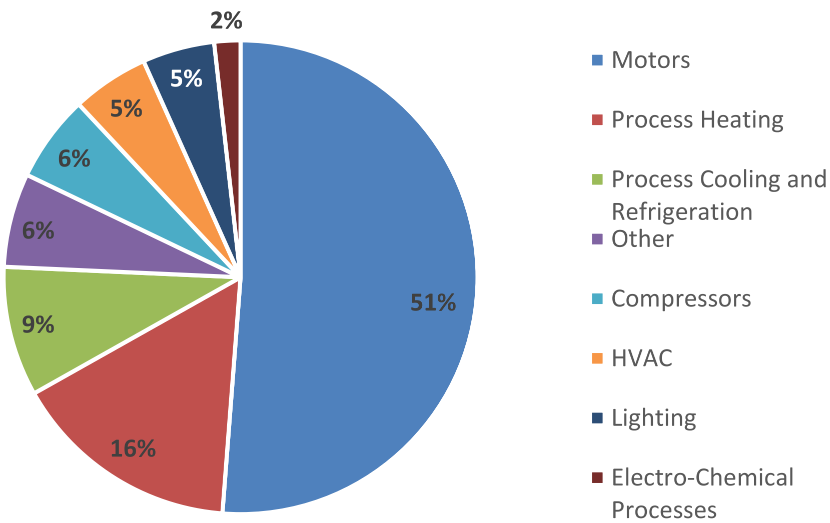


Figure 4-10. Electricity Consumption End-Use Breakdown 2030 – Industrial



4.1.4 COINCIDENT FACTORS

To estimate demand savings for each sector, peak demand was broken down by end-use, applying coincident factors to translate the electricity consumption breakdowns to the units of electricity demand. The coincident factor for each end-use specifies what percentage of the end-use consumption can be assigned to the peak-demand period.

Figure 4-11 shows the average daily load shape for the grid, with a clear peak at the end of the day from residential consumption. For this analysis, the peak-demand period is defined as 6PM – 12AM, based on the peak tariff definition from UMEME. Therefore, for end-uses such as residential lighting, the coincidence factor is high (80%) whereas for residential refrigeration, the coincidence factor is low (25%) because this end-use operates throughout the day. The coincidence factors for the end-uses within each of the sectors are shown in Table 4-5 through Table 4-7.

Table 4-5. On-Grid Urban, On-Grid Rural, and Off-Grid Residential Sector Coincidence Factors

	On-Grid Urban	**On-Grid Rural**	**Off-Grid**
End-use	**Coincidence Factor (%)**	**Coincidence Factor (%)**	**Coincidence Factor (%)**
Lighting	80	80	80
TV	80	80	80
Refrigeration	25	25	25
Radio	60	60	60
Air conditioning	60	60	N/A
Irons	20	20	N/A
Kettles	60	60	N/A
Cooking plates	60	60	N/A
Fans	60	60	60
Water heating	30	30	N/A
Computer	80	N/A	N/A

Table 4-6. Commercial Sector Coincidence Factors

End-use	**Coincidence Factor (%)**	**End-use**	**Coincidence Factor (%)**
Air conditioning	10	Fans	10
Appliances/other	20	Lighting	20
Computer equipment	15	Refrigeration	25
Cooking	40	Water heating	30

Figure 4-11. Average Daily Demand, June 2012 – July 2013 (ERA, 2016)

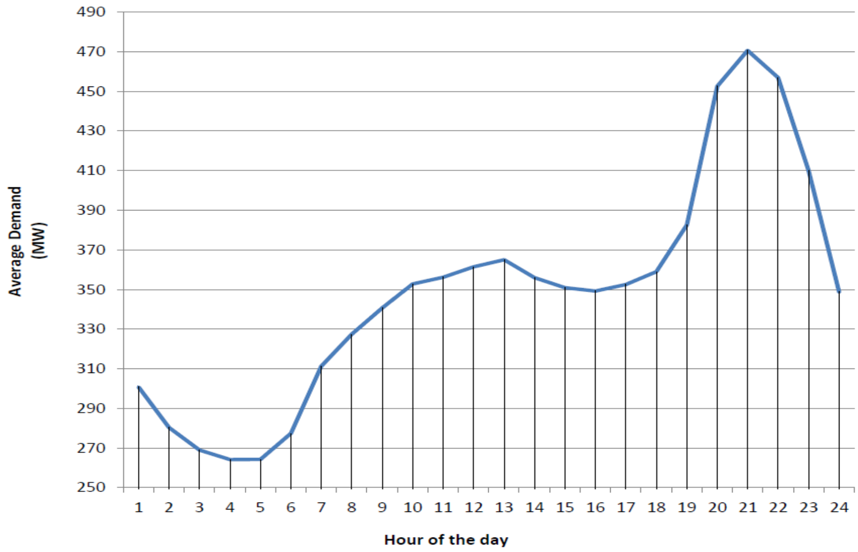


Table 4-7. Industrial Sector Coincidence Factors

End-use	Coincidence Factor (%)
Electro-chemical processes	15
HVAC	15
Industrial lighting	15
Industrial motors	15
Industrial compressed air	15
Other	15
Industrial process cooling	15
Industrial process heating	15

To calculate the energy efficiency potential, 59 energy efficiency measures are examined. The key assumptions for each measure are presented in Table 4-8 to Table 4-10, with separate tables for the residential, commercial, and industrial sectors. These measures are assumed to be representative of the types of measures and associated savings possible within each of the sectors; however, they are not intended to be comprehensive. Therefore, a more detailed analysis specific to the focus of an energy efficiency program should be conducted prior to undertaking the design of such a program.

Both the technical and the economic potentials are calculated by applying the average percent savings to the end-use consumption estimates. The medium case of the achievable economic potential also uses the average percent savings estimates; however, the low and high cases of the achievable economic potential use the low and high percent savings estimates, respectively. The cost-per-kWh data presented in the tables are also scaled for the low and high scenarios, based on the changes in savings percentages for the measures. For the cost data, all measures that can be implemented as either replacements on burnout or retrofits are assumed to be implemented with a replacement-on-burnout methodology. Therefore, an incremental cost of implementing the measures is used rather than the full cost. Utilizing incremental cost for all measures allows for a level comparison among measures without the need to explicitly break down measures by delivery type. It should also be noted that the cost data in Table 4-8 through Table 4-10 are presented in terms of the incremental cost per average annual savings. This is used as an input along with the retail rates and measure lifetime values to calculate the Cost of Conserved Energy (CCE) for each measure.

For all measure lifetimes in every sector, the measure-life estimates found in the literature are halved. This is because the estimations of measure life are sourced from Technical Resource Manuals for developed countries that do not experience the same power quality issues as are experienced in Uganda. Finally, the assumptions about possible savings from the lighting end-use for the on-grid urban and rural residential sectors assume a lighting baseline prior to the start of the LED distribution program that UMEME is currently carrying out. Therefore, the energy and capacity savings that can be achieved through an energy efficiency program are effectively included in the estimations of potential in this report.

Table 4-8. On-Grid Urban, On-Grid Rural and Off-Grid Residential Sector; Measure-Level Assumptions for Savings, Cost, and Lifetime[11]

On-Grid Urban and On-Grid Rural									
Measure	**End-Use**	**Average Electricity Savings (%)**	**Savings Source**	**Savings Low (%)**	**Savings High (%)**	**Measure Lifetime (year)**	**Lifetime Source**	**Incremental Cost per Average Annual Savings (USD/kWh)**	**Source**
LED lighting	Lighting	58	(GIZ, 2014; Home Depot, 2016b)	50	65	10	(Shelter Analytics, 2013)	$0.10	(GIZ, 2014; Home Depot, 2016b; MEMD, 2016)
LCD TV	TV	50	(Energy Star, 2016a; GTZ, 2008; Parris, 2011)	40	55	2	(Shelter Analytics, 2013)	$1.58	(ENERGY STAR, 2016a; GTZ, 2008; Parris, 2011; MEMD, 2016)
High-efficiency fan	Fans	55	(Energy Star, 2016a)	30	60	2	(Shelter Analytics, 2013)	$0.25	(Global LEAP, 2016; MEMD, 2016)
High-efficiency refrigerator	Refrigeration	50	(GIZ, 2014; GTZ, 2008; Energy Star, 2016b)	40	60	6	(Shelter Analytics, 2013)	$0.52	(GIZ, 2014; GTZ, 2008; MEMD, 2016)
High-efficiency room AC*[12] unit	Air conditioning	22	(GIZ, 2014; Home Depot, 2016a)	15	35	6	(Shelter Analytics, 2013)	$0.98	(GIZ, 2014; Home Depot, 2016a; MEMD, 2016)
Solar hot water heater	Water heating	75	(Silva & Mugisha, 2005)	60	90	8	(SBW Consulting, Inc., 2013)	$0.57	(ICF, 2016c)
Heat-pump hot water heater	Water heating	63	(SBW Consulting, Inc., 2013)	55	75	8	(SBW Consulting, Inc., 2013)	$0.19	(ICF, 2016c)
Off-Grid									
LED lighting	Lighting	67	(Kaggwa, 2016)	45	75	10	(Shelter Analytics, 2013)	$0.40	(Amazon, 2016; Solarpowergetics, 2016)
LED TV	TV	53	(Global Leap, 2016)	40	65	2	(Shelter Analytics, 2013)	$1.29	(Global LEAP, 2016)
High-efficiency fan	Fans	57	(Global Leap, 2016)	40	70	2	(Shelter Analytics, 2013)	$0.39	(Global LEAP, 2016)
High-efficiency refrigerator	Refrigeration	43	(Global Leap, 2016)	35	60	6	(Shelter Analytics, 2013)	$1.22	(Global LEAP, 2016)

[11] Please note that due to customs duty, tax, transaction costs, etc., the prices and range of products available may change from country to country.

[12] AC – air conditioning

Table 4-9. Commercial Sector; Measure Level Assumptions for Savings, Cost, and Lifetime

Measure	End-Use	Average Electricity Savings (%)	Savings Source	Savings Low (%)	Savings High (%)	Measure Lifetime (year)	Lifetime Source	Incremental Cost [O&M* Cost] per Average Annual Savings (USD/kWh)	Source
Computer hibernation and auto turn-off	Computer equipment	17	(EECD, 2015a)	13	20	1	(ICF, 2016a)	$0.15	(EECD, 2015a)
High-efficiency laptops and desktops	Computer equipment	43	(EECD, 2015a)	30	50	2	(Shelter Analytics, 2013; ICF, 2016a)	$0.54	(EECD, 2015a)
LED fixture lighting	Lighting	66	(EECD, 2015a)	50	70	10	(Shelter Analytics, 2013)	$0.33	(EECD, 2015a)
LED drop-in lighting	Lighting	66	(EECD, 2015a)	50	70	8	(ICF, 2016a; Shelter Analytics, 2013)	$0.13	(EECD, 2015a; Grainger, 2016; Light Up, 2016)
Weatherization: apply blinds, shutters, air-sealing, etc.	Air conditioning	7	(EECD, 2015a)	5	10	5	(Shelter Analytics, 2013) (Public Utility Commission of Texas, 2016)	$1.20	(EECD, 2015a)
AC energy-saver system	Air conditioning	9	(EECD, 2015a)	6	12	4	(Shelter Analytics, 2013; ICF, 2016a)	$1.95	(EECD, 2015a)
Network sharing for printers, photocopiers, scanners	Computer equipment	50	(MEMD, 2015a)	35	65	5	(ICF, 2016a)	$0.56	(ICF, 2016a)
Efficient packaged air conditioner	Air conditioning	28	(SBW Consulting, Inc., 2013)	20	40	8	(SBW Consulting, Inc., 2013)	$0.16	(ICF, 2016c)
Variable-speed-drive on chiller system	Air conditioning	19	(ICF, 2016b)	16	24	8	(SBW Consulting, Inc., 2013)	$0.24	(ICF, 2016c)
Solar water heater	Water heating	75	(ICF, 2016c; Silva & Mugisha, 2005)	60	90	8	(SBW Consulting, Inc., 2013)	$0.28	(ICF, 2016c)
Heat pump water heater	Water heating	63	(ICF, 2016c)	55	75	8	(SBW Consulting, Inc., 2013)	$0.15	(ICF, 2016c)
Low-flow faucet aerator	Water heating	55	(SBW Consulting, Inc., 2013)	45	60	5	(SBW Consulting, Inc., 2013)	$0.04	(SBW Consulting, Inc., 2013)

Measure	End-Use	Average Electricity Savings (%)	Savings Source	Savings Low (%)	Savings High (%)	Measure Lifetime (year)	Lifetime Source	Incremental Cost [O&M* Cost] per Average Annual Savings (USD/kWh)	Source
High-efficiency reach-in cooler	Refrigeration	14	(Waide et al., 2014)	10	20	5	(Shelter Analytics, 2013)	$0.09	(Waide et al., 2014)
High-efficiency solid-door freezer	Refrigeration	56	(Waide et al., 2014)	45	65	5	(Shelter Analytics, 2013)	$0.24	(Waide et al., 2014)
Variable-speed-drive on fans	Fans	19	(ICF, 2016b)	16	24	5	(SBW Consulting, Inc., 2013; ICF, 2016a)	$0.34	(SBW Consulting, Inc., 2013; ICF, 2016a)
Building energy management system	Total consumption	10	(Envidatec, 2015a; ICF, 2016a)	5	15	8	(ICF, 2016b)	$0.07 [$0.0045]	(Envidatec, 2015a; ICF, 2016a)
Low solar heat gain window film	Air Conditioning	21	(Vista Window Film, 2016)	15	25	5	(Public Utility Commission of Texas, 2016)	$0.61	(DeBusk, 2012)

* O&M – operations and maintenance

Table 4-10. Industrial Sector; Measure Level Assumptions for Savings, Cost, and Lifetime

Measure	End-Use	Average Electricity Savings (%)	Savings Source	Savings Low (%)	Savings High (%)	Measure Lifetime (year)	Lifetime Source	Incremental Cost [O&M Cost] per Average Annual Savings (USD/kWh)	Source
Energy Management System (EMaS), ISO50001	Total Consumption	10	(Envidatec, 2015a)	7	15	3	(ICF, 2015)	$0.07 [$0.0045]	(Envidatec, 2015a)
Energy Monitoring System (EMoS), ISO50006	Total Consumption	5	(Envidatec, 2015a)	3	10	3	(ICF, 2015)	$0.08 [$0.0045]	(Envidatec, 2015a)
Using variable speed drives on air compressors	Compressed Air	25	(Envidatec, 2015a)	20	30	8	(ICF, 2015)	$0.11 [$0.0091]	(Envidatec, 2015a)
Reduce compressed air leaks	Compressed Air	20	(Envidatec, 2015a)	15	30	2	(ICF, 2015)	$0.02 [$0.0068]	(Envidatec, 2015a)
Reduce compressed air tank pressure	Compressed air	7	(Envidatec, 2015a)	5	9	1	(ICF, 2015)	$0.01 [0.0046]	(Envidatec, 2015a)
Demand- controlled compressed air	Compressed air	15	(Envidatec, 2015b)	10	20	3	(ICF, 2015)	$0.09	(Envidatec, 2015b)
LED lighting fixtures	Lighting	50	(Envidatec, 2015b)	40	55	10	(ICF, 2015)	$0.30	(Envidatec, 2015b)
Lighting control system	Lighting	20	(Envidatec, 2015a)	15	25	5	(ICF, 2015)	$0.54 [$0.0136]	(Envidatec, 2015a)
Variable-speed-drive motors	Motors	25	(Envidatec, 2015c)	20	30	8	(ICF, 2015)	$0.27	(Envidatec, 2015c)
High-efficiency large motors	Motors	6	(Envidatec, 2015b)	5	7	8	(ICF, 2015)	$0.21	(Meyers et al., 1993)
High-efficiency small motors	Motors	18	(U.S. DOE, 2002)	14	20	8	(ICF, 2015)	$0.43	(Meyers et al., 1993)
Properly sized motors and drives	Motors	3	(Meyers, Monahan, Lewis, & Greenberg, 1993)	2	4	8	(ICF, 2015)	$0.02	(ICF, 2015, 2016a; Envidatec, 2015c)
Preventative maintenance for motors /drives	Motors	4	(Envidatec, 2015c)	3	5	2	(ICF, 2015)	$0.03	(Envidatec, 2015c)
Process cooling pipe insulation	Process cooling	5	(ICF, 2015)	4	6	5	(ICF, 2015)	$0.50	(ICF, 2015)

Measure	End-Use	Average Electricity Savings (%)	Savings Source	Savings Low (%)	Savings High (%)	Measure Lifetime (year)	Lifetime Source	Incremental Cost [O&M Cost] per Average Annual Savings (USD/kWh)	Source
Refrigeration plant variable- speed drives	Process cooling	20	(Envidatec, 2015a)	15	25	8	(ICF, 2015)	$0.27	(Envidatec, 2015a)
Optimized chilled water temperature	Process cooling	3	(ICF, 2015)	2	4	1	(ICF, 2015)	$0.02	(ICF, 2015, 2016a)
Preventative refrigeration/ cooling system maintenance	Process cooling	5	(ICF, 2015)	4	6	2	(ICF, 2015)	$0.03	(ICF, 2015)
High-efficiency chiller	Process cooling	19	(ICF, 2015)	15	23	10	(ICF, 2015)	$0.48	(ICF, 2015)
Improved process heating insulation	Process heating	5	(ICF, 2015)	4	6	8	(ICF, 2015)	$0.29	(ICF, 2015)
Advanced heating and process control	Process heating	5	(Envidatec, 2015c)	4	6	3	(ICF, 2015)	$0.05	(Envidatec, 2015c)
Preventative furnace/boiler maintenance	Process heating	5	(ICF, 2015)	4	6	2	(ICF, 2015)	$0.03	(ICF, 2015)
Reduction in steam pressure	Process heating	5	(Envidatec, 2015c)	4	6	2	(ICF, 2015)	$0.29	(Envidatec, 2015c)
Process heat recovery	Process heating	6	(ICF, 2015)	4	8	10	(ICF, 2015)	$0.88	(ICF, 2015)
LED lighting drop-in	Lighting	50	(MEMD, 2015c)	40	55	8	(ICF, 2015)	$0.21	(MEMD, 2015c)

4.1.5 END-USER TARIFF ASSUMPTIONS

The cost-effectiveness of energy efficiency measures depends heavily on the price of electricity. Therefore, tariffs play a very important role in determining the economic and achievable economic potential. Because UMEME is responsible for 95% of the power distribution in Uganda, UMEME's tariff structure and rates are used for this analysis. For the on-grid residential sectors, there is a one-to-one relationship between sector and tariff class; both of these sectors are in the "domestic" tariff class. However, the commercial and industrial sectors fall into multiple tariff classes, as discussed in subsection 4.1.2. Therefore, the breakdown from Table 4-1 is used to determine an average tariff for each sector. Table 4-11 shows the rates that are assumed for each UMEME tariff class, based on data from the 2015 Annual Tariff Review (ERA, 2015b). Table 4-12 shows the resulting tariffs for the commercial and industrial sectors, as well as the residential tariffs. For the off-grid residential category, there is no tariff, so the price of electricity for off-grid customers is estimated as the levelized cost of electricity for off-grid solar and diesel systems in Sub-Saharan Africa (Jenkins & Baurzhan, 2014).

Table 4-11. UMEME 2016 Proposed Electricity Tariffs

Price of Electricity	USD/kWh	USD/kW/year
Domestic	0.18	0
Commercial	0.16	0
Medium Industrial	0.15	55.32
Large Industrial	0.10	18.48

Table 4-12. Roadmap Tariffs Assumed for Each Sector

Price of Electricity	USD/kWh	USD/kW/year
On-Grid Urban Res	0.18	0
On-Grid Rural Res	0.18	0
Off-Grid Res	0.63	0
Commercial	0.14	23.64
Large Industrial	0.11	23.04

4.2 TECHNICAL ELECTRICITY SAVINGS POTENTIAL

The estimated total meter level technical potential for energy savings in the year 2030 is 2,224 GWh, which is equivalent to 31% of the predicted total consumption for that year. Figure 4-12 illustrates the technical potential savings for each sector through 2030. This graph shows that the largest share of savings comes from the industrial sector; however, significant savings are possible from the residential and commercial sectors as well. In total, energy efficiency savings offset approximately 54% of anticipated load growth from 2017-2030. This is an extremely large opportunity for energy efficiency to help manage load growth so that new electricity capacity can be used to increase access for new customers. Assuming a total electricity consumption of 1,060 kWh per year for urban customers and 369 kWh per year for on-grid rural customers (Parsons Brinckerhoff, 2011), the on-grid efficiency savings in 2030 could allow grid access to an estimated additional 2.1 million urban customers, or 6 million rural customers, without the need for additional generation. In other words, including efficiency in the national planning process could mean electricity access will be provided to more citizens at a cost that is likely to be lower than the investment to build additional grid supply capacity.

Figure 4-12. Electricity Consumption Technical Potential per Sector, 2017 - 2030

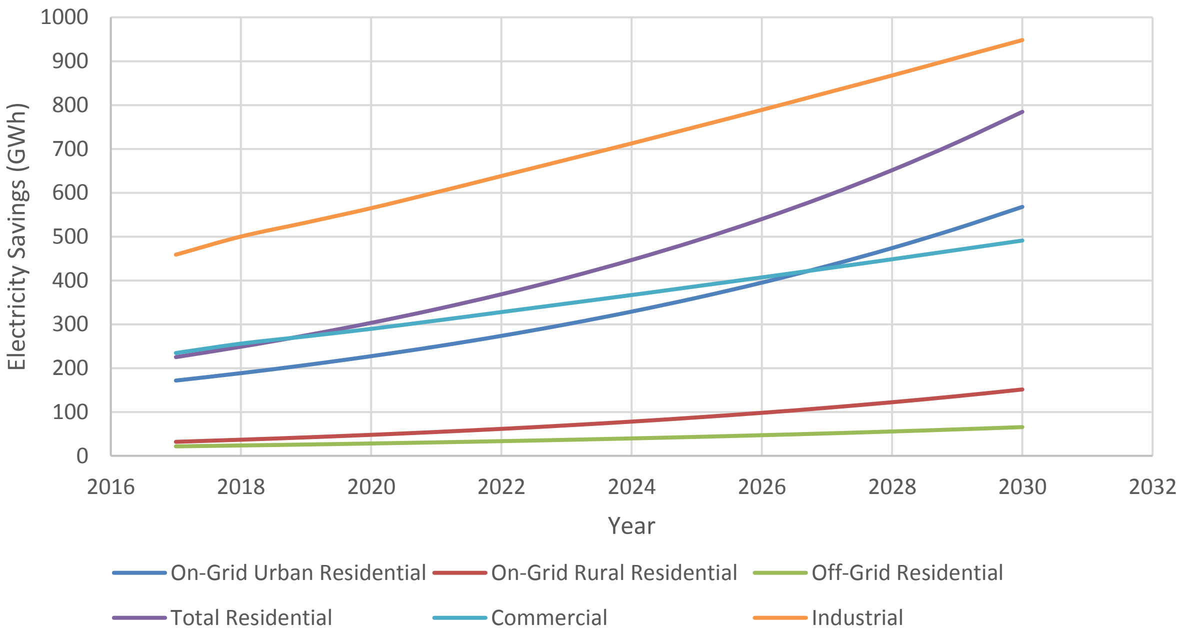


Table 4-13 breaks down the meter-level technical potential for four selected years within the analysis period. The table shows that although the commercial sector offers a larger savings potential in comparison to the residential sector in 2017, by 2030 the potential from the residential sector far exceeds that of the commercial sector. This is a result of the higher growth rates predicted for the domestic sector in comparison to the commercial sector because of the extensive electrification efforts planned for the country. The breakdown of the residential sector shows that, in 2030, 72% of the predicted savings come from on-grid urban households. The high concentration of potential savings within urban areas is advantageous for the implementation of domestic energy efficiency programs because it implies reduced logistical effort and transportation costs for distributing equipment and information.

Table 4-13. Electricity Consumption Technical Potential

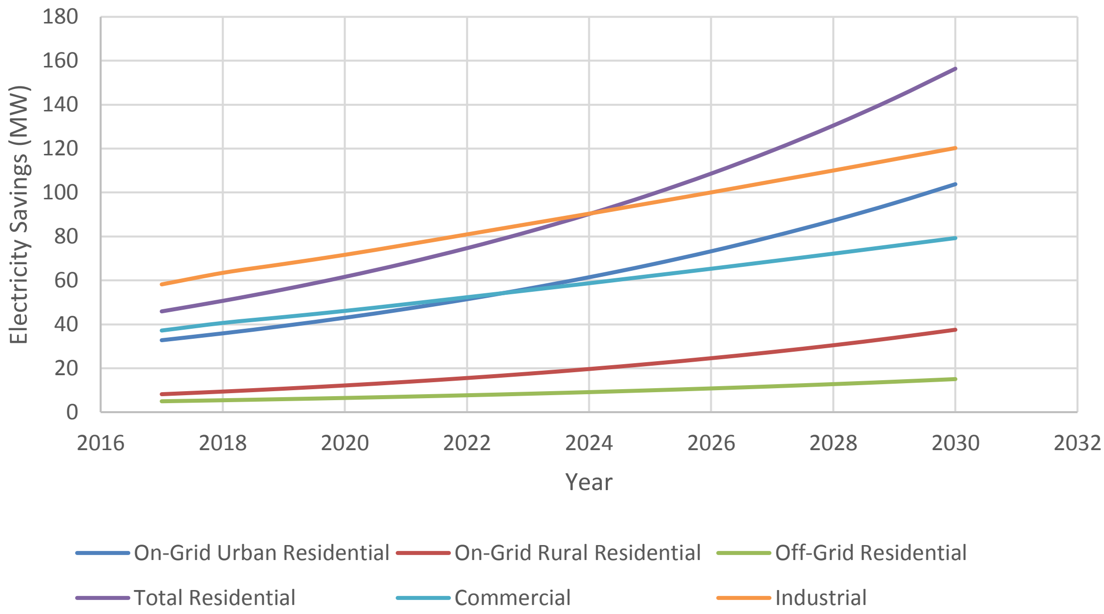
Sector	Electricity Savings (GWh)			
	2017	**2020**	**2025**	**2030**
On-Grid Urban Residential	172	227	360	568
On-Grid Rural Residential	32	48	88	151
Off-Grid Residential	22	28	43	65
Total Residential	*225*	*303*	*491*	*784*
Commercial	234	290	387	491
Industrial	459	565	751	948
Total	**918**	**1,158**	**1,629**	**2,224**

The importance of energy efficiency is further emphasized by the impact that energy efficiency can have on reducing anticipated demand on the electricity grid. Figure 4-13 shows a breakdown of the total meter-level capacity that energy efficiency can offset during the entire analysis period, with selected years highlighted in Table 4-14. In contrast to the consumption savings results, which show that the large industrial sector has the largest savings throughout the analysis, the residential sector shows the highest potential capacity savings during the later years of the analysis. This is not surprising because of the concentration of residential electricity consumption during peak hours. Implementing energy efficiency measures can avoid the need for additional power plants, particularly peak generation plants. Assuming a transmission loss of 2.8% and a distribution loss of 8% in 2030 (ERA, 2014), a total of 381 MW of on-grid generation capacity could be offset through end-user efficiency.

Table 4-14. Electricity Demand Technical Potential

Sector	Demand Savings (MW)			
	2017	**2020**	**2025**	**2030**
On-Grid Urban Residential	33	43	67	104
On-Grid Rural Residential	8	12	22	38
Off-Grid Residential	5	6	10	15
Total Residential	*46*	*62*	*99*	*156*
Commercial	37	46	62	79
Industrial	58	72	95	120
Total	**141**	**179**	**256**	**356**

Figure 4-13. Electricity Demand Technical Potential, 2017 – 2030



Offsetting the need for additional power plants has significant environmental benefits. One of the ways that the environmental impacts are most easily quantified is through the reduction of CO_2 emissions for each kWh saved. The emissions reductions for the technical efficiency potential are calculated using the build margin CO_2 emissions factor of 0.454 tonnes (t) CO_2/MWh for on-grid electricity and 0.485 tCO_2/MWh for off-grid electricity, both of which were provided by MEMD (MEMD, 2015b). Table 4-15 shows the GHG emissions reductions for several years during the analysis period. In total, 10.6M tCO_2 can be avoided through implementation of end-user energy efficiency measures. This is equivalent to the emissions from 62 thousand cars in Uganda during the analysis period (Mutenyo, 2015).

Table 4-15. Technical Potential GHG Emissions Reductions for Selected Years

	2017	2020	2025	2030	Total (2017-2030)
GHG Emissions (tCO_2)	493,520	594,631	804,928	1,095,659	10,619,865

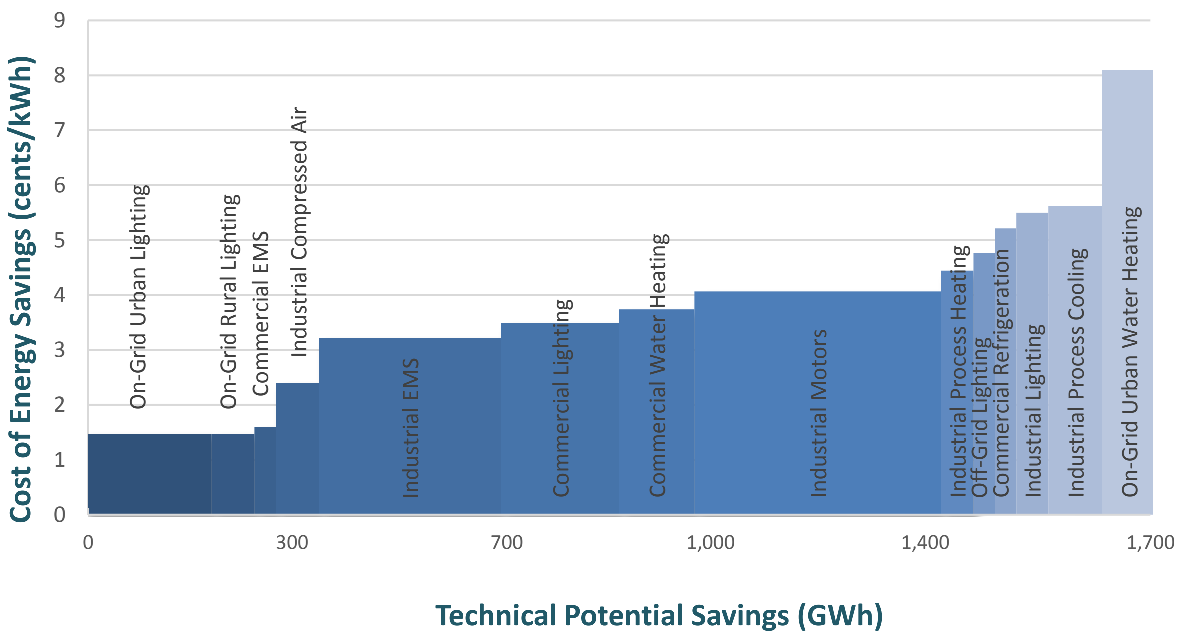
GHG emissions in Uganda are principally attributable to the agriculture sector (50%) and land use change and forestry (38%). Energy sector emissions are low compared to those in other countries because of Uganda's high reliance on hydropower as a main source of. Uganda's nationally determined contribution (NDC) proposes to reduce the country's GHG emissions by 22% in 2030, representing a reduction of 17 $MtCO_2$. Therefore, emissions reductions from the technical scenario in 2030 would contribute 6% of the total emissions reduction pledged.

4.2.1 BREAKDOWN OF 2030 TECHNICAL POTENTIAL BY CATEGORY OF MEASURE

As stated previously, technical savings potential is estimated for a total of 59 individual energy efficiency measures. These measures can be broken down into 29 different categories of measures, many of which are taken directly from the end-uses for each sector. Figure 4-14 shows a graph of the top savings opportunities for 2030, prioritized by CCE. CCE is equivalent to the levelized cost of electricity (LCOE), and, for the technical potential, CCE is calculated with a 7% discount rate. Categories of measures that contribute less than 1% to the total projected savings are omitted from the graph. In addition, the analysis of the breakdown is limited to the results from 2030 because the results from that year are compounded and therefore are the most influential for decision making. This graph shows that the most cost-effective energy efficiency opportunities are in the residential and commercial sectors. As expected, upgrades in commercial and residential lighting are some of the most cost-effective, impactful measures, with a combined opportunity of 488 GWh.

However, lighting is not the only area that shows a promising opportunity for large amounts of cost-effective savings. The implementation of Energy Management Systems (EMSs) can save 285 GWh in the industrial sector and an additional 30 GWh in the commercial sector. The implementation of EMSs is the most cost-effective measure for the industrial sector, reinforcing the importance of the provision in the draft Energy Efficiency and Conservation Bill that makes these types of systems mandatory for large energy consumers. Next to the implementation of EMSs, the next most cost-effective measures for the industrial sector are upgrades to compressed air and motor systems (which includes motors for process-related fans and pumps that are not directly tied to process heating or cooling). Improvement in industrial motors has the largest technical potential of any measure category: a total of 391 GWh. This is not surprising as motors are estimated to account for 51% of all industrial consumption.

Figure 4-14. Measure Types with Greatest Technical Potential, Prioritized by End-User Cost of Conserved Energy



On the residential side, additional categories of measures that show significant promise are high-efficiency refrigerators (see Table 4-16) and water heaters (including solar water heaters). Although the penetration of water heaters is estimated to be relatively low compared to that of other appliances in 2030 (only 5% for on-grid urban homes), because of the large electricity consumption of standard electric-resistance water heaters and the significant savings from solar water heaters, a total of 92 GWh can be saved in the residential sector from water-heater upgrades. A less cost-effective but larger savings potential exists for upgrades to high efficiency refrigerators in the residential sector. Given the high penetration of secondhand and refurbished refrigerators in Uganda, this is not surprising. It is estimated that a total of nearly 200 GWh can be saved through on-grid high-efficiency refrigerators, with an additional 8 GWh savings from off-grid refrigerators, reinforcing the need for S&L programs. Table 4-16 shows a breakdown of the consumption and demand savings for all types of measures included in the technical potential, prioritized by CCE.

Table 4-16. Technical Potential Savings in 2030 by Category of Measure, Prioritized by End-User Cost of Conserved Energy

Measure Category	CCE (c/kWh)	Consumption Savings (GWh)	Demand Savings (MW)
On-Grid Urban Lighting	1.5	197	52
On-Grid Rural Lighting	1.5	70	23
Commercial EMS	1.6	30	5
Industrial Compressed Air	2.4	72	9
Industrial EMS	3.2	285	36
Commercial Lighting	3.5	191	30
Commercial Water Heating	3.7	114	27
Industrial Motors	4.1	391	50
Industrial Process Heating	4.4	56	7
Off-Grid Lighting	4.8	31	8
Commercial Refrigeration	5.2	23	5
Industrial Lighting	5.5	62	8
Industrial Process Cooling	5.6	82	10
On-Grid Urban Water Heating	8.1	81	8
On-Grid Rural Water Heating	8.1	11	1
Commercial Fans	8.3	15	1
On-Grid Urban Fridge	10.9	163	14
On-Grid Rural Fridge	10.9	37	4
Commercial AC	13.6	64	5
On-Grid Rural Fan	13.8	10	2
On-Grid Urban Fan	13.8	33	7
Commercial Computers	18.2	55	7
On-Grid Rural AC	20.6	3	1
On-Grid Urban AC	20.6	23	5
Off-Grid Fan	25.3	9	2
Off-Grid Fridge	36.8	8	1
Off-Grid TV	84.4	17	4
On-Grid Rural TV	87.5	21	7
On-Grid Urban TV	87.5	70	19

4.3 ECONOMIC ELECTRICITY SAVINGS POTENTIAL

Although the technical potential estimates show a very large opportunity for energy efficiency to help curb anticipated growth in energy consumption (54% of the total consumption projected for 2030), these results do not account for any limitations related to cost-effectiveness. Therefore, an economic potential is calculated that excludes all measures that are not cost-effective for the end-user. For this analysis, only the potential in 2030 is examined, to allow for direct comparison to the technical potential breakdown examined in the previous section. A discount rate of 7% is assumed for this analysis because this is the standard rate used for assessing economic potential from the societal viewpoint. Although societal economic potential analyses may consider additional non-energy benefits, only the benefits from electricity savings are considered in this analysis. Table 4-17 compares the technical and economic potential results for each sector and shows that limiting the potential to cost-effective measures results in only a 9% decrease in consumption savings from energy efficiency and a 12% decrease in demand savings.

Table 4-17. Comparison of Technical and Economic Potential Electricity Consumption and Demand Savings for 2030

	Consumption Savings (GWh)			Demand Savings (MW)		
Sector	**2030 Technical**	**2030 Economic**	**% Decrease**	**2030 Technical**	**2030 Economic**	**% Decrease**
On-grid Urban Residential	568	474	16	104	81	22
On- grid Rural Residential	151	128	16	38	30	20
Off- grid Residential	65	48	26	15	11	30
Total Residential	*784*	*650*	*17*	*156*	*121*	*22*
Commercial	491	447	9	79	75	5
Industrial	948	925	2	120	117	2
Total	**2,224**	**2,022**	**9**	**356**	**314**	**12**

The largest reduction in consumption potential, 26%, is seen in the off-grid residential sector. This results from the high savings potential but low cost-effectiveness of off-grid TVs, which is the only off-grid measure excluded from the economic potential. The on-grid urban and on-grid rural residential sectors also show significant decreases in total potential; both are reduced by 16%. The majority of this change is a result of the low cost-effectiveness of TVs, which have the highest CCE of all measures considered in the analysis (0.87 USD/kWh for both urban on-grid and rural on-grid, and 0.84 USD/kWh for off-grid).

In comparison to the residential sector, the commercial and industrial sectors show greater resilience when economic screening is added, with consumption potential decreases of 2% and 9%, respectively. From the low CCE numbers presented in the technical potential section for many of the commercial measures, it is to be expected that the savings for this sector would show the least amount of change in economic potential. Figure 4-15 shows a breakdown of the top categories of measures in the economic potential analysis, prioritized by CCE. By comparing Figure 4-14 and Figure 4-15, it can be seen that the priority of measures such as commercial air conditioning (AC) and industrial process heating has increased. This is because of the elimination of non-cost-effective measures from these categories of measures, so that the overall measure category is more cost-effective. In general, a comparison of these two figures reveals that, for the categories of measures with the largest potential, there is little change between the technical and economic potential analysis results.

Figure 4-15. Top Measure Opportunities for Economic Potential, Prioritized by End-User Cost of Conserved Energy

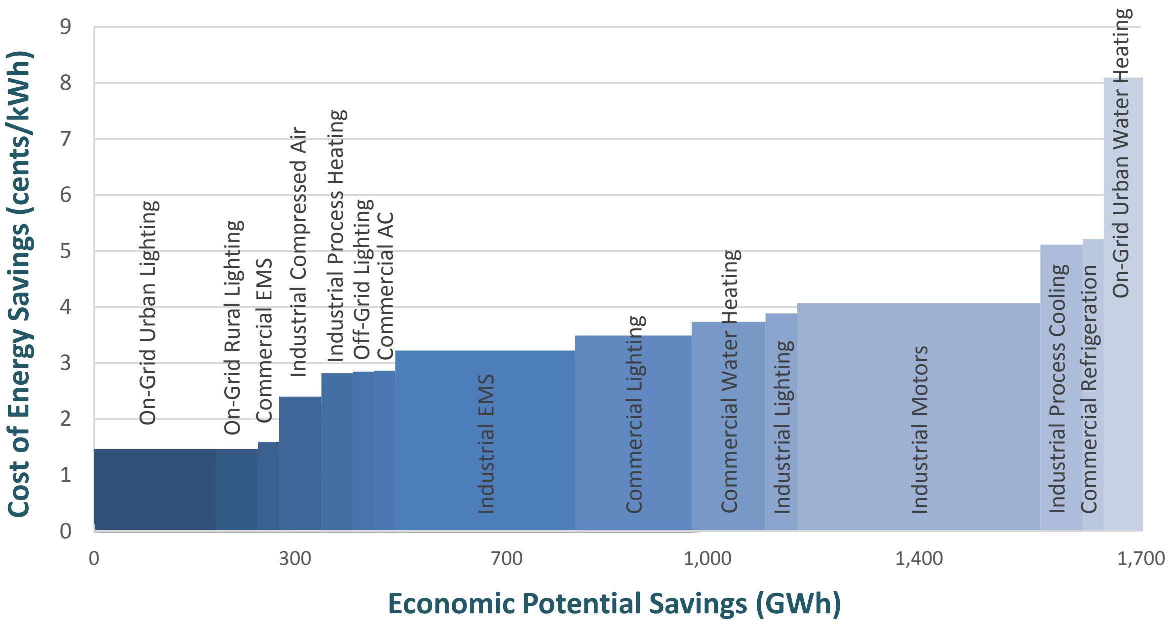


Table 4-18 shows the full list of measures for both the technical and economic potentials. The measures are prioritized by the end-user benefit-to-cost ratio (BCR), with all measures below the bold line having a BCR less than one and therefore excluded from the economic potential. In general, the results show that often the measures that have the highest BCR for the end-user also have the lowest CCE. Measures that exhibit both a low CCE and high end-user BCR are prime targets for energy efficiency programs. However, the measures examined here are representative measures based on high-level data, so further, more detailed, analysis should be conducted prior to the selection of measures for a portfolio of DSM programs.

Table 4-18. 2030 Technical and Economic Potential Savings by Measure, Prioritized by End-User Benefit-to-Cost Ratio

Measure Category	Sector	Measure	Consumption Savings (GWh)	Demand Savings (MW)	CCE (US cents /kWh)	End-user BCR
Industrial motors	I	Properly sized motors and drives	22	3	1	32.8
Commercial water heating	C	Low-flow faucet aerator	18	4	1	13.3
On-grid urban lighting	R	On-grid urban LED lighting	197	52	1	12.3
On-grid rural lighting	R	On-grid rural LED lighting	70	23	1	12.3
Industrial compressed air	I	Reduce compressed air tank pressure	7	1	1	11.7
Off-grid lighting	R	Off-grid LED lighting	31	8	6	11.0
Commercial EMS	C	Energy management system	30	5	2	8.8
Industrial compressed air	I	Reduce compressed air leaks	19	2	2	6.8
Industrial motors	I	Preventative maintenance for motors/drives	28	4	2	6.6
Industrial process cooling	I	Preventative refrigeration/cooling system maintenance	6	1	2	6.6
Industrial process heating	I	Preventative furnace/boiler maintenance	15	2	2	6.6
Commercial refrigeration	C	High-efficiency reach-in cooler	5	1	2	6.5
Commercial lighting	C	LED drop-in lighting	95	15	2	6.3
Industrial process heating	I	Advanced heating and process control	16	2	2	5.9
On-grid urban water heating	R	On-grid urban heat pump hot water heater	18	2	3	5.6
On-grid rural water heating	R	On-grid rural heat pump hot water heater	2	0	3	5.6
Commercial water heating	C	Heat pump water heater	21	5	2	5.6
Commercial AC	C	Efficient packaged air conditioner	34	3	3	5.3
Industrial process cooling	I	Optimized chilled water temperature	3	0	3	4.1
Industrial compressed air	I	Use variable speed drive on air compressors	32	4	3	4.0
Industrial EMS	I	Energy management system, ISO50001	190	24	3	3.6
Commercial AC	C	Variable speed drive on chiller system	6	0	4	3.5
Industrial compressed air	I	Demand-controlled compressed air	14	2	3	3.3
Industrial motors	I	High-efficiency large motors	42	5	3	3.2
Industrial lighting	I	LED drop-in lighting	27	3	4	3.1
Industrial EMS	I	Energy monitoring system, ISO50006	95	12	4	3.1

Measure Category	Sector	Measure	Consumption Savings (GWh)	Demand Savings (MW)	CCE (US cents /kWh)	End-user BCR
Commercial water heating	C	Solar water heater	75	18	5	3.0
Commercial lighting	C	LED fixture lighting	95	15	5	2.9
Off-grid fan	R	Off-grid efficient fan	9	2	21	2.9
Industrial lighting	I	LED lighting fixtures	27	3	4	2.6
Industrial motors	I	Variable speed drive motors	276	35	4	2.5
Off-Grid refrigerator	R	Off-grid high-efficiency refrigerator	8	1	26	2.4
Industrial process cooling	I	Refrigeration plant variable speed drives	38	5	5	2.4
Commercial refrigeration	C	High-efficiency solid-door freezer	18	4	6	2.3
Industrial process heating	I	Improved process heating insulation	17	2	5	2.3
On-Grid Urban Water Heating	R	On-grid urban solar hot water heater	63	6	9	1.9
On-grid rural water heating	R	On- grid rural solar hot water heater	9	1	9	1.9
Commercial fans	C	Variable speed drive on fans	15	1	8	1.7
On-grid urban refrigerator	R	On-grid urban efficient refrigerator	163	14	11	1.7
On-grid rural refrigerator	R	On-grid rural efficient refrigerator	37	4	11	1.7
Industrial process cooling	I	High-efficiency chiller	29	4	7	1.6
Industrial motors	I	High-efficiency small motors	22	3	7	1.5
On-grid urban fan	R	On-grid urban efficient fan	33	7	14	1.3
On-grid rural fan	R	On-grid rural efficient fan	10	2	14	1.3
Commercial computers	C	Network sharing for printers, photocopiers, scanners	35	4	14	1.0
Commercial AC	C	Low-solar-heat-gain window film	12	1	15	0.9
Industrial process cooling	I	Process cooling pipe insulation	6	1	12	0.9
Off-grid TV	R	Off-grid high-efficiency TV	17	4	71	0.9
On-grid urban AC	R	On-grid urban high-efficiency AC	23	5	21	0.9
On-grid rural AC	R	On-grid rural high-efficiency AC	3	1	21	0.9
Industrial process heating	I	Process heat recovery	4	1	13	0.9
Commercial computers	C	Computer hibernation and auto turn-off	6	1	16	0.9
Industrial lighting	I	Lighting control system	9	1	15	0.8

Measure Category	Sector	Measure	Consumption Savings (GWh)	Demand Savings (MW)	CCE (US cents /kWh)	End-user BCR
Industrial process heating	I	Reduction in steam pressure	4	0	16	0.7
Commercial AC	C	Weatherization: apply blinds, shutters, air-sealing, etc.	4	0	29	0.5
Commercial computers	C	High-efficiency laptops and desktops	15	2	30	0.5
Commercial AC	C	Air conditioning energy-saver system	8	1	58	0.2
On-grid urban TV	R	On-grid urban efficient TV	70	19	87	0.2
On-grid Rural TV	R	On-grid rural efficient TV	21	7	87	0.2

Many of the measures with the highest end-user BCRs are associated with preventative maintenance or proper design/operation in the industrial sector. Although easy to overlook, these types of measures can be influential for energy savings and present a combined opportunity of nearly 100 GWh. In total, the industrial sector again shows the highest potential for consumption savings from energy efficiency (925 GWh). More than 70% of these savings are from the EMS and motor measures, which points to the importance of improved energy efficiency in these areas. Although the industrial sector is the most influential for energy savings, the residential sector presents the greatest opportunity for demand savings (121 MW). Although this opportunity is only slightly larger than the 117 MW projected for industrial sector, the assumptions used for the on-grid residential sectors are based on current planned connections through 2030. If there is a significant increase in electrification efforts, the residential sector might exhibit even greater demand savings and therefore exceed the industrial sector savings by a larger margin.

4.4 ACHIEVABLE ELECTRICITY SAVINGS POTENTIAL

To further examine the cost-effective energy efficiency potential, the “achievable economic” potential is calculated. This potential uses a much more stringent definition of cost-effectiveness than is used for the societal economic potential. For the achievable economic potential, a discount rate of 20% is used for cost-effectiveness calculations (in contrast to 7% for the societal economic potential) as well as a requirement that the end-user BCR be at least two, in contrast to a value of one for the societal economic potential. These more stringent conditions provide a more realistic representation of what is achievable under the economic constraints currently faced by those looking to fund energy efficiency projects in Uganda. To examine the impact of the uncertainty of the savings estimates, the achievable potential is presented for three different sets of savings assumptions: low, medium, and high. The details of the assumptions for each case can be reviewed in Table 4-8 and analysis of results for the low and high case in Appendix 6. In contrast to the achievable economic potential, both the technical and economic potentials are calculated using the medium assumptions. This must be kept in mind when comparing the low and high achievable economic potentials to the societal economic or technical potentials.

Table 4-19 shows the results for the achievable economic potential analysis by sector for all three cases for 2030. An estimated total of 1,052 GWh is economically achievable under the medium scenario. This is approximately 47% of the technical potential and 52% of the societal economic potential. This is a very encouraging result. It indicates that, given the availability of capital, there are a large number of cost-effective energy efficiency options available to end-users in Uganda. Nearly half of the potential savings (516 GWh) are from the industrial sector, which underscores that a strong focus should be placed on lowering the energy consumption of this sector. Significant savings are also possible from efficiency improvements in the commercial (209 GWh) and residential (327 GWh) sectors, with similar ratios of savings between sectors as was the case for the societal economic potential savings.

Table 4-19. 2030 Achievable Economic Potential Savings, Medium, Low, and High Cases

	Consumption Savings 2030 (GWh)			Demand Savings 2030 (MW)		
	Med	**Low**	**High**	**Med**	**Low**	**High**
On-grid Urban Residential	215	186	242	54	47	61
On-grid Rural Residential	72	62	81	23	20	26
Off-grid Residential	40	21	58	10	6	12
Total Residential	*327*	*269*	*381*	*87*	*72*	*99*
Commercial	209	148	344	33	24	61
Industrial	516	246	762	66	31	97
Total	**1,052**	**663**	**1,487**	**185**	**128**	**257**

The medium case results for demand savings show percentage reductions comparable to those observed for consumption savings, with a decrease of 52% to a total of 185 GWh. As observed in both the technical and societal economic potentials, the residential sector has the largest potential for demand savings, with a total of 77 MW in on-grid savings and an additional 10 MW in off-grid savings. The 175 MW total of on-grid savings is more than 70% of the projected demand for the entire commercial sector, emphasizing the significant demand savings that can be realized through efficiency. This highlights the importance of considering energy efficiency as an alternative to the creation of additional power plants because every MW that is saved through energy efficiency can be used, without straining natural resources, to bring electricity to additional customers that are added to the grid.

A comparison of the medium scenario results to the low and high scenario results reveals that the greatest fluctuation in savings is in the industrial sector. The low-case industrial results are nearly 53% lower than the medium case, and the high-case results are approximately 47% higher. This wide range of uncertainty captures the sensitivity of the industrial sector results to measure parameters that affect the BCR, such as the measure incremental cost, lifetime, and savings. In addition, and more importantly for regulators, this uncertainty reveals the sensitivity of the economically achievable potential to changes in tariff structure. If tariff levels rise significantly, the medium-case results will move closer to the high-case results, and vice versa. The overall range encompassed by the low and high cases is 824 GWh, from a low of 663 GWh to a high of 1,487 GWh. This indicates that if the economics are favorable, as much as 21% of the anticipated consumption for 2030 could be offset by energy efficiency. To put this in perspective, the on-grid portion alone (1,429 GWh) is equivalent to adding nearly 1.35M urban customers to the grid without the need for additional generation resources.

The additional environmental benefits of energy efficiency have not been monetized for this analysis, but the GHG savings from the three scenarios are included in Table 4-20, which shows cumulative GHG savings over the entire analysis period from 2017-2030. As much as 7.3M tonnes of CO_2 can be saved, equivalent to the emissions of approximately 43 thousand cars in Uganda during the analysis period.

Table 4-20. Cumulative GHG Emissions Reductions from Low, Medium, and High Case Achievable Economic Potential Savings

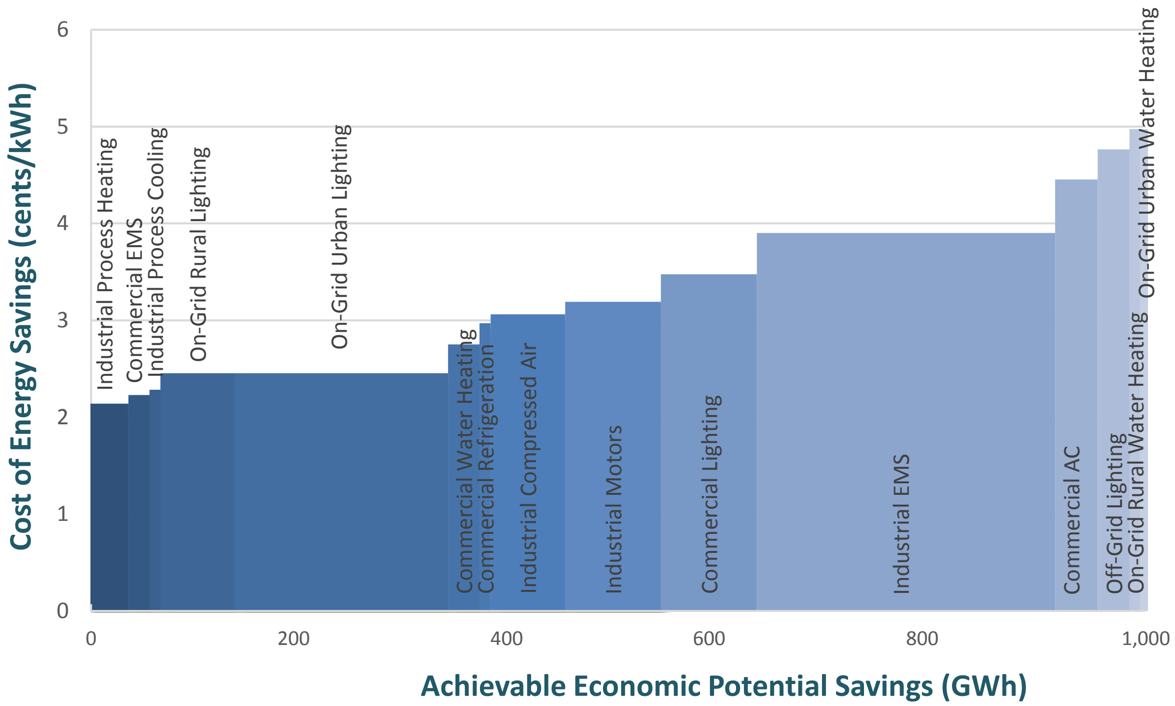
	Low	Med	High
GHG Emissions (tCO_2)	3,215,551	5,143,605	7,307,503

Figure 4-16 shows a breakdown of the medium case results by type of efficiency measure. In comparison to the economic potential results (Figure 4-15), the starkest difference is the reduction in the size of the industrial motor measure savings. This is a result of the exclusion of non-cost-effective measures previously included in this measure category, such as variable-speed-drive motors and high-efficiency small motors. However, even with these changes, the overall results appear quite similar in terms of the categories of measures that are included. The achievable economic results still prominently feature lighting measures for all sectors, as well as EMSs for the commercial and industrial sectors. Moreover, while the CCE of the industrial EMS measure has increased in comparison to the economic potential results because of the higher discount rate, it is now the measure with the largest available savings potential.

An examination of the measures for the medium-case scenario in Figure 4-16 reveals that one of the biggest differences between the savings estimates for this scenario and the societal economic potential is the exclusion of the on-grid urban and rural refrigerators. Although the refrigerators offer a combined savings potential of nearly 200 GWh, these appliances are not yet cost-advantageous for end-users because of the relatively high incremental cost of an efficient refrigerator. Another set of prominent measures from the societal economic potential that are excluded in the achievable economic potential results are commercial and residential solar hot water heaters. Although these measures are cost-effective for end-users, with BCRs of 1.9 and 1.2 for commercial and residential on-grid, respectively, a high incremental cost keeps their BCR below 2 in the medium scenario. An important similarity between the societal economic potential and medium scenario results is that many of the measures with the highest BCRs are design, operations, and maintenance measures for the industrial sector. Given the high starting BCRs of these measures, it is to be expected that their potential of nearly 100 GWh is not reduced by more stringent cost-effectiveness limits.

Figure 4-16. Top Measures for Achievable Economic Potential, Medium Case

Prioritized by End-User Cost of Conserved Energy



Viewed in their entirety, the achievable economic potential results show that significant savings can be obtained from energy efficiency even when considering a high discount rate of 20%. With a minimum of 663 GWh of savings, approximately 16% of the anticipated growth in consumption can be offset through energy efficiency. At a maximum, the 1,487 GWh from the high case offsets more than 36% of the anticipated load growth. In either case, energy efficiency can help to free up generation resources to provide electricity to new customers and allow Uganda to continue along its development path.

The significant savings potential in both energy and capacity point towards the need to continue to increase the focus of the government, businesses, and citizens of Uganda on energy efficiency. The numbers for this analysis can be used to help set targets for savings from energy efficiency and perhaps even targets for avoiding the construction of additional power generation facilities. The actions outlined in next section of this Roadmap provide a path for maximizing the influence of energy efficiency and working toward obtaining the potential savings quantified in this analysis.

5. ENERGY EFFICIENCY ACTION PLAN FOR UGANDA

Achieving greater levels of energy efficiency is a multi-effort endeavor that requires bundling packages of policy instruments to address the market failures that hinder energy efficiency investment. Energy efficiency opportunities are distributed across all sectors of the economy and across many technologies and practices. Policy makers have three basic types of tools to address barriers to energy efficiency: regulations, knowledge diffusion, and financial incentives. A combination of these tools, along with target setting and continuous monitoring, has been shown to accelerate energy efficiency improvements. The recommendations developed in this Roadmap build on these basic policy tools to provide *building blocks* for energy efficiency: energy performance standards, target setting, information diffusion, capacity building, public awareness, and financing support.

- **Performance Standards** — Product energy efficiency standards raise the energy efficiency floor and eliminate inefficient technologies and practices from the market. They also stimulate technological innovation.
- **Target setting** — Voluntary or mandatory targets form an essential framework for action. They focus attention, maintain priorities, and provide a clear long-term goal to stimulate and accelerate progress.
- **Information Diffusion** — Appliance labels, building energy performance disclosure, and best-practice sharing are among the key programs that, by clearly identifying efficient products and practices while educating consumers about the benefits of greater efficiency, help consumers and building managers make informed purchase and investment decisions.
- **Capacity Building** — Capacity development and training activities are crucial to foster uptake of energy efficiency practices and technologies, ensure compliance with standards and other targets, and secure a full integration of energy efficiency as an energy resource for the country.
- **Public Awareness** — Awareness campaigns are needed to inform consumers about the benefits of the programs and policies being developed, and to maximize acceptance and adoption. Awareness campaigns also inform consumers about technology and product performance and life-cycle cost.
- **Financial Support** — Financial support incentivizes energy efficiency investment by providing financing options, rebates, and other discounts, as well as technical assistance.

Each of these buildings blocks has strengths and weaknesses, but if they are well designed and coordinated, they complement and reinforce each other, working toward addressing the goal of accelerating deployment of energy efficient technologies and lowering costs. A comprehensive policy package that puts these buildings blocks into place has proven critical for successful promotion of energy efficiency in many countries.

This section of the Roadmap describes highly actionable policies, programs, and capacities needed to assemble the building blocks for achieving the significant energy efficiency potential in Uganda.

Table 5-1 lists recommended actions and indicates the page of this Roadmap where more detail is found. Recommended actions are ranked by order of priority based on the multi-criteria decision analyses described in Section 5.1. Section 5.1 also describes the methodology used to estimate cost of implementation and standard actions used to support larger efforts. Section 5.2 describes each recommendation in detail. Section 5.3 presents the Roadmap.

This Roadmap can be used to track progress on each action in the short, medium, and long term in Uganda. MEMD is the lead implementer of this action Roadmap and should be supported by stakeholders in designing and implementing the actions listed.

Table 5-1. Energy Efficiency Policy and Program Recommendations

SECTION	RECOMMENDED ACTIONS	SECTOR FOCUS	PAGE
5.2.1	Enact Energy Efficiency & Conservation Bill	Cross-cutting	74
5.2.2	Prioritize Energy Efficiency in Integrated Resource Planning	Cross-cutting	75
5.2.3	Develop Regulation for Energy Audits	Industry and Commercial (Large Energy Users)	77
5.2.4	Develop Regulations for Energy Management System	Industry and Commercial (Large Energy Users)	79
5.2.5	Enforce Energy Efficiency Standards & Labeling	Cross-cutting	80
5.2.6	Expand Standards and Labeling Program	Residential	83
5.2.7	Set Industry Targets	Industry	86
5.2.8	Encourage Markets for Energy Access	Rural Residential	88
5.2.9	Encourage Small-Scale Enterprise Energy Efficiency	SMEs	91
5.2.10	Develop Training and Accreditation Scheme	Industry and Commercial	93
5.2.11	Develop Energy Efficiency Performance Code for Buildings	Commercial and Residential	94
5.2.12	Recognize Champions of Energy Efficiency	Industry	97
5.2.13	Create an Energy Efficiency and Conservation Fund	Cross-cutting	99
5.2.14	Encourage Clean Industry Development	Industry	104
5.2.15	Develop Building Energy Use Disclosure and Benchmarking	Commercial and Residential	105
5.2.16	Government Lead by Example	Institutional	108
5.2.17	Cities and Municipal Councils Develop Energy Efficiency Action Plans	Commercial and Residential	110

5.1 RECOMMENDATION PRIORITIZATION AND IMPLEMENTATION COST ESTIMATION METHODOLOGY

This section describes the methods used to prioritize recommendations and to estimate the cost of implementing programs.

5.1.1 PRIORITIZATION METHODOLOGY

This Roadmap proposes the use of an MCDA approach to prioritize energy efficiency recommendations. MCDA allows decision makers to integrate different program impacts in their final decision and to control the relevance of different impacts. MCDA techniques have been applied extensively to energy and environmental investment decisions, as noted by Huang et al. (2011). MCDA is a reliable, transparent methodology to rank alternative initiatives in the presence of numerous objectives and constraints. Moreover, MCDA allows inclusion of qualitative aspects decision makers' preferences, which can be important influences in the decision process. The MCDA approach generally consists of (1) selecting a number of criteria relevant to stakeholder interests, (2) weighting each criterion, (3) selecting a qualitative or quantitative measurement for each criterion, (4) rating criteria for each recommendation, and (5) ranking the recommendations based on the score obtained. Table 5-2 summarizes the criteria selected for prioritizing the recommendations in this Roadmap.

Table 5-2. Definition of MCDA Criteria

Criteria	Description	Estimation
Energy Savings	The level of energy savings is estimated based on the energy savings estimated at the sectoral level from *Section ELECTRICITY SAVINGS POTENTIAL.*	Quantitative
First Cost to Government	First cost to government is estimated based on the cost of implementation of programs as described in Section *0* *Cost* Methodology.	Quantitative
Speed of Implementation	Speed of implementation reflects the complexity of implementing a program and the level of stakeholder engagement needed.	Qualitative
Prerequisite to Other Measures	Prerequisite to other criteria represents the level at which a program or policy enables other programs and measures to be implemented successfully.	Qualitative
Multiple Benefits	Investment in energy efficiency can deliver many different environmental, social, and economic benefits. Multiple benefits are evaluated as the life-cycle impact of the program on GHG emissions; pollution; waste reduction; and the potential to increase jobs, increase competition, and foster the development of the local manufacturing industry.	Qualitative

Table 5-3 shows the ranking scale for each criterion. Some criteria are based on a quantitative assessment and are estimated with modeling tools. Others are based on a qualitative assessment using expert judgment. To increase the reliability of expert judgment, a composite score resulting from the assessments of two independent researchers from the team was used for these qualitative criteria. Each researcher rated the recommendation based on the scale provided in Table 5-3, and the average of this rating was used for each measure. It is also possible to weight some criteria to increase their influence in the final decision. The decision criterion "Prerequisite to other measures" was given a higher weight to emphasize its importance.

The team also developed a simple spreadsheet tool containing all the recommendations and criteria rankings, which can be used by MEMD for further decision making based on additional expert assessment.

Table 5-3. Ranking Criteria for MCDA

Criteria	Score / Weight (%)	1	2	3
Technical Electricity Consumption Savings by 2030	100	<100 GWh	100-500 GWh	>500 GWh
First Cost to Government (4-year budget)	100	Above US$500k	US$250k-500k	US$0-250k
Speed of Implementation	100	Extended >5 year	Moderate 2-5 years	Rapid < 2 years
Prerequisite to Other Measures	200	Highly independent	Somewhat independent	Highly enabling
Multiple Benefits	100	Low: No major benefits besides cost savings	Medium: Contributes to local manufacturer competitiveness	High: Contributes significantly to creating jobs as well as enhancing the sustainability of the economy and social development

5.1.2 COST METHODOLOGY

Implementation costs of the energy efficiency programs outlined in this Roadmap are estimated using a budgeting approach familiar to project managers and government officials. Each program is broken down into discrete implementation steps, including the cost of annual administration over four years. This step approach provides the foundation for a first level of estimation that can be independently reviewed and adjusted to increase accuracy or incorporate future updates.

For each implementation step, an estimated level of effort (LOE), expressed as the number of days needed to complete the task, is assigned for three generic labor categories: senior, mid-level, and specialist. Personnel costs are then obtained using an annual salary assumption for each category. Non-personnel costs are also assigned to each implementation step; these include: workshop, study, survey, software, marketing, capacity building, data collection, and third-party contract. The total of these costs represents all of the systems, activities, staff time, and investment needed to implement each program for four years. However, these estimates do not include the cost of actual incentives, only the cost of their development and administration.

To ensure that cost estimates are consistent and realistic, uniform cost assumptions are applied to certain types of standard actions and implementation steps that are found across multiple programs (e.g., stakeholder consultation, media outreach). A list of descriptions of standard actions is available in Appendix 7. The use of uniform cost assumptions simplifies future updates of the estimates and is described further in Appendix 7. Where data on implementation costs from similar programs exist, estimates incorporate those data. For example, data on the cost of implementing S&L programs were obtained from the Ghana Energy Commission and integrated into this estimation. Data from the GEF energy efficiency program implementation description database were also used for determining costs of similar-scope programs for Uganda (GEF, 2016). Finally, MEMD reviewed the current estimates and provided input on local costs and salaries.

This exercise was conducted using a simple Excel spreadsheet. Where appropriate, context or justification for the assumptions made was given in a comments column. The spreadsheet has been submitted as a budgeting tool under the Energy Efficiency Roadmap so that it can be used to further refine and update estimates during implementation planning.

5.2 POLICY RECOMMENDATIONS

The following subsections describe specific energy efficiency policy recommendations for Uganda. Each subsection summarizes, in the form of bullet points, the type of policy being recommended, the implementers or stakeholders, the status of the policy, and actionable steps to carry out the recommendation. The summary is followed by a description of resources for global best practices related to the specific policy. Each subsection also contains a table showing prioritization scores for the policy.

5.2.1 ENACT ENERGY EFFICIENCY & CONSERVATION BILL

The draft Energy Efficiency and Conservation Bill is an essential framework document that provides the statutory basis for promulgation of rules and regulations to promote energy efficiency in Uganda, defines the rationales for pursuing energy efficiency, and lays out overall objectives and strategies to achieve them. The bill also includes specific regulations on appliance efficiency labeling, MEPS, energy audits, and EMS requirements for large energy users. The main benefit of the bill is to introduce a clear line of sight between the need for energy efficiency in Uganda and the implementation of policies and programs to improve energy efficiency.

Prioritization Criteria	Score
Energy Savings	2.0
First Cost to Government	3.0
Speed of Implementation	3.0
Prerequisite to Other	3.0
Multi-benefits	2.9
Average Score	2.8
RANK	1

- Policy type: Cross-Cutting/Framework Policy
- Implementers/Stakeholders: Parliament, MEMD, and the Ministry of Justice and Constitutional Affairs
- Current status: Principles of the bill were approved by Cabinet in January 2016; the draft bill has been prepared for submission to Parliament.
- Actionable steps: Parliament enactment of the draft bill. MEMD can help accelerate the enactment of the bill into law by increasing support across all stakeholders.

Best Practices/Resources:

World Energy Council: The World Energy Council (WEC) periodically produces reports on identifying, documenting, and evaluating energy efficiency policies and trends around the world. WEC (2013) covers 85 countries and includes examples of framework policies implemented in different countries. The report notes that legal frameworks are essential for the adoption of regulations, such as labeling, MEPS, obligations for large consumers (e.g., in Turkey, India), or energy-savings obligations for utilities (e.g., in France). Energy efficiency laws can also provide a legal framework for setting up an energy efficiency fund (e.g., in Thailand, Uruguay).

International Energy Agency: The International Energy Agency (IEA) produced a handbook for practitioners and stakeholders that provides guidance on addressing many energy efficiency governance issues (IEA, 2010). The guidebook draws on the experience of hundreds of energy efficiency experts around the world as well as extensive searches of energy efficiency good-governance case studies and literature.

5.2.2 PRIORITIZE ENERGY EFFICIENCY IN INTEGRATED RESOURCE PLANNING

Integrated Resource Planning (IRP) is a process of planning to meet a country's needs for electricity through a combination of supply-side and demand-side resources over a specified future period. This process ensures that DSM[13] potential is included in national energy planning investment decisions. DSM is often referred to as the least-cost resource and is often prioritized because its implementation cost is significantly lower than the cost of constructing new capacity.

Utilities are generally well positioned to undertake planning efforts that are then reviewed by government energy regulators. The economic potentials developed in this report (Table 4-18) can be used to prioritize energy efficiency measures to be incentivized and to set energy-savings goals. As mentioned in Section *4.3 Economic Electricity Savings Potential*, measures that exhibit both a low CCE and high end-user BCR are prime targets for energy efficiency programs. However, the measures examined here are representative measures based on high-level data, so further, more detailed, analysis should be conducted prior to the selection of measures for a portfolio of DSM programs.

ERA has already developed a DSM plan (see 3.3.6, Demand-Side Management) and UMEME has implemented an LED procurement and distribution program and a public awareness campaign for energy efficiency. The next step is to institutionalize the DSM plan in an IRP process to optimize resource allocation for the benefit of Ugandan consumers.

- Policy type: Cross-Cutting/Framework Policy
- Implementers/Stakeholders: National Planning Authority, ERA, MEMD
- Actionable steps:

  (1) Develop Integrated Resource Plan and set energy-savings goal

Prioritization Criteria	Score
Energy Savings	3.0
First Cost to Government	3.0
Speed of Implementation	2.5
Prerequisite to Other	2.5
Multi-benefits	2.5
Average Score	2.7
RANK	2

1. DEVELOP INTEGRATED RESOURCE PLAN

A workshop should be organized initially to define the steps needed to institutionalize national energy planning and set energy efficiency as an energy resource. The following steps can then be pursued:

- Establishing a policy to recognize DSM as a priority resource
- Developing a process to identify cost-effective potential for DSM
- Establishing energy-savings goals or targets consistent with the cost-effective potential

[13] As mentioned previously, DSM refers to electricity demand reductions through efficiency improvements or load shifting on the customer side of the electrical meter.

- Establishing DSM programs to achieve the potential, including behavior-based programs such as demand response to reduce or shift electricity usage during peak periods in response to time-based rates or other forms of financial incentives
- Defining who should administer and implement programs

Best Practices/Resources:

Some governments have integrated energy efficiency in their resource planning for meeting future electricity demand by setting mandatory energy-savings goals or requirements for utilities. In doing so, they fully integrate energy efficiency as a prime resource in energy investment decisions for the country.

California: The U.S. state of California raises approximately US$1 billion annually through a public-benefit charge on electricity rates to fund DSM programs. California's portfolio of DSM programs delivered 7,745 GWh of electricity savings and 1,300 MW of peak summertime energy savings between 2010 and 2012 (CPUC, 2016). The California Public Utilities Commission[14] annually approves each utility's plan for efficiency programs, and each utility then carries out its plan within its service territory. Utilities contract with energy efficiency consulting firms to implement some programs.

South Africa: The National Energy Regulator of South Africa determines a funding allocation cycle for Energy Efficiency Demand-Side Management (EEDSM) through the Multi-Year Price Determination (MYPD). The determination is based on submission by the utility, Eskom, of estimated program costs and energy-savings goals. A small environmental levy[15] is then set in the electricity tariff, with the monies directed to a public fund that is used to implement EEDSM programs. The MYPD for the third period (2013 to 2018) has allocated US$431M with a goal of saving 1,471 MW (NERSA, 2013; de la Rue du Can et al., 2013) and shows the portfolio of energy efficiency programs established by Eskom and supported by the public fund. Through the establishment of these programs, Eskom has been able to report a total cumulative savings of 3,072 MW, representing an offset of five generators' worth of output in the past 10 years.

U.S.: The U.S. Environmental Protection Agency (U.S. EPA) published a guide entitled "The Guide to Resource Planning with Energy Efficiency" to assist gas and electric utilities, utility regulators, and others in integrating energy efficiency into resource planning. (US EPA, 2007)**.**

Regulatory Assistance Project: The Regulatory Assistance Project (RAP) published a report entitled "The Treatment of Energy Efficiency in Integrated Resource Plans: A Review of Six State Practices," which provides useful lessons learned about IRP implementation (RAP, 2013).

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[14] http://cpuc.ca.gov/energyefficiency/

[15] Currently, the environmental levy is equal to 0.035 South Africa Rand/kWh (0.0023 US$/kWh). Discussions are ongoing in South Africa about temporarily augmenting the environmental levy to 0.055 Rand/kWh to help reduce load shedding.

5.2.3 DEVELOP REGULATION FOR ENERGY AUDITS

Conducting an energy audit is the first step toward improving energy efficiency in an industrial facility or a building. An energy audit is an inspection, survey, and analysis of the facility's energy flows to determine how energy can be conserved and productivity can be improved. There are many types of energy audits ranging from general "walk-through" surveys to comprehensive "process audits." They should be carried out regularly and independently by qualified and/or accredited experts with specific, relevant qualifications.

Energy audits recommend energy efficiency measures and give estimated energy savings, costs, payback periods, and life-cycle costs for recommended measures. Audits also help build capacity and at industrial facilities should dovetail with installation of EMSs, described in Section 5.2.4, Develop Regulations for Energy Management System, to support integration of the audit results and ensure continued progress in efficiency at the facility.

- Policy type: Industry and Commercial/Regulation
- Implementers/Stakeholders: MEMD; UMA; PFSU; UNBS; Ministry of Trade, Industry, and Cooperatives (MTIC)
- Current status: Draft Energy Efficiency and Conservation Bill directs large energy users to undertake energy audits.
- Actionable steps:

Prioritization Criteria	Score
Energy Savings	3.0
First Cost to Government	3.0
Speed of Implementation	2.5
Prerequisite to Other	2.7
Multi-benefits	2.3
Average Score	**2.7**
RANK	3

(1) Develop methodology and specifications for audits

(2) Develop incentives for industry to undertake audits

1. DEVELOP METHODOLOGY AND SPECIFICATIONS FOR AUDITS

Develop the "Methodology and Specifications for the Performance of Energy Audits on Buildings or Facilities in Uganda" as described in the draft of the Energy Efficiency and Conservation Bill and determine the period to which the requirement of conducting an audit applies. A guidebook for energy auditors should describe the key elements of preparing for an energy audit, including conducting an inventory and measuring energy use, analyzing energy bills, benchmarking, analyzing energy-use patterns, identifying energy efficiency opportunities, conducting cost-benefit analysis, preparing energy audit reports, and undertaking post-audit activities. The purpose of this guidebook is to assist energy auditors and engineers to conduct well-structured, effective energy audits (Hasanbeigi and Price, 2010).

2. DEVELOP INCENTIVES FOR INDUSTRY TO UNDERTAKE AUDITS

Energy audits should be prerequisites for applying to energy efficiency financial incentive programs, such as concessional loans, as described in *Section 5.2.13*, *Create an Energy Efficiency and Conservation Fund*. For example, in South Africa, anyone wanting to apply for Eskom's DSM program is required to first perform an energy audit to identify eligible energy efficiency measures, draw up an energy monitoring and verification plan, and submit the proposal to Eskom for approval. Energy audits under this program have generated information essential for monitoring and verifying the energy savings resulting from the investment that is partly financed by Eskom's incentive program.

Best Practices/Resources:

India: The Indian Energy Conservation Act 2001 (amended in 2010) requires large, energy-intensive industries and other large energy consumers (DCs) to have energy audits by an accredited energy auditor, to designate or appoint an energy manager, and to report annually on energy consumption. There are approximately 700 DCs in nine energy-intensive sectors in India. The Indian Bureau of Energy Efficiency (BEE) supports these companies in implementing energy management and energy auditing by providing certified examinations for energy auditors and energy managers. To become a certified energy manager, candidates must score at least 50% in three areas: general aspects of energy management and energy audit, energy efficiency in thermal utilities, and energy efficiency in electrical utilities.

U.S.: The U.S. Department of Energy (U.S. DOE) Advanced Manufacturing Office provides tools and resources to help manufacturers track energy, identify areas for improvement, and establish energy management systems at the plant level. Some tools have been developed to help manufacturers improve the efficiency of specific systems and pieces of equipment within a plant; these tools address the following end-uses: steam production, process heating, combined heat and power, compressed air, motor, pumps, and fans. Other tools help facilities implement an EMS and prepare to become certified to International Standards Organization (ISO) standard 50001. For example, U.S. DOE developed the DOE eGuide for ISO 50001, which is a comprehensive online reference that provides free, step-by-step guidance for ISO 50001 implementation from start to finish.[16]

Copenhagen Centre for Energy Efficiency: *Best Practices and Case Studies for Industrial Energy Efficiency Improvement – An Introduction for Policy Makers* (Fawkes et al., 2016) is a guidebook to support energy efficiency policy making for industry through sharing of international experiences. The guide explains pre-conditions for successful implementation of policies and programs and provides concrete examples.

[16] https://energy.gov/eere/amo/software-tools

5.2.4 DEVELOP REGULATIONS FOR ENERGY MANAGEMENT SYSTEMS

EMSs encompass managerial, tracking, and reporting activities that guide companies in continuously improving energy efficiency. EMSs facilitate integration of energy efficiency into daily operational practices and engage companies at the management level. Implementation of EMSs helps organizations conserve an estimated 10-40% of energy use (IEA, 2012). The main direct benefit is an increase in companies' energy productivity. This, in turn, improves country competitiveness and creates jobs.

- Policy type: Industry and Commercial/Regulation
- Implementers/Stakeholders: MEMD, UMA, PFSU, UNBS, MTIC
- Current status: Energy Efficiency and Conservation Bill directs companies and businesses that consume 1 GWh/year or more to implement EMSs.
- Actionable steps:

  (1) Implement energy management system

Prioritization Criteria	Score
Energy Savings	3.0
First Cost to Government	3.0
Speed of Implementation	2.7
Prerequisite to Other	2.2
Multi-benefits	2.3
Average Score	2.6
RANK	4

I. IMPLEMENT ENERGY MANAGEMENT SYSTEMS

Adopting a recognized national or international EMS standard can facilitate the implementation of EMSs. ISO 50001, developed in 2011 (ISO, 2011), has become the international standard for EMSs and is now replacing national energy management standards in many countries, including the European standard EN 16001. More than 7,345 sites worldwide had achieved ISO 50001 certification by May 2014, with almost half of those sites in Germany (UNIDO, 2015a). MEMD could adopt this standard, effective framework that is widely used internationally.

Best Practices/Resources:

International Energy Agency: A significant number of governments around the world have developed programs to encourage the adoption of EMSs. Some programs are mandatory (Australia, China, South Korea, South Africa), and some are voluntary (Denmark, Ireland, Sweden, the U.S.). The IEA Policy Pathway series includes a report on energy management system implementation (IEA, 2012) that describes in detail the steps to adopt an EMS.

Energy Management Working Group: The Energy Management Working Group (EMWG) is an initiative of the Clean Energy Ministerial that provides a wealth of technical and informational resources to encourage and facilitate adoption of EMSs (EMWG, 2016). A toolbox contains guidance on EMS training and monitoring and verification schemes. The working group has launched a campaign to achieve 50001 ISO 50001 certifications by 2020.

5.2.5 ENFORCE ENERGY EFFICIENCY STANDARDS & LABELING

S&L programs are the cornerstone of energy efficiency programs worldwide and have been implemented in more than 80 countries, covering more than 50 different types of energy-using products in the commercial, industrial, and residential sectors (IEA, 2015a). These programs encourage removal of inefficient technologies from the market; avoid dumping of older, less-efficient technologies from more advanced economies; and empower consumers to make informed purchasing choices. These programs have saved an estimated 10 - 25% of national or relevant sectoral energy consumption (IEA, 2015a) and are essential to transform markets toward more advanced technologies and foster innovation, contributing to the improvement of technology in a country. Enforcement is critical to achieving these outcomes and is often the most difficult component of S&L programs.

Prioritization Criteria	Score
Energy Savings	3.0
First Cost to Government	2.0
Speed of Implementation	2.0
Prerequisite to Other	3.0
Multi-benefits	2.4
Average Score	2.5
RANK	5

- Policy type: Cross-Cutting/Regulation
- Implementers/Stakeholders: MEMD, UNBS, Uganda Revenue Authority (URA)
- Current status: As discussed in Section *0*, *Standards and Labeling*, UNBS issued MEPS for five products in 2012 (lighting, refrigerators, freezers, motors, air conditioners), but these standards have not been enforced because the regulation to enforce them has not been issued. That regulation is included in the draft Energy Efficiency and Conservation Bill.
- Actionable steps[17]:

(1) Enforce existing Minimum Energy Efficiency Standards
(2) Develop a compliance, certification, and enforcement plan
(3) Develop a product registration database
(4) Establish energy efficiency testing laboratory

1. ENFORCE EXISTING MINIMUM ENERGY EFFICIENCY STANDARDS

Enforcement of energy efficiency S&L programs requires regulation that clearly defines roles and responsibilities to ensure that the market adopts the new standards. Most S&L programs around the world are mandatory. The enactment of the Energy Efficiency and Conservation Bill will give MEMD the authority necessary to issue the rules establishing and enforcing mandatory MEPS. Typically, such a rule requires that all manufacturers comply with the standards within one year, which gives industry time to make any required investments or changes to meet the standard.

[17] This list focuses on action to enforce the current S&L program. Additional actions are described in Section *5.2.6*, *Expand Standards and Labeling Program* to revise standards to more stringent levels and expand the program to additional products.

2. DEVELOP A COMPLIANCE, CERTIFICATION, AND ENFORCEMENT PLAN

A compliance, certification, and enforcement plan is necessary to ensure that products meet MEPS and to verify manufacturers' energy efficiency performance claims. This plan is essential to the success of S&L programs. A compliance, certification, and enforcement plan entails the following:

- Compliance: Developing a market intelligence strategy that checks a small number of targeted products to assess compliance with the program
- Certification: Establishing test procedures and identifying testing laboratories (domestic, regional, or foreign) to certify products
- Enforcement: Defining clear penalties for manufacturers and others that do not meet the requirements

Enforcement could be part of Pre-Export Verification of Conformity, an international inspection and verification program adopted in Uganda. This program checks compliance against technical regulations and standards.

3. DEVELOP A PRODUCT REGISTRATION DATABASE

In most countries that have S&L programs, governments have developed public databases that provide authoritative information about the energy performance and other characteristics of the products available on their markets. These databases are a useful source of information on whether products comply with efficiency standards. The databases also support consumers in making informed purchasing decisions. Some databases contain information on energy efficiency ratings for electrical appliances that are required to display energy rating labels. The Super-Efficient Equipment and Appliance Deployment (SEAD) initiative maintains a list of product registration websites.[18]

4. ESTABLISH TESTING LABORATORY

Energy efficiency testing laboratories are necessary to verify the accuracy of the stated energy performance of equipment available on the market. Testing is part of S&L program verification and enforcement schemes. Testing facilities can either be government establishments or independent commercial enterprises. They generally require a suitably equipped facility and a high level of skill to operate it (CLASP, 2010). Because testing facilities require qualified staff, they support the growth of local technical capacity. In some instances, facilities are located at universities to facilitate training.

An assessment of local capacity should be conducted to evaluate testing needs and investment required. This assessment should consider the option of using international testing facilities or making arrangements with laboratories in the countries of origin of particular products. Finally, the assessment should also consider regional collaboration and harmonization with neighboring countries' protocols, to facilitate regional market

[18] http://www.superefficient.org/Tools/Product-Certification-Databases.aspx

performance verification and optimize regional investment by avoiding the costs of duplicative testing facilities.

Best Practices/Resources:

Collaborative Labeling and Appliance Standards Program (CLASP) & Lawrence Berkeley National Laboratory (LBNL): CLASP, in collaboration with LBNL, published a guidebook on developing, designing, implementing, and maintaining S&L programs (CLASP, 2005). Additionally, a spreadsheet-based tool developed by LBNL, the Policy Analysis Modeling System,[19] can be used to estimate potential energy savings and financial impacts resulting from government MEPS, based on user inputs or default parameters. CLASP also developed a manual focusing on compliance, certification, and enforcement (CLASP, 2010).

Ghana: Ghana was the first Sub-Saharan country to implement a mandatory S&L program for lighting and air conditioners in 2003. As part of its energy efficiency program, Ghana banned imports of used appliances effective January 2013. This ban has been an important component of achieving energy efficiency because many of the energy-consuming products, notably refrigerators, sold and used in Ghana were secondhand, inefficient products coming from Europe. The ban is strictly enforced by the Energy Commission and the Customs Division of the Ghana Revenue Authority. For example, in November 2013, the UK recycling firm Environcom was found to have illegally imported to Ghana 4,000 secondhand refrigerators. The containers were impounded by the Revenue Authority and sent back to the UK.

Super-Efficient Equipment and Appliance Deployment Initiative (SEAD): The Super-efficient Equipment and Appliance Deployment Initiative is a voluntary collaboration among governments working to promote the manufacture, purchase, and use of energy-efficient appliances, lighting, and equipment worldwide. The SEAD website[20] provides valuable information for implementing S&L programs.

International Electrotechnical Commission and United Nations International Development Organization: A publication from UNIDO and the International Electrotechnical Commission (IEC) describes the steps necessary to establish a laboratory for testing the energy performance of products. The publication also gives examples of overcoming challenges in establishing a laboratory: a proposed electrical testing laboratory in Bhutan, and ISO/IEC 17025 accreditation of an electrical laboratory in Pakistan (UNIDO, 2012).

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[19] Tool available at: https://ies.lbl.gov/project/policy-analysis-modeling-system

[20] http://www.superefficient.org/

5.2.6 EXPAND STANDARDS AND LABELING PROGRAM

Energy efficiency standards should be regularly revised to more stringent levels to reflect rapid changes in markets. Consumers should be educated about energy efficiency when they are investing in electrical equipment. This is particularly important for households newly connected to the grid that are buying electric appliances for the first time. Investment decisions need to be fully informed and take into account the total cost of appliance ownership,[21] i.e., not only the purchase price but also the operating costs over the appliance lifetime. Consumer decisions can be informed by energy efficiency labels with the labels' significance explained by the retailer to the buyer. Retailers have an important role to play in this process and need to be informed, trained, and incentivized so that they understand the information on the labels, can educate buyers, and are encouraged to offer more efficient products.

- Policy type: Residential/Regulatory and Awareness Campaign
- Implementers/Stakeholders: MEMD, UNBS, Uganda Revenue Authority (URA), REA
- Actionable steps:

  (1) Launch an awareness campaign
  (2) Revise standards to more stringent level
  (3) Develop standards and labels for new products
  (4) Establish Incentives for energy-efficient equipment

Prioritization Criteria	Score
Energy Savings	3.0
First Cost to Government	2.0
Speed of Implementation	2.0
Prerequisite to Other	2.7
Multi-benefits	2.4
Average Score	2.4
RANK	6

1. TOTAL OWNERSHIP COST AWARENESS CAMPAIGN

An awareness campaign is necessary to help consumers, businesses, and retailers understand the value of selecting a high-efficiency appliance to avoid higher operating costs. Lighting and household appliance purchase decisions are too often based entirely on purchase price and not on a consideration of the total energy costs of operating the equipment. This is especially important for newly grid connected customers that make long-term investment by buying new energy-consuming products. An awareness campaign focused on explaining the need to take into account the total cost of ownership will influence the purchase of these consumers toward energy-efficient equipment and therefore lower the share of their disposable income spent on energy costs, freeing up money that can be used to obtain the benefits of other services, including increased energy services.

2. REVISE STANDARDS AND LABELS

Standards need to be revised and updated regularly to reflect changing market conditions. Improving or "ratcheting" standards to more stringent levels over time helps transform the market to greater efficiency, which benefits consumers. Labels also need to be revised over time; when the top energy efficiency tier of the label has saturated the market, policy

[21] The total cost of ownership is often referred as the life-cycle cost.

makers need to revise the labeling tiers to differentiate among models and increase the stringency of the top levels. For example, in the U.S., a market share of ENERGY STAR-certified products in a particular category of 50% or higher will prompt consideration of a revision of the specification for that category. UNBS issued MEPS for five appliances in 2012 (lighting, refrigerators, freezers, motors, air conditioners). These MEPS should be updated on the basis of a market analysis, an assessment of the costs and benefits for customers, and comparison with efficiency levels in neighboring countries as well as countries from which equipment is imported (to avoid dumping of less efficient equipment). Because UNBS has a five-year revision period, the MEPS issued in 2012 should be up for review in 2017.

3. DEVELOP STANDARDS AND LABELS FOR NEW PRODUCTS

Although the products that use the most energy in Uganda are already covered by the UNBS MEPS S&L program, S&L programs in some countries cover a larger number of products; for example, South Africa's program covers 10 products, and the U.S. has standards and labeling for more than 60 categories of appliances and equipment, which saved $63 billion utility bills in 2015. Additional products for UNBS to consider are TVs, water heaters, fans, ovens, air coolers, irons, and radios. This process should start with a thorough analysis of the efficiency levels of products available in the market.

4. ESTABLISH INCENTIVES FOR ENERGY-EFFICIENT EQUIPMENT

Financial incentives are an important instrument for encouraging investment in energy efficiency by making technologies and products more cost competitive and reducing the payback period for consumers. Typically, incentives are implemented through downstream programs where they are provided directly to the customer, midstream programs where they are directed to distributors or retailers, and upstream programs where they target manufacturers. Financial incentives complement S&L programs by increasing the market share of highest-efficiency products, therefore preparing the market for future S&L revisions. Financial incentives can take many forms, such as price discounts, grants, concessional loans, and exemption or reduced sales tax on eligible products. Because Uganda is part of the EAC, import duty exemptions are regulated at a regional level, so the EAC must be engaged if tax incentives are considered. Examples of programs are numerous as described de la Rue du Can (2014).

Funding for these types of programs can come from the Energy Efficiency and Conservation Fund, see Section *5.2.13, Create an Energy Efficiency and Conservation Fund*. Bulk purchasing can also be considered to leverage buying power to lower market prices. In this case, a large buyer, or a coordinated group of smaller buyers, purchase in quantities large enough to attract favorable pricing from manufacturers, often through competitive bidding. This is the model used by Energy Efficiency Services Limited (EESL) in India as described below.

Best Practices/Resources:

India: In India, a joint venture of utilities formed a company, Energy Efficiency Services Limited (EESL), to scale up energy efficiency implementation by offering super-efficient products to consumers at a lower cost than the market price. EESL's business model is based on high-volume purchases through competitive bidding that significantly lower the price of super-efficient equipment. One of EESL's flagship programs is the Domestic Efficient Lighting Programme, which offers LEDs that are 75% cheaper than market prices. EESL is currently launching a new program to distribute super-efficient fans at Rupees (Rs) 1,680 apiece on upfront payment compared to the market price of Rs 3,000. The companies also offer a financing option to spread the upfront cost by paying monthly (Singh, 2016).

Ghana: With support from UNDP, the Ghana Energy Commission launched a replacement rebate program in 2012. The program[22] is helping Ghanaians make an energy efficient choice when purchasing an appliance by offering rebates of up to Cedis (GHS) 200 ($47) for the purchase of a labeled energy-efficient refrigerator and exchange of their old functioning refrigerator. The program replaces inefficient residential appliances before the end of their useful lives with significantly more efficient appliances. This reduces electricity use by encouraging the deployment of efficient appliances and ensuring that older, less-efficient appliances are removed from the stock. The program was also accompanied by an awareness campaign launched on television and radio, reaching out to the general public to promote the value of energy efficient appliances.

UK: The UK government offers a reduced value-added tax (VAT) of 5% (instead of the normal 20%) for the purchase of energy-saving residential products such as heat pumps and insulation materials. When these products are installed in new houses, a zero VAT applies. The program does not cover white appliances.

Japan: Another innovative program is the Eco-Point program in Japan. This program grants eco-points for the purchase of air conditioners, refrigerators, and televisions that are rated four or more stars by the national energy efficiency S&L program. An evaluation found the share of products that had four or more stars increased from 20% to 96% for ACs, from 30% to 98% for refrigerators, and from about 84% to 99% for televisions.

United Nations Environment Programme: United for Efficiency (U4E) and Enlighten Initiative[23] are two global programs supporting developing countries and emerging economies to move their markets to energy-efficient appliances and equipment.

Global Lighting Challenge[24]: This program is a race to reach cumulative global sales of 10 billion high-efficiency, high-quality, and affordable advanced lighting products, such as LED lamps. The race showcases the ways businesses, governments, and other public-sector leaders are taking action to accelerate this transition.

[22] http://www.energycom.gov.gh/energyguide/
[23] http://united4efficiency.org and www.enlighten-initiative.org/
[24] http://www.globallightingchallenge.org/

5.2.7 SET INDUSTRY TARGETS

Targets create an essential framework for action. Setting quantitative energy reduction targets for industries and companies is a well-recognized tool for policy makers to focus attention, monitor progress, and achieve long-term goals. Targets have been used for decades in many countries. They can be set through voluntary agreements negotiated with or without the government or be mandated by the government. Industry participation can be stimulated through incentives or disincentives. Incentives include access to subsidized audits and technical assistance. Disincentives include the threat of future regulations or energy/GHG emission tax policies if no progress is made. Mandatory targets are generally legally binding, with penalties for non-compliance. Targets can also include trading schemes through which companies and industries can comply.

- Policy type: Industry/Target Setting
- Implementers/Stakeholders: MEMD, UMA, PSFU, CREEC
- Actionable steps:

  (1) Benchmark performance
  (2) Develop sectoral collaborations
  (3) Negotiate targets

Prioritization Criteria	Score
Energy Savings	3.0
First Cost to Government	3.0
Speed of Implementation	2.0
Prerequisite to Other	2.0
Multi-benefits	2.0
Average Score	**2.4**
RANK	7

1. BENCHMARK PERFORMANCE

Benchmarking enables comparison of the energy performance of companies or plants against each other. It provides useful information on the range of energy performance within a group of plants or companies that produce the same type of product or use energy in a similar way. It also helps to estimate the potential for energy savings when lower performers improve their performance to achieve higher levels of efficiency.

2. DEVELOP SECTORAL COLLABORATIONS ON TARGET SETTING

Targets are more likely to be adopted if they are set with involvement of the companies that are directly affected. It is therefore recommended that sector-based collaborations be created for discussing energy efficiency improvements and target setting.

3. NEGOTIATE TARGETS

Effective target setting agreement programs are generally based on signed, legally binding agreements with realistic, long-term (typically 5- to 10-year) targets. Typically, company-level implementation plans are required along with annual monitoring and reporting of progress toward the targets. Programs should include a real threat of increased government regulation or energy/GHG taxes if targets are not achieved and should provide effective assistance to industry in reaching the goals outlined in the agreements.

As with any program, it is necessary to monitor, inspect, and assess progress to ensure compliance. In the case of target setting, quantitative targets enable tangible measurement of progress.

Best Practices/Resources:

Netherlands: Voluntary agreements have been part of the Netherlands' energy policy since 1992. The first Long Term Agreements (LTAs) focused primarily on the efficiency of production process for energy-intensive sectors. The average target was a 20% increase in energy efficiency over 1989 levels by 2000. The first LTA program ended in 2000 with an average improvement in energy efficiency of 22.3% over the program period (UNIDO, 2008). More than 1,000 companies and 29 sectors had signed the LTAs, representing about 90% of industrial primary energy consumption in the country. The current LTAs span the period 2015 to 2020 and focus on SMEs because large industrial companies are already required to participate in a program related to the European Union Emissions Trading System. The current aim of the new LTA is to achieve an average saving of 1.5% per annum on final energy consumption, and a total saving of 100 petajoules (PJ) by 2020.

China: In 2005, the Chinese government established the "Top 1000 Industrial Energy Efficiency Programme" in support of an ambitious national goal of reducing energy consumption per unit of gross domestic product by 20% between 2005 and 2010. Under this program, 2010 energy consumption targets were determined for the 1,000 enterprises that accounted for 33% of national energy usage in 2004. By the end of 2010, the Top 1,000 Program reportedly exceeded its energy-saving target of 100M tce (Mtce) (2,931 PJ) and achieved 125 Mtce (3,663 PJ) of savings (Lu et al., 2014). Because of the success of the Top-1000 Program, the program was expanded to the Top 10,000 program during China's 12th Five-Year Plan period (2011–2015). The Top 10,000 program covers roughly 15,000 industrial enterprises or about two-thirds of China's total energy consumption.

India: BEE launched the Perform, Achieve, and Trade scheme in July 2012. Specific energy consumption reduction targets were set for 478 large energy users from eight energy-intensive sectors, representing about 289 PJ of energy consumption. The scheme includes a market-based mechanism to enhance the cost-effectiveness of energy efficiency improvements, which allows energy-savings certifications to be traded. A preliminary assessment of the scheme found saving of about 363 PJ which is more than 20% higher than the original savings target (BEE, 2016).

Lawrence Berkeley National Laboratory: A survey of target setting agreements identified 23 energy efficiency or GHG emissions voluntary reduction agreement programs in 18 countries, including in Europe, the U.S., Canada, Australia, New Zealand, Japan, Republic of Korea, and Taiwan (Price, 2005). International best practice shows that target setting works best when a coordinated set of policies is established that provides strong economic incentives as well as technical and financial support to participating industries.

5.2.8 ENCOURAGE MARKETS FOR ENERGY ACCESS

Energy efficiency has an important role to play in increasing the energy access of off-grid Ugandan households. Uganda's low electricity access rates, high frequency of power shortages, and expensive electricity prices make off-grid solar electricity system, coupled with highly efficient appliances, highly competitive. Super-efficient appliances (TVs, fans, mobile chargers, and LED lights) require 75% less power than less efficient appliances, reducing overall SHS costs by as much as 50% (Phadke, 2015). Therefore, adopting super-efficient equipment enables consumers to purchase smaller (and therefore less expensive) SHSs, reducing the overall costs of providing energy service. The goal of the markets for energy access policy recommendation is to support market growth for rural on-grid and off-grid energy-efficient products to increase energy access.

- Policy type: Off-Grid Households/Regulatory, Awareness and Financing
- Implementers/Stakeholders: MEMD, REA, PSFU, UNBS
- Current Status: WB's ERT III project has a sub-component to promote quality assurance and awareness of solar products, to enable the market for quality products in rural area.
- Actionable steps:

  (1) Develop product quality standards
  (2) Encourage market development
  (3) Incentive energy efficient product purchases

Prioritization Criteria	Score
Energy Savings	2.0
First Cost to Government	3.0
Speed of Implementation	2.2
Prerequisite to Other	2.3
Multi-benefits	2.2
Average Score	2.4
RANK	8

1. DEVELOP PRODUCT QUALITY STANDARDS FOR OFF-GRID EQUIPMENT

Tapping energy efficiency's benefits for rural energy access requires quality standards for equipment and awareness about energy efficiency. Standards for off-grid equipment exist with WB's Lighting Global quality standards and Global LEAP's standards. This activity could build on these standards as well as ERT III activities to develop solar-related labeling—such as "solar efficient" —to inform consumers about product quality and performance and to increase confidence.

2. ENCOURAGE MARKET DEVELOPMENT

A market development strategy increases retail and distribution knowledge about energy-efficient products and about market opportunities and strategies by organizing annual expositions, trade shows, award competitions, market updates, awareness campaigns, and peer training with regional partners.

3. INCENTIVIZE ENERGY EFFICIENT PRODUCT PURCHASES

Financial incentives help reduce upfront cost barriers to adoption of early-stage, high-efficiency technologies. Other market interventions, such as most-efficient awards or energy-efficient bulk procurement, can complement incentive programs and accelerate diffusion of technologies. Bulk procurement by a centralized agency can lower retail costs to consumers and increase product quality. Global LEAP offers an off-grid procurement incentive in Bangladesh. Global LEAP, Power Africa, and the U.K. Department for International Development are partnering to bring this procurement incentive to East Africa, see below. Also see description of EESL in Section 5.2.6 as a best-practice procurement program that leverages buying power to lower the market price of residential equipment.

Best Practices/Resources:

World Bank: WB is currently developing a new multi-tier approach in which the definition of energy access is based on the performance of the energy supplied. The benefits of energy efficiency are defined as an increase in the duration of energy services and an improvement in the affordability of energy services. In this framework, tier 1 energy access includes lighting (in lumen-hours per day) and phone charging. As the tier level increases, the level of energy services increases (ESMAP, 2014, SEforALL, 2016b). WB also recently published a study to identify opportunities to integrate energy efficiency into energy access projects (WB, 2015b).

Global LEAP: Global LEAP supports quality assurance frameworks for off-grid energy products and services and sponsors an international competition that identifies the world's best, most energy-efficient off-grid appliances. Global LEAP also recently developed an off-grid appliance procurement incentives program. The program provides incentives to companies that procure and sell best-in-class Global LEAP Awards Winner and Finalist appliances. The program's first round took place in Bangladesh in 2016 and led to the procurement and distribution of 12,000 quality-assured off-grid televisions. The second round of the program will continue in Bangladesh and will include an expansion into East Africa, which will be launched in 2017 (Global LEAP, 2017).

Lighting Africa and Lighting Global: Lighting Global and Lighting Africa are the WB Group's platform to support sustainable growth of the off-grid solar market globally and in Africa. A quality assurance (QA) framework was developed to support growing markets for modern off-grid lighting. The QA framework includes key activities to measure, test and communicate information about product quality and performance. Notably, the framework contains standards that can be used to set a baseline level of quality and performance to regulate the market in a country. Lighting Africa is active in Uganda where a solar photovoltaic market assessment was conducted in 2014. Following this assessment, an off-grid component to expand access to modern energy in rural areas was added to the WB ERT-III project (Lighting Global, 2017).

Rwanda: Since November 2014, the Government of Rwanda has introduced exemptions to the VAT for solar lighting products whose quality is assured by the Lighting Global Quality Assurance standards. This gives quality products a competitive pricing advantage compared to low-quality products and incentivizes consumers to buy superior products (UNEP, 2015).

5.2.9 ENCOURAGE SMALL-SCALE ENTERPRISE ENERGY EFFICIENCY

Promoting and incentivizing energy efficiency in SMEs presents a number of challenges. Relative to larger industries, SMEs have low overall consumption and therefore a relatively small financial incentive to save energy; they also typically have fewer internal resources for managing and financing energy efficiency projects. Programs promoting energy efficiency in SMEs have to address the diversity of sectors in which these enterprises operate even though few data on energy use may be available. Also, because of the number of stakeholders in this sector, there is a high cost of promotion and administration for the amount of energy saved.

Despite these challenges, energy efficiency of SMEs is an issue worth addressing. In aggregate, SMEs represent a large proportion of total energy consumption (as well as employment) in the commercial and industrial sectors. SMEs account for 33% of industry-sector electricity consumption and 59% of commercial-sector electricity consumption. One approach to enabling these enterprises to undertake energy efficiency improvements is to lower the administrative burden needed to implement efficiency measures.

Examples of strategies with lower administrative burden include: campaigns targeting specific measures or appliance upgrades (rather than audits leading to a full suite of measures); pared-down versions of industrial energy management tools, such as a "light" EMSs or "energy checks" rather than full EMSs; standardized savings assumptions for particular measures; and standard voluntary savings agreements. In all cases, programs targeting SMEs should leverage existing avenues for promotion by, for example, advertising energy-efficient appliance incentives through a small-scale business association.

- Policy type: Industry/Capacity Building and Financing
- Implementers/Stakeholders: MEMD, UMA, PSFU, UCPC, USSIA, UNREEA
- Actionable steps:

Prioritization Criteria	Score
Energy Savings	2.0
First Cost to Government	2.0
Speed of Implementation	2.0
Prerequisite to Other	1.8
Multi-benefits	2.3
Average Score	2.0
RANK	9

(1) Build sectoral knowledge and capacity for energy efficiency opportunities
(2) Develop voluntary agreement to commit to energy efficiency
(3) Provide incentives for encouraging investment in specific measures or appliance upgrades

1. BUILD SECTORAL KNOWLEDGE

Efforts should be made to increase SMEs' awareness of and capacity to undertake energy efficiency investment opportunities. Guidance documents should disseminate to SMEs information on energy-efficient technologies and good practices. Workshops and training developed in collaboration with industry sectoral associations are good strategies to increase information among SMEs. Raising awareness of energy efficiency benefits can result in, for example, an increase in the use of energy-efficient motors and in the demand for highly efficient products. Efforts should also be made to develop support programs to help SMEs adopt pared-down versions of industrial EMSs. Cooperation networks should be tapped to support energy efficiency in SMEs. Cooperation with agencies and organizations that have international experience in energy efficiency will transfer knowledge, experience, and technology to Uganda. At the national level, knowledge sharing platforms can be created through agency cooperation to raise the SMEs' awareness of energy efficiency.

2. DEVELOP VOLUNTARY AGREEMENT TO COMMIT TO ENERGY EFFICIENCY

Voluntary energy efficiency agreements are an especially effective way to promote energy efficiency among SMEs because these agreements use a standardized, systematic approach to monitoring and verification and to access to incentives. Voluntary agreements outline energy management processes to be undertaken by the SME, usually in line with ISO 50001 but in a reduced or "light" form that can later be upgraded to a full EMS. U.S. DOE developed the e-Guide Lite to teach the basics to organizations new to energy management.[25]

The voluntary agreement should lower the burden of adopting energy efficiency practices relative to what larger enterprises are required to do. To maximize the potential of voluntary agreements, initiatives promoting them should focus on particular sectors or subsectors. This targeted approach allows implementation via existing industry associations, which limits promotional costs and utilizes the sector network.

3. PROVIDE INCENTIVES TO ENCOURAGE INVESTMENT

SMEs that implement the energy management approach and measures included in the voluntary agreement should be granted access to incentives targeted to the specific industry. For example, in industries where special energy taxes are applicable, a tax break can be offered, or, if financing is made available for industrial energy audits, those incentives should be extended to SMEs in the same sector.

Best Practices/Resources:

International Energy Agency: The IEA Policy Pathway series guidebook[26] for SMEs describes how governments and other stakeholders can design and implement energy efficiency programs that deliver cost-effective savings to these enterprises. Ten steps, divided into four phases, are described to accelerate energy efficiency in SMEs (IEA, 2015b).

European Union: A 2015 report from the EU Concerted Action group identifies energy efficiency best-practice projects for SMEs. Twelve case studies illustrate how practical communication strategies can be key to achieving energy efficiency. The projects target a variety of sectors and use different communication tools (Lundqvist et al., 2012).

[25] https://energy.gov/eere/amo/articles/doe-eguide-lite
[26] https://www.iea.org/publications/freepublications/publication/SME_2015.pdf

5.2.10 DEVELOP TRAINING AND ACCREDITATION SCHEME

Building skills and human resources is crucial for implementing EMSs and energy audits. Training programs and professional certification are necessary to develop expertise in energy efficiency methods and practices. Certification schemes signal the credibility of certain types of professionals, such as energy managers, who have developed the right combination of skills to conduct audits and implement EMSs. Certification schemes also create a professional community that can share information on best practices, lessons learned, and the latest developments in technology and practices.

Prioritization Criteria	Score
Energy Savings	1.0
First Cost to Government	2.0
Speed of Implementation	2.2
Prerequisite to Other	2.4
Multi-benefits	2.3
Average Score	**2.0**
RANK	10

- Policy type: Industrial and Commercial/Capacity building
- Implementers/Stakeholders: MEMD, UMA, PFSU, UNBS, MTIC, UNREEA, CREEC
- Current status: MEMD, in collaboration with UMA, is organizing training workshops for companies in different parts of the country and working with GIZ to develop a certification scheme (See Section 3.5.1 on Training, mainly).
- Actionable steps: Training and certification can focus on different aspects of energy efficiency implementation depending on the sector and goal. For example, certification programs may be developed for the following specialties:

  - Certified Energy Manager
  - Certified Energy Auditor
  - Certified Monitoring and Verification Professional

  Developing training materials, curricula, and guidebooks is also necessary to make information readily available to applicants. Finally, an accreditation institution for energy efficiency professionals is needed. Professional certification can be based on completing required training to confirm that individuals possess the skills, knowledge, and competencies needed.

Best Practices/Resources:

Energy Management Working Group: The Energy Management Working Group (EMWG) is an initiative of the Clean Energy Ministerial that provides a wealth of technical and informational resources to encourage and facilitate adoption of EMSs (EMWG, 2016). A toolbox contains guidance on EMS training and monitoring and verification schemes. The working group has launched a campaign to achieve 50001 ISO 50001 certifications by 2020.

United Nations Industrial Development Organization: UNIDO offers training and implementation support to promote energy management. As of January 2015, UNIDO EMS programs were active in 17 developing countries and emerging economies, including Egypt and South Africa (UNIDO, 2015a and 2015b).

5.2.11 DEVELOP ENERGY EFFICIENCY PERFORMANCE CODE FOR BUILDINGS

Building codes have historically provided a valuable public service by setting minimum requirements for public safety. Building energy codes add legal requirements for buildings' energy performance to address energy consumption for heating, cooling, and lighting. Energy codes can cover different types (e.g., residential or commercial) or sizes of buildings. Building codes may also include renewable energy requirements.

In growing economies where the rate of new construction is increasing rapidly and a large share of a city's building stock is yet to be added, building energy codes can save significant energy in the medium to long term. Development of a building energy code should be considered early to unlock energy efficiency potential that otherwise will be unreachable during the lifetime of the building except at very high cost through retrofits. A building's lifetime is generally between 50 and 100 years, and certain energy efficiency measures can only be implemented during the design and construction stages. In many countries, energy efficiency of buildings falls under the jurisdiction of the national government, but implementation is the responsibility of local governments.

Prioritization Criteria	Score
Energy Savings	1.0
First Cost to Government	3.0
Speed of Implementation	1.8
Prerequisite to Other	2.0
Multi-benefits	2.0
Average Score	**2.0**
RANK	11

- Policy type: Commercial and Institutional Buildings /Regulation
- Implementers/Stakeholders: Ministry of Works and Transport (MWT), Ministry of Lands, Housing & Urban Development (MLHUD), MEMD, Ministry of Local Government (MoLG), KCCA and other municipalities
- Current status: The draft Building Control Regulations (October 2015), under the Ministry of Works and Transport, provide definitions, a compliance procedure, enforcement process, fire safety and seismic requirements, and other specific requirements for various building elements, e.g., walls, windows, roofs. MEMD has been consulted to provide input regarding incorporating energy efficiency in the building code. Regulations, including those focused on energy efficiency in buildings, are being drafted.
- Actionable steps:

  (1) Develop energy efficiency specifications for building codes
  (2) Engage with stakeholders
  (3) Train the workforce
  (4) Carry out pilot demonstration

1. DEVELOP ENERGY EFFICIENCY SPECIFICATIONS FOR BUILDING CODES

Code development requires that data be collected to assess building energy use across different building types (hotel, offices, etc.), climate zones, and energy-using components. It is also necessary to identify energy-saving construction techniques, materials, and energy-use components applicable to local conditions, including insulation materials, fenestration materials (windows and doors), heating and cooling distribution systems, and water heating systems. As a first step, it is therefore necessary to survey and collect data on the energy requirements of current building construction practices in Uganda, the options for improvement, and their costs.

Two types of codes can be considered:

- Prescriptive codes that set performance criteria for the different components of a building shell (thermal transfer values for walls, roofs, and windows) and for building equipment (heating/cooling system, lights, fans, pumps, etc.)
- Overall building performance codes, which are based on the total annual energy consumption of the building.

Codes in early stage development tend to focus on technical requirements (prescriptive approach) because of the lack of data to create baselines for setting overall building performance and the complexity of doing so. Overall building performance can be added to the code once more data have been collected.

2. ENGAGE WITH STAKEHOLDERS

To be effective, building energy codes must be developed through a coordinated process of adoption, implementation, compliance, and enforcement by local jurisdictions. National building codes typically rely on local government adoption for implementation. Communicating specific requirements is an important step along with:

- Strengthening institutional, economic, and policy frameworks and local enforcement
- Developing guidelines for dissemination

3. TRAIN THE WORKFORCE

By setting a baseline for building construction, energy codes set in motion training and education across multiple industries. The design, engineering, and construction industries all need to incorporate energy efficiency into their certification processes so that their professionals are prepared to meet new requirements. The adoption of a building code is a process that requires awareness and educational programs for the many stakeholders involved in building construction (architects, developers, designers, builders, inspectors, examiners, and energy consultants among others). Once these industries are engaged and robust enforcement is in place, opportunities to go beyond codes and to develop new standards are likely to emerge.

4. DEMONSTRATION PILOT

Demonstrations of buildings constructed based on the building code requirements can provide evidence that what the code prescribes is adequate and cost effective.

Best Practices/Resources:

Global Alliance for Buildings and Construction (GABC)[27]: GABC is an initiative that aims to mobilize the many stakeholders from the buildings and construction sector to foster the development of appropriate policies for sustainable, energy-efficient buildings, which allows a concrete value-chain transformation of the sector.

Best-Practice Policies and Policy Packages: A review of the use of building energy codes, energy labels, and financial instruments in China, the EU, India, and the U.S. offers shared experience and best practices that can inspire the development of policy to reduce energy use in the buildings sector in developing countries (Levine et al, 2012).

South Africa: South Africa has developed a building code, the SANS 204, published in 2008 as a National Standard for "Energy Efficiency in Buildings." It became mandatory for all new construction after the amendment of the National Building Code SANS 10400 XA in 2011. One interesting aspect of the South African building code is that it requires that 50% of hot water be provided by means other than electric resistance heating (e.g., by solar heating, heat pumps, renewable combustibles, etc.). Part XA concerns energy usage and requires that the orientation, shading, services, and building envelope be designed according to specific requirements. Alternatively, a building permit may be accepted if a competent person "demonstrates that the energy usage of a building is equivalent to or better than that which would have been achieved by compliance with the requirements of SANS XA, or has a theoretical energy usage performance, determined using certified thermal calculation software, less than or equal to that of a reference building in accordance with SANS 10400 Part XA."

Ghana: In Ghana, the African Climate Technology Centre started a project in 2016 to improve energy efficiency in commercial and public buildings. The first phase of the project entails conducting energy audits to provide inputs to a baseline study of energy consumption by building type in the country. The second phase will consist of developing energy efficiency standards and regulations for public and commercial buildings. The project also involves stakeholder collaboration and public education components to ensure that new standards are accepted and integrated into design and construction practices (ACTC, 2017).

India: In India, the Energy Conservation Building Code (ECBC) was modeled on the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE, 2012) 90.1-2004 standard.[28] The ECBC was developed in 2007 and amended in 2010 to expand the number of buildings covered. The code now applies to commercial buildings and large rental apartment buildings with connected loads greater than 100 kW as well as large-scale commercial building retrofits in which the final air-conditioned space of the building is greater than 1,000 m^2. In 2016, ECBC was mandatory in eight Indian states.

[27] http://www.globalabc.org

[28] In the U.S., the ASHRAE 90.1 standard is a model code adopted by states for commercial buildings.

5.2.12 RECOGNIZE CHAMPIONS OF ENERGY EFFICIENCY

Early adopters play an important role in shifting business-as-usual practices. Improvements in efficiency often require companies willing to take risks and experiment with modifications to standard operations. Creation of a recognition program is recommended to award companies in major subsectors (cement, textile, tea, etc.) who deliver significant advancements in energy efficiency. This recognition program will increase awareness of flagship energy efficiency projects and create an incentive for recognition. The program will contribute to demonstrating the value and benefits of energy efficiency investments and reduce perceived risk among industries. Such programs can also help create peer pressure within sectors that encourages more energy-efficient practices, as companies receiving awards seek to use them for competitive advantage. Furthermore, the data and information collected over time through a recognition program provide evidence to financial institutions of positive payback and benefit, paving the way for increased lending for efficiency improvements.

Ultimately, awards can also be part of a broader program to bring industries together to commit to greater energy efficiency and set target, see recommendation *5.2.7, Set Industry Targets*.

- Policy type: Industry/Informational
- Implementers/Stakeholders: MEMD, GIZ, UMA, PSFU, UNREEA, CREEC
- Actionable steps: Specific actions to develop an award program include:

  (1) Develop criteria for recognition
  (2) Develop a communications strategy
  (3) Develop a platform for disseminating best practices

Prioritization Criteria	Score
Energy Savings	1.0
First Cost to Government	3.0
Speed of Implementation	2.0
Prerequisite to Other	1.8
Multi-benefits	1.6
Average Score	**1.9**
RANK	12

1. DEVELOP CRITERIA FOR RECOGNITION

An effective recognition program is performance-based and provides awards or other benefits only for documented energy-saving improvements.

It is suggested to form a multi-stakeholder committee to develop criteria for recognition as well as to develop the process to verify claims. The committee can also develop the methods for giving awards and public recognition.

2. DEVELOP A COMMUNICATIONS STRATEGY

Communication about the energy efficiency recognition program and the benefits of energy efficiency improvements is key to attracting and motivating industries and companies to participate and outperform.

Next steps in this area may include:

- Use Energy Week as a platform for recognizing energy efficiency champions
- Develop a pilot competition focused on key sectors to attract attention and generate interest; options include industries that consume the most energy, industries with the highest profiles, and/or the subsectors with the most innovative leadership.

3. DEVELOP A PLATFORM FOR DISSEMINATING BEST PRACTICES

Collecting case studies in a database and creating a sound dissemination strategy for sharing best-practice results will lead to increased awareness about successful energy efficiency measures and increase confidence in the results of energy efficiency investment. Information should be easily accessible and include detailed information so that potentially interested industries can use the database to inform their investment decisions and so that the database will attract more industry investment in energy efficiency upgrades. The case studies can also be a resource for estimating the potential for energy efficiency measure implementation and provide concrete examples for future training efforts.

Best Practices/Resources:

India: Beginning in 1991, India's National Energy Conservation Awards asked industrial, commercial, and public-sector enterprises to voluntarily report on energy conservation performance so that the best-performing firms could be rewarded. Participation by companies has increased significantly over the years. Nearly 600 companies took part in 2010 with representation from 35 industrial sectors, the power sector, and seven commercial sectors. The award program is administered by India's BEE. In 2014, participants' collective investment in energy efficiency saved 5,197M kWh of electrical energy, which is equivalent to the energy generated from a 751-MW thermal power station (India MOP, 2015). All the case studies are reported on a website that is publicly accessible.[29]

U.S.: Since 2001, the U.S. EPA and the U.S. DOE ENERGY STAR Awards have honored organizations that make outstanding contributions to protecting the environment through energy efficiency. The ENERGY STAR Award ceremony is organized annually. Awards are given in several categories, including energy management. See U.S. EPA (n.d.) for a full description of the different categories. In 2014, 70 plants earned the ENERGY STAR certification by achieving energy performance in the top quartile nationally, bringing the cumulative number of certified plants to 139. Overall, the ENERGY STAR program for the industry sector reduced utility bills by $3.4 billion in 2014 (U.S. EPA, 2016).

[29] https://www.beeindia.gov.in/awards/national-energy-conservation-awards-2016

5.2.13 CREATE AN ENERGY EFFICIENCY AND CONSERVATION FUND

Energy efficiency funds provide essential resources for implementing energy efficiency programs and address the lack of affordable financing for energy efficiency and the lack of end-user incentives for investing in energy efficiency. A fund's main objective is to use public monies to leverage private investment in energy efficiency. The fund can be used to support financial incentives, concessional loans, awareness campaigns, demonstration projects, technical assistance, and other energy efficiency programs. The main challenge of developing a public fund is establishing mechanisms that sustain and increase the funding level over time. Moreover, because large capital transfers are involved, it is critical to ensure transparency and validation of results by establishing a clear, robust process for reporting, monitoring, verifying, and evaluating costs and benefits of funding allocations. Energy efficiency funds contribute to job creation, business growth, and new business investment. Energy efficiency projects are known to be labor intensive and to require advanced skills compared to other types of public investment. Thus, an energy efficiency fund helps develop a skilled local workforce, often through the development of ESCOs.

Prioritization Criteria	Score
Energy Savings	2.5
First Cost to Government	1.0
Speed of Implementation	1.0
Prerequisite to Other	2.9
Multi-benefits	1.9
Average Score	**1.9**
RANK	13

- Policy type: Cross-Cutting/Financing
- Implementers/Stakeholders: Uganda Energy Credit Capitalization Company Limited (UECCC); MEMD; Ministry of Finance, Planning, and Economic Development
- Current status: The draft Energy Efficiency and Conservation Bill requires that an Energy Efficiency and Conservation Fund be established to finance implementation of national energy efficiency programs. The bill further specifies that the fund shall comprise funds appropriated by Parliament, loans, and donations or grants. A number of uses for the fund are enumerated.
- Action needed:
  (1) Establish a legal framework
  (2) Secure sustainable funding sources
  (3) Establish a revolving fund for concession loans
  (4) Develop a standard offer program (SOP)
  (5) Define the criteria and mechanisms to disburse funding
  (6) Develop an evaluation, monitoring, and verification scheme
  (7) Start with pilot programs

1. ESTABLISH A LEGAL FRAMEWORK

Legislative steps can be considered to establish the funding mechanism, institutional setup, governance arrangements, implementation organization, and collaborative goals. The establishment of the fund can be developed within the framework of prioritization of energy efficiency in integrated resource planning, see 5.2.2 *Prioritize Energy Efficiency in Integrated Resource Planning*.

2. SECURE SUSTAINABLE FUNDING

Identifying and securing financial resources to support energy efficiency can be challenging for countries that face many other demands for limited resources. Table 5-4 lists a variety of source options that can be considered and examples of where these resources have been used.

Table 5-4. Funding Source options for Energy Efficiency and Conservation Fund

Options	Description	Examples
Levy	Funds raised through a dedicated levy	• In Thailand, the government has raised funds through a petrol levy since 1992. The tax revenues are deposited in a fund to support energy efficiency projects. See Best Practices. • Ghana levies a surcharge on all heavy consumers of electricity whose power factors are below 0.9. The surcharge is paid into the Electricity Demand Management Fund. The objective is to push consumers with high electricity demand to practice energy efficiency and to make money available for energy efficiency activities. • Brazil requires utilities to spend 1% of annual revenues on end-use energy efficiency improvements and research and development. • The U.S. state of California raises approximately US$1 billion annually through a public-benefit charge on electricity rates to fund DSM programs. See Best Practices.
International development organization support	Grants from international development organizations	Donor agencies (notably the Government of Norway, Government of UK, Germany, and the EU) recently committed €94.5M (US$104M) to subsidize development of small-scale renewable energy (GET FiT Program). Similar commitments can be envisioned for a feed-in energy efficiency program, such as SOPs described below.
International financial institutions	WB and African Development Bank can provide low-interest loans and grants	In Romania, the WB has used funding from GEF as seed capital to develop a revolving energy efficiency fund. See Best Practices. WB has also provided loans to the Mexican government to develop a replacement of old, inefficient refrigerators with more efficient ones. In Tunisia, WB offered a dedicated line of credit to local banks to fund industrial energy efficiency and cogeneration projects. See Best Practices.
Climate fund	Global Environment Facility (GEF) Green Climate Fund	GEF has been funding energy efficiency projects for many years through its implementing agencies: UNDP, UNEP, and WB. The newly created Green Climate Fund has developed new programs, including energy efficiency programs.

It is essential that part of the fund be developed through a constant stream of funding that is sustainable, domestic, and resilient to cyclical changes; as such, it is highly recommended that some level of funding be raised through a levy that would provide steady income support. As a start, one possibility is to use the power factor charge that is collected by ERA to incentivize medium and large industrial consumers to correct for power factor without distributing rewards, see *Power Factor Charge and Reward* for more detail. As described in Table 5-4, this is the example of the Ghana Electricity Demand Management Fund. Also, dedicated lines of credit, supported by complementary resources and arrangements, such as setup of guarantee mechanisms and technical assistance to financial intermediaries, can provide financing solutions to targeted beneficiaries like large industrial energy users, See Tunisia Best Practice. Dedicated lines of credit tend to work best in a well-established institutional and legal framework for energy efficiency with a relatively sound financial sector.

3. ESTABLISH A REVOLVING FUND

A revolving fund provides low-interest financing with capital replenished as individual projects pay back their loans so that new loans can be made available to other projects. Because revolving funds offer affordable financing specifically for energy efficiency, they are a valuable complement to energy audit programs. Low-interest financing can be used to implement energy efficiency improvements identified through energy audit programs. This helps build experience among energy efficiency suppliers, contractors, and consumers and enhances the market for ESCOs. Furthermore, this type of financing arrangement helps establish credit history among implementing parties, lowering barriers to their access to commercial debt for future energy efficiency investments. See U.S. DOE (2009) for the General Steps to Establish a Revolving Loan Fund.

4. DEVELOP A STANDARD OFFER PROGRAM

SOPs enable project developers and ESCOs to finance efficiency projects by obtaining a price for each kWh saved. Under this type of program any energy user (customer), project developer, or ESCO that can deliver verifiable energy savings (in kW or kWh) can propose projects, and, if successful, be paid a fixed amount per kWh saved. The rate per kWh saved is generally determined based on the value of the reductions to the utility system. The standard offer is the mirror image of a renewable feed-in-tariff mechanism in which a price for energy savings is offered (WB, 2011). Eskom has developed such a program in South Africa to stabilize its power system. The program has greatly benefited the ESCO industry, which has witnessed enormous growth since the establishment of Eskom DSM programs (IDC, 2012). However, Eskom has placed some of its programs on hold because of financial constraints.

5. DEFINE MECHANISMS TO DISBURSE FUNDING

Once a portfolio of programs has been defined, the next step is to develop the criteria to select projects to be funded. Criteria need to relate to the fund’s main goal of saving energy, but additional benefits can be considered, such as emissions reductions, job creation, etc. Eligibility criteria and mechanisms to disburse the fund entail many components that need to be considered and developed, including determining the percentage of investment covered, defining loan terms, establishing a competitive bidding process, forming an application review committee, and devising an application and reporting forms.

6. DEVELOP AN EVALUATION, MONITORING AND VERIFICATION SCHEME

The success of energy efficiency funds depends on rigorous and strategically focused methods of performance evaluation, monitoring, and verification, which helps to assess the performance of project implementers, verify energy savings, and improve the design of future energy efficiency programs.

- *Evaluation* is generally developed at the level of the programs or portfolios to assess whether program goals are being met.
- *Monitoring is the process of routinely gathering information on all aspects of project implementation.*
- *Verification* determines energy savings at individual sites or projects through metering measurements in combination with engineering calculations, statistical analysis, and/or computer modeling.

Several guidelines and protocols exist for evaluation, monitoring, and verification. The most widely used is the International Performance Measurement and Verification Protocol (IPMVP), which has been adopted by entities in many countries, including the South African utility Eskom for its energy efficiency and DSM program. Useful guides for evaluation, monitoring, and verification at the program or portfolio level include the *Energy Efficiency Program Impact Evaluation Guide* (U.S. SEE Action, 2012) and international *Energy Performance Measurement and Verification Guidance and Quality from 2014* (GSEP, 2013).

7. START WITH PILOT PROGRAMS

Starting with pilot programs is recommended. Pilot programs are small-scale, short-term experiments that help reveal how a large-scale project might work in practice. They enable implementing agencies to assess opportunities and see what policies and activities are most effective in removing barriers to energy efficiency investment.

Best Practices/Resources:

Thailand: The Government of Thailand established the Energy Conservation Promotion Fund in 1992 to foster investment in energy efficiency and renewable energy. The fund's monies come from a tax on all petroleum sold in the country (Thai baht [THB] 0.04/US$ 0.001 per liter). The annual funding increased from US$40M in 1992 to US$200M in 2012 (CCAP, 2012; IEA, 2016b). Successes from the fund include:

- The Energy Efficiency Revolving Fund (EERF) initially provided credit lines at 0% interest to participating local banks to finance energy efficiency projects at no more than 4%.
- In 2008, an ESCO Fund was created to offer a range of financing and technical assistance to ESCOs.

From 2003 to 2012, the EERF funded 294 projects resulting in a total of 13.4 PJ of energy savings per year, which represents an annual cost savings of THB5,423M ($153M).[30] The ratio of savings to investment was 3.4. (Frankfurt School and UNEP, 2012)

Romania: In 2002, WB used GEF funds as seed capital for the establishment of an Energy Efficiency Development and Financing Facility Fund. The project was designed to attract commercial co-financing and to provide a market-oriented approach. The facility fund targeted primarily the private sector to fill a financing gap by originating transactions not pursued by the Romanian financial sector. The project aimed at lowering transaction costs by improving the knowledge and availability of mechanisms necessary for financiers and energy consumers to fund viable energy efficiency projects. Loan repayments from implemented energy efficiency projects are being returned to the fund and are available for a new round of clean energy investments. After five years, the facility fund had signed 18 loan contracts for US$11.4 million (US$8 million from original GEF grant and $3.4 million from repaid funds) for a total investment (including co-financing) of US$34.2 million in energy efficiency projects. More than 86% of total investment was in the industrial sector (World Bank 2009).

Tunisia: In the early 2000's, the Government of Tunisia (GOT) adopted an aggressive strategy to enhance energy efficiency. Energy audits were already mandatory for large energy users were not translating into actual investments. The GoT and the World Bank designed a GEF-financed program to "achieve a deeper penetration of sustainable commercial energy efficiency investment activities in Tunisia's industrial sector, by removing barriers and lowering transaction costs." The project had three components: (1) providing output-based subsidies; (2) guaranteeing energy efficiency investments to ensure their bankability; and (3) providing technical assistance to improve the understanding of companies, financial institutions, and government agencies on how such investments could be made. Part of the subsidy was offered by the GOT from a newly created national energy efficiency fund, the Fonds National pour la Maîtrise de l'Energie (FNME), and supplemented by an incentive offered by WB. The project supported 116 investment projects (World Bank, 2012c). This was further supplemented by another WB project in 2009 that provided dedicated lines of credit to finance industrial energy efficiency and cogeneration projects. The project offered funds at attractive terms to participating banks, which made loans to industrial companies for eligible projects at market rate. The project resulted in the implementation of 12 cogeneration subprojects. No energy efficiency project was financed under the credit line, mainly because energy efficiency projects were relatively small, with high transaction costs (World Bank, 2016c).

World Bank: WB produced a guidebook for policy makers, "Establishing and Operationalizing an Energy Efficiency Revolving Fund." The guidebook defines the typical structure of revolving energy efficiency funds, the conditions under which they can be useful and effective, ways in which they can address financing barriers, and implementation options. The guide also provides examples, case studies, lessons learned, and a "roadmap" for establishing revolving funds (Limaye, et al., 2014).

[30] Using an exchange rate of 0.03 USD per baht.

5.2.14 ENCOURAGE CLEAN INDUSTRY DEVELOPMENT

Energy management and audit regulations go a long way toward improving overall efficiency in industrial sectors; however, industry should also be encouraged to take the lead in developing recycling, water conservation, and by-product use initiatives. Clean industrial parks and by-product synergy activities complement energy efficiency initiatives and support the evolution of an integrated, environmentally friendly industrial sector.

- Policy type: Industry
- Implementers/Stakeholders: MEMD, UMA, PSFU, UCPC, NEMA, KCCA, and local governments
- Actionable steps:
  (1) Establish low-carbon industrial parks
  (2) Facilitate recycling economy & byproduct synergy

Prioritization Criteria	Score
Energy Savings	2.0
First Cost to Government	1.0
Speed of Implementation	1.8
Prerequisite to Other	2.1
Multi-benefits	2.3
Average Score	1.8
RANK	14

1. LOW-CARBON INDUSTRIAL PARKS

A low-carbon industrial park is an association of industries and businesses in the same location that work together to address energy and water usage, waste management, and other environmental concerns such as recycling and by-product synergy. The key argument for participation in a low-carbon industrial park is the opportunity to tackle environmental issues in a more economic manner than is possible when an enterprise is acting alone. Concrete examples of collaboration within an industrial park include: joint energy management and energy auditing, coordination of shipping and logistics, use of waste heat from neighboring facilities, and coordinated fuel use and purchasing. These measures can address any point in an industry's value chain, from energy expenditure to production efficiency and product distribution.

2. RECYCLING ECONOMY AND BY-PRODUCT SYNERGY ACTIVITIES

By-product synergy is a core concept of industrial ecology and an advanced approach to industrial economics and environmental impacts. Recycling and up-cycling are central to this concept. By-product synergies, where waste from one process can be used as a feedstock for another productive process, can be found within individual facilities and among groups of complementary industries. District heating utilizing process heat from industrial facilities is a straightforward example, but more advanced examples exist, for example between the steel and cement industries when steel slag is converted into raw material for cement production. Like establishing low-carbon industrial parks, identification of by-product synergies requires an intentional effort to identify complementary processes and materials.

Best Practices/Resources:

China: China facilitates and incentivizes development of low-carbon industrial parks and by-product synergy. A guidance document from the International Institute for Sustainable Development provides examples of how such initiatives can be managed and implemented, including recommendations for monitoring and training (Thieriot and Sawyer, 2015).

5.2.15 DEVELOP BUILDING ENERGY USE DISCLOSURE AND BENCHMARKING

Labeling and information disclosure about the energy use of buildings increases energy efficiency awareness among prospective property owners and tenants, thereby incentivizing efficiency among real estate developers. Disclosure and benchmarking of building energy use encompasses two mechanisms: energy performance certificates (EPCs) and efficiency labeling through a green building certification program.

An EPC is issued to buildings by a government assessor and disclosed to consumers at the time of sale or rental. The EPC summarizes the building's projected energy consumption and cost for lighting, HVAC, and other end-uses. EPCs can be a standard component in each property's assessor report, thereby integrating energy considerations into property valuations. EPCs can also suggest additional efficiency measures and predict their potential impact on the building's certified energy performance rating.

A separate or parallel approach is promotion of an existing green building certification program. Popular green building programs, such as Leadership in Energy and Environmental Design (LEED)[31] and the BRE Environmental Assessment Method (BREEAM),[32] are used throughout the world to incentivize efficiency and sustainability in the building stock. Under these programs, building efficiency is certified at various levels according to criteria that are more stringent for higher ratings, and a label is issued that may be placed on the premises and advertised in promotional material. These ratings provide an easy way for companies, municipalities, and institutions to institute policies regarding buildings they occupy, in order to manage their carbon footprint and demonstrate their commitment to sustainability.

- Policy type: Commercial and Institutional Buildings/Informational and Target Setting
- Implementers/Stakeholders: Ministry of Lands, Housing & Urban Development (MLHUD), MEMD, Ministry of Local Government (MoLG), UNREEA, KCCA and other municipalities
- Actionable steps:

Prioritization Criteria	Score
Energy Savings	2.0
First Cost to Government	2.0
Speed of Implementation	1.7
Prerequisite to Other	1.9
Multi-benefits	1.6
Average Score	1.8
RANK	15

(1) Establish legal basis for efficiency reporting
(2) Develop energy performance certification criteria
(3) Develop benchmarking database
(4) Develop procedure for issuing EPCs
(5) Incentivize to outperform certification requirements
(6) Set building targets

[31] LEED is a green building certification program developed in the U.S. that recognizes best-in-class building strategies and practices.
[32] BREEAM is an environmental standard developed in the UK that rates the sustainability of a building.

1. ESTABLISH LEGAL BASIS FOR EFFICIENCY REPORTING

A legal framework must be established to require building energy performance disclosure. The framework should define which buildings are subject to mandatory disclosure, which energy performance metrics must be reported, and how EPCs will be issued and tracked. This legal framework may be built on a combination of legislative action and determinations by Commissioners.

2. DEVELOP ENERGY PERFORMANCE CERTIFICATION CRITERIA

Criteria must be defined for the types of buildings subject to mandatory disclosure along with requirements for how their energy performance is to be evaluated and reported. A threshold may be set (e.g., floor area, occupancy), with all buildings above the threshold required to disclose their energy performance. The type of performance indicators to be measured and disclosed must also be determined. These could include Watts per unit floor area or projected annual energy consumption/cost. These indicators can take advantage of existing building code requirements.

3. DEVELOP BENCHMARKING DATABASE

A database is needed to track buildings' performance metrics and compliance with disclosure regulations. This database should, to the extent possible, utilize existing benchmarking or compliance databases such as those used for building code compliance. EPCs can be tracked and issued alongside certifications that buildings comply with the building code.

4. DEVELOP PROCEDURE FOR ISSUING ENERGY PERFORMANCE CERTIFICATES

The effectiveness of the application of labels is strongly dependent on consumers' view of their trustworthiness. Therefore, it is important that the EPC development process is based on a robust method with skilled assessors. Buildings must be inspected by an accredited official (potentially the building code inspector) who gathers the relevant energy performance data. The certificates must include the performance data and may also include information on how to improve the building's energy performance.

5. INCENTIVIZE TO OUTPERFORM

Upfront cost is often a major barrier to improving energy efficiency in buildings. A variety of programs can overcome this barrier and encourage greater investment in efficiency by building operators, owners, and occupants. Grants, rebates, and tax incentives help offset some of the upfront cost of investing in energy efficiency. A building has a long lifetime, but concessional loans from revolving funds can help make efficiency investments more attractive over the medium term. Non-financial incentives can also be considered, including expedited building permitting and relaxed density restrictions. These incentives can be linked to obtaining green building certification.

6. SETTING BUILDING TARGETS

A voluntary energy efficiency target program allows private-sector real estate developers and property owners to demonstrate leadership in energy efficiency by committing to quantifiable efficiency improvement targets. Targets can be developed in relation to the building code to add a competitive impetus for energy efficiency investments (see the Canada example below).

Best Practices/Resources:

European Union: In the EU, member states are obligated to introduce EPCs when a property is sold or rented. These certificates rank a building's energy performance in comparison with the performance of peer buildings. The goal of these comparative labels is to raise purchaser and/or renter awareness about building energy performance. EPCs are also required to include recommendations for cost-effective energy efficiency measures. Denmark and Portugal have established obligations to implement measures that are identified as cost-effective in selected building types. For example, for non-residential buildings with ratings lower than a certain threshold in Portugal, all recommended efficiency improvements that have a simple payback time shorter than eight years must be implemented during the first three years after certification. In public buildings in Denmark, recommendations with a simple payback time shorter than five years must be implemented in the first four years after certification (Levine et al., 2012).

Canada: The "2030 Challenge," endorsed by Architecture Canada, calls on design professionals to reduce fossil fuel use in building construction and operation. The 2030 Challenge proposes targets for the energy consumption of new buildings according to the following schedule: all new buildings shall be designed to consume 60% less fossil fuel energy than buildings of the same type in the region today, 70% less by 2015, 80% less by 2020, 90% less by 2025, and carbon neutral by 2030.

U.S.: In 2000, the U.S. EPA developed a tool, ENERGY STAR Portfolio Manager[33] that is widely used in the U.S. to measure and track energy use, water use, and GHG emissions. The tool compares the energy performance of a user's building to that of similar buildings across the country and generates a benchmark score from 1 (the worst) to 100 (the best) to incentivize the user to improve the building's performance over time. Since 2007, two states (California and Washington) and five large cities (Austin, New York City, San Francisco, Seattle, and Washington DC) have passed legislation requiring benchmarking and disclosure of building energy ratings. Each of these jurisdictions requires benchmarking using the ENERGY STAR Portfolio Manager tool. Recently, U.S. DOE has launched the Better Building Challenge, which calls on commercial building leaders and residential housing developers to pledge publicly to reduce the energy use of their entire building portfolios. More than 310 leaders from diverse sectors have stepped up to the challenge, representing more than 4.2 billion square feet, 1,000 manufacturing plants, and $5.5 billion in investment.

[33] https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager

5.2.16 GOVERNMENT LEAD BY EXAMPLE

Governments can lead by example, by promoting energy efficiency improvements in their own buildings and in all public facilities, equipment, and operations. As a first step, governments typically mandate energy-savings targets for their facilities and/or fleets, then collect energy usage data to target the least-efficient buildings. Finally, governments can enter into energy performance savings contracts with ESCOs. These contracts allow the government to pay the ESCO with utility savings accrued after completion of the retrofit. Governments can also set procurement targets to accelerate penetration of energy efficient equipment and to demonstrate the value of investing in energy efficient products for the benefit of the public.

- Policy type: Commercial and Institutional Buildings/Target Setting
- Implementers/Stakeholders: MEMD, KCCA
- Actionable steps:

  (1) Require public agencies to procure energy-efficient products

  (2) Retrofit inefficient government-owned buildings using ESCOs

  (3) Carry out a demonstration pilot

Prioritization Criteria	Score
Energy Savings	2.0
First Cost to Government	1.0
Speed of Implementation	1.0
Prerequisite to Other	2.5
Multi-benefits	2.0
Average Score	**1.7**
RANK	16

1. REQUIRE PROCUREMENT OF ENERGY-EFFICIENT PRODUCTS

Public agencies routinely procure and replace building systems and appliances that have a long-term impact on energy consumption and spending. Instituting a procurement policy that mandates energy efficiency is a way of boosting the market for energy efficient goods, demonstrating leadership in sustainability, and ensuring the best use of public funds.

At the heart of an energy efficiency public procurement policy is the recognition that energy efficient equipment often has a lower lifetime cost than standard equipment despite a higher upfront cost. Barriers to implementing an energy efficient procurement policy may include existing procurement policies preferring the lowest-first-cost equipment and the fact that many procurement officers lack information about energy efficient products. Thus, in addition to instituting a formal mandate to consider the total life-cycle cost of equipment, the government should provide tools to assist in selecting efficient products. Two simple approaches include a preference for products already certified by an efficiency labeling program and development of sample language and specifications that can be adapted to public tenders. Two more complex but more broadly applicable approaches are to develop a catalogue of pre-approved equipment (beyond equipment that carries labels) or a life-cycle cost analysis tool that enables procurement officers to assess products for themselves.

A public procurement policy must be supported by training and enforcement. Public procurement officers should be trained to understand energy efficiency and the tools they've been provided for procuring efficient products. To ensure compliance with the policy, an independent inspector should monitor new procurements.

2. RETROFIT INEFFICIENT GOVERNMENT-OWNED BUILDINGS USING ESCOS

Leading by example addresses the most significant challenge for a growing ESCO market: gaining access to financing. Government-run programs can (1) demonstrate the potential value of the ESCO model; (2) build trust for the ESCO process among financial institutions and customers; (3) identify market needs such as data, assessment models, and contracts; and (4) identify and address barriers specific to Uganda's market. In global literature, government-run ESCOs are commonly referred to as "super-ESCOs." The long-term goal of super-ESCOs is to foster a private-sector ESCO industry through a short-term strategy of directly supporting capacity development and facilitating financing.

3. DEVELOP PILOT DEMONSTRATION

The government should start with a pilot program to demonstrate the validity of the ESCO business model, to speed up the learning curve, and to facilitate agency contracts with private ESCOs. ESCOs use a performance-based contracting model in which they arrange financing for energy efficiency technologies, with loans paid back from the energy cost savings that result from the efficient technology. Government agencies that work with ESCOs help ESCOs gain experience, nurturing a self-sustaining, growing ESCO industry.

Best Practices/Resources:

Mexico: Mexico has been addressing energy consumption in federal building since 1992. In 1999, a decision by the country's energy minister to require all federal buildings larger than 5,000 square meters to perform energy audits and implement cost-effective retrofits provided the original impetus for the launch of the Administración Pública Federal (APF) program. This high-level support had an enormous positive impact on Mexican federal agencies' participation in the program which resulted in 30% electricity reduction in facilities where energy-saving retrofits were implemented. In 2009 a specific unit was given the responsibility of creating and monitoring Mexico government's purchasing policies. In 2011, Mexico City published General Guidelines for the Procurement of Goods with Less Environmental Impact, which are mandatory for all city agencies. (USAID, 2015)

U.S. Agency for International Development: USAID published the Guide to Promoting an Energy Efficient Public Sector, which offers a detailed look at strategies and success stories related to government action on energy efficiency. Details and examples of how these programs can be designed and implemented are provided along with guidance on project financing (USAID, 2015).

Super-efficient Equipment and Appliance Development Initiative: The SEAD Initiative published a guidebook on energy-efficient public procurement to illustrate the key implementation issues and considerations (Payne et al., 2013).

World Bank: WB produced a report in 2012 entitled Public Procurement of Energy-efficient Products: Lessons from Around the World (World Bank, 2012b).

5.2.17 CITIES AND MUNICIPAL COUNCILS DEVELOP ENERGY EFFICIENCY ACTION PLANS

Energy consumption is typically highest in urban areas. Because of the synergy between increased efficiency and economic development, many cities around the world are pursuing innovative strategies to improve their infrastructure, stabilize their power supply, reduce operating costs for businesses, and create jobs through energy efficiency. A city energy efficiency action plan can often be more innovative and more rapidly executed than a nationwide program and can play an important role in leading the rest of the country forward by developing best practices. Working on energy efficiency at a city level is an effective method to capture economic development benefits including job growth, business support, and infrastructure improvement. Instead of energy efficiency being seen as a trade-off for economic growth, city programs can fully integrate efficiency into planning and develop important public-private partnerships.

Recognizing the role that cities can play in leading global GHG emissions reduction, several international and regional organizational frameworks and assistance programs have recently emerged to support city action plans, as described in the following Best Practices/Resources sub-section.

Prioritization Criteria	Score
Energy Savings	2.0
First Cost to Government	1.0
Speed of Implementation	1.0
Prerequisite to Other	1.7
Multi-benefits	2.2
Average Score	**1.6**
RANK	17

- Policy type: Commercial and Institutional Buildings/Target Setting
- Implementers/Stakeholders: Municipalities
- Current Status: KCCA has developed the Kampala Climate Change Action Strategy to guide low-emission development and incorporate climate change actions into city services as described in *Section 0 City Leadership*. The Climate Change Action Plan suggests requiring renewable energy and energy efficiency measures for building permits. The plan also proposes development of city “eco guidelines” that set high environmental standards and include energy and climate elements for public construction and renovations. Activities leading up to the Paris climate talks in 2015 included an official roadmap launch, a city festival, and a stakeholders’ dialogue at Makerere University. However, no specific energy efficiency-related action has been implemented to date.
- Actionable steps:

  (1) Establish municipal building energy efficiency task force
  (2) Expedite permitting for green buildings
  (3) Institute reporting and benchmarking
  (4) Retrofit municipal-owned buildings
  (5) Enforce local building codes

1. MUNICIPAL BUILDING ENERGY EFFICIENCY TASK FORCE

An energy efficiency task force made up of key government officers and representatives of public and private institutions is a basic enabling mechanism for nearly any municipal-led energy efficiency initiative. Energy efficiency programs to be considered at the urban level include efficient equipment procurement, building retrofits, target setting, and energy use disclosure. Design and implementation of these programs require governance and consensus-building.

An energy efficiency task force must be championed by a senior official who brings leadership and legitimacy to the project. A steering committee should be established that brings together representatives from the affected public and private sectors as well as subject-matter experts and consumer-rights representatives. This steering committee is central to creating consensus and prioritizing the efficiency programs to be undertaken to implement actions described in the KCCA Climate Change Action Strategy for the building sector. Finally, a team skilled in energy efficiency and public administration must be assembled to design and implement the programs under the leadership of the senior champion and steering committee.

2. EXPEDITED PERMITTING FOR GREEN BUILDINGS

Establishment of city "eco guidelines," also called green building guidelines, promotes the development of buildings that are environmentally responsible and resource-efficient throughout their life-cycle. As mentioned in Section 5.2.11*,* two green building certification programs already exist, LEED and BREEAM. It is therefore recommended that construction of buildings certified by these internationally recognized schemes be promoted. Additionally, the development of a more localized certification scheme can respond to country-specific environmental factors, such as the waste disposal and the use of biomass.

Offering fast-track permitting for green buildings is a simple, low-cost way to incentivize energy-efficient buildings. Real estate developers will see this permitting opportunity as reducing cost and risk for their construction projects, and the program costs the government little or nothing. Implementation requires revising the existing permitting process to give priority status to buildings that are designed to meet specified efficiency criteria.

3. REPORTING AND BENCHMARKING

Reporting and benchmarking programs are growing in cities around the world. These programs require large buildings to report, benchmark, and disclose building energy-consumption data. For example, the city of Singapore has developed the Green Mark benchmarking scheme, which rates buildings on their environmental performance with different tiers of performance awards (e.g., Gold, GoldPlus, Platinum). The criteria take into account the type of building (residential, retail, commercial). This is an effective way to get building owners, constructors and managers to integrate building energy performance in their investment decisions and to incentivize these stakeholders to produce more efficient buildings than their peers.

4. RETROFIT MUNICIPAL-OWNED BUILDINGS

City governments can lead by example by making their own building portfolio more energy efficient, demonstrating the value of efficiency and creating demand for more efficient buildings. In addition, cities can use municipal buildings as test sites for innovative technology, inviting industry to trial new green building technologies on city-owned buildings before marketing the technologies more broadly.

5. ENFORCE NATIONAL BUILDING CODES

Energy efficiency building codes are developed at the national level, with cities playing a major role in implementing and enforcing codes within their jurisdictions. Ultimately, cities can set targets for increasing the rate of construction of buildings that outperform the national code and develop more stringent local code requirements. However, in Uganda, the national code is yet to be developed as described in Section 5.2.11 Develop Energy Efficiency Performance Code for Buildings.

Best Practices/Resources:

100 Resilient Cities program: A large number of cities committed to the 100 Resilient Cities goal of climate resiliency in which energy efficiency plays an important part. The 100 Resilient Cities program includes Enugu and Lagos, Nigeria and Kigali, Rwanda, which are working to address chronic energy shortages through improved development. In Enugu, the city is committed to improving the reliability of power to keep manufacturing in the city and to reduce stress on the power system by reducing the energy demand of new buildings.

Tool: WB's ESMAP[34] provides case studies and access to the decision-support Tool for Rapid Assessment of City Energy, which can be used to identify and prioritize actions.

Sustainable Energy for All: A recent guidebook for city leaders provides a comprehensive list of actions that can transform energy use and accelerate energy efficiency in their communities. Eight actions are described in detail with numerous case studies to illustrate each action in practice. The guidebook shows that for every $1 invested in building efficiency, $2 is saved in new electricity generation and distribution costs (WRI, 2016).

C40: A *Global Survey of Building Energy Efficiency Policies* in Cities[35] is a resource for city officials to assist in designing new policies for building energy efficiency or reviewing existing policies. This survey aims to capture the range of policies being implemented in cities worldwide and is an initial attempt to reduce the evidence gap regarding city-level activity in this field. The survey also provides detailed information on the necessary conditions, opportunities, and potential challenges when introducing and implementing efficiency initiatives, and discusses which approaches have been successful in which contexts and why (C40, 2015).

[34] https://esmap.org/Energy_Efficient_Cities
[35] http://www.kankyo.metro.tokyo.jp/en/int/c40/c40_pse_r.html

5.3 ROADMAP

The Roadmap presented here gives MEMD, the government, the private sector, and international development organizations a framework for pursuing Uganda's energy efficiency goals. The program recommendations were prioritized based on the methodology described in Section 5.1.1, including consideration of their cost and interdependency.

Each recommendation was scored using the multi-criteria analysis approach. The ranked list of recommendations was divided into four priority lists, each with four or five recommendations. Each priority list corresponds to a year for initiating implementation. The priority list with the highest-ranked scores corresponds to implementation year 2017, and the subsequent lists of priorities with descending scores correspond to the following years. Table 5-5 shows the ranked recommendations for each year of initial implementation and sector of activity. The summary detailed score for each recommendation is available in Appendix 8.

Table 5-5. Recommendation Priority Lists per Implementation Year and Sector

	2017	2018	2019	2020
CROSS CUTTING	Enact the Energy Efficiency & Conservation Bill Prioritize Energy Efficiency in Integrated Resource Planning Enforce Energy Efficiency Standard & Labeling		Create an Energy Efficiency and Conservation Fund	
INDUSTRY	Develop Regulations for Energy Audits Develop Regulations for Energy Management System	Set Industry Targets Encourage SME Energy Efficiency	Develop Training and Accreditation Scheme Recognize Champions of Energy Efficiency	Clean Industry Development
RESIDENTIAL		Expand Standards and Labeling Program Encourage Market for Energy Access		
BUILDINGS			Develop Buildings Energy Efficiency Code	Develop Building Disclosure and Benchmarking Cities and Municipal Councils Energy Efficiency Action Plans Government Lead by Example

The energy efficiency program recommendations with the highest scores are programs that are included in the draft Energy Efficiency and Conservation Bill. This is not surprising because these programs target sectors with the highest potential (large industrial and on-grid residential sectors) and have relatively low implementation costs. Most importantly, these programs also create the basis for further initiatives by establishing the regulatory frameworks, data systems, and stakeholder relationships needed to carry out successful energy efficiency programs.

To provide a sectoral perspective, the program recommendations are organized according to the main sector of activities in Figure 5-1.

Figure 5-1. Energy Efficiency Roadmap for Uganda

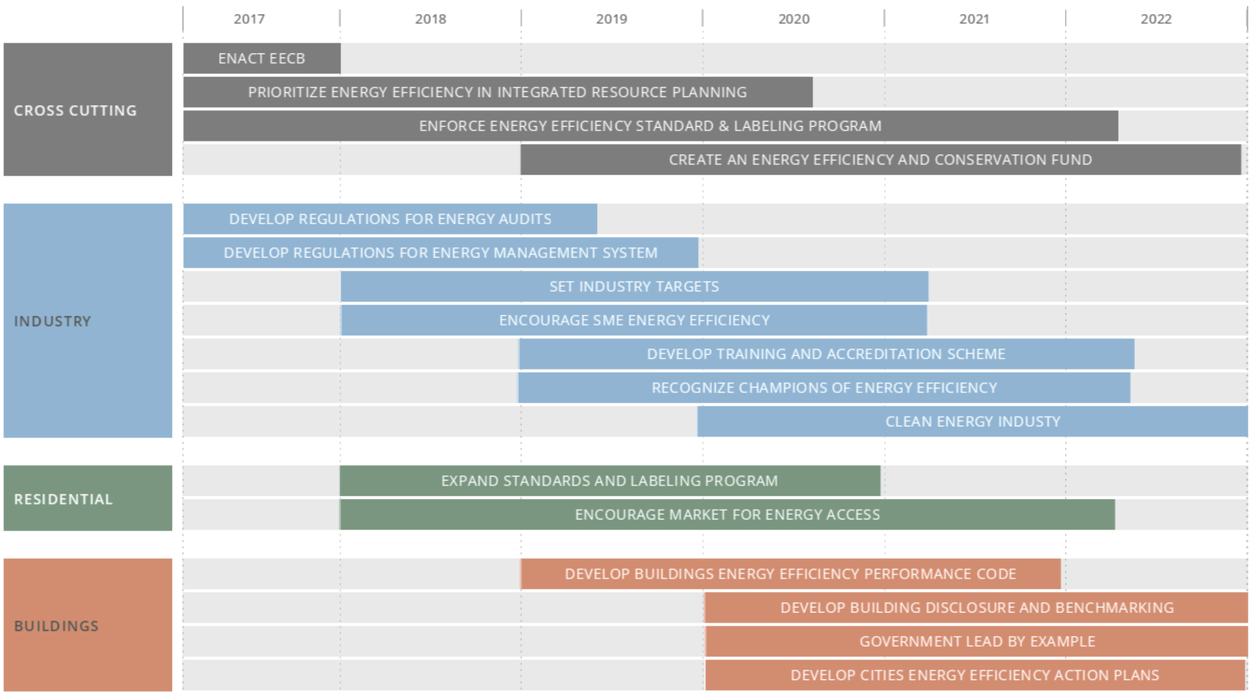


Figure 5-2, Figure 5-3, Figure 5-4, and Figure 5-5 show the timing for actions needed by sector. These schedules are based on the experience and benefits described in the subsections earlier in the report that correspond to each action but will ultimately need to be adjusted to fit the Government of Uganda's priorities and resources as they develop.

5.3.1 CROSS-CUTTING RECOMMENDATIONS

Several program recommendations affect all sectors of the economy. This is the case for the enactment of the Energy Efficiency and Conservation Bill; the current S&L program, which covers lighting, air conditioners, refrigerators, freezers, and motors; the creation of an energy efficiency fund; and the national goal to prioritize energy efficiency as a resource.

Cross-cutting programs constitute the foundational elements for the development of a variety of energy efficiency programs. They build the basis necessary to overcome barriers to energy efficiency investment and to support the development of energy efficiency technologies and practices. Figure 5-2 provides the cross-cutting energy efficiency program recommendations and corresponding actionable steps to start implementation.

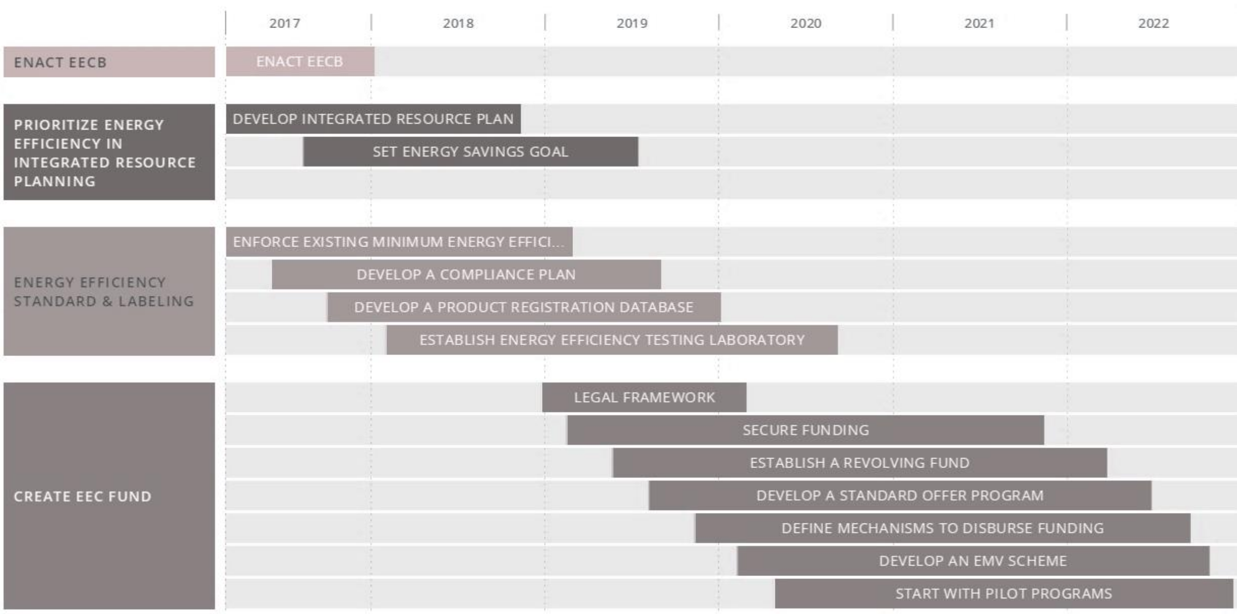
The enactment of the Energy Efficiency and Conservation Bill represents the highest priority because it provides the statutory basis for promulgation of rules and regulations to promote energy efficiency in Uganda.

Likewise, the prioritization of energy efficiency in integrated resource planning will create a fundamental framework to recognize energy efficiency as a resource of choice to meet electricity demand for the benefit of Ugandan households and businesses.

The enforcement of S&L is also a high priority because the current S&L program is at an advanced stage of development but lacks the enforcement requirements to make it impactful. Moreover, S&L is an essential tool for further energy efficiency program developments such as consumer awareness and incentive programs.

Finally, the Energy Efficiency and Conservation Fund appears last in the cross-cutting measures framework, because, despite its importance to support energy efficiency incentives and investments, it is a measure that requires time to develop and represents significant implementation cost to government. The main goal of public funding is to trigger and leverage private capital investments in energy efficiency. The dedication of public resources to an energy efficiency fund also demonstrates the national commitment to energy efficiency as a high-priority resource for meeting Uganda's energy demand.

Figure 5-2. Cross-Cutting Energy Efficiency Actions Roadmap



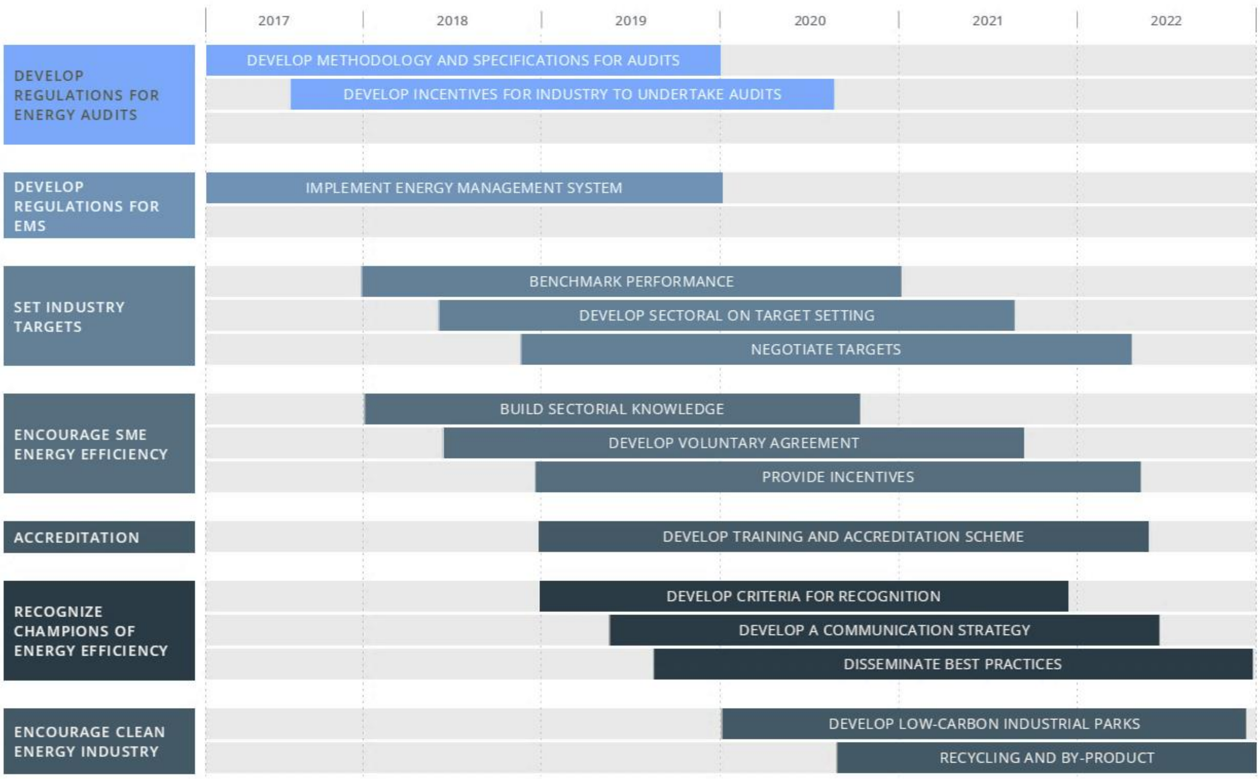
5.3.2 PRIORITY ACTIONS IN THE INDUSTRIAL SECTOR

Industrial energy efficiency is a priority because of the enormous potential for energy savings and the high concentration of actors in this sector. Indeed, 77% of the sector's electricity is consumed by only about 30 large industrial customers. Targeting a relatively smaller number of industries makes tracking progress and assessing impacts more doable. Moreover, the highest-priority programs recommended have proven to be effective in many countries and are relatively low-cost to implement. The highest-priority programs are the establishment of legal requirements for large industries to conduct energy audits and to implement EMSs.

The next priority program complements audits and EMSs, requiring industries to go a step beyond and set energy efficiency targets. Targets create high-level accountability, establish a basis for monitoring results, and send long-term signals to investors. Next come programs targeting SMEs to increase their awareness of and capacity to undertake energy efficiency investments.

Recognition of energy efficiency champions to galvanize industry toward greater collaboration and more aggressive efficiency strategies is the next priority for the industrial sector. Finally, the development of clean energy industries is the last recommendation because it requires advanced levels of stakeholder collaboration and a deep understanding of circular economy energy-savings potential.

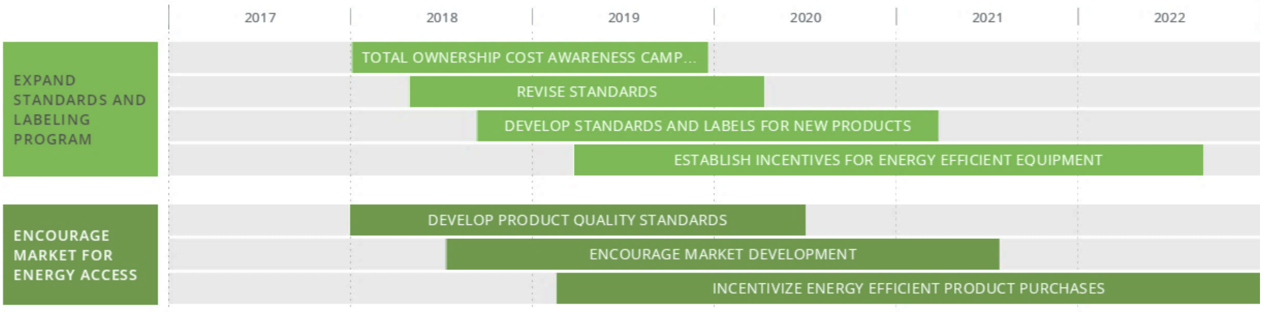
Figure 5-3. Industry Energy Efficiency Actions Roadmap



5.3.3 PRIORITY ACTIONS IN THE RESIDENTIAL SECTOR

Energy efficiency has an important role to play in increasing the energy access of Ugandan households. By increasing the energy services a consumer can obtain from 1 kWh, energy efficiency contributes to providing reliable energy access at the lowest possible cost. Residential efficiency programs will be largely centered on uptake of efficient products enabled through the S&L program. Additional residential products should be considered for inclusion in the program, and standards for the products already covered should be revised to reflect market changes and provide the most accurate information to customers. Uganda also has an opportunity to promote energy efficiency in its off-grid communities, enhancing the off-grid sector at large. The well-documented benefits of energy efficiency for off-grid users can be achieved through accelerating the growth of Uganda's nascent off-grid appliance market, often in partnership with off-grid household solar and mini-/micro-grid companies.

Figure 5-4. Residential Energy Efficiency Actions Roadmap



5.3.4 PRIORITY ACTIONS IN THE BUILDINGS SECTOR

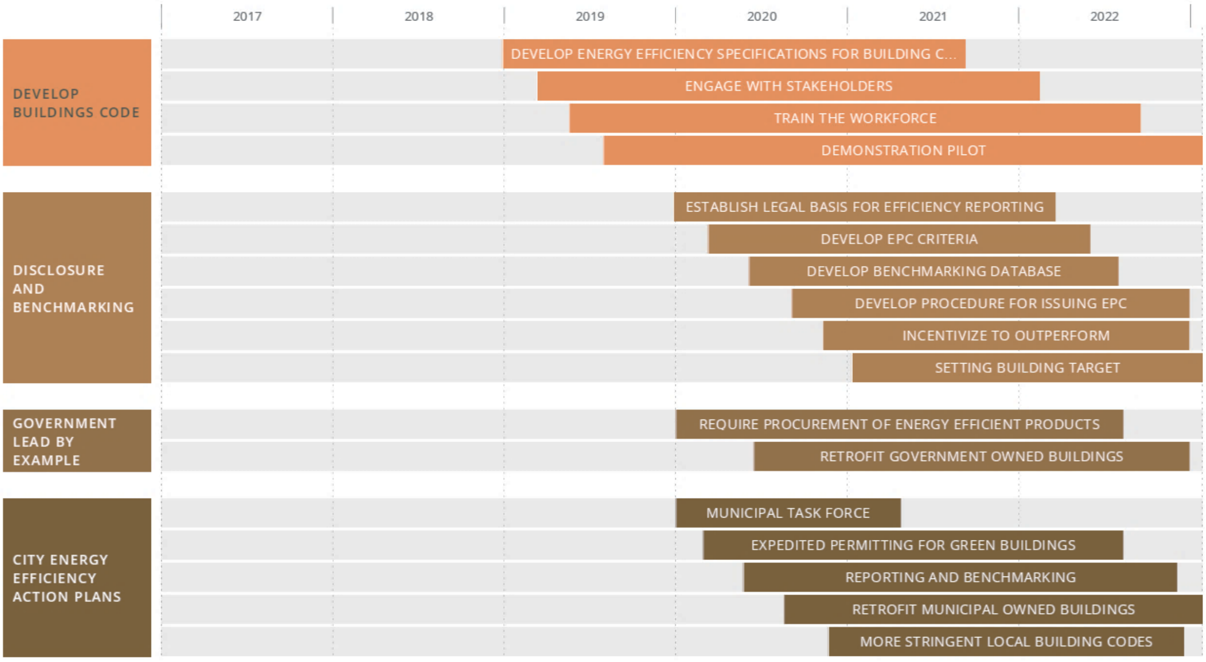
Uganda is experiencing economic growth and rapid urbanization, which are driving a steady increase in building construction and energy demand. The long lives of buildings create a strong impetus for improving building efficiency; improving building energy codes now will reap benefits for the next 50 years or more. Implementation of building codes helps prevent costly energy waste, over the life cycles of buildings, in air conditioning, lighting, and other energy service requirements. Seen in this light, building energy codes are the priority first step.

Building disclosure and benchmarking programs are also important tools to advance building efficiency using tools and approaches such as certification, incentives, and target setting.

Government facilities and services are often a country's largest energy users and major purchasers of energy-using equipment. Government "lead by example" programs are the next priority programs because they can play an important role in shifting the market toward energy efficiency, complementing other elements of a national energy efficiency strategy.

Finally, municipal leadership is a priority program because of the great impact that city policy can have on a city's building stock.

Figure 5-5. Buildings Energy Efficiency Actions Roadmap



6. SUMMARY AND CONCLUSIONS

This Energy Efficiency Roadmap lays out realistic, achievable energy-savings options that can help meet Uganda's growing electricity demand at a low cost, with no pollution, and that can ensure that all Ugandans receive maximum energy services from each kWh supplied.

Despite the strong business case for energy efficiency, a significant share of the potential to improve efficiency remains untapped in the country, and the level of investment in energy efficiency is generally low.

The analysis of potentials presented in this Roadmap indicates a significant opportunity for energy efficiency to moderate growing levels of electricity consumption and demand in Uganda. The technical potential for 2030 suggests that 2,224 GWh of meter-level consumption can be saved across all sectors, which is equivalent to 31% of the forecasted load. The potential for savings is spread across all sectors, with the largest opportunities in the industrial (948 GWh), commercial (491 GWh), and on-grid urban residential (568 GWh) sectors. In addition to providing consumption-savings benefits, energy efficiency improvements translate into significant peak-demand reductions. Approximately 341 MW of forecasted on-grid meter-level peak demand (and an additional 15 MW of off-grid demand) in 2030 can be saved through energy efficiency improvements. Assuming the current T&D loss rate of 22.8%, these savings equate to nearly 2.5 times the demand that will be supplied by the Isimba dam (183 MW), which is currently under construction. With demand projections showing no signs of declining in the short term, energy efficiency offers an opportunity to maximize the value from each power generation facility and minimize the environmental impact and cost of supplying electricity. In total, an estimated 10.6M tonnes of CO_2 emissions can be avoided through the implementation of energy efficiency, which is equivalent to the emissions of approximately 62 thousand vehicles in Uganda.

The technical potential presented in this document removes all economic constraints, but even under stringent cost-effectiveness requirements, the achievable economic potential analysis indicates that 47% of the technical potential is economically feasible (1,052 GWh, Medium Case). This provides a strong argument for the cost-effectiveness of energy efficiency improvements in Uganda, highlighting that energy efficiency can be both an environmentally and economically wise decision for end-users. A breakdown of the different types of opportunities for each sector reveals highly cost-effective options across a multitude of sectors and end-uses. The most competitive and impactful opportunities include measures such as on-grid residential lighting, commercial water heating, and industrial motor improvements. Of all opportunities examined, the implementation of energy audits and EMSs in the industrial sector offers the largest potential savings. This strongly supports the priority that these actions have been given in the current draft Energy Efficiency and Conservation Bill and suggests that their current scope should eventually be expanded to include more than just the top consumers.

One important step in scaling up energy efficiency investments in Uganda is to create and increase demand through long-term enabling policies and financial incentives combined with development of technical expertise in the labor force and promotion of new business models, such as ESCOs. A combination of enabling policies, financial schemes, regulations, enforcement, and skill development are needed to open the energy efficiency market.

This Roadmap recommends a variety of policies and programs that promote investments in energy efficiency. Recommendations include priority actions that can be implemented right away, actions that are highly recommended and can be implemented in the short term with additional support, and actions that require time and discussion to be adapted to local conditions but that have significant long-term energy-saving potential and will allow for a sustained contribution of energy efficiency to future energy development.

A comprehensive policy package covering the buildings blocks introduced in this Energy Efficiency Roadmap has proven critical for successful promotion of energy efficiency in many countries. In a number of developing countries, for example, governments have introduced legal and regulatory frameworks but failed to enforce them because of a lack of information, education strategy, and/or financial support or incentive mechanisms. Addressing these elements in an integrated, balanced and well-sequenced manner is one key to achieving energy efficiency and ensuring its sustainability.

This Roadmap should be used to track progress on each action in the short, medium, and long term in Uganda.

MEMD has a key role to play in leading the implementation of energy efficiency action plans for Uganda. Leadership is essential to motivate actions and communicate vision and purpose, as well as to set goals and monitor progress, to focus efforts, and to optimize resources. MEMD can oversee the implementation of the Energy Efficiency Roadmap by collecting data and information to demonstrate progress and ensuring effective implementation and rigorous compliance. Setting targets and monitoring progress are important elements of success in achieving the many benefits of energy efficiency.

MEMD also can lead others to consensus by reaffirming to all actors the critical role that improved energy efficiency can play in addressing energy reliability and energy access and achieving Uganda's environmental and economic objectives. International development organizations have an important role to play in supporting MEMD in its efforts, sharing their experience in successfully raising the level of energy efficiency in their economies and committing to energy efficiency as a resource for energy access and an opportunity for economic development in Uganda.

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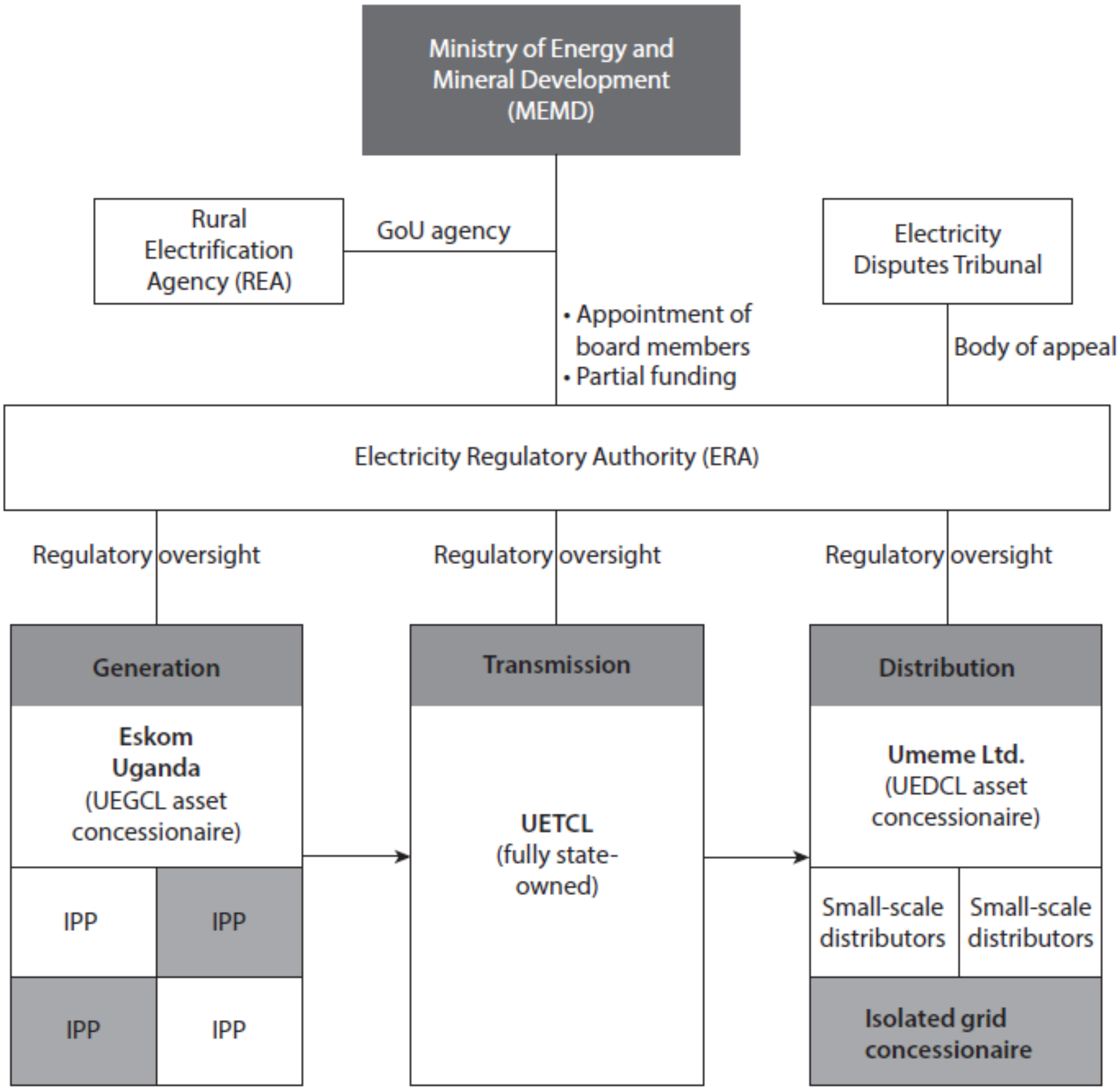
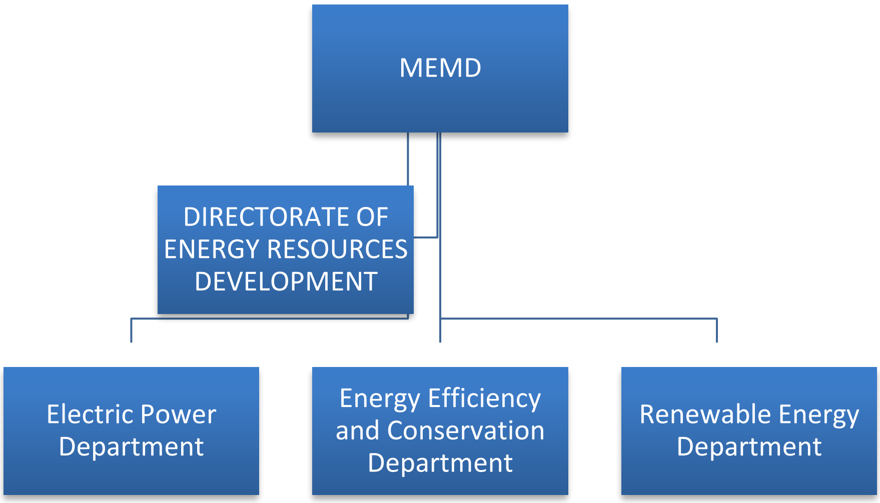
8. APPENDICES

Appendix 1. Structure of Uganda's Power Sector



Source: World Bank. 2016.

Appendix 2. Ministry of Energy and Mineral Development Organigram



Appendix 3. Installed Capacities for Electricity Generation Companies in Uganda

GENERATOR	OPERATOR	TECHNOLOGY	INSTALLED CAPACITY
Large Hydros			
Bujagali Hydro Power Plant (HPP)	Bujagali Electricity Company Limited (BEL)	Hydro	250.0
Nalubaale and Kiira (HPPs)	Eskom (U) Limited	Hydro	380.0
Mini-Hydros			
Mpanga	Africa Energy Management System, Mpanga	Hydro	18.0
Bugoye(Mobuku II)	Bugoye Hydro Limited*****	Hydro	13.0
Kabalega (Buseruka)	Hydromax Limited	Hydro	9.0
Ishasha	Eco-Power Limited	Hydro	6.6
Mobuku 1	Tibet Hima Mining Co Ltd****	Hydro	5.0
Mobuku III	Kasese Cobalt Company Limited	Hydro	9.9
Nyagak**	West-Nile Rural Electricity Company	Hydro	3.5
Thermals			
Namanve***	Jacobsen (U) Limited	Thermal	50.0
Tororo***	Electro-Maxx (U) Limited	Thermal	86.0
Co-generation/ Bagasse			
Kakira	Kakira Sugar Limited	Co-generation	50.0
Kinyara	Kinyara Sugar Works Limited	Co-generation	14.5

Source: ERA, 2015b

Notes:

** - Off-grid generation

*** - Plants retained but at a minimum dispatch of 7 MW

**** - Formerly Kilembe Mines Limited

***** - Formerly Tronder Power Limited

Appendix 4. Uganda's 2015 Load Profile

Customer category		Domestic	Commercial	Small Industrial	Large Industrial	Street Lighting
		Code 10.1	Code 10.2	Code 20	Code 30	Code 50
2015	Peak	36.0%	25.0%	24.0%	23.7%	60.0%
	Shoulder	44.0%	55.7%	58.4%	52.4%	0.0%
	Off-peak	20.0%	19.3%	17.6%	23.9%	40.0%

Source: ERA. 2015a

Appendix 5. Residential Sector Baseline Consumption and Demand Assumptions

Assumption	Value	Based on Information From
Number of New On-Grid Connections, 2016-2030, millions (Households)	2.547	(SEforALL, 2015)
Percent of New Connections that are Urban (%)	53%	(SEforALL, 2015)
2016 New On-Grid Connections (Households)	101,352	(ERA, 2015a)
2015 Urban On-Grid Connections (Households)	769,756	(SEforALL, 2015)
2015 Rural On-Grid Connections (Households)	366,190	(SEforALL, 2015)
Average Annual Consumption per On-Grid Rural Home, 2011, uncalibrated (kWh)	368	(Parsons Brinckerhoff, 2011)
Average Annual Consumption per On-Grid Urban Home, 2011, uncalibrated (kWh)	1,060	(Parsons Brinckerhoff, 2011)
Total Annual Domestic Consumption 2015 (GWh)	591	(ERA, 2015a)
Urban On-Grid Conversion Factor, MW to GWh	5.69	(Parsons Brinckerhoff, 2011)
Rural On-Grid Conversion Factor, MW to GWh	4.38	(Parsons Brinckerhoff, 2011)
On-Grid Electrification Rate Rural Households, 2014	7%	(SEforALL, 2015)
Total Electrification Rate Rural Households, 2014	19.90%	(SEforALL, 2015)
Rural Households, 2015	6,498,097	(SEforALL, 2015)
Annual Growth Rate of Rural Off-Grid Connections (2017-2030)	6%	(Global Leap, 2016)
Ratio of On-Grid Rural Consumption to Off-Grid Rural Consumption	2.4	(Peters & Sievert, 2014)
Rural Off-Grid Conversion Factor, MW to GWh	4.38	(Parsons Brinckerhoff, 2011)

Appendix 6. Results for Achievable Economic Potential, Low and High Cases

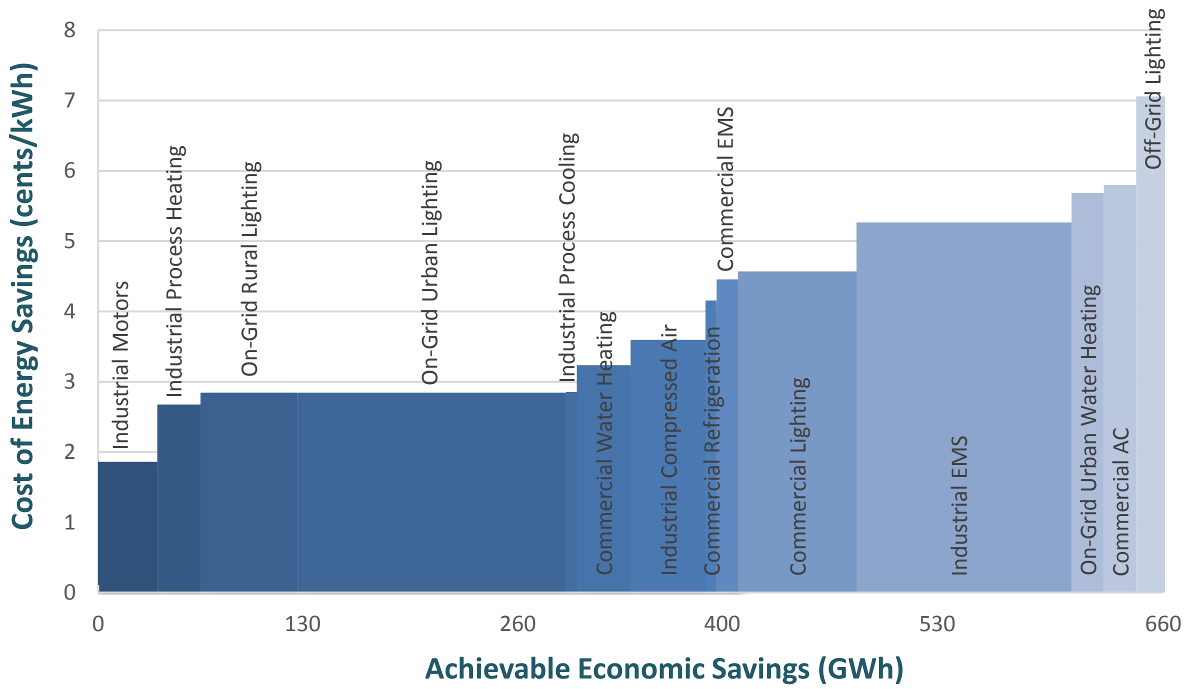
To examine the impact of the uncertainty of the savings estimates, the achievable potential is presented for two additional sets of savings assumptions: low and high. The details of the assumptions for each case can be reviewed in Table 4-8 through Table 4-10 of the main body of this report.

Figure A6-1 below shows the top opportunities for the low scenarios of the achievable economic potential. In comparison to the medium-case results, the low-scenario results show a smaller but more cost-effective opportunity for the industrial motor measure category. This is a result of the inclusion of only two of the five original measures examined for this category of measure. As Table A6-1 shows, these two measures are the two focused on proper design and operations and maintenance (O&M): properly sizing drives and conducting preventative maintenance.

Another significant change is that, for the first time, a lighting category of measures shows the highest savings potential, with the estimated savings from on-grid urban lighting (170 GWh) eclipsing the savings for industrial EMSs (133 GWh). This is a result of the exclusion of some of the EMS specific measures from the overall EMS measure category because these individual measures have a BCR of only 1.5. Although it is common for EMSs to have very quick payback periods with the short measure lifetime assumed (3 years), the lower savings estimate, and a discount rate of 20%, some measures cannot achieve a BCR greater than two.

Figure A6-1. Top Opportunities for Achievable Economic Potential, Low Case

Prioritized by End-User Cost of Conserved Energy



In the low case, the importance of savings from residential and commercial lighting is highlighted because the industrial sector savings potential is much less than in the medium-scenario results. Nearly half (324 GWh) of the potential to reduce consumption in the low case is a result of efficient lighting measures; only industrial lighting is excluded for being below the end-user BCR threshold because the industrial tariff is relatively low in comparison to the tariffs for the other sectors. It should be noted that the projected savings do not exclude the savings that will result from the ongoing ERA LED distribution DSM program. If that program is successful (ERA, 2016), a total of 59 GWh will be saved. Therefore, 265 GWh of savings from efficient lighting remain that are not encompassed by a current energy efficiency plan.

Lighting savings account for nearly half of the low case achievable potential, but the results for the high case (Figure A6-2 and Table A6-3) show a decrease in the influence of this end-use. In total, lighting measures account for approximately a little less than one-third (30%) of the high scenario potential. This decrease is largely a result of the increased influence of the industrial sector as a whole, as discussed previously in this section. As is observed in the medium case, industrial EMS is the most influential measure category for the high case. However, in this instance the next-most-influential measure category (on-grid urban lighting) has less than half of the potential of the industrial EMS measure category (475 GWh). This potential encompasses nearly one-third of the total high-case consumption savings (1,487 GWh). This result once again underscores the importance of implementing EMSs for large industrial customers, as outlined in the current draft Energy Efficiency and Conservation Bill.

Figure A6-2. Top Opportunities for Achievable Economic Potential, High Case

Prioritized by End-User Cost of Conserved Energy

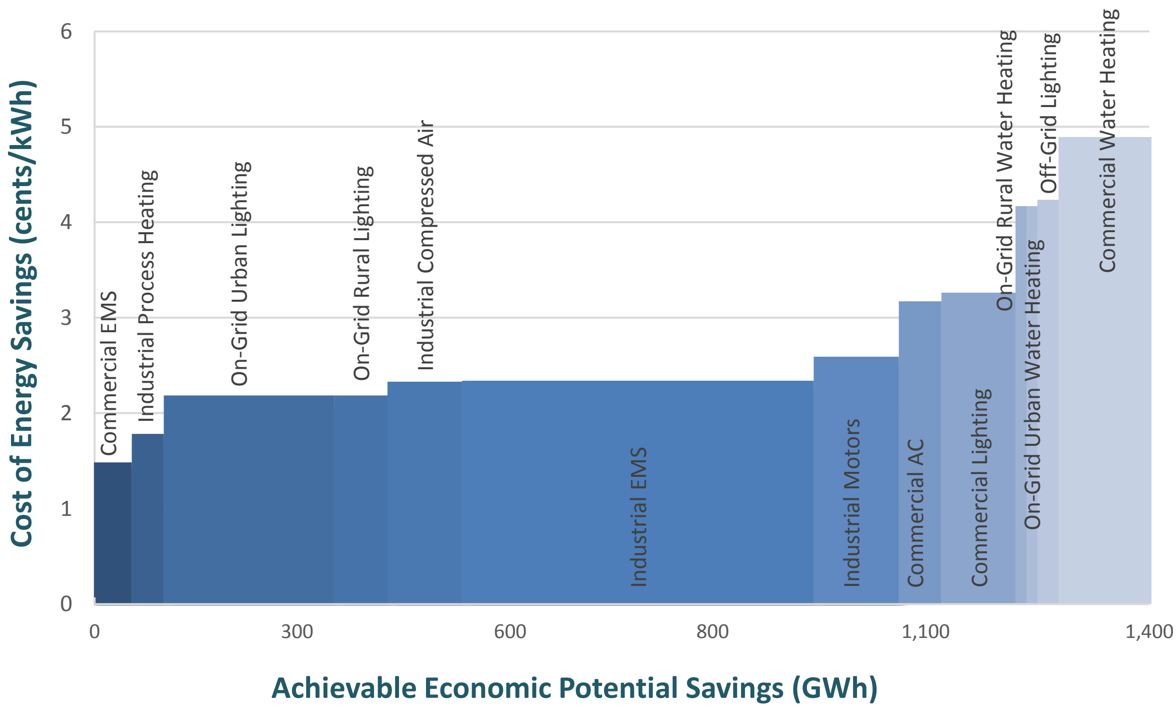


Table A6-1. Measure-Level Results for Achievable Economic Potential, Low Case

Prioritized by Customer Benefit-to-Cost Ratio

Program	Sector	Measure	Consumption Savings (GWh)	Demand Savings (MW)	CCE (US cents/ kWh)	End-user BCR
Industrial motors	I	Properly sized motors and drives	15	2	1	14.1
Commercial water heating	C	Low-flow faucet aerator	15	4	2	8.0
Industrial compressed air	I	Reduce compressed air tank pressure	5	1	1	7.8
On-grid urban lighting	R	On-grid urban LED lighting	170	45	3	6.3
On-grid rural lighting	R	On-grid rural LED lighting	60	19	3	6.3
Industrial compressed air	I	Reduce compressed air leaks	14	2	2	4.6
Industrial process cooling	I	Preventative refrigeration/cooling system maintenance	5	1	2	4.5
Industrial process heating	I	Preventative furnace/boiler maintenance	12	2	2	4.5
Off-grid lighting	R	Off-grid LED lighting	21	5	14	4.4
Industrial motors	I	Preventative maintenance for motors/drives	21	3	3	4.2
Industrial process heating	I	Advanced heating and process control	13	2	3	3.8
Commercial refrigeration	C	High-efficiency reach-in cooler	3	1	4	3.4
On-grid urban water heating	R	On-grid urban heat pump hot water heater	15	2	6	3.2
On-grid rural water heating	R	On-grid rural heat pump hot water heater	2	0	6	3.2
Commercial water heating	C	Heat pump water heater	18	4	4	3.1
Commercial EMS	C	Energy management system	15	2	4	3.1
Commercial lighting	C	LED drop-in lighting	72	11	5	3.1
Industrial process cooling	I	Optimized chilled water temperature	2	0	4	3.0
Commercial AC	C	Efficient packaged air conditioner	25	2	6	2.4
Industrial compressed air	I	Using variable-speed drive on air compressors	25	3	5	2.3
Industrial EMS	I	Energy management system, ISO 50001	133	17	5	2.1

Table A6-2. Measure-Level Results for Achievable Economic Potential, Medium Case

Prioritized by Customer Benefit-to-Cost Ratio

Measure Category	Sector	Measure	Consumption Savings (GWh)	Demand Savings (MW)	CCE (US cents/ kWh)	End-user BCR
Industrial motors	I	Properly sized motors and drives	22	3	1	21.1
Industrial compressed air	I	Reduce compressed air tank pressure	7	1	1	11.0
Commercial water heating	C	Low-flow faucet aerator	18	4	1	9.7
On-grid urban lighting	R	On-grid urban LED lighting	197	52	2	7.3
On-grid rural lighting	R	On-grid rural LED lighting	70	23	2	7.3
Off-grid lighting	R	Off-grid LED lighting	31	8	6	6.6
Commercial EMS	C	Energy management system	30	5	2	6.3
Industrial compressed air	I	Reduce compressed air leaks	19	2	2	6.1
Industrial motors	I	Preventative maintenance for motors/drives	28	4	2	5.6
Industrial process cooling	I	Preventative refrigeration/cooling system maintenance	6	1	2	5.6
Industrial process heating	I	Preventative furnace/boiler maintenance	15	2	2	5.6
Industrial process heating	I	Advanced heating and process control	16	2	2	4.8
Commercial refrigeration	C	High-efficiency reach-in cooler	5	1	3	4.7
Commercial lighting	C	LED drop-in lighting	95	15	3	4.0
Industrial process cooling	I	Optimized chilled water temperature	3	0	3	3.7
On-grid urban water heating	R	On-grid urban heat pump hot water heater	18	2	5	3.6
On-grid rural water heating	R	On-grid rural heat pump hot water heater	2	0	5	3.6
Commercial water heating	C	Heat pump water heater	21	5	4	3.6
Commercial AC	C	Efficient packaged air conditioner	34	3	4	3.4
Industrial EMS	I	Energy management system, ISO50001	190	24	4	3.0
Industrial compressed air	I	Using variable-speed drive on air compressors	32	4	4	2.9
Industrial compressed air	I	Demand-controlled compressed air	14	2	4	2.6
Industrial EMS	I	Energy monitoring system, ISO50006	95	12	4	2.5
Off-grid fan	R	Off-grid efficient fan	9	2	21	2.5
Commercial AC	C	Variable-speed drive on chiller system	6	0	6	2.2
Industrial motors	I	High-efficiency large motors	42	5	5	2.0
Industrial lighting	I	LED drop-in lighting	27	3	5	2.0

Table A6-3. Measure-Level Results for Achievable Economic Potential, High Case

Prioritized by Customer Benefit-to-Cost Ratio

Program	Sector	Measure	Consumption Savings (GWh)	Demand Savings (MW)	CCE (US cents/ kWh)	End-user BCR
Industrial motors	I	Properly sized motors and drives	30	4	0	28.1
Industrial compressed air	I	Reduce compressed air tank pressure	9	1	1	14.1
Commercial water heating	C	Low flow faucet aerator	20	5	1	10.7
Commercial EMS	C	Energy management system	44	7	1	9.4
Industrial compressed air	I	Reduce compressed air leaks	29	4	1	9.2
On-grid urban lighting	R	On-grid urban LED lighting	221	59	2	8.2
On-grid rural lighting	R	On-grid rural LED lighting	78	25	2	8.2
Off-grid lighting	R	Off-grid LED lighting	35	9	7	7.4
Industrial motors	I	Preventative maintenance for motors/drives	35	4	1.6	7.0
Commercial refrigeration	C	High-efficiency reach-in cooler	7	1	2	6.7
Industrial process cooling	I	Preventative refrigeration/cooling system maintenance	7	1	2	6.7
Industrial process heating	I	Preventative furnace/boiler maintenance	18	2	2	6.7
Industrial process cooling	I	Optimized chilled water temperature	4	1	2	5.9
Industrial process heating	I	Advanced heating and process control	19	2	2	5.7
Industrial EMS	I	Energy monitoring system, ISO 50006	190	24	2.2	5.1
Commercial AC	C	Efficient packaged air conditioner	49	4	3	4.8
Industrial EMS	I	Energy management system, ISO 50001	285	36	2	4.5
On-grid urban water heating	R	On-grid urban heat pump hot water heater	21	2	4	4.3
On-grid rural water heating	R	On-grid rural heat pump hot water heater	3	0	4	4.3
Commercial lighting	C	LED drop-in lighting	101	16	3	4.3
Commercial water heating	C	Heat pump water heater	25	6	3	4.3
Industrial compressed air	I	Using variable-speed drive on air compressors	38	5	3	3.5
Industrial compressed air	I	Demand controlled compressed air	19	2	3	3.5
Off-grid fan	R	Off-grid efficient fan	12	2	3	3.0
Commercial AC	C	Variable speed drive on chiller system	7	1	5	2.8
Off-grid fridge	R	Off-grid high-efficiency fridge	11	1	2	2.4
Industrial motors	I	High-efficiency large motors	49	6	5	2.4
Commercial water heating	C	Solar water heater	90	21	6	2.3
Industrial lighting	I	LED lighting drop-in	29	4	5	2.2

Appendix 7. Standard Actions Description

The energy efficiency initiatives described in this Roadmap represent a diverse set of measures affecting the industrial, commercial, public, and consumer sectors. A number of common, standard activities will support these efforts. Not all of the steps are essential for every program, but the value of each step should be considered when putting the supporting frameworks for each program in place.

Some of these “standard actions” overlap with the “building blocks” described in this Roadmap. Building blocks are a high-level categorization of policy interventions, and standard actions can be seen as a set of specific processes or activities. For example, “target setting” as a policy measure entails a process of consulting stakeholders, defining indicators, and disseminating information, and “target setting” as a standard action refers to the actual activity of defining targets by incorporating stakeholder input and indicators that obtained through other separate actions. All of these basic steps needed to develop an energy efficiency program entail some administrative costs.

- **Consult/collaborate with stakeholders** – Ultimately, energy efficiency measures can only be adopted by leaders responsible for investment decisions, whether in the private or public sector. Energy efficiency programs led or mandated by the government will be more effective if they respond to needs and constraints of the institutions or sectors they target. Stakeholder consultation is therefore an important component of almost any energy efficiency initiative and provides an opportunity for decision makers, financial institutions, and technical experts to develop proposals that can produce real investment and savings.

  The initiatives described in this Roadmap target the industrial sector, real estate owners/developers, public services, and ordinary consumers, as represented by the list of DCs in the draft Energy Efficiency and Conservation Bill. Industry and consumer associations are excellent resources to approach to efficiently identify and engage broad groupings of stakeholders. These associations will not only facilitate access to key business leaders and consumer advocates, but can also serve as important partners in disseminating information and marketing or in collecting data (which may already be housed within certain associations). Establishing relationships with these associations during early-stage initiatives (e.g., design of financing programs or target setting) will facilitate collaboration on subsequent initiatives.

- **Develop governance/management structure** – Some programs will be able to leverage existing institutional frameworks, but others will require new governance and management structures. This type of activity will be most applicable to new financing initiatives for which oversight is critical but for which there are no existing frameworks. Important to this process is striking a balance between accountability to government and stakeholders on the one hand and independent administration on the other. New, qualified personnel or contracts with third parties might be needed to obtain managers for these programs.

- **Assess existing programs/resources/options** – Resources or examples of best practice exist for all of the programs recommended in this Roadmap. In some cases, international standards, platforms, or certification organizations can be adopted, modified, or otherwise leveraged to facilitate development of a program suited to Uganda. Even where such institutions are not available for a particular type of program, a review of best practices and experiences is recommended.

- **Develop monitoring and verification approach/procedures** – The importance of monitoring and verification of energy efficiency programs and projects cannot be overstated. At the level of an individual energy efficiency investment, these activities are the only ways to determine how much energy a particular project or measure is saving. Monitoring and verification protocols must define specific measurement and calculation methodologies to ensure that savings are accurately quantified. At a program level, such as a building efficiency code or an industrial tax incentive, monitoring and verification are more oriented toward tracking outcomes, like the rate of building compliance or the disbursement of tax breaks. Such high-level program goals must also be put into the context of energy savings, however, so project-specific monitoring and verification results must also feed into program indicators.

  No matter the type of indicator being monitored and verified, a monitoring and verification protocol has a number of essential elements, all geared toward ensuring consistent collection and reporting of data. The protocol should specify what kind of data are being collected, how the data are collected, and by whom. For example, the International Performance Measurement and Verification Protocol (IPMVP) prescribes a methodology for determining savings from a lighting retrofit by requiring that a statistically significant number of lighting fixtures be measured for power draw before and after the retrofit. Similarly, specific rules will need to be adopted for building inspectors, energy auditors, and energy services contractors to ensure compliance with regulatory and incentives programs.

- **Collect data** – Data inform a number of the key components of energy efficiency programs, including development of program targets. Data are used to baseline energy usage, track project savings, and quantify program results. Data collection is therefore an important process that needs to be repeated throughout the life of an energy efficiency program. Key to reporting and target tracking is to formalize the methods and sources of data collection through a monitoring and verification approach, which must be developed in consultation with stakeholders. Data collection may require specialist expertise and is often accomplished through surveys or by tapping into existing databases.

- **Develop reporting regime** – Program stakeholders and funders, including the public, will want to know about program success and results. A reporting regime will specify the timing and distribution of program progress reports. Reporting will often include quantifiable indicators tracked through the program monitoring and verification protocol. Qualitative assessments should also be included, such as discussion of changes in program design or case studies of successful projects. The report's audience will dictate the contents and preparation required. Funders may only need to see periodic results tracked through the monitoring and verification system while public stakeholders should be presented with a qualitative argument for the program's value.

- **Establish indicators** – When determining appropriate tracking indicators, it is essential to consider data availability, program objectives and targets, and monitoring ease. Above all, selected indicators must be relevant to the program: for example, financing programs should track funding disbursement and cost savings, building efficiency programs may track energy and CO_2 impacts as well as the type of buildings taking part. Careful definition of indicators is key to developing a successful monitoring and verification protocol.

- **Establish targets** – Targets are high-level, quantifiable objectives and rallying points for stakeholders. A target is a program goal expressed in terms of a tracking indicator, so it should define a quantifiable result and a deadline for achievement. Stakeholder consultation is an important step in determining an achievable target, and targets that are both realistic and aggressive can spur enthusiasm for (and uptake of) the program.

- **Define objectives/markets** – Program objectives and target sectors or markets are meant to maximize the impact of a given program and should be defined in consultation with stakeholders. The Roadmap lays out a number of potential programs targeting buildings and industry; for these programs to be effective, managers and stakeholders must further refine the focus. For instance, industrial tax incentives could be applied to all of the sectors listed as DCs, but not all would result in a cost-effective use of resources; starting with a target for major consumers like cement or steel may be a more effective approach.

- **Develop eligibility/compliance criteria** – Eligibility or compliance criteria can be seen as narrowing of the scope of a particular program. For example, if the goal were to establish a tax incentive for the cement industry, the process of defining eligibility criteria would address questions like: What savings measures should be covered by the incentive? What are the limits to the size of the incentive? What level of energy intensity or consumption must a facility demonstrate to gain access to the incentive? These questions also apply in the context of a compliance program; the compliance criteria will influence the cost and administrative burden to stakeholders.

- **Develop application/administrative procedure** – Details of program operation are determined by application and administrative procedures. The development of these procedures entails creating application forms, delineating staff responsibilities, and managing databases as well as customer-service capacity and other program administration elements. These procedures will vary depending on the program and level of stakeholder engagement. In some cases, such as a building efficiency code, existing processes and institutions can carry out portions of program administration. Third parties can also be contracted to manage some programs, for example a revolving loan fund.

- **Marketing strategy/campaign** – Marketing builds awareness among a large pool of potential participants, which is important to maximize program effectiveness and encourage sound investments. In many cases, marketing can be carried out through industry associations or public-sector institutions. However, public campaigns to raise and maintain awareness of a program (for S&L, for example) require significant effort and expense. Marketing specialists may be required to build an effective strategy.

- **Training/capacity building** – Understanding and implementing energy efficiency measures often requires acquisition of new skills and changes in energy management and procurement practices. For compliance programs, in particular, both public- and private-sector staff need to be trained in new regulations and methodologies. Training activities can be simple workshops or can entail development of a large-scale curriculum and certification program.

Appendix 8. MCDA Program Recommendation Score

List of EE Recommendations	Energy Savings	First Cost to Government	Speed of Implemen-tation	Prerequisite to other	Multi-Benefits	Average Score	RANK	PRIORITY			
	0.10	0.10	0.10	0.20	0.10			Priority 1	Priority 2	Priority 3	Priority 4
Support and Expand Current Policies and Programs											
Enact Energy Efficiency & Conservation Bill	2	3	3.0	3.0	2.9	**2.8**	1	1			
Create an Energy Efficiency and Conservation Fund	3	1	1.0	2.9	1.9	**1.9**	13			13	
Enforce Energy Efficiency Standard & Labeling	3	2	2.0	3.0	2.4	**2.5**	5	5			
Develop Regulations for Energy Audits	3	3	2.5	2.7	2.3	**2.7**	3	3			
Develop Regulations for Energy Management System	3	3	2.7	2.2	2.3	**2.6**	4	4			
Develop Training and Accreditation Scheme	1	2	2.2	2.4	2.3	**2.0**	10			10	
Additional Policies and Programs						**0.0**					
Expand Standards and Labeling Program	3	2	2.0	2.7	2.4	**2.4**	6		6		
Encourage Market for Energy Access	2	3	2.2	2.3	2.2	**2.4**	8		8		
Recognize Champions of Energy Efficiency	1	3	2.0	1.8	1.6	**1.9**	12			12	
Set Industry Targets	3	3	2.0	2.0	2.0	**2.4**	7		7		
Encourage SME Energy Efficiency	2	2	2.0	1.8	2.3	**2.0**	9		9		
Encourage Clean Industry Development	2	1	1.8	2.1	2.3	**1.8**	14				14
Develop Buildings Energy Efficiency Code	1	3	1.8	2.0	2.0	**2.0**	11			11	
Develop Building Disclosure and Benchmarking	1	3	1.7	1.9	1.6	**1.8**	15				15
Government Lead by Example	2	1	1.0	2.5	2.0	**1.7**	16				16
Cities and Municipal Councils Energy Efficiency Action Plans	2	1	1.0	1.7	2.2	**1.6**	17				17
Prioritize Energy Efficiency in Integrated Resource Planning	3	3	2.5	2.5	2.5	**2.7**	2	2			

As a global platform, Sustainable Energy for All (SEforALL) empowers leaders to broker partnerships and unlock finance to achieve universal access to sustainable energy, as a contribution to a cleaner, just and prosperous world for all. We marshal evidence, benchmark progress, amplify the voices of our partners and tell stories of success and connect stakeholders. Follow SEforALL on Twitter at @SEForALLorg for the latest updates.

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The Ministry of Energy and Mineral Development's mandate is to establish, promote development of, strategically manage, and safeguard the rational and sustainable exploitation and utilization of energy and mineral resources for social and economic development. Key Energy Efficiency and Conservation Department functions are to develop strategies and programs to improve energy efficiency and conservation.

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Power Africa is a U.S. Government-led partnership launched in 2013. Power Africa's goals are to increase electricity access in sub-Saharan Africa by adding more than 30,000 megawatts of generation capacity and 60 million new home and business connections by 2030. For more information on Power Africa activities in Uganda, visit usaid.gov/powerafrica/uganda.

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