Partnership for Growth - Energy Efficiency in Tanzania

Demand Side Management

Final Report

April 2014

This document was prepared for the United States Agency for International Development (USAID) by ICF International under Cooperative Agreement No. AID-OAA-L-11-00003-00.

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Executive Summary

ICF International (ICF) is pleased to submit this report to the United States Agency for International Development (USAID) entitled *Partnership for Growth—Energy Efficiency in Tanzania*, a project under ICF's current Leader with Associates Cooperative Agreement with USAID, *Energy Efficiency for Clean Development Program* (EECDP), No. AID-OAA-L-11-00003-00. This project includes two work streams: (1) Demand Side Management (DSM), and (2) Green Buildings. This report covers activities carried out under the first project work stream, DSM. The objectives for the DSM work stream are to build capacity on DSM among staff at TANESCO, Tanzania's primary utility, and to inform action related to TANESCO's next Power System Master Plan (PSMP).

Seven activities were performed under this work stream: (1) document review, (2) electric meter data analysis, (3) development of customer load profiles, (4) development of a DSM measure database, (5) estimation of technical and economic DSM potential, (6) estimation of achievable DSM potential, and (7) development of DSM implementation plan guidelines.

Under this project ICF identified seven recommended programs, and developed guidelines for each: (1) Residential Refrigerator Recycling and Replacement, (2) Residential Lighting, (3) Energy Solutions for Commercial, (4) Commercial Refrigerated Vending, (5) Commercial Direct Load Control, (6) Energy Solutions for Industrial, and, (7) Industrial Time-of-Use Tariff.

Figure 1 shows the total estimated savings and costs associated with these seven programs in each year of the analysis, and Figure 2 shows the combined cost-effectiveness of the programs. In summary, this analysis shows that DSM programs in Tanzania could cost-effectively reduce system peak demand 11.5 percent after five years; such capacity savings would have significant positive impacts on grid reliability and system costs, amongst other benefits. There are important demand savings opportunities across all customer segments, but the largest MW savings potential is in the industrial sector, where the implementation of a time-of-use rate could save 87 MW after five years. There are also significant energy savings opportunities in all customer segments; in total, 2.1 percent of total TANESCO sales in 2018. These demand and energy savings are robustly cost-effective. Based on our estimates, for every 1 TZS invested by TANESCO in these programs, TANESCO customers will save 2.4 TZS, and total net benefits are over 151 Billion TZS, or $95 Million.

Figure 1 - Total Energy Efficiency Program Portfolio Savings & Costs

Total Portfolio Estimate	2014	2015	2016	2017	2018
Cumulative MWh Savings	18,049	37,904	81,038	108,009	142,067
MWh Savings as % of Forecasted System Annual Load	0.3%	0.7%	1.4%	1.7%	2.1%
Cumulative MW Savings	7	59	86	122	153
MW Savings as % of System Forecasted System Peak Demand	0.8%	5.6%	7.6%	9.9%	11.5%
Annual Program Costs ($Millions, Real 2013)	$ 3.1	$5.7	$15.1	$14.2	$16.7
Annual Program Costs (Millions TZS, Real 2013)	TZS 4,871	TZS 9,030	TZS 24,076	TZS 22,657	TZS 26,584

Figure 2 - Total Energy Efficiency Program Portfolio Cost-Effectiveness

Metric	Estimate
Utility Cost-Test Benefit/Cost Ratio	2.4
Net Utility Benefits ($Millions, Real 2013)	$94.8
Net Utility Benefits (Millions TZS, Real 2013)	TZS 151,012

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1 Introduction

ICF International (ICF) is pleased to submit this report to the United States Agency for International Development (USAID) entitled *Partnership for Growth—Energy Efficiency in Tanzania* a project under ICF's current Leader with Associates (LWA) Cooperative Agreement with USAID, *Energy Efficiency for Clean Development Program* (EECDP), No. AID-OAA-L-11-00003-00. This project includes two work streams: (1) Demand Side Management (DSM) and (2) Green Buildings. This report covers activities carried out under the first project work stream.

1.1 Objectives

There are two objectives for the DSM Work Stream:

1. **Build utility staff capacity on DSM**. Like most utilities, planning and operations at Tanzania Electric Supply Company (TANESCO) have traditionally focused on generation, transmission, and distribution of electricity, not on DSM. During the course of the project, ICF staff provided education and training to TANESCO staff[1] on various aspects of DSM, including building energy analysis, meter data analysis, as well as DSM program planning, management, regulation, administration, and evaluation.
2. **Support Integrated Resource Planning ("IRP").** Historically, DSM has not been included in utility long range planning in Tanzania. Outputs from this study can be used by the electric utilities, the Energy and Water Utilities Regulatory Authority (EWURA), and the Ministry of Energy and Mines (MEM) in their IRP analyses and in future updates to the Power System Master Plan (PSMP) for Tanzania.

1.2 Approach

Seven activities were performed under this project work stream:

- **Activity 1: Document Review.** The objective of this activity was to gain a thorough understanding of the power sector in Tanzania, including TANESCO operations, business and cost structure, customer base, load, and technical challenges, as well as the related political, economic, and historical contexts relevant to DSM. The included tasks established key underlying assumptions and conditions for ICF's DSM potential analysis. Documents reviewed included the PSMP, TANESCO's cost of service study, previously completed DSM analyses in Tanzania, and current and proposed utility sector regulation and policy.
- **Activity 2: Electric Meter Data Analysis.** TANESCO collects interval electric meter data, demand factor, power factor, and other data on approximately 16,000[2] customers with advanced meters installed.

[1] Zanzibar Electric Corporation (ZECO) staff also attended the workshop presentations given on DSM.

[2] TANESCO has installed advanced meters on all T3 (industrial) and T2 (commercial) rate class customers as well as on outgoing feeders. TANESCO is actively installing advanced meters on large T1 rate class customers taking power at 3-phase.

TANESCO's Advanced Metering Infrastructure program was launched when the World Bank, through TEDAP (Tanzania Energy Development and Access Project), funded the initial 1,200 advanced meters. Since then, TANESCO has continued to buy and install additional meters to achieve cost savings on meter reading and to reduce non-technical losses at larger customers. Per TANESCO’s request, ICF conducted detailed analyses on a sample of these customers with the objective of identifying energy efficiency and load management options. For a sample of 16 commercial and industrial customers, ICF combined TANESCO meter data with site audit data to develop hourly (8,760 hour per year) and end-use profiles of each building or facility. These analyses were also used to inform the system-wide analyses in activities 3 and 4.

- **Activity 3: Development of Load Profiles**. Under this activity, ICF developed aggregate end-use load profiles for each customer segment—residential, commercial, and industrial. Understanding how electricity is currently used by each sector is important in crafting DSM program designs. Interval meter data (gathered during Activity 2) was combined with other TANESCO customer data and secondary research to develop the load profiles.
- **Activity 4: DSM Measure Database**. ICF developed a database of DSM measures applicable to the residential, commercial, and industrial customer segments. The database included measures covering each major end use within each sector. For each measure, energy savings and demand savings were estimated either through calibrated building simulations, engineering calculations, or secondary desktop research. Measure costs and lifetime were researched through secondary sources. These measures were used in calculating DSM potential.
- **Activity 5: Technical and Economic Potential.** Taking into consideration the information gained through the conduct of activities 1 through 4, as well as input from TANESCO staff, ICF used its Energy Efficiency Planning Model ("EEPM") to develop estimates of technical and economic potential. We define *technical potential* to be the level of hypothetical savings attainable by DSM programs in the absence of economic and other market barriers. Economic potential is a subset of technical potential; it is the level of savings attainable by DSM programs given economic barriers.
- **Activity 6: Achievable Potential.**[3] Based on information gained during the conduct of activities 1 through 5 ICF identified seven preliminary DSM program options for TANESCO's consideration. These recommendations were refined based upon input by TANESCO staff during in-person DSM workshops in October 2013. The revised program options are presented in this report. Achievable potential – i.e. the level of cost-effective savings which can be realistically achieved by DSM programs, taking into consideration financial barriers, lack of awareness, and other market barriers – was estimated for each program included in this study. Total (system-wide) achievable DSM potential is the sum of achievable potential estimated for each of the seven program options for the 2014-2018 time horizon.
- **Activity 7: Develop DSM Implementation Plan Guidelines.** The final activity within this DSM work stream was to develop DSM program guidelines for each program included in the achievable potential analysis.

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[3] Achievable potential is the level of savings attainable by DSM programs given economic and other market barriers.

These guidelines provide a basic structure for each program option, and include indicative load and cost forecasts. Detailed implementation plans, including more detailed cost and savings forecasts, may be developed by TANESCO.

1.3 TANESCO's Goals for DSM

During an in person DSM workshop in Dar es Salaam, ICF worked with TANESCO to establish a set of goals, or objectives, against which to evaluate DSM program options. These goals include the following:

1. **Energy and Capacity Savings** are evaluated for each program based on the level of estimated achievable MWh and MW potential.
2. **Market Transformation** is evaluated based on how programs influence their relevant market channels over the long run (e.g., the extent to which the program may change retailer stocking practices).
3. **Equity** is evaluated based on how the set of programs designed for each sector would perform in providing DSM options to each customer class within that sector. Equity is also evaluated based upon how the total portfolio (across all sectors) delivers DSM options to each customer class.
4. **Political Feasibility** is evaluated based on how likely TANESCO and government stakeholders are to accept the program. Without buy in from key stakeholders from the beginning, a program is likely to never make it out of the planning stage.

In addition to these goals, ICF developed two additional goals against which TANESCO can evaluate program recommendations:

1. **Cost-effectiveness** is evaluated based on program net benefits and Utility Benefit-Cost Test[4] ("UCT") ratios.
2. **Risk Mitigation** is evaluated based on the risks posed by program start-up activities, and implementation.

1.4 Program Recommendations

Based on the data and information gathered and analyzed under activities 1 through 7, ICF developed guidelines for 7 DSM program recommendations:

1. **Residential Refrigerator Recycling and Replacement**. This program removes old and substandard refrigerators from D1 (*domestic low usage*) and T1 (*general usage*) customer homes, and recycles them at a facility developed for the purposes of this program. Removed units are replaced by efficient refrigerators, free of charge to participating customers.
2. **Residential Lighting**. This is a compact fluorescent light bulb (CFL) "giveaway" program consistent with the initiative set forth in the Tanzanian government's *Big Results Now* policy agenda.

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[4] UCT measures cost-effectiveness from the viewpoint of the sponsoring utility. It compares the avoided supply costs to the cost of the DSM program.

3. **Energy Solutions for Commercial.** This program is designed to help commercial customers in Tanzania overcome market barriers to energy efficiency, including lack of energy efficiency awareness, lack of accessibility to qualified vendors and installers, absence of tools to quantify savings, and limited funds for capital improvements. The program would offer financial incentives and technical assistance to all eligible commercial customers seeking to improve the efficiency of existing facilities, and provide resources for higher-efficiency new equipment purchases and facility upgrades.
4. **Commercial Refrigerated Vending**. This program would work with beverage companies to increase the installation of efficient refrigerated beverage vending machines in commercial buildings and facilities.
5. **Commercial Direct Load Control.** This program would enable TANESCO to cycle off participating commercial customers' air conditioners (ACs) during periods of peak demand.[5] Through the installation by TANESCO (or a contractor) of a remote control switch or other enabling technology on the participant's AC or HVAC system, TANESCO can cycle off ACs for specified lengths of time during designated peak periods through a signal transmitted from cell phone towers.
6. **Energy Solutions for Industrial.** Designed to help industrial customers in Tanzania overcome market barriers to energy efficiency, this program addresses lack of energy efficiency awareness, lack of accessibility to qualified vendors and installers, absence of tools to quantify savings, and limited funds for capital improvements. The program would offer financial incentives and technical assistance to all eligible industrial customers seeking to improve the efficiency of existing facilities, and provide resources for higher-efficiency new equipment purchases, facility modernization, and industrial process improvements.
7. **Industrial Time-of-Use Tariff.** This tariff for T3 (*high voltage*) industrial customers is designed to motivate facility owners and managers to shift electricity use from periods when there is the greatest demand on the grid to periods of lower demand. This is done by setting price signals for the cost of energy that better align with the costs of production at different times of day.

ICF developed these program recommendations based upon data gathered and analyses performed under activities 1 through 4, consideration of TANESCO's stated goals for DSM programs, as well as ICF experience with program design and implementation. In general, these programs are well-understood designs with proven performance in numerous jurisdictions in developed and developing countries. They are adapted here to address market barriers specific to Tanzania.

The program guidelines in Section 4 of this report provide a basic structure for each program and show indicative load and cost impacts. Detailed implementation plans, including more detailed cost and savings forecasts, should be developed by TANESCO; most utilities in other parts of the world have found it most effective to seek support from a qualified DSM implementation contractor selected through a competitive procurement process.

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[5] The air-handler fan remains powered to circulate air and minimize participant discomfort.

Figure 3 below, the Goals/Program Alternatives Matrix, provides a summary of each of ICF's program recommendations relative to each of TANESCO's goals for DSM. The programs in the table are listed by sector (residential, commercial, and industrial).

Figure 3 - Goals/Program Alternatives Matrix

Program	TANESCO's Goals					Additional Considerations		
	Achievable MWh Savings Potential (Cumulative, 2018)	Achievable MW Savings Potential (Cumulative, 2018)	Market Transformation Potential	Equity	Political Feasibility	Program Complexity	Implementation Risk	Net Utility Benefits ($Millions)
Residential Refrigerator Replacement & Recycling	46,498	3	Low. Potential could be increased through complementary efforts to develop and enforce minimum unit efficiency and labeling standards, especially if the program is operated for a longer time horizon (than the 2016-2018 period modeled for this study).	Equitable within the residential sector (both D1 and T1 customers would be eligible participants). Non-equitable in geographic distribution (assuming recycling center is established in Dar Es Salaam for cost reasons).	Medium. The program would offer attractive services free of charge to residential customers, but could be perceived as risky due to program complexity.	High. Program involves three elements requiring significant resources and training prior to launch. In long run, the design is not complex to maintain.	Medium-High. Program design is proven in many jurisdictions. However, the complexities and costs of establishing the recycling facility may be challenging, as may be executing unit removal and recycling protocols.	$15.4

Program	TANESCO's Goals					Additional Considerations		
	Achievable MWh Savings Potential (Cumulative, 2018)	Achievable MW Savings Potential (Cumulative, 2018)	Market Transformation Potential	Equity	Political Feasibility	Program Complexity	Implementation Risk	Net Utility Benefits ($Millions)
Residential Lighting	59,743	25	Low. Potential could be increased through complementary efforts to develop and enforce minimum bulb efficiency and labeling standards, and to offer discounted prices on efficient bulbs at retail locations following the completion of the giveaway program.	Equitable within the residential sector (both D1 and T1 customers will receive bulbs). Non-equitable in geographic distribution (assuming bulb distribution is focused on Dar Es Salaam for cost reasons).	High. Recommended element of *Big Results Now*.	Low. Simple program design that can be implemented with minimal additional resources or personnel training.	Low. Successful model programs elsewhere in Africa.	$37.7
Energy Solutions for Commercial	11,472	6	High - provided that program is maintained over the long run.	Equitable within the commercial sector (all commercial customers would be eligible to participate).	Medium.	Medium. Program involves three elements requiring significant resources and training prior to launch. In long run, the design is not complex to maintain.	Medium. Successful program model in developed and developing countries. However, TANESCO and/or program contractor may be challenged to find and train a sufficient number of qualified contractors to conduct energy audits and implement recommendations.	$4.7

Program	TANESCO's Goals					Additional Considerations		
	Achievable MWh Savings Potential (Cumulative, 2018)	Achievable MW Savings Potential (Cumulative, 2018)	Market Transformation Potential	Equity	Political Feasibility	Program Complexity	Implementation Risk	Net Utility Benefits ($Millions)
Commercial Refrigerated Vending	3,285	1	High. Small number of major vendors can drive market transformation.	Equitable. All commercial customers with refrigerated vending will benefit.	High. Low risk for all stakeholders involved.	Low.	Low. Requires minimal program investment and will be driven by vendors.	$1.4
Commercial Direct Load Control	Not applicable.	25	Not applicable.	Equitable within the commercial sector (all customers would be eligible to participate).	Medium.	Medium-high. Requires considerable investment upfront in equipment, training, and communication protocols.	Medium-high. Possible some customers may remove controlling devices. Also, some risk that AC effective-useful life is too short given climate to make program cost-effective.	$8.2

Program	TANESCO's Goals					Additional Considerations		
	Achievable MWh Savings Potential (Cumulative, 2018)	Achievable MW Savings Potential (Cumulative, 2018)	Market Transformation Potential	Equity	Political Feasibility	Program Complexity	Implementation Risk	Net Utility Benefits ($Millions)
Energy Solutions for Industrial	21,069	6	High - provided that program is maintained over the long run.	Equitable within the industrial sector (both T2 and T3 customers would be eligible participants). However, customers with existing resources to implement efficiency measures would not be targeted by this program.	High. Recommended element of Big Results Now.	High.	Medium. Successful program model in developed and developing countries. However, TANESCO and/or program contractor may be challenged to find and train a sufficient number of qualified contractors to conduct energy audits and implement recommendations.	$8.5
Industrial Time-of-Use Tariff	Not applicable.	87	Not applicable.	Equity within the industrial sector will be determined by the regulatory requirements of the tariff (e.g., whether it is opt-in or opt-out). Overall, the tariff increases system-wide equity by reducing cross-subsidies and outages caused in part by energy charges being misaligned with energy costs.	High. Required by policy. Some industrials may initially object to higher on-peak energy charges.	Low. Start-up could be complex. Ongoing implementation involves low complexity.	Low. Requires minimal infrastructure investment with potentially high system benefits.	$18.9

1.5 Report Overview and Organization

The remainder of this report is organized as follows:

- **Section 2** summarizes baseline (existing) energy use by customer segment and for the TANESCO system.
- **Section 3** outlines the DSM measure selection process and measures included in the analysis.
- **Section 4** includes discussion and estimates of technical, economic, and achievable DSM potential, as well as ICF's program recommendations.
- **Section 5** summarizes ICF's additional recommendations for improving energy efficiency in existing buildings/facilities in Tanzania.
- **Section 6** provides a conclusion to this study, including a summary of activities conducted in this work stream, as well as of ICF's achievable potential estimates and recommendations.

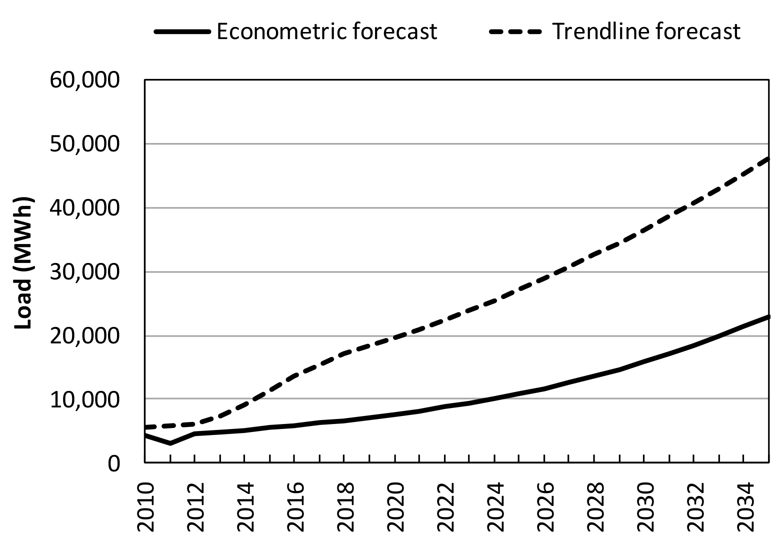
2 Baseline Energy Use

Understanding how energy is currently used within a utility's service territory is the first step to developing estimates of DSM potential. Data and information collected during activities 1 through 3 were used by ICF to estimate baseline energy use in Tanzania. In the subsections below, we summarize baseline energy use starting at the service territory level, by tariff class, and then at the end-use level, by sector.

2.1 Total Electricity Use

In the most recent Power System Management Plan (PSMP), the Ministry of Energy and Minerals (MEM) specifies two different load forecasts: one derived using a trendline forecast, and another derived using econometric analysis. These approaches are described in Section 2 of the PSMP report. Each of the PSMP forecasts is illustrated in Figure 4, below. The econometric forecast can be characterized as an *aggressive scenario*, under which MEM assumed rural electrification plans occur on schedule and the economy grows 7 percent per year over the 25 year forecast.[6] The trendline forecast can be characterized as a *very aggressive scenario*. In this scenario, MEM assumed very high load growth over the mid-term (19 percent per year between 2012 and 2019), dropping to an average of 6 percent annual growth from 2020 to 2035. These forecasts are important to show in the context of DSM because they help demonstrate the possible magnitude, or impacts of the DSM potential estimates.

Figure 4 - TANESCO Load Forecasts



Source: MEM, 2012 PSMP.

6 In the econometric forecast, MEM estimates that the large industrial share of load (T3 customers) will grow from 37% in 2012 to 47% in 2035. The share of load represented by T1 and T2 customers is forecasted to decline slightly; most of the new load in the D1 sector will be due to new connections. The load forecast in TANESCO's most recent corporate business plan is largely consistent with the econometric load forecast shown below.

2.2 Electricity Use by Tariff Class

Figure 5 shows customer counts and load by rate class. Combined, T2 (*low voltage supply*) and T3 (*high voltage supply*) customers constitute less than 0.3 percent of total customers but use over half the electricity. This is important information for DSM program planning purposes because it means that most marketing, education, and other program activities for these sectors can be highly targeted, even site-specific (e.g., through direct outreach by regional managers).

Conversely, the D1 (*domestic low usage*) tariff class constitutes 47 percent of total customers, but uses only 10 percent of total system electricity. Indeed, average household consumption in this rate class is only 70 kWh per month. Since most D1 customers live in informal housing and have incomes placing them below the poverty line, program activities in this sector will need to involve mass marketing and free DSM measures.

Figure 5 - Customers and Sale by Tariff Class (2013)

Tariff Class	Customers in Tariff Class	% Total Cust.	Total Sales (GWh)	% Sales	Average Annual Sales per Customer (kWh)
D1—Domestic Low Usage	613,618	47%	515	10%	839
T1—General Usage	699,287	53%	2,203	43%	3,150
T2—Low Voltage Supply	2,483	0.2%	634	12%	255,336
T3—High Voltage Supply	461	<0.1%	1,804	35%	3,913,232
Total	**1,315,849**		**5,156**		

Source: TANESCO

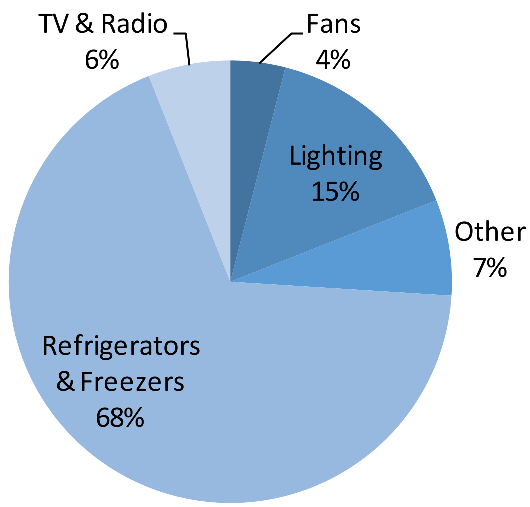
2.3 Electricity Use by End Use by Sector

Residential

Figure 6 and Figure 7 show the distributions of average annual household electricity use for residential customers on D1 and T1 tariffs, respectively. A breakdown of the T1 tariff class by sector (residential and commercial) was not available; therefore, we cannot calculate average consumption for a T1 household. As a proxy, given the information shown in Figure 5 above, we estimate the average consumption of a T1 household is three times that of a D1 household.

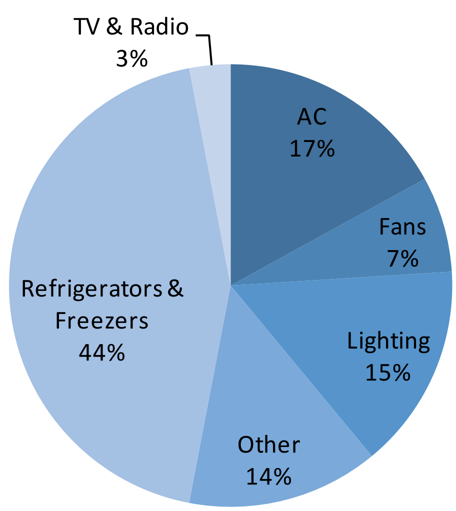
Further, without a detailed residential baseline study, it is difficult to characterize the additional annual load in T1 households. However, based on the information available, it is reasonable to state that T1 households have much higher cooling and lighting loads, and have more electronics and appliances than D1 households.

Figure 6 - Distribution of Average Annual Household kWh Use, D1 Tariff Class



Sources: Hatch, TANESCO.

Figure 7 - Distribution of Average Annual Household kWh Use, T1 Tariff Class

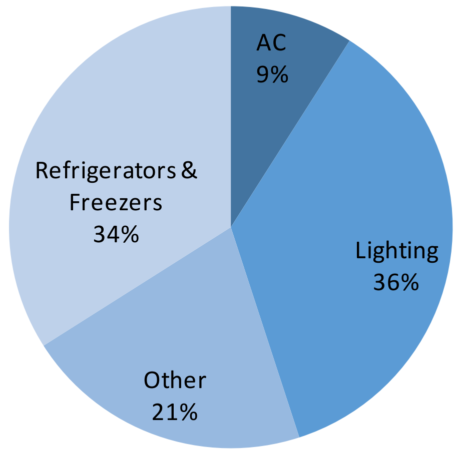


Sources: Hatch, TANESCO.

Commercial

Figure 8 shows the distribution of annual electricity use for an average commercial customer on the T1 tariff. T1 commercial customers can be described as small businesses consuming between 284 kWh and 7,500 kWh annually. A distribution of T1 commercial load by sub-sector was not available at the time of this analysis. A description of T2 commercial load by end use was also not available. However, ICF conducted meter data analysis and site audits of specific T2 facilities, which helped to inform the commercial analysis.

Figure 8 - Distribution of Average Annual Commercial Customer kWh Use, T1 Tariff Class



Sources: Hatch, TANESCO.

Industrial

Summary information on industrial load by subsector was not available at the time of this study; average consumption by end-use for industrial as a whole is not meaningful given the heterogeneity of facilities in this sector. However, based upon information in a previous DSM study on Tanzania,[7] and data collected by ICF on a small sample of industrial facilities,[8] ICF estimates that motors consume between 65 percent and 90 percent of electricity in the industrial sector. ICF also estimates the higher levels of consumption occur in subsectors such as mining and cement production. Other important end-uses were observed to include compressed air, process heating, and process cooling. Facility cooling and lighting were observed to be less important end uses in regard to energy consumption.

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7 Hatch Consulting. Tanzania Electric Supply Company: Consultancy Services on Energy Rationalization & Demand Response in Tanzania. December 10, 2010.

8 Data collected by ICF during industrial facility audits was combined with facility interval meter data to develop end-use load profiles for these specific facilities.

3 DSM Measures

The next step in the analysis was developing a database of DSM measures, including energy efficiency and demand response options, as well as a time-of-use tariff for the industrial sector. Measures were selected for inclusion in the analysis based upon: (1) the document review (Activity 1), (2) the site audit data and baseline characterization (Activity 2), (3) ICF DSM measure databases, and (4) ICF DSM program experience. While the measure database was not exhaustive, a large number of measures were analyzed to make sure each energy end use within each sector was sufficiently represented by commercially-available technologies.

For example, commercial air conditioning measures are represented by efficient split AC Units (units with an IEER rating of 10 or better). Although there are other efficient options available, split units are the dominant cooling technology installed in Tanzania in commercial facilities. Therefore, ICF used split units as the proxy for all cooling in the commercial sector. As additional data is collected by DSM programs or through other studies on commercial cooling, more AC measures, such as efficient chillers and packaged rooftop units, can be included in future forecasts.

Measure types included in the database are shown in tables 9-11 below, by sector. For each measure, ICF developed the type of information shown in the example in Figure 12.

Figure 9 - Residential Measures Analyzed

Tariff Class	End Use	Measure Type
D1	Lighting	CFL
	Refrigeration	Efficient Refrigerator
T1	Cooling	Efficient AC
	Envelope	Air Sealing
	Lighting	CFL
	Refrigeration	Efficient Refrigerator

Figure 10 - Commercial Measures Analyzed

Measure Category	End Use	Measure Type
Energy Efficiency	Cooling	Efficient Split AC
	Envelope	Air Sealing
	Lighting	CFL
		LED Reflector Lamps
		Lighting Occupancy Sensor
		Linear LED Lamps
		T8/T5 Linear Florescent
	Refrigeration	Efficient Refrigerated Case Display
		Efficient Refrigerator
Demand Response	Cooling	AC Direct Load Control

Figure 11 - Industrial Measures Analyzed

Measure Category	Measure Type
Energy Efficiency	Compressed Air Upgrades
	Custom Project
	Lighting Upgrades
	Motor Upgrades
	Process Cooling Upgrades
	Process Heating Upgrades
	Variable Speed Drives
Demand Response	Time-of-Use Rate

Figure 12 - Illustrative Measure Characteristics

Measures Characteristic	Value
Applicable Tariff Class	T2
Applicable Sector	Commercial
Annual Usage Bin[9]	33rd to 66th Percentile
Energy End Use	Cooling
Measure Name	Efficient Split AC
Measure Definition	10 EER
Baseline Definition	6 EER
Measure Unit	Tons Cooling Capacity
Measure Type[10]	Replace-On-Burnout
Measure Lifetime (Years)	5
Annual kWh Savings per Measure Unit	463
Peak kW Savings per Measure Unit	0.3
Incremental Measure Cost per Measure Unit (USD)	$71

Each measure was tested for cost-effectiveness using the Measure Total Resource Cost (TRC) test. Measure TRC benefits include the present value of the lifetime of avoided kWh and kW saved due to installation of the measure. Measure TRC costs include all measure incremental costs,[11] including additional equipment and operations and maintenance costs. Measure TRC results were used in the following manner in the DSM potential analysis:

- **Technical potential**. Measure cost-effectiveness is not considered in the technical potential analysis since technical potential by definition does not account for cost.
- **Economic potential**. Only measures with a TRC result of 1.0 or better were included in the economic potential analysis.
- **Achievable potential**. As a general rule, only measures with a TRC result of 1.0 or better were included in the achievable potential analysis. This helped ensure that - once program delivery costs are added to measure costs - program cost-effectiveness is minimally compromised. Two exceptions were made to this general rule. The first exception was for certain LED lighting measures where recent data shows both improving quality and price reductions, indicating that these measures will soon be cost-effective. The

9 Since commercial energy use could not be disaggregated by building type, ICF binned customers by annual energy use. Measure savings were then estimated for average customers within each usage bin.

10 Measure types include replace-on-burnout and retrofit. New construction measures were not considered in this work stream.

11 The difference in cost between the efficient unit and the baseline, or standard unit

second exception was made for a subset of variable speed drives (VSDs); since most VSD applications were cost-effective, ICF decided to also include the non-cost-effective applications. In implementation, it is often impractical to restrict measure installations only to applications that are cost-effective.

4 DSM Potential

4.1 Technical Potential

Technical potential is defined as the level of savings that would result today by removing all existing equipment and replacing it with the most technically efficient options, regardless of cost or market barriers. Technical potential is a theoretical construct used only for the purpose of estimating the absolute upper limit of savings that is technically feasible. ICF estimates that total technical potential in TANESCO's service territory is:

- 1,748 GWh, or 30 percent of total forecasted load in 2014 (based on the PSMP "econometric" load forecast)
- 593 MW, or 61 percent of total forecasted system peak demand in 2014

4.2 Economic Potential

Economic potential is defined as the level of savings that would result today by removing all existing equipment and replacing it with the most technically efficient, cost-effective options. It is the economic subset of technical potential. Economic potential is a theoretical construct used only for the purpose of estimating the absolute upper limit of savings that is economically feasible. ICF estimates that total economic potential in TANESCO's service territory is:

- 1,509 GWh, or 26 percent of total forecasted load in 2014 (based on the PSMP "econometric" load forecast)
- 533 MW, or 55 percent of total forecasted system peak demand in 2014

4.3 Achievable Potential

Achievable potential is the level of cost-effective savings which can be realistically achieved by DSM programs, taking into consideration financial barriers, lack of awareness, and other market barriers. Achievable potential for TANESCO's service territory was estimated using a bottom-up approach based upon an analysis of cost-effective measures and market barriers for each sector.

Since programs are the vehicles that deliver DSM savings, achievable potential was developed on a program by program basis. The program analysis was a collaborative process between ICF and TANESCO staff. ICF first developed preliminary program designs and achievable potential estimates based on our understanding of the available information and data. These preliminary designs and estimates were then presented to TANESCO in program workshops where market barriers and other factors impacting program design were discussed. Based upon information gained during these workshops, ICF revised the DSM program designs and estimates accordingly.

ICF estimates of achievable potential are illustrated in Figure 13 and Figure 14. Cumulative achievable MWh[12] savings potential in 2018 is equivalent to 2.2 percent of forecasted load in 2018. Cumulative achievable MW savings potential in 2018 is equivalent to 11.5 percent of forecasted peak demand in 2018.

ICF estimates of annual program costs and cost-effectiveness are shown in Figure 13 and Figure 14, respectively.

Figure 13 - Cumulative Achievable MWh Savings Potential, by Program

Sector	Program Name	2014	2015	2016	2017	2018
Residential	Refrigerator Recycling & Replacement	0	0	14,180	29,640	46,498
Residential	Residential Lighting	18,049	37,904	59,743	59,743	59,743
Commercial	Energy Solutions for Commercial	0	0	1,670	5,281	11,472
Commercial	Commercial Refrigerated Vending	0	0	603	1,677	3,285
Commercial	Commercial Direct Load Control	0	0	0	0	0
Industrial	Energy Solutions for Industrial	0	0	4,842	11,668	21,069
Industrial	Time-of-Use Tariff	0	0	0	0	0
	Total Portfolio	**18,049**	**37,904**	**81,038**	**108,009**	**142,067**

Figure 14 - Cumulative Achievable MW Savings Potential, by Program

Sector	Program Name	2014	2015	2016	2017	2018
Residential	Refrigerator Recycling & Replacement	0	0	1	2	3
Residential	Residential Lighting	7	16	25	25	25
Commercial	Energy Solutions for Commercial	0	0	1	3	6
Commercial	Commercial Refrigerated Vending	0	0	0	1	1
Commercial	Commercial Direct Load Control	0	4	10	17	25
Industrial	Energy Solutions for Industrial	0	0	1	3	6
Industrial	Time-of-Use Tariff	0	39	48	71	87
	Total Portfolio	**7**	**59**	**86**	**122**	**153**

12 Cumulative savings is the total amount of savings due to still active measures installed in each year of the study. For example, cumulative savings for the Residential Lighting program in 2016 includes savings due to CFLs installed in 2016, as well as bulbs installed in 2015, since the bulbs installed in 2015 are assumed to still be "active" (i.e., not burned out).

Figure 15 - Annual[13] Program Costs ($ Millions, Real 2013; Real 2013 TZS)

Sector	Program Name	2014	2015	2016	2017	2018
Residential	Refrigerator Recycling & Replacement	$0.0	$0.0	$7.1	$7.8	$8.5
Residential	Residential Lighting	$3.1	$3.1	$3.4	$0.0	$0.0
Commercial	Energy Solutions for Commercial	$0.0	$0.0	$0.5	$1.2	$2.0
Commercial	Commercial Refrigerated Vending	$0.0	$0.0	$0.2	$0.2	$0.3
Commercial	Commercial Direct Load Control	$0.0	$2.1	$2.5	$3.2	$3.5
Industrial	Energy Solutions for Industrial	$0.0	$0.0	$1.0	$1.6	$2.2
Industrial	Time-of-Use Tariff	$0.0	$0.5	$0.3	$0.3	$0.3
	Total Portfolio ($ Millions)	**$3.1**	**$5.7**	**$15.1**	**$14.2**	**$16.8**
	Total Portfolio (Millions TZS)	**TZS 4,871**	**TZS 9,030**	**TZS 24,076**	**TZS 22,657**	**TZS 26,584**

Figure 16 - Program Cost-effectiveness

Sector	Program Name	Utility Cost Test (UCT) B/C Ratio	UCT Net Benefits ($ Mil.)	UCT Net Benefits (Mil. TZS)	Levelized Cost per kWh ($)	Levelized Cost[14] per kWh (TZS)	Levelized Cost per kW ($)	Levelized Cost per kW (1,000 TZS)
Residential	Refrigerator Recycling & Replacement	1.0	$15.4	TZS 24,542	$0.06	TZS 96	$978	TZS 1,558
Residential	Residential Lighting	4.8	$37.7	TZS 60,039	$0.04	TZS 62	$94	TZS 150
Commercial	Energy Solutions for Commercial	1.9	$4.7	TZS 7,498	$0.07	TZS 104	$140	TZS 223
Commercial	Commercial Refrigerated Vending	3.3	$1.4	TZS 2,200	$0.03	TZS 46	$89	TZS 142
Commercial	Commercial Direct Load Control	1.0	$8.2	TZS 13,047	N/A	N/A	$108	TZS 171
Industrial	Energy Solutions for Industrial	2.6	$8.5	TZS 13,607	$0.04	TZS 57	$123	TZS 196
Industrial	Time-of-Use Tariff	19.1	$18.9	TZS 30,080	N/A	N/A	$6	TZS 9
	Total Portfolio	**2.4**	**$94.8**	**TZS 151,012**	**$0.06**	**TZS 100**	**$98**	**TZS 156**

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13 Estimated program expenditures incurred in each year (i.e., costs shown are not cumulative).

14 The sum of present value of the capital and engineering cost and the annual operation & maintenance cost divided by the present value of the cost of energy saved over the lifetime of the measure

4.4 Program Recommendations

ICF developed guidelines for seven recommended programs:

1. **Residential Refrigerator Recycling and Replacement**. This program removes old and substandard refrigerators from D1 (*domestic low usage*) and T1 (*general usage*) customer homes and recycles (destroys) them at a facility developed for the purposes of this program. Removed units are replaced by efficient refrigerators, free of charge to participating customers.
2. **Residential Lighting**. This is a CFL "giveaway" program consistent with the initiative set forth in the Tanzanian government's *Big Results Now* policy agenda.
3. **Energy Solutions for Commercial.** This program is designed to help commercial customers in Tanzania overcome market barriers to energy efficiency, including lack of energy efficiency awareness, lack of accessibility to qualified vendors and installers, absence of tools to quantify savings, and limited funds for capital improvements. The program would offer financial incentives and technical assistance to all eligible commercial customers seeking to improve the efficiency of existing facilities, and provide resources for higher-efficiency new equipment purchases and facility upgrades.
4. **Commercial Refrigerated Vending**. This program would work with beverage companies to increase the installation of efficient refrigerated beverage vending machines in commercial buildings and facilities.
5. **Commercial Direct Load Control.** This program would enable TANESCO to cycle off participating commercial customers' air conditioners (ACs) during periods of peak demand.[15] Through the installation by TANESCO (or a contractor) of a remote control switch or other enabling technology on the participant's AC or HVAC system, TANESCO can cycle off ACs for specified lengths of time during designated peak periods through a signal transmitted from cell phone towers.
6. **Energy Solutions for Industrial.** Designed to help industrial customers in Tanzania overcome market barriers to energy efficiency, this program addresses lack of energy efficiency awareness, lack of accessibility to qualified vendors and installers, absence of tools to quantify savings, and limited funds for capital improvements. The program would offer financial incentives and technical assistance to all eligible industrial customers seeking to improve the efficiency of existing facilities and provide resources for higher-efficiency new equipment purchases, facility modernization, and industrial process improvements.
7. **Industrial Time-of-Use Tariff.** This tariff for T3 (*high voltage*) industrial customers is designed to motivate facility owners and managers to shift electricity use during periods when there is the greatest demand on the grid, to periods of lower demand, by setting price signals for the cost of energy that better align with the costs of production at different times of day.

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[15] The air-handler fan remains powered to circulate air and minimize participant discomfort.

ICF developed the following program recommendations based upon data gathered and analyses performed under activities 1 through 4, consideration of TANESCO's stated goals for DSM programs, as well as ICF experience with program design and implementation. In general, these programs are well-understood designs with proven performance in numerous jurisdictions in developed and developing countries. They are adapted here to address market barriers specific to Tanzania.

The program guidelines below provide a basic structure for each program and show indicative load and cost impacts. Detailed implementation plans, including more detailed cost and savings forecasts, should be developed by TANESCO in partnership with a qualified DSM implementation contractor selected through a competitive procurement process.

Residential Programs

Program 1: **Refrigerator Recycling & Replacement**

Program Summary

Refrigerators use the largest share of electricity in the residential sector (68 percent in T1; 44 percent in D1). This is partly because the refrigerator market in Tanzania is saturated with inexpensive imported secondary units, and because sub-standard/unbranded new units are also readily available. Further, there are many small businesses that specialize in refrigerator repair. This program is designed to overcome these and other barriers to efficient household refrigeration in Tanzania. The program involves three key delivery elements: (1) the removal of installed inefficient/older units, (2) unit replacement with efficient refrigerators, and (3) recycling/proper disposal of removed units.

Market Barriers

Based upon discussions with TANESCO staff and market research conducted by ICF, the following key market barriers to efficient residential refrigeration in Tanzania were identified:

1. **First cost**. Efficient refrigerators (European Class "B" or more efficient) cost at least three times as much as a new standard refrigerators. Residential customers are very sensitive to price, which pushes most suppliers to offer appliance designs that minimize production costs at the expense of energy efficiency.
2. **Opportunity costs**. TANESCO's experience is that for most families, the opportunity costs of purchasing an efficient refrigerator are too high. For example, in Tanzania, education is privatized; therefore, all parents who send their children to school pay tuition fees. Given the choice, parents are naturally more inclined to prioritize school tuition fees over expenses such as efficient refrigeration.
3. **Secondary markets**. The refrigeration market in Tanzania is saturated with inexpensive sub-standard and/or unbranded units,[16] and secondary (used) units. According to TANESCO, functioning used units are imported from Europe and Persian Gulf countries and can be acquired easily in Tanzania for the price of the import fee.

[16] Such products have been banned from the U.S., the European Union and other developed countries because of their poor design and excessive energy consumption rates.

4. **Refrigerator repair**. There are many small businesses that specialize in repairing refrigerators. Replacing a refrigeration coil or compressor is cheaper than buying a new unit.

Program Goal(s)

- Promote the retirement and recycling of inefficient, working refrigerators and freezers.
- Increase the saturation of efficient refrigerators.

Target Market(s)

- D1 & T1 residential customers

In order to keep program costs down (especially transport and labor costs associated with unit removal and replacement), it is recommended that the program initially target customers only in Dar es Salaam.

Measures

- Refrigerator removal and recycling
- Efficient refrigerator installation (European Class B or more efficient)

Incentives

- Level: both unit removal and replacement are 100 percent of cost (free)
- Recipient: end-user (home occupants)
- Method of delivery:
  - Unit removal: pick-up at participating homes
    - Recycling: At established facility
  - Unit replacement: delivered to participating homes at time of old unit pick-up
- Financing: N/A

Delivery

The primary activities performed by this program are unit removal/pick-up, unit replacement, and unit recycling. As such, the final program implementation plan will need to include, at a minimum, the following program functions, processes, and procedures:

- **The establishment of a dedicated appliance recycling facility**.[17] At such facilities, refrigerant and other harmful substances are removed, and the appliance shell is then placed in an automobile shredder.[18] The shredded metals, plastics, and glass are sent to a recycling facility and the recovered refrigerant is sent to a reclamation facility. Foam is either removed using manual techniques (i.e., using saws and other extraction tools)[19], or automatically (using fully automated appliance dismantlers), and destroyed.[20] Establishing the facility will also require leasing a suitably sized existing warehouse in Dar es Salaam.
  - This program will also require processes and procedures for unit recycling and disposal.
- **Criteria for recycled unit selection and measurement.** It is important to develop a reasonable set of criteria for choosing units that will be targeted for removal. Typically, appliance recycling programs will not remove a unit unless it is still plugged in and functioning. It is also recommended that the program take a spot measurement of unit power draw using a watt-meter; a minimum power threshold should be established in order to maximize per unit savings. To calculate unit energy consumption (UEC), the program will also need to develop an estimate of average annual operating hours.[21] The program may consider additional participation criteria, such as a minimum unit age.
- **A procurement process for new refrigerators.** This might include unit qualifying criteria (e.g., price, size, efficiency and other characteristics), as well as a processes for purchasing units from existing retailers, or distributors, and storage.
- **Processes and procedures for unit removal and replacement.** This might include (1) contractor training, (2) scheduling or geo-targeting of selected residential areas,[22] (3) a contractor checklist for verifying unit program qualification, (4) protocols for customer communications, unit removal, and replacement, and (5) procedures for unit transport and delivery to the recycling facility.

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[17] Household refrigerators and stand-alone freezers contain refrigerants and foam-blowing agents (embedded in the insulating foam) that are ozone-depleting substances (ODS) and/or potent greenhouse gases ("GHGs"). Foam-blowing agents can be, and typically are, shredded along with the rest of the appliance. The shredded foam, mixed with other waste components (collectively known as “auto shredder residue” or "ASR"), is sometimes used as alternative daily cover ("ADC") at landfills. Because the blowing agents contained in the foam insulation of refrigerators and freezers can have global warming potential ("GWP") values ranging from 700 to 3,800,the treatment of appliance foam at equipment end-of-life is important for avoiding the release of GHG emissions

[18] Alternatively, the appliance shell could be sent to an existing automobile shredding facility.

[19] Estimated costs of establishing a recycling facility (including the cost of leasing a warehouse in Dar es Salaam, with manual foam removal equipment) are included in this analysis.

[20] Approved technologies for destroying ODS are presented in Annex II of the Report of the 15th Meeting of the Parties of the Montreal Protocol.

[21] One value for operating hours should be developed for D1 customers and another for T1. Operating hours should be reviewed and revised during program evaluation, measurement, and verification.

[22] If geo-targeting is performed, the program should notify the targeted residents of program activity in their neighborhood in advance - this might include advertisements through various media, direct mail, SMS, etc.

- **Processes for marketing and education**. This could include mass-market television, radio, internet, bill inserts, leave-behind materials[23], and an informational Web site. Suggested key messages include: (1) estimates of the annual (electric bill) costs to operate an inefficient refrigerator, (2) the amount of cost savings expected through the installation of an efficient unit, (3) participation requirements, (4) the free nature of refrigerator removal, and replacement.

Key Trade Allies & Partners

- Appliance importers
- Appliance distributors
- Appliance retailers
- Tanzania Bureau of Standards (TBS)

Strategic Planning

- Work with TBS and qualified international entities to develop and refrigerator quality and labeling standards, as well as enforcement mechanisms such as a strict ban on import of inefficient refrigerators.

Program Implementation Period

- 2016 to 2018[24]

Program Metrics

Figure 17 summarizes program costs and savings over the forecasted period. Based on a 2016 start-up participating customers could save over 46.5 GWh and 2.9 MW in total by 2018.

Figure 18 summarizes program cost-effectiveness. Based on the UCT results this program is cost-effective; we estimate that for every 1 TZS invested by TANESCO in the program, TANESCO customers would save 1.0 TZS. In other words, the costs equal the benefits.

[23] For participating customers

[24] Program start year set to 2016 to accommodate schedule for completion of TANESCO generation capacity additions, grid stabilization, and Company financial stabilization.

Figure 17 - Residential Refrigeration Program Savings and Cost Estimates

Program Metric	2014	2015	2016	2017	2018
Incremental MWh Savings	0	0	14,180	15,460	16,858
Cumulative MWh Savings	0	0	14,180	29,640	46,498
Incremental MW Savings	0	0	1	1	1
Cumulative MW Savings	0.0	0.0	0.9	1.8	2.9
Incremental Participation (Units)	0.0	0.0	10,016	10,920	11,908
Cumulative Participation (Units)	0.0	0.0	10,016	20,936	32,844
Annual Program Costs ($Millions)	$0.0	$0.0	$7.1	$7.8	$8.5
Annual Program Costs (Millions TZS)	TZS 0	TZS 0	TZS 11,466	TZS 12,485	TZS 13,599

Figure 18 - Residential Refrigeration Program Cost-Effectiveness

Utility Cost Test (UCT) Ratio	1.0
Net UCT Benefits ($Millions)	$15.4
Net UCT Benefits (Millions TZS)	TZS 24,788
Levelized cost per kWh ($)	$0.06
Levelized cost per kWh (TZS)	TZS 97
Levelized cost per kW ($)	$978
Levelized cost per kW (1000 TZS)	TZS 1,573

Program 2: **Lighting**

Program Summary

The Residential Lighting program is designed to help overcome the market barriers to efficient residential lighting in Tanzania: first cost, awareness, and lack of national standards. Consistent with the recommendations set forth in the Tanzanian government initiative – *Big Results Now*, the program is designed to deliver, door-to-door, 3.2 million efficient light bulbs to homes in Tanzania. The next stage of this program would involve a retail-based initiative where efficient lighting products are discounted on store shelves.[25]

[25] Including this stage of the program is beyond the scope of this analysis.

Market Barriers

Based upon discussions with TANESCO staff and market research conducted by ICF, the following key market barriers to efficient residential lighting in Tanzania were identified:

1. **First cost**. CFLs cost approximately 8 to 15 times as much as incandescent bulbs with comparable light output.
2. **Awareness**. Customers do not know the difference between low and high quality CFLs, nor do they understand the benefits of efficient lighting.
3. **Standards**. The Tanzania Bureau of Standards may not have the internal capacity to develop CFL product quality (and labeling) standards, or the resources to enforce such standards.

Program Goal(s):

- Implement the *Big Results Now* agenda, which specifies the lighting program as one of two "targeted" demand management initiatives.
- Reduce first costs of efficient light bulbs.
- Increase customer awareness and understanding of benefits high-quality residential lighting options.
- Increase market penetration of high-quality residential lighting options, with the long run goal of increasing market penetration of both CFLs and LED bulbs.

Target Market(s)

- D1 & T1 residential customers

Estimated current penetration rates of CFLs are 33 percent in D1 residential and 70 percent in T1 residential.[26] However, this data does not account for bulb quality; the penetration rate of high-quality CFLs is assumed to be much lower than these values.

Measures

- Standard (non-specialty) CFLs
- A-Line (Omni-directional) LEDs (could defer to later retail portion of program)

Incentives

- Level: 100% of cost (free)
- Recipient: end-user (home occupants)
- Method of delivery: bulbs distributed door-to-door

[26] Based upon data provided in Table 5-5 of Hatch, p. 65

- Financing: N/A

Program Delivery Requirements

The fastest way to implement the *Big Results Now* objective for this program is door-to-door delivery of efficient light bulbs. For the purposes of program planning, the current assumption is that two efficient bulbs will be distributed to each household. The final program implementation plan will need to include, at a minimum, the following program processes and procedures:

- **A process for determining bulb quality.** Including but not limited to using existing international standards, such as the EU CFL Quality Charter, the US ENERGY STAR® standard, or Asia Lighting Council guidelines. TANESCO should work with Tanzania Bureau of Standards (TBS) to develop and finalize bulb quality selection guidelines.

- **A bulk bulb purchasing process.** Once bulb quality criteria are determined, TANESCO will need to issue a tender (or tenders) for bulk purchase of efficient bulbs. Depending on the final program design, TANESCO could purchase all 3.2 million bulbs in advance, or purchase them on an annual basis. There are pros and cons to each procurement strategy.

  A lower per unit price may be negotiated if one large bulk purchase is made. However, among other risks, this strategy involves quality and stranded-cost risks. If one bulk purchase is performed, and the bulbs have consistent quality issues, then - even if the supplier signs a performance guarantee - there will be significant transaction costs in returning remaining bulbs and acquiring new ones. This will also result in program delays. The stranded-cost risk is that the program is terminated prematurely or indefinitely delayed for unforeseen reasons; in such a case TANESCO would be burdened with the full costs of the bulbs without seeing the full benefits (of kWh savings due to a full distribution of the bulbs) if one advanced bulk purchase is made.

  Alternatively, an annual bulb procurement process risks a higher per unit negotiated price, and higher transaction costs (since there would be multiple tenders/procurements). However, this strategy helps mitigate the quality and stranded-cost risks discussed above. In addition, an annual procurement process provides TANESCO the flexibility to purchase better quality bulbs, more cost-effective bulbs, or alternative technologies (e.g., LEDs) in procurements after year one.[27]

- **A customer targeting process**. Including considerations for tariff class, geographic location, distribution costs, and other factors.

- **A bulb distribution process.** This includes considerations for multiple storage facilities, depending on the determined targeting process, as well as whether bulbs will be distributed by TANESCO staff, a contractor, or both. It also considers the logistics of delivery (e.g., scheduling, transport door-to-door), and other elements of bulb distribution.

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[27] Given the momentum of the *Big Results Now* agenda and TANESCO's progress on implementing this program, there is a low probability of a bulk LED purchase in program year 1 (2014).

- **Processes for marketing and education**. This includes mass-market television, radio, internet, point-of-purchase and in-store displays, bill inserts, an informational Web site, product demonstrations, and on-site events (e.g. bulb exchanges) among other activities.
- **A process for program tracking.** Tracking of bulb home deliveries should be included with other key program information.
- **Quality Assurance/Quality Control.** Procedures include those for monitoring bulb delivery.
- **Other processes and procedures**. This includes a training manual for program staff detailing delivery protocols, as well as program safety protocol and other guidelines.

Key Trade Allies & Partners

- Bulb manufacturers
- Lighting importers
- Tanzania Bureau of Standards (TBS)

Strategic Planning

- Work with TBS and qualified international entities to develop and enforce bulb quality and labeling standards, as well as enforcement mechanisms.
- Enforce a strict ban on export of CFLs to ensure that the distributed CFLs stay in Tanzania and end up on TANESCO's grid.
- Terminate giveaway program after *Big Results Now* goals are fulfilled; transform to midstream (retailer) lighting program. The analysis conducted for this report does not include program activities associated with a retail-based program.
- Include LEDs in measure mix. A-line LED bulbs have many advantages over CFLs as an efficient lighting alternative, including a longer lifetime and better light quality. Although today they cost significantly more than CFLs, advances in technology, manufacturing, and other factors are driving down LED prices quickly.

Program Implementation Period

- 2014 to 2016

Program Metrics

Figure 19 summarizes program costs and savings over the forecasted period. Based on a 2014 start-up participating customers could save over 59.7 GWh and 24.6 MW in total by 2016 (the program would only have a three year lifecycle).

Figure 20 summarizes program cost-effectiveness. Based on the UCT results this program is cost-effective; we estimate that for every 1 TZS invested by TANESCO in the program, that TANESCO customers would save 4.8 TZS.

Figure 19 - Residential Lighting Program Savings and Cost Estimates

Program Metric	2014	2015	2016	2017	2018
Incremental[28] MWh Savings	18,049	19,854	21,840	0	0
Cumulative MWh Savings	18,049	37,904	59,743	59,743	59,743
Incremental MW Savings	7	8	9	0	0
Cumulative MW Savings	7.4	15.6	24.6	24.6	24.6
Incremental Bulbs Distributed (Millions)	1.0	1.1	1.2	0	0
Cumulative Bulb Distributed (Millions)	1.0	2.0	3.2	3.2	3.2
Annual Program Costs ($Millions)	$3.1	$3.1	$3.4	$0.0	$0.0
Annual Program Costs (Millions TZS)	TZS 4,920	TZS 5,030	TZS 5,505	TZS 0	TZS 0

Figure 20 - Residential Lighting Program Cost-Effectiveness

Utility Cost Test[29] (UCT) Ratio	4.8
Net UCT Benefits ($Millions)	$37.7
Net UCT Benefits (Millions TZS)	TZS 60,642
Levelized cost per kWh ($)	$0.04
Levelized cost per kWh (TZS)	TZS 62
Levelized cost per kW ($)	$94
Levelized cost per kW (TZS)	TZS 151,329

Commercial Programs

Program 3: **Energy Solutions for Commercial**

Program Summary

The *Energy Solutions for Commercial* program is designed to help commercial customers in Tanzania overcome market barriers to energy efficiency, such as lack of energy efficiency awareness, lack of accessibility to qualified

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28 "Incremental savings are the savings due to installations of measures in a give program year. They are also sometimes called "annual" savings.

29 Utility Cost Test benefits include the present value of the lifetime avoided kWh and kW costs due to measure installations. UCT costs include DSM program costs, including incentive costs and non-incentive program delivery costs.

vendors and installers, absence of tools to quantify savings, and limited funds for capital improvements. The program would provide simple solutions for commercial customers interested in purchasing efficient electric technologies, such as efficient lighting and air conditioning, as well as site-specific custom measures. The program would offer financial incentives and technical assistance to all eligible commercial customers seeking to improve the efficiency of existing facilities, and provide resources for higher-efficiency new equipment purchases and facility upgrades.

Market Barriers

Based upon discussions with TANESCO staff and market research conducted by ICF, the following key market barriers to commercial energy efficiency in Tanzania were identified:

1. **Customer awareness.** Commercial customers are generally not aware of efficient alternatives. At the T2 level this is largely driven by trade allies, since the commercial sector relies on contractors to deliver services related to energy use (e.g., lighting and AC installations). In most cases, the customer installs what the contractor recommends. There may be a small number of commercial customers with contracts with energy service companies (ESCOs), or that have on-site facility management staff with better knowledge of building energy use.
2. **Contractor profit motive**. Contractors are interested in maximizing profit and minimizing costs. Since most customers cannot distinguish between an efficient product and a baseline product, or discern product quality, contractors are motivated to sell customers products that maximize short-term profit.
3. **Financial barriers**. Most T1 commercial customers face first-cost barriers to implementing energy efficiency. Financial barriers are also a concern for T2 customers, but TANESCO identified awareness as a more significant issue for this customer segment.

Program Goal(s)

- Help commercial customers overcome first- cost and other financial barriers to implementing energy efficiency improvements.
- Help commercial customers overcome technical skill and resource barriers to efficiency (such as the absence of tools to quantify savings) through technical assistance in identifying and implementing prescriptive (e.g., measures with predictable/pre-determined savings levels) and site-specific (custom) efficiency improvements to existing facilities.
- Increase customer and trade ally awareness of benefits of efficient products and services.
- Improve customer access to qualified vendors and installers.

Target Market(s)

- The primary target market is T2 commercial customers.
- T1 commercial customers would also be eligible for program services and incentives.

Measures

- Efficient lighting

- Efficient air conditioners
- Custom projects (i.e., site -specific improvements)

Incentives

- Types: two types of incentives are designed to be offered:
  - *Prescriptive Incentives* offer pre-specified monetary incentives on individual efficient technologies. Incentives and claimed savings are based on pre-defined technologies and calculation methods that offer a simplified method to make choices regarding engagement in potential energy-savings measures. Equipment must meet specified minimum energy performance requirements. Prescriptive incentives were modeled to equal $0.14 (225 TZS) per kWh saved.
  - *Custom Incentives* offer individually calculated incentives based on the kW and kWh saved by the individual customer's project; equipment would be required to meet specified minimum energy performance standards. Custom incentives were modeled to equal $0.10 (161 TZS) per kWh saved.
- Recipient: commercial customers
- Method of delivery: mail-in upon project verification
- Financing: N/A

Delivery

The final program implementation plan will need to include, at a minimum, the following program functions, processes, and procedures:

- **Program outreach and marketing** through mass media, trade associations, trade allies (e.g. motor suppliers and contractors), program Web site, and other media, as appropriate.
- **Education** to improve customer and trade ally awareness of efficient options and their benefits, as well as the costs and other issues associated with inefficient standard practices, such as motor rewinding.
- **A process for selecting qualifying equipment**, such as efficient lighting and cooling measures.
- **Processes and procedures for commercial facility audits**.
- **QA/QC processes and procedures** (e.g. a process for verifying equipment installations).
- **An incentive processing department.**

Key Trade Allies & Partners

- Commercial trade associations
- Manufacturers, importers, and distributors of efficient equipment
- Contractors
- Tanzania Bureau of Standards (TBS)

Strategic Planning

Program should start with a simple approach with a limited number of measures. With program experience and feedback through evaluation, measurement, and verification (EM&V), the program can expand its offerings.

Program Implementation Period

- 2016 to 2018[30]

Program Metrics

Figure 21 summarizes program costs and savings over the forecasted period. Based on a 2016 start-up participating customers could save over 11.5 GWh and 5.6 MW in total by 2018.

Figure 22 summarizes program cost-effectiveness. Based on the UCT results this program is cost-effective; we estimate that for every 1 TZS invested by TANESCO in the program, that TANESCO customers would save 1.9 TZS.

Figure 21 - Energy Solutions for Commercial Program Savings and Costs

Program Metric	2014	2015	2016	2017	2018
Incremental MWh Savings	0	0	1,670	3,612	6,191
Cumulative MWh Savings	0	0	1,670	5,281	11,472
Incremental MW Savings	0	0	0.8	1.7	3.0
Cumulative MW Savings	0.0	0.0	0.8	2.6	5.6
Measure installations	0	0	12,592	27,232	46,679
Annual Program Costs ($Millions, USD)	$0.0	$0.0	$0.5	$1.2	$2.0
Annual Program Costs (Millions TZS)	TZS 0	TZS 0	TZS 860	TZS 1,859	TZS 3,186

Figure 22 - Energy Solutions for Commercial Program Cost-Effectiveness

Utility Cost Test (UCT) Ratio	1.9
Net UCT Benefits ($Millions)	$4.7
Net UCT Benefits (Millions TZS)	TZS 7,573
Levelized cost per kWh ($)	$0.07
Levelized cost per kWh (TZS)	TZS 105

30 Program start year set to 2016 to accommodate schedule for completion of TANESCO generation capacity additions, grid stabilization, and Company financial stabilization.

Levelized cost per kW ($)	$140
Levelized cost per kW (1000 TZS)	TZS 225

Program 4: **Refrigerated Vending**

Program Summary

This program is designed to work with beverage companies to increase the installation of efficient refrigerated beverage vending machines in commercial buildings and facilities.[31]

Market Barriers

- **Awareness**. Local distributors of major beverage companies may not be aware of efficient units; commercial customers with vending machines are not aware of efficient units, or their benefits.
- **Financial**. Beverage companies may be opposed to installing efficient units due to incremental costs.

Program Goal(s):

- Increase market saturation of efficient refrigerated vending machines.

Target Market(s)

- Beverage companies (e.g., Coca Cola, Pepsi Cola)

Measures

- Efficient refrigerated vending machines:[32]
  - For the purposes of this study, this measure was modeled as "replace-on-burnout." That is, it was assumed that beverage companies would not replace functioning units, only those that have expired. It is possible that the program could meet more aggressive savings targets if beverage companies were compelled to also replace some portion of existing units (i.e., on a retrofit basis), although such a scenario is less plausible without government policy intervention.

Incentives

- **None.** The incremental cost of efficient units is close to zero. It is recommended that TANESCO sign a memorandum of understanding ("MOU") with each participating beverage company. Under this agreement, beverage companies should commit to replacing expired beverage machines in accordance with a timetable agreed upon with TANESCO. Financial incentives should not be required to encourage beverage company participation.

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[31] Beverage companies own and maintain the units.

[32] Units must meet ENERGY STAR specifications (http://www.energystar.gov/certified-products/sites/products/uploads/files/vending_mach_prog_req_v3_1.pdf?6e85-35f0) or similar.

Delivery

The final program implementation plan will need to include, at a minimum, the following program functions, processes, and procedures:

- A process for marketing the program to individual beverage companies.[33]
- A flexible MOU template that can be negotiated with individual beverage companies.
- A process for monitoring and tracking beverage company progress towards meeting the goals set forth in the MOUs.

Key Trade Allies & Partners

- Beverage companies
- Beverage distributors

Strategic Planning

This initiative is designed as a low-cost program intended to target accessible energy savings with minimal operational costs.

Program Implementation Period

- 2016 to 2018[34]

Program Metrics

Figure 23 summarizes program costs and savings over the forecasted period. Based on a 2016 start-up participating customers could save over 3.3 GWh and 1.1 MW in total by 2018.

Figure 24 summarizes program cost-effectiveness. Based on the UCT results this program is cost-effective; we estimate that for every 1 TZS invested by TANESCO in the program, that TANESCO customers would save 3.3 TZS.

Figure 23 - Midstream Commercial Refrigerated Vending Program Savings and Costs

Program Metric	2014	2015	2016	2017	2018
Incremental MWh Savings	0	0	603	1,074	1,608
Cumulative MWh Savings	0	0	603	1,677	3,285

33 Mass marketing is unnecessary for this program.

34 Program start year set to 2016 to accommodate schedule for completion of TANESCO generation capacity additions, grid stabilization, and Company financial stabilization.

Incremental MW Savings	0	0	603	1,074	1,608
Cumulative MW Savings	0.0	0.0	0.2	0.5	1.1
Measure installations	0	0	979	1,745	2,612
Annual Program Costs ($Millions, USD)	$0.0	$0.0	$0.2	$0.2	$0.3
Annual Program Costs (Millions TZS)	TZS 0	TZS 0	TZS 258	TZS 334	TZS 420

Figure 24 - Midstream Commercial Refrigerated Vending Program Cost-Effectiveness

Utility Cost Test (UCT) Ratio	3.3
Net UCT Benefits ($Millions)	$1.4
Net UCT Benefits (Millions TZS)	TZS 2,222
Levelized cost per kWh ($)	$0.03
Levelized cost per kWh (TZS)	TZS 0
Levelized cost per kW ($)	$89
Levelized cost per kW (1000 TZS)	TZS 143

Program 5: **Direct Load Control**

Program Summary

This program is designed to enable TANESCO to cycle off participating commercial customers' air conditioners (ACs) during periods of peak demand.[35] Through the installation by TANESCO (or a contractor) of a remote control switch or other enabling technology on the participant's AC or HVAC system, TANESCO can cycle off ACs for specified lengths of time during designated peak periods through a signal transmitted from cell phone towers.

Market Barriers

- **Customer awareness.** Customers may not have information on the system costs of peak electricity production.
- **Customer comfort**. Customers may be resistant to the idea of AC cycling if they believe it will adversely impact occupant comfort or damage their ACs.
- **Company risk.** TANESCO management may be concerned about the risks associated with installing enabling devices on customer equipment.

[35] The air-handler fan remains powered to circulate air and minimize participant discomfort.

Program Goal(s):

- Reduce system peak demand while minimizing reductions to participant comfort.

Target Market(s)

- T1 and T2 commercial customers

Measures

- AC load control switches or other enabling technologies. Multiple options should be explored that would be compatible with various AC technologies.
- Most cycling strategies employed in other locations are 25 percent or 50 percent options. For example, a 50 percent cycling strategy would allow TANESCO to cycle-off and on a participant's AC every 30 minutes during the designated peak period.

Incentives

- As currently modeled, participating customers would receive an incentive of $USD 50 (80,200 TZS) per kW of load shed per year. Actual incentives should be based upon the number of hours cycled and estimated kW shed per year.

Delivery

The final program implementation plan will need to include, at a minimum, the following program functions, processes, and procedures:

- A procurement process for enabling technologies
- A process for equipment installation, including installation of the controlling devices and customer education about device operations and maintenance
- A process for handling customer inquiries
- A process for communicating load shedding events in advance of the events, e.g., though SMS, email, or automated calls
- A process for the administration of cycling events, including service agreements with cell tower owners
- A process for payment of customer incentives
- A plan for maintenance and repair or replacement of units
- A system for monitoring actual load impacts
- A process for program marketing and customer targeting, including:
  - Target customer identification, including, where possible, analysis of consumption data to identify customers which customers' usage patterns suggest the presence of CAC and operation during periods of anticipated cycling events.

- Customer recruitment, including marketing channels such as direct mail, web site, bill inserts, targeted media events, HVAC trade ally promotion, local events, and other activities.

Key Trade Allies & Partners

- Cell phone tower owners and operators
- HVAC contractors
- Commercial business trade associations

Strategic Planning

This program is currently modeled as a pilot. The pilot should test various load cycling and incentive strategies. Based upon an evaluation of the effectiveness of those strategies in shedding load, and taking into consideration customer satisfaction, the program can be redesigned and expanded to a wider population.

Program Implementation Period

- 2015 to 2018

Program Metrics

Figure 25 summarizes program costs and savings over the forecasted period. Based on a 2015 start-up participating customers could save 25.3 MW in total by 2018 (see footnote 35 for discussion on kWh savings estimates).

Figure 26 summarizes program cost-effectiveness. Based on the UCT results this program is cost-effective; we estimate that for every 1 TZS invested by TANESCO in the program, that TANESCO customers would save 1 TZS; that is, the costs equal the benefits. Note, however, that due to uncertainty about air conditioning operating conditions and hours, ICF intentionally used conservative measure savings assumptions. Note also that the UCT test does not account for system benefits other than avoided costs. For example, the economic benefits of avoiding black-outs (which are difficult to quantity but do have value to TANESCO and their customers), are not accounted for. As such, the program is likely more cost-effective than estimated for this study.

Figure 25 - Commercial Direct Load Control Program Savings and Costs

Program Metric	2014	2015	2016	2017	2018
Incremental MWh Savings[36]	0	0	0	0	0
Cumulative MWh Savings	0	0	0	0	0
Incremental MW Savings	0	4.3	5.8	7.4	7.9
Cumulative MW Savings	0.0	4.3	10.1	17.5	25.3
Participants	0	2,970	3,968	5,091	5,442
Annual Program Costs ($Millions, USD)	$0.0	$2.1	$2.5	$3.2	$3.5
Annual Program Costs (Millions, TZS)	TZS 0	TZS 3,367	TZS 4,069	TZS 5,220	TZS 5,580

Figure 26 - Commercial Direct Load Control Program Cost-Effectiveness

Utility Cost Test (UCT) Ratio[37]	1.0
Net UCT Benefits ($Millions)	$8.2
Net UCT Benefits (Millions TZS)	TZS 13,178
Levelized cost per kWh ($)	N/A
Levelized cost per kWh (TZS)	N/A
Levelized cost per kW ($)	$123
Levelized cost per kW (1000 TZS)	TZS 198

Industrial Programs

Program 6: **Energy Solutions for Industrial**

Program Summary

The *Energy Solutions for Industrial* program is designed to help industrial customers in Tanzania overcome market barriers to energy efficiency, such as lack of energy efficiency awareness, lack of accessibility to qualified vendors and installers, absence of tools to quantify savings, and limited funds for capital improvements. The

[36] Evaluations of DLC programs in other jurisdictions have shown that kWh savings can be negligible; participants sometimes increase AC use following load shedding events. The evaluation of the pilot program should measure both kW and kWh savings to ensure that any kWh savings are counted as program benefits.

[37] Due to the absence of commercial AC load data in Tanzania, this program was modeled using conservative savings assumptions. Even under this scenario, the program is estimated to be cost-effective. ICF assumed that only two load shedding events occur per year, and that each participant sheds 1.5 kW per year. Further, average measure life was assumed to be only 5 years, which is consistent with field data on AC service lives in Tanzania. Given TANESCO's historical system peaking periods, the actual number of load shedding events may be higher. Average load shed per customer may also be higher depending on actual customer cooling load and the final cycling strategies implemented.

program would provide a simple solution for industrial customers interested in purchasing efficient electric technologies, such as premium efficiency motors, and variable frequency drives (VFDs), as well as site-specific custom measures. The program would offer financial incentives and technical assistance to all eligible industrial customers seeking to improve the efficiency of existing facilities, and provide resources for higher-efficiency new equipment purchases, facility modernization, and industrial process improvements.

Market Barriers

Based upon discussions with TANESCO staff and market research conducted by ICF, the following key market barriers to industrial energy efficiency in Tanzania were identified:

1. **Awareness.** Customer awareness of efficient options and their benefits was identified as the number one barrier to industrial energy efficiency by TANESCO staff.[38]
2. **Technical skill and resource barriers.** A lack of training and skill, and access to related tools and resources are also a significant issue in the industrial sector. For example, many facility managers lack the tools to quantify energy savings.
3. **Inefficient standard practices.** For example, facility managers, especially those in small to medium industrial plants, typically elect to rewind rather than replace failed motors, which can result in efficiency losses.
4. **Lack of market availability of efficient units.** This barrier is widespread. In some cases, efficient equipment may not currently be available in Tanzania.
5. **Financial barriers**. According to discussions with TANESCO, financial barriers are less significant to industrial efficiency than the other barriers listed above. This is especially the case for large industrial customers, who are more likely to have access to the cash or credit required for efficiency investments; small to medium industrials may require higher incentives from this program than large industrials.

Program Goal(s)

- Help industrial customers overcome technical skill and resource barriers to efficiency through technical assistance in identifying and implementing prescriptive (e.g., measures with predictable/pre-determined savings levels) and site-specific (custom) efficiency improvements to existing facilities.
- Increase customer and trade ally awareness of benefits of efficient products and services.
- Help industrial customers overcome first cost and other financial barriers to implementing energy efficiency improvements.
- Improve customer access to qualified vendors and installers.

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[38] A small number of industrials, mostly foreign owned entities, are aware of efficient options, and have personnel with the technical skills necessary to implement efficient technologies and practices. Some of these companies, e.g., SABMiller, have already made significant efficiency investments to their facilities in Tanzania.

Target Market(s)

- The primary target market is T3 industrials.
- T2 industrial customers would also be eligible for program services and incentives.

Measures

- Premium efficiency motors
- Variable speed drives (VSDs)
- Custom projects (i.e., plant -specific industrial process improvements)
- Other measure types, such as compressed air and process improvements

Incentives

- Type: two types of incentives are designed into the program be offered:
  - *Prescriptive Incentives* are pre-specified monetary incentives on individual efficient technologies. Incentives and claimed savings are based on pre-defined technologies and calculation methods. Equipment must meet specified minimum energy performance requirements. Prescriptive incentives were modeled in this study to equal $0.14 (225 TZS) per kWh saved.
  - *Custom Incentives* are individually calculated based on the kW and kWh saved by an individual customer's project, using equipment that is required to meet specified minimum energy performance standards. Custom incentives were modeled in this study to equal $USD 0.10 (161 TZS) per kWh saved.
- Recipient: Industrial customers
- Method of delivery: mail-in upon project verification
- Financing: financing for some projects could be made available through Tanzanian Investment Bank or other lenders.

Delivery

The final program implementation plan will need to include, at a minimum, the following program functions, processes, and procedures:

- **Program outreach and marketing** through TANESCO corporate liaisons and regional managers, trade allies (e.g., motor suppliers and contractors), program Web site, and other media, as appropriate.
- **Education** to improve customer and trade ally awareness of efficient options and their benefits, as well as the costs and other issues associated with inefficient standard practices.
- **A process for selecting qualifying equipment**, such as premium efficient motors.
- **Processes and procedures for industrial facility audits.**
- **QA/QC processes and procedures** (e.g., a process for verifying motor installations).
- **An incentive processing department.**

Key Trade Allies & Partners

- Industry trade associations
- Manufacturers, importers, and distributors of efficient equipment
- Contractors
- Tanzanian Investment Bank
- Tanzania Bureau of Standards (TBS)

Strategic Planning

The program should start with a simple approach with a limited number of measures. With program experience and feedback through evaluation, measurement, and verification (EM&V), the program can expand its offerings.

Program Implementation Period

- 2016 to 2018[39]

Program Metrics

Figure 27 summarizes program costs and savings over the forecasted period. Based on a 2016 start-up participating customers could save over 21.1 GWh and 6.4 MW in total by 2018.

Figure 28 summarizes program cost-effectiveness. Based on the UCT results this program is cost-effective; we estimate that for every 1 TZS invested by TANESCO in the program, that TANESCO customers would save 1.2 TZS.

Figure 27 - Energy Solutions for Industrial Program Savings and Costs

Program Metric	2014	2015	2016	2017	2018
Incremental MWh Savings	0	0	4,842	6,826	9,402
Cumulative MWh Savings	0	0	4,842	11,668	21,069
Incremental MW Savings	0	0	1.2	2.1	3.1
Cumulative MW Savings	0.0	0.0	1.2	3.3	6.4
Prescriptive measure installations	0	0	421	911	1,561
Custom projects completed	0	0	6	6	7
Annual Program Costs ($Millions, USD)	$0.0	$0.0	$1.1	$1.7	$2.5
Annual Program Costs (Millions TZS)	TZS 0	TZS 0	TZS 1,789	TZS 2,746	TZS 3,998

39 Program start year set to 2016 to accommodate schedule for completion of TANESCO generation capacity additions, grid stabilization, and Company financial stabilization.

Figure 28 - Energy Solutions for Industrial Program Cost-Effectiveness

Utility Cost Test (UCT) Ratio	1.2
Net UCT Benefits ($Millions)	$8.5
Net UCT Benefits (Millions TZS)	TZS 13,744
Levelized cost per kWh ($)	$0.04
Levelized cost per kWh (TZS)	TZS 135
Levelized cost per kW ($)	$135
Levelized cost per kW (1000 TZS)	TZS 217

Program 7: **Time-of-Use Tariff**

Summary

TANESCO's T3 industrial customer class includes less than 0.1 percent of total system customers, but uses 35 percent of system electricity. Further, industrial operating schedules do not account for the time-varying cost of electricity production, given that the energy charge on the current tariff is a flat price per kWh for all hours of the day/year. This misalignment has contributed to system outages (when TANESCO has been unable to meet the high levels of demand by industrial users), revenue loss by TANESCO, lost production/revenue by manufacturing companies, cross subsidies, and other inefficiencies. While an industrial time-of-use (TOU) tariff alone cannot fix all of these problems, better alignment of energy charges with energy costs will help improve the economic efficiency of the system, and may help reduce the number of system outages.

For the purposes of this analysis, ICF designed a TOU rate with a critical peak price (CPP) component. The tariff is designed primarily to shift load from periods of critical peak demand (roughly 2 percent of total hours per year) by setting a critical peak energy charge that is consistent with the cost of energy during such periods. Due to the nature of TANESCO's system load shape, a large shift in load from on- to off-peak could result in moving the peak without actually reducing the level of peak demand. The design sets the non-critical on-peak energy charge at a price point designed to motivate industrials to shift only a modest amount of load from on-peak to off-peak.

The proposed tariff was also designed with simplicity in mind. Experience shows that overly complex TOU rates can be counterproductive to utility goals, mainly because they can be difficult for customers to understand and act upon.

Analysis

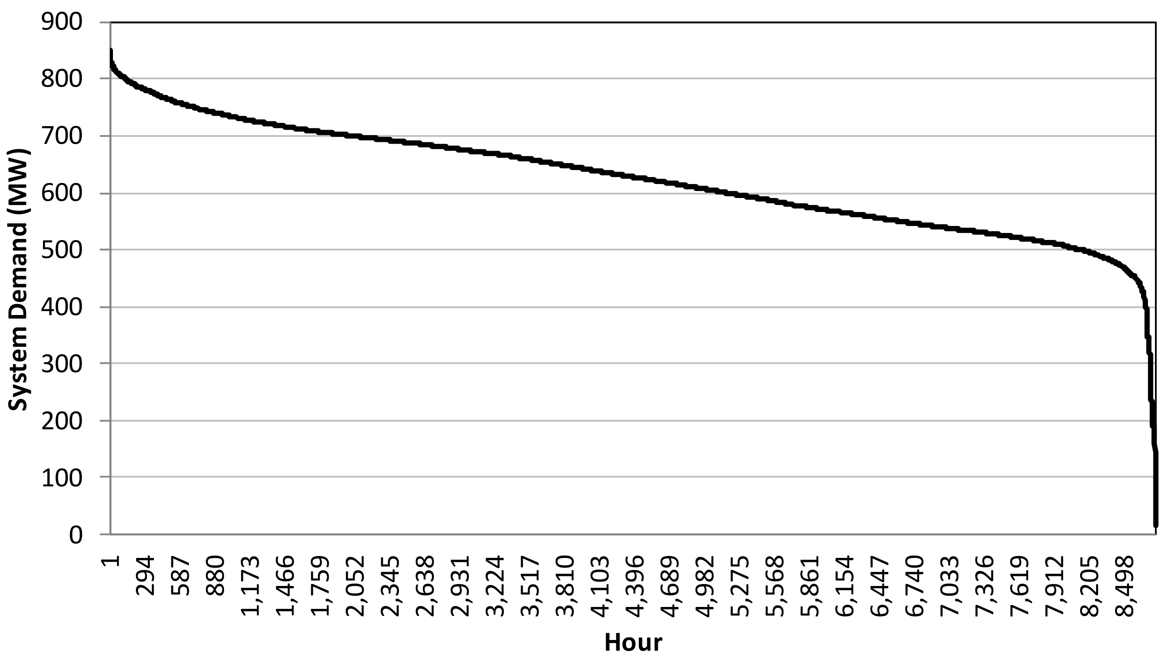
Figure 29 shows TANESCO's load duration curve for 2012. A load duration curve is created by sorting system hourly demand for a given year from highest demand to lowest, and then plotting that data series on the Y-axis against annual hours on the X-axis. Plotting a load duration curve is useful in analyzing possible TOU rates: the shape of the curve illustrates variance in annual demand; inflection points on the curve can be used to help determine different TOU periods. TANESCO's load duration curve has a relatively high, shallow slope across a large majority of hours. This is consistent with the high annual system load factor of 73.2 percent for this period

(2012). In fact, system demand was between 500 MW and 700 MW for 70 percent of hours during 2012. Twenty-three percent of the time, system demand was greater than 700 MW (as shown in

Figure 30, where 76.7 percent of hours have demand less than 700 MW).. Periods where system demand was 700 MW or greater were designated as "peak" periods in ICF's analysis; periods where system demand was 800 MW or great were designated "critical peak" periods.

Some TOU tariffs have seasonal components. In TANESCO's case, there is little variance in seasonal demand, as shown in Figure 31. Therefore, it is not necessary to vary TANESCO's TOU tariff by season. One benefit of this simpler rate design is that it will be easier to explain to customers and, therefore, easier for affected facility owners and managers to plan their operations accordingly.

Figure 29 - TANESCO System Load Duration Curve (2012)[40]



Source: TANESCO

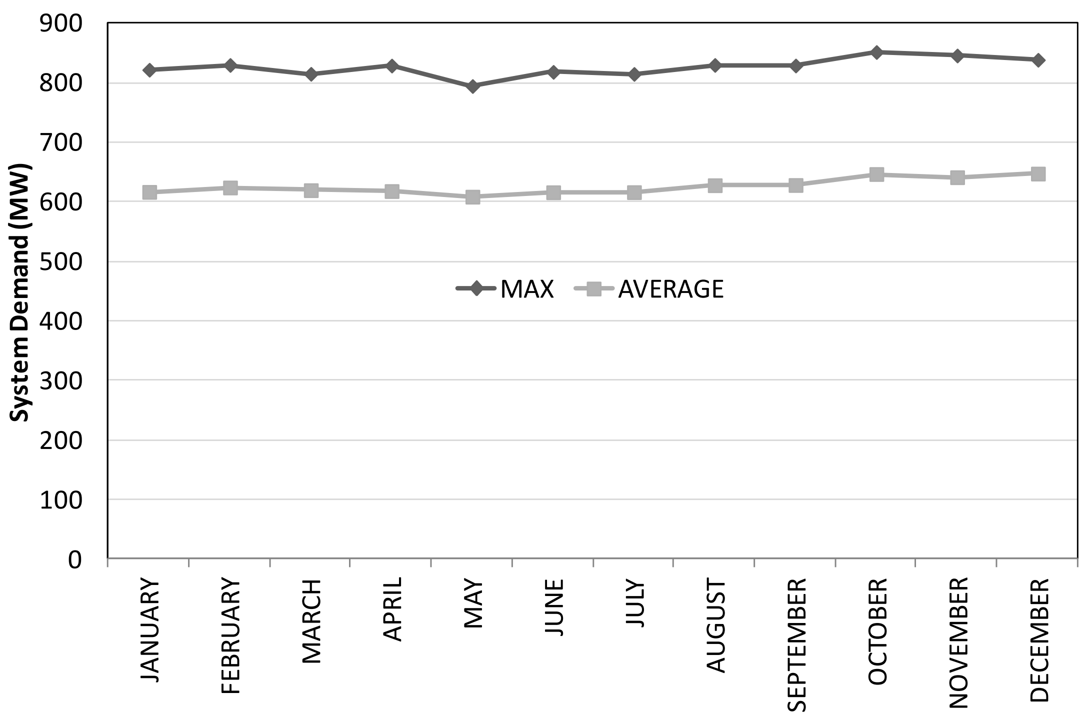
[40] During all hours below 250 MW, either a partial or full-grid power failure occurred.

Figure 30 - Distribution of Annual Hours by Level of System Demand (2012)

System Demand Bin	% 2012 Hours	% Cumulative Hours
0<MW<=100	0.1%	0.1%
100<=MW<200	0.1%	0.2%
200<=MW<300	0.1%	0.3%
300<=MW<400	0.2%	0.5%
400<=MW<500	6.2%	6.7%
500<=MW<600	34.2%	40.9%
600<=MW<700	35.8%	76.7%
700<=MW<800	21.7%	98.4%
800<=MW<900	1.6%	100%

Source: TANESCO

Figure 31 - TANESCO System Demand, by Month (2012)



Source: TANESCO

Proposed Time-of-Use Tariff

ICF's proposed TOU tariff for T3 customers is shown in Figure 32. Note this tariff only includes proposed energy prices for different time-blocks. Demand[41] and other non-energy service charges were not addressed in this analysis.

This tariff design takes into account the relatively shallow slope of TANESCO's load duration curve and the lack of variation in seasonal load; the system load-bins shown in Figure 30 were combined with the system time-of use data shown in Figure 33 to help determine the appropriate time-blocks for each period in the proposed tariff (as defined in Figure 32). The proposed tariff is a two-tier TOU design with a *critical peak* component. The main purpose is to encourage industrials to shift production from periods of highest system demand (critical peak periods) to periods of lower system demand, as well as to encourage a modest amount of load shifting from non-critical on-peak times to off-peak times. Given TANESCO's load curve, a large shift in load from on- to off-peak could simply result in changing the time period in which the system peak is likely to occur, without actually reducing system peak demand.

Figure 32 - T3 TOU with Critical Peak Period (CPP) Tariff Summary

Tariff	Period Definition	Ratio to Off-Peak Price	Energy Charge per kWh (Real 2013 USD)	Energy Charge per kWh (Real 2013 TZS)	Time Block	Hours per Day	Total Hours per Year	% Total Annual Hours
Current Flat Tariff*	All Hours	N/A	$0.102	TZS 163	All hours	24	8,760	N/A
TOU w/ CPP Tariff	Off-Peak	N/A	$0.097	TZS 156	12AM-7PM	19	6,722	77%
	On-Peak	1.2	$0.117	TZS 187	7PM-12AM	5	1,899	22%
	Critical Peak[42]	4.0	$0.389	TZS 622	7PM-12AM[43]	5	140	2%

**Shown for comparison purposes only.*

The tariff includes a CPP energy charge that accounts for the cost of energy production during *critical peak periods*. By comparison, the recommended *non-critical on-peak* energy charge is a small increase over the existing flat tariff charge to facilitate a modest amount of load shift from *non-critical on-peak periods* to *off-peak periods*, which will help to lower the system load shape instead of simply shifting the peak.

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41 Although some TOU tariffs also include demand charges that vary by period, such charges add a layer of complexity that can be counterproductive. In addition, focusing on energy is most consistent with the overall goal of TOU tariffs, is to better align retail energy charges with long run marginal energy costs.

42 For the purposes of this analysis, a critical peak period is defined as a timeframe where forecasted system demand for a time window the next day will be within 6% of maximum forecasted system demand (for example, in 2012, this is estimated to equal all hours where system demand was 800 MW or greater). Based on historical TANESCO data, critical peak periods are estimated to occur for a total of 140 hours per year, or 2% of total annual hours. Critical peak events are typically called a day ahead; customers on CPP rates are notified of an event through agreed-upon communication methods.

43 Some CPP events may be called outside this time window.

Finally, the off-peak period energy charge provides a small discount relative to the current flat rate for T3 customers. This would be counterbalanced by the increase in energy charges during on- and critical-peak periods. It is not reasonable to expect that 100 percent of load will be shifted off of these periods; therefore, it is extremely unlikely that this small discount would cause TANESCO difficulty in meeting its revenue requirement for the T3 tariff class under the proposed TOU tariff. In any case, once the system is implemented, TANESCO could use data on revenues to make adjustments to rates such that the system is revenue-neutral (or, if appropriate, revenue-positive).

The period time-blocks were determined by analyzing the sub-set of hours during which TANESCO's system demand was 700 MW or greater (the 23 percent of hours of highest system demand). As shown in Figure 33, 58 percent of hours of peak demand occurred between 7PM and 12AM (19:00-24:00), which defined the *on-peak time-block*. Conversely, the *off-peak time-block* was defined as 12AM-7PM (24:00-19:00). Given historical data available, it is likely that most critical peak periods will occur during this on-peak time-block. However, this should not preclude TANESCO from the ability to call peak events that they predict might occur during other hours of the day.

Figure 33 - Distribution of TANESCO On-Peak Hours (2012)

Hour of Day where System Demand =>700 MW ("On-Peak")	% of On-Peak Hours	Cumulative % of On-Peak Hours
9–10AM	2%	2%
10–11AM	4%	6%
11 AM–12 PM	6%	12%
12–1PM	6%	19%
1–2PM	7%	25%
2–3PM	4%	29%
3–4PM	4%	33%
4–5PM	4%	37%
5–6PM	3%	40%
6–7PM	1%	42%
7–8PM	7%	49%
8–9PM	16%	64%
9–10PM	16%	81%
10–11PM	14%	95%
11PM–12AM	5%	100%

Program Metrics

Figure 34 summarizes program costs and savings over the forecasted period. Based on a 2015 start-up the customers on the tariff could achieve total demand savings of 87 MW by 2018. Program costs are higher in 2015 to account for start-up costs. No MWh savings were estimated as it was assumed that load would be shifted from on- to off-peak.

Figure 35 summarizes program cost-effectiveness. This program includes no direct incentive costs; non-incentive costs are relatively low, as these are largely administrative and marketing costs. Weighted against the large avoided capacity savings, this program is very cost-effective. Based on the UCT result, we estimate that for every 1 TZS invested by TANESCO in the program, that TANESCO customers would save 19.1 TZS.

Figure 34 - Industrial Time-of-Use Tariff Savings & Costs

Program Metric	2014	2015	2016	2017	2018
Incremental MWh Savings	0	0	0	0	0
Cumulative MWh Savings	0	0	0	0	0
Incremental MW Savings	0	39	48	71	87
Cumulative MW Savings	0.0	39	48	71	87
Annual Program Costs ($Millions, USD)	$0.0	$0.5	$0.3	$0.3	$0.3
Annual Program Costs (Millions TZS)	TZS 0	TZS 717	TZS 478	TZS 478	TZS 478

Figure 35 - Industrial Time-of-Use Tariff Cost-Effectiveness

Utility Cost Test (UCT) Ratio	19.1
Net UCT Benefits ($Millions)	$18.9
Net UCT Benefits (Millions TZS)	TZS 30,382
Levelized cost per kWh ($)	N/A
Levelized cost per kWh (TZS)	N/A
Levelized cost per kW ($)	$6
Levelized cost per kW (1000 TZS)	TZS 9

Additional Program Notes

During the course of the study ICF and TANESCO staff met with industrial groups to vet the concept of a TOU rate. Generally the concept of TOU is understood by TANESCO's customers, especially the large customers. Some of the large customers encouraged the introduction of a TOU rate to help them avoid the increase in production costs due to the anticipated electricity rate increases. There were no concerns from the introduction of TOU that came up during ICF's discussion with the customers during the workshops and site-visits.

5 Conclusion

This report summarizes ICF's analysis of DSM potential in Tanzania over the 2014 to 2018 timeframe. ICF developed seven program recommendations and guidelines for the residential, commercial, and industrial sectors. ICF estimates that this portfolio of programs could save a total of 142 GWh, and 153 MW, by 2018. This is equal to 2.1 percent of forecasted load and 11.5 percent of peak demand in 2018, respectively. Total system benefits due to DSM measures implemented over the 2014 to 2018 timeframe are estimated to equal $16.7 million (TZS 26,584,000) in 2018. The *Utility Cost Test Benefit-Cost Ratio* for these programs is estimated to equal 2.4, meaning that for every TZS invested by TANESCO in DSM, customers will save 2.4 TZS in the long run.

During the course of the analysis ICF met in person with TANESCO staff, government officials, and other key stakeholders, including large industrial customers. Feedback gained during these meetings informed the program designs described in this report, and the achievable potential estimates.