Partnership for Growth – DSM Support in Tanzania

A project of USAID's Energy Efficiency for Clean Development Program (EECDP)

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July 27, 2013

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Overview: Activities to Date

1. Document Review
2. Electric Meter Data Analysis
3. Develop Customer and System Load Profiles
4. Conduct Energy Analyses of DSM Measures
5. Quantify System wide DSM Potential

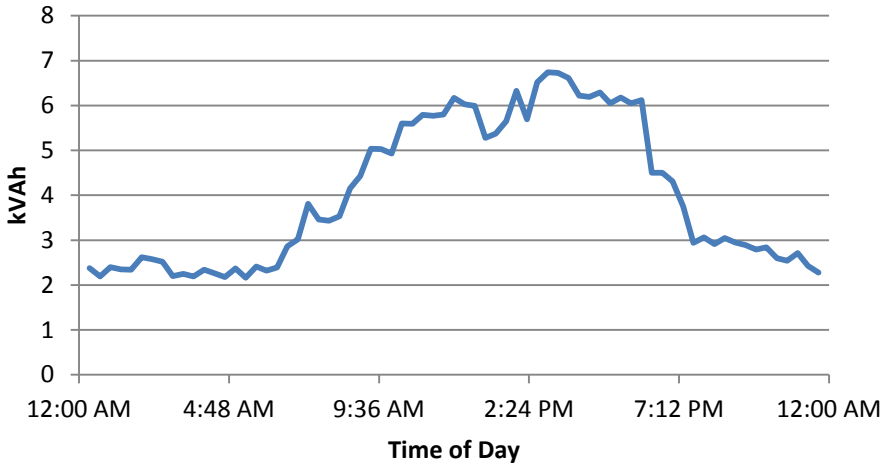
Activity 1. Document Review

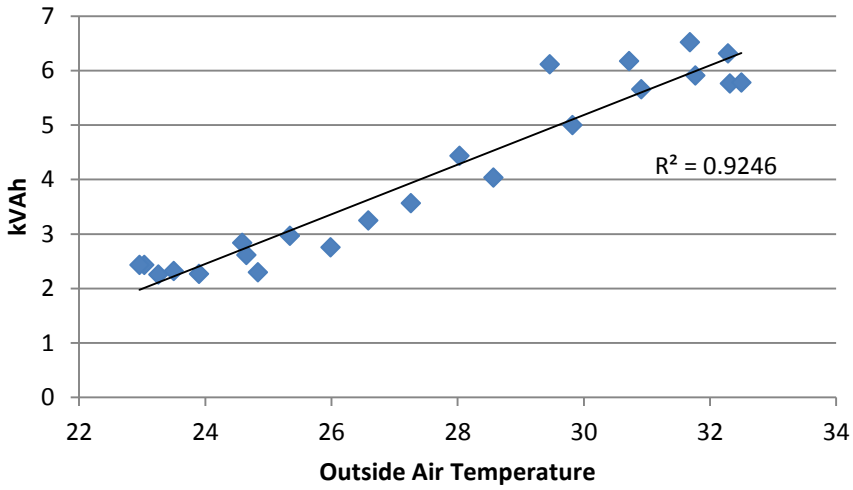
- POWER SYSTEM MASTER PLAN
  - Avoided costs
- EWURA Cost of Service Study
  - Total consumption and number of customers
- Hatch Report
  - End-use energy disaggregation
  - Measures and costs
- Journal and Conference Publications
  - Typical measures in the region and costs of the measures

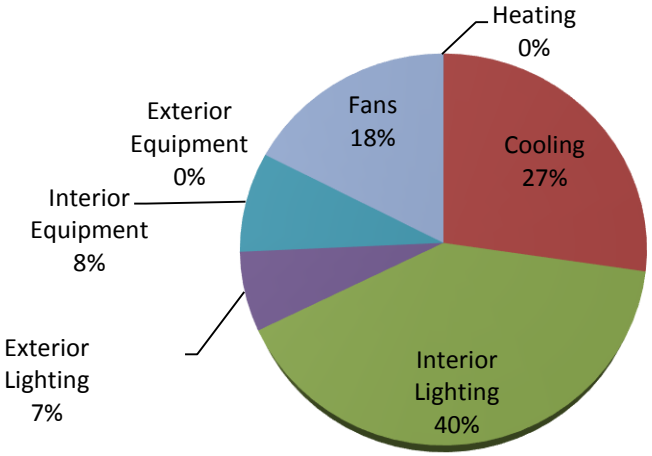
Activity 2. Electric Meter Data Analysis

- Disaggregate electricity consumption into end-uses
  - Analyze data to identify energy efficiency and load management potential
- Determine baseline energy use

Activity 2. End-Use Disaggregation - Stand-Alone Retail

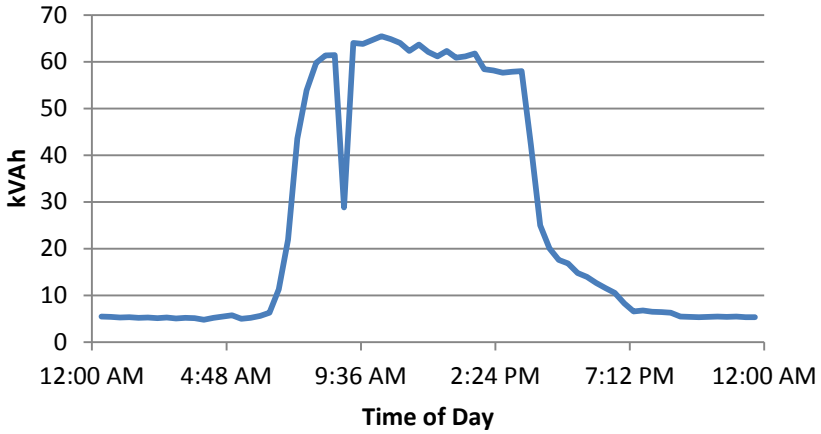


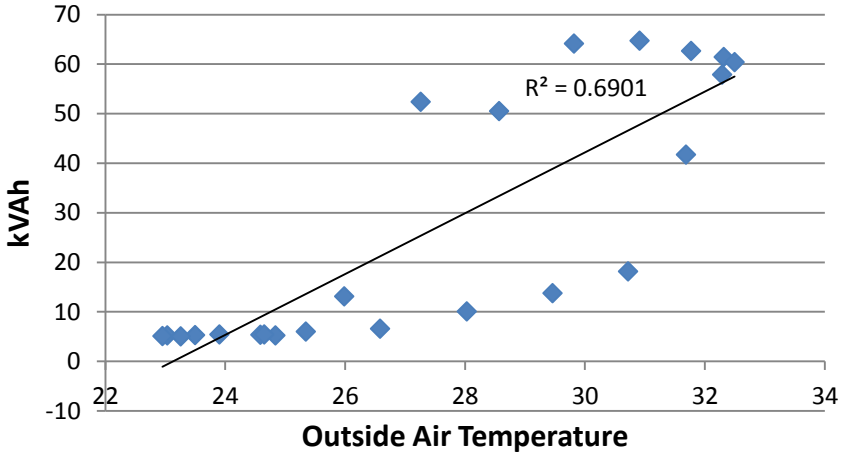


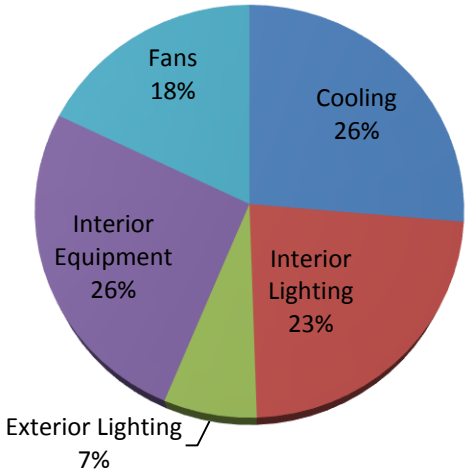


Client Name & Acc #:
Star Media TBC 1-209169070

Activity 2. End-Use Disaggregation - Medium Office

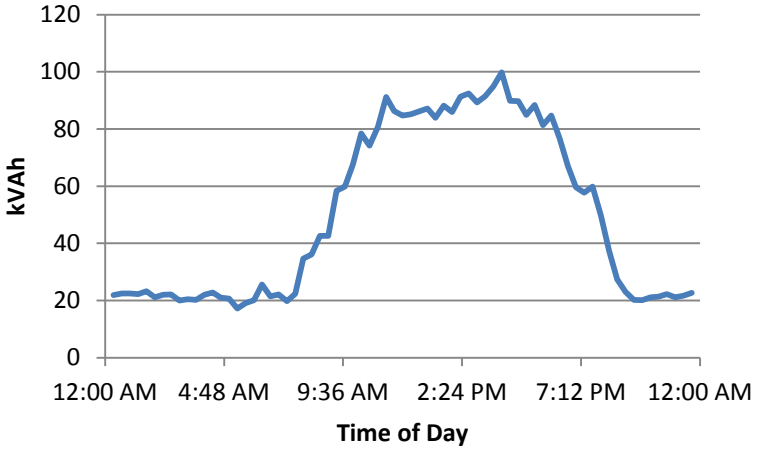


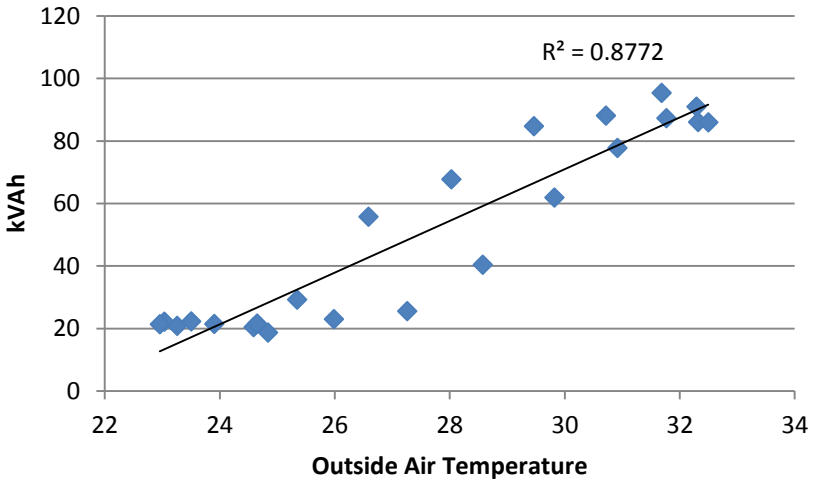


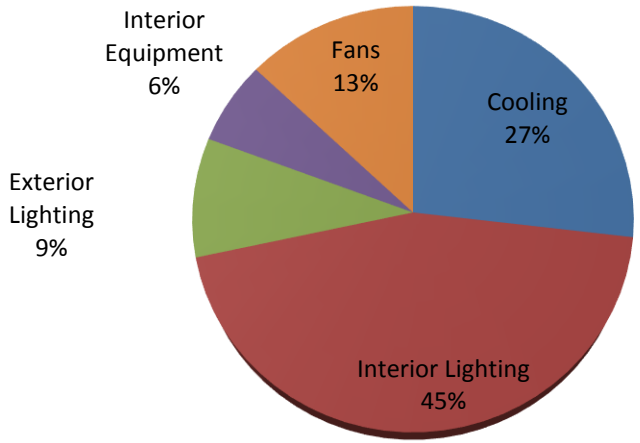


Client Name & Acc #:
PCCB Ilala-209421198

Activity 2. End-Use Disaggregation - Strip Mall

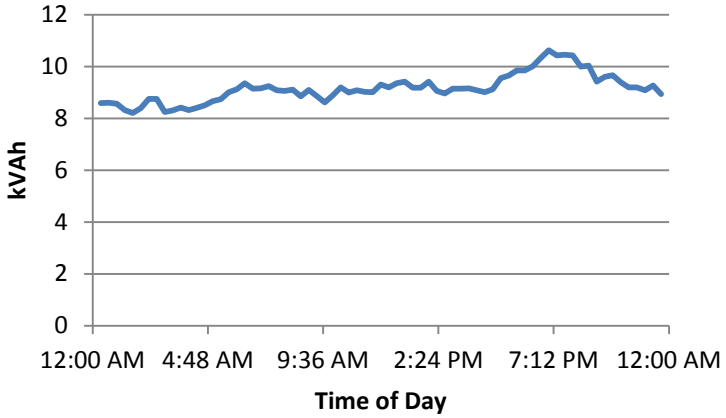


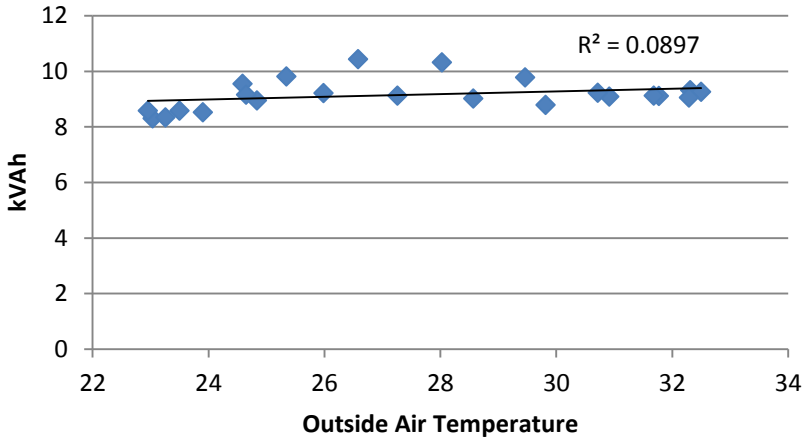


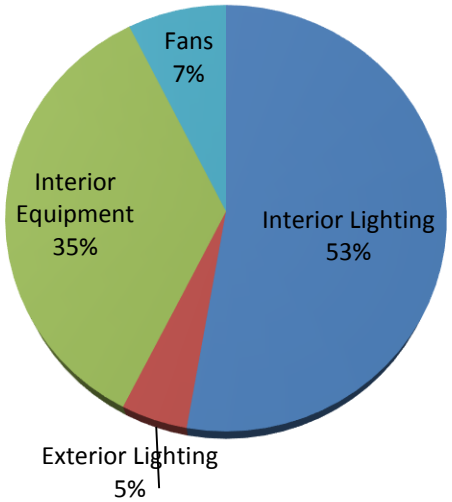


Client Name & Acc #:
Shoppers Plaza-209421737

Activity 2. End-Use Disaggregation - Primary School

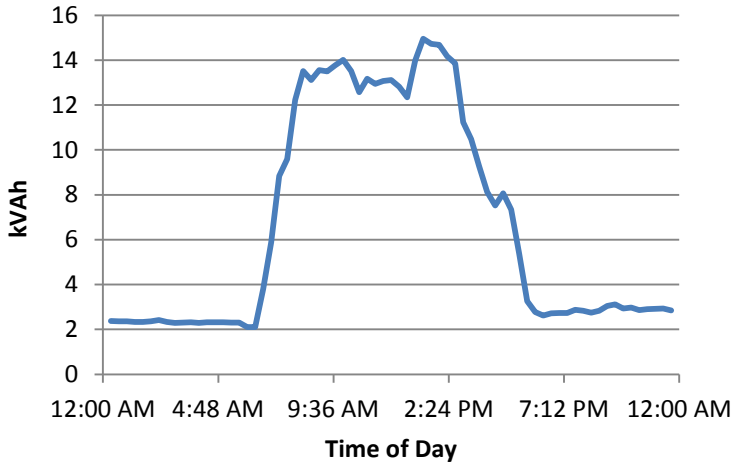


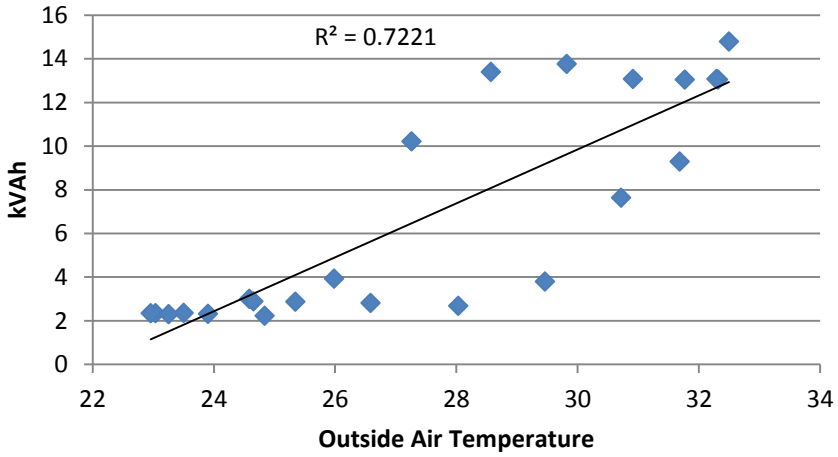


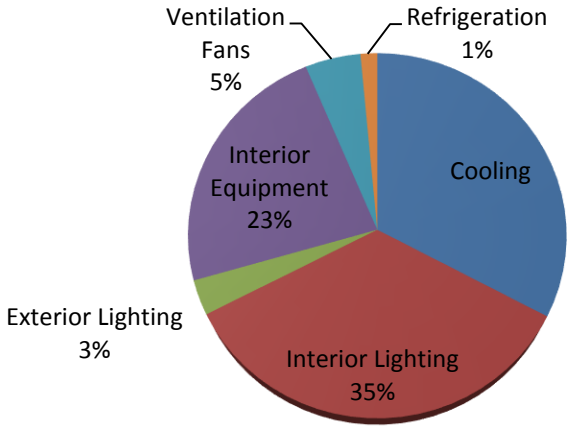


Client Name & Acc #:
Lugalo Primary School-209420340

Activity 2. End-Use Disaggregation - Secondary School

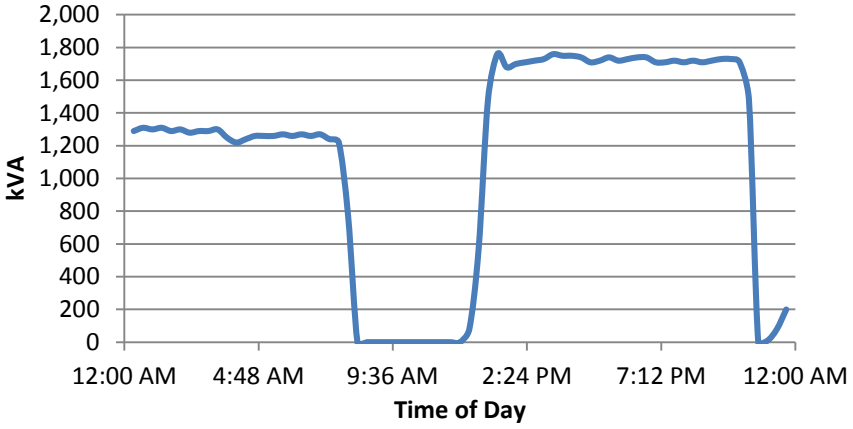


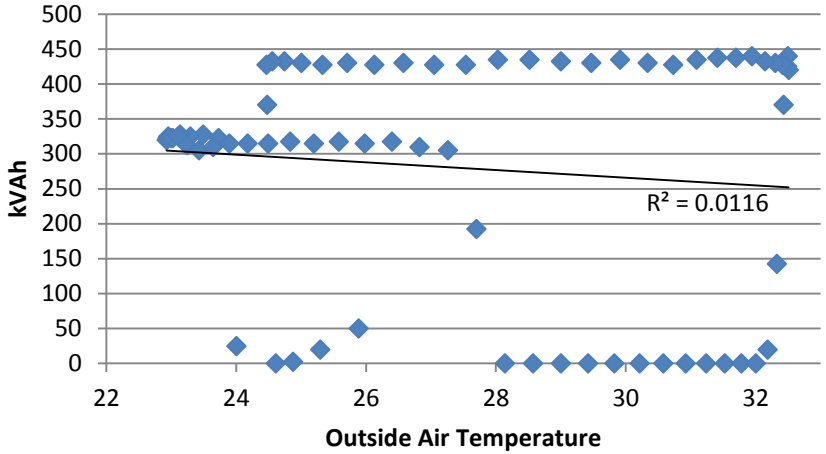


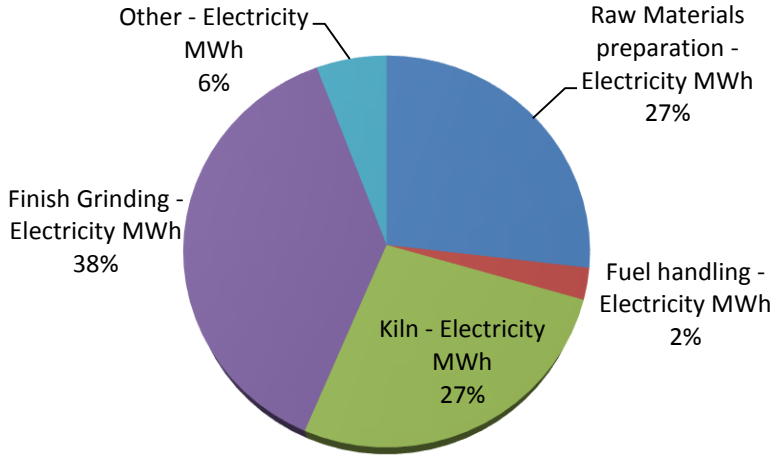


Client Name & Acc #:
Mzizima Sec School-209421455

Activity 2. End-Use Disaggregation – Cement Factory







Client Name & Acc #:
MBEYA CEMENT LTD 209421993

Activity 2. Baseline Energy Use - Challenges

- The backend server is not flexible and the database schema is not known internally to TANESCO
- Annual load shape electricity or demand data is not available for download in spreadsheet format.
- Customer classification is absent - (see Appendix slides 2.1)
- Cannot use the end-use disaggregation as the classification is missing for the customers

Activity 3. Develop Customer and System Load Profiles

- Analyze trends across sample of customers
  - Build local capacity
- Create system load profile for T1, T2, & T3 customers

Activity 3. Analyze Trends Across Sample of Customers

- ASHRAE Level 1 (walk through)
  - Tanzania Cigarette Company
  - Iron and Steel
  - Metal Products
- Site Visit
  - Quality Group Limited- shopping mall

Activity 3. Analyze Trends Across Sample of Customers - Tanzania Cigarette Company

- Facility Characteristics
  - 1.6MW Electric Boilers
  - 184kW Chiller
  - 18.5+7.5kW Air handling units
  - Cooling tower
  - Electric fork lift charging station
  - Ductless Split air conditioner
  - Lighting
  - Motors

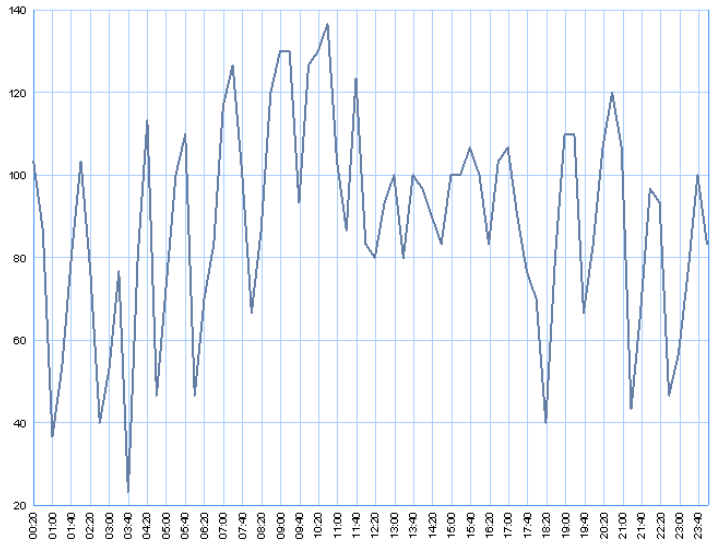
- Energy Efficiency Features:
  - Variable speed drives on compressors
  - High efficiency instantaneous steam boilers
  - Staggering of boilers
  - Staggering of air compressors
  - High efficiency lighting -T-5 in office space and Metal Halide (currently being installed)
  - Variable Refrigerant Volume (VRV) ductless split AC (Currently out for bid)
  - Double pane windows in most areas
  - Cool roof
  - High efficiency motors (motors are rewound a maximum of 2 times before being replaced)
  - Overhangs on windows

Activity 3. Analyze Trends Across Sample of Customers - Tanzania Cigarette Company

- Recommendations:
  - Battery charging should be done at night during off-peak hours
  - Air sealing for conditioned space
  - Variable speed drive on the air handler
  - Variable speed chiller
  - Variable speed drive on cooling tower
  - Complete window upgrade to double pane

Activity 3. Analyze Trends Across Sample of Customers - Iron and Steel

- Facility Characteristics:
  - Large motors
    - Multiple motors for conveyer belt- including one 800 HP motor
    - motors for air compressor,
    - motors for rolling machines,
    - motors for cooling tower fan
  - Induction furnace

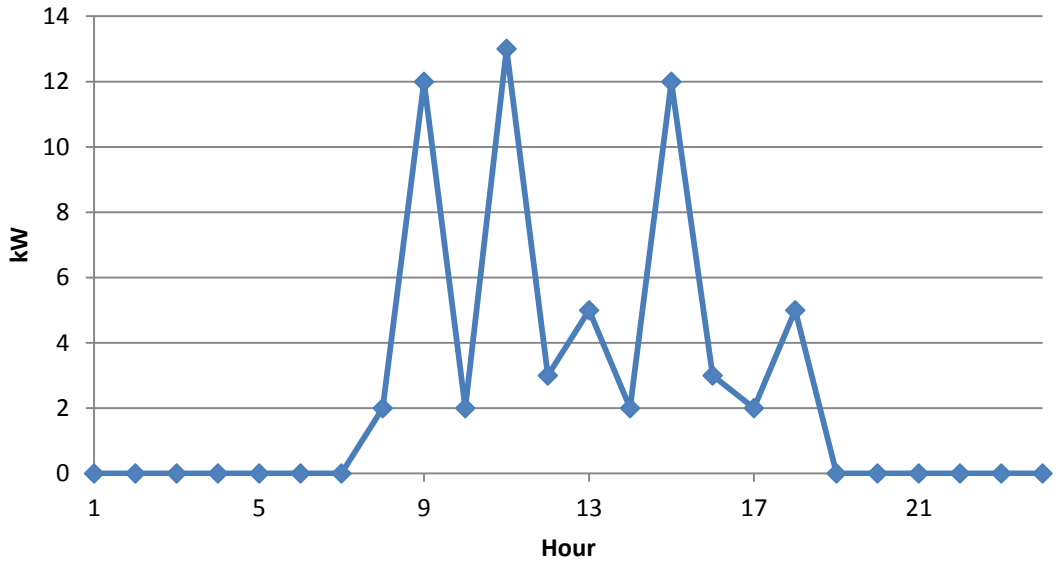


Activity 3. Analyze Trends Across Sample of Customers - Iron and Steel

- Recommendations
  - Shift coreless induction furnace operations to nights and mornings i.e. off-peak.
    - Use of channel induction furnaces
    - Or, use energy management systems
  - Upgrade motors to premium efficiency motors.
  - Upgrade cooling tower controls to multispeed or two speed controls.
  - Air-seal office area building envelope to reduce cooling load.
  - Install metal halide lighting instead of sodium lighting
  - Use high efficiency lighting or day light in the office area.

Activity 3. Analyze Trends Across Sample of Customers - Metal Products

- Facility Characteristics:
  - 50kW Electric tunnel type paint drying oven (kiln)
  - Seam welding machine
  - Motors for rollers
  - Two 10kW presses



Activity 3. Analyze Trends Across Sample of Customers - Metal Products

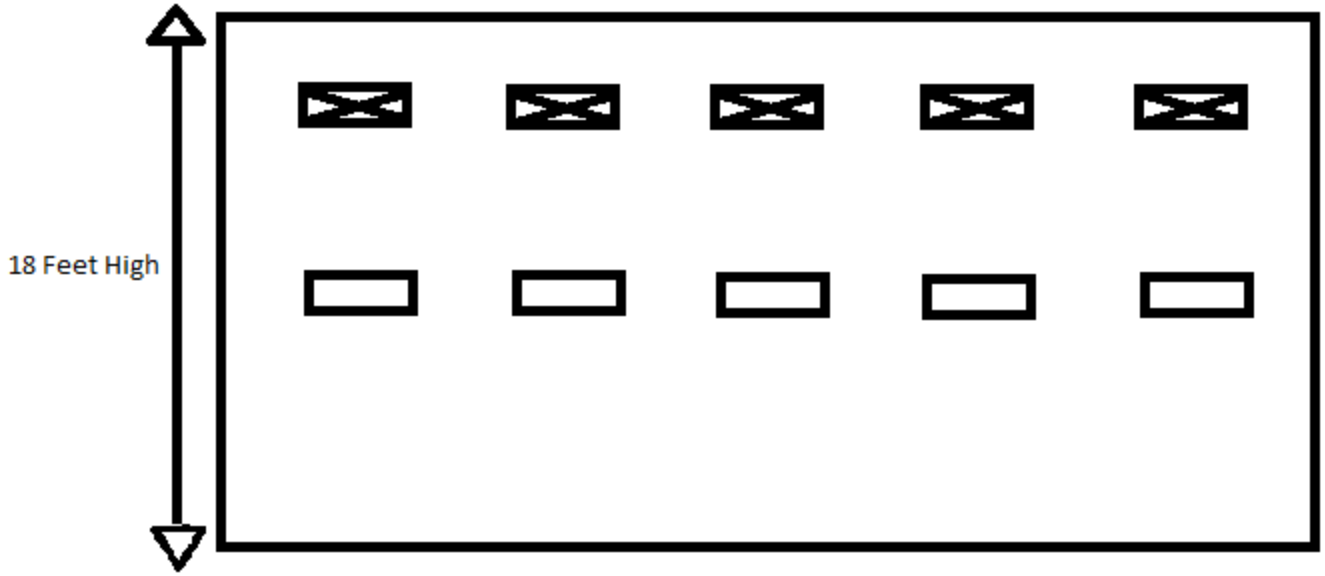
- Recommendations:
  - Upgrade motors
  - Insulate walls of the oven
  - Operate oven and seam welder at off-peak hours

Activity 3. Analyze Trends Across Sample of Customers - Quality Group Limited

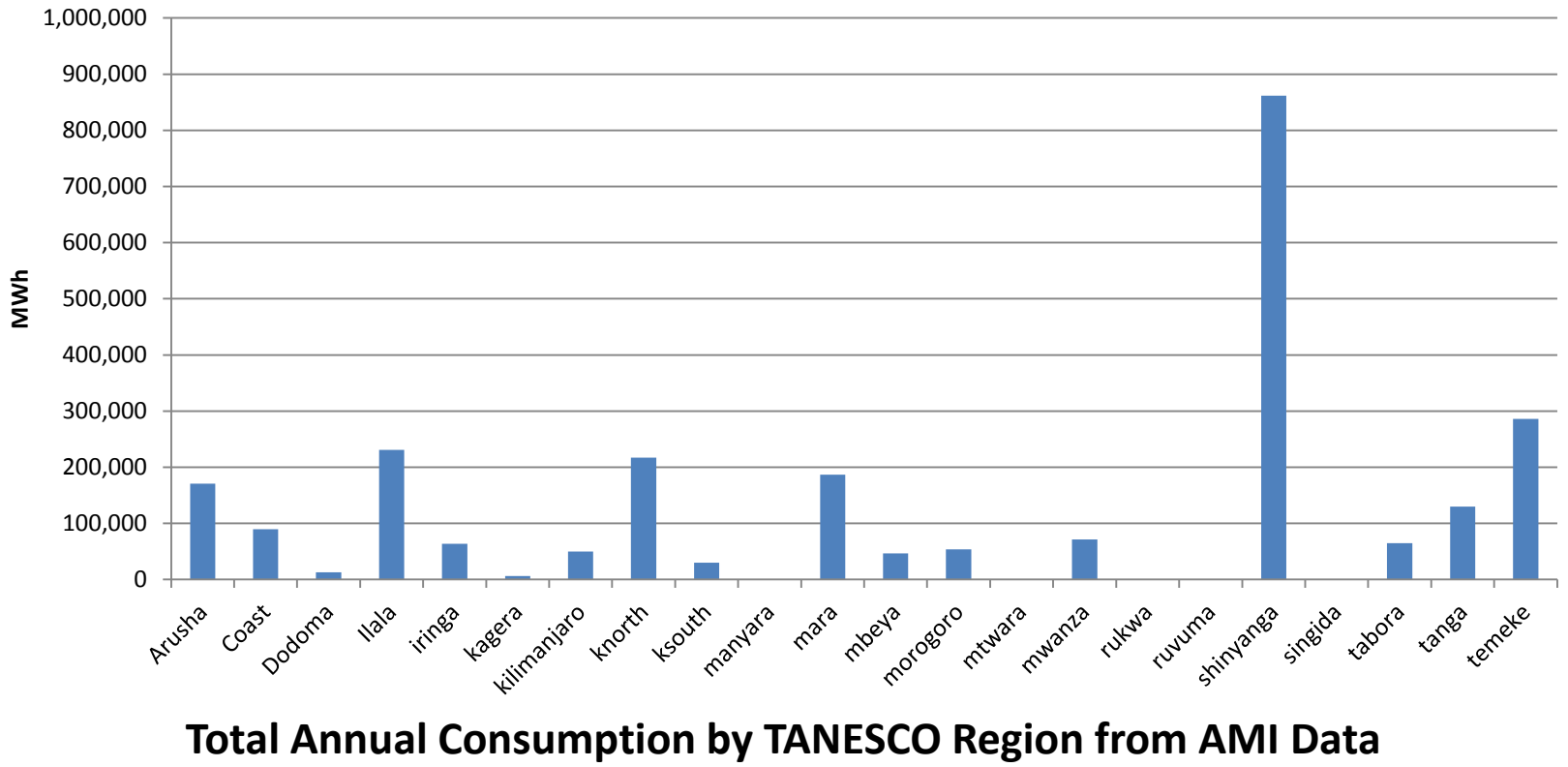
- Facility Characteristics:
  - Air Conditioners
  - Lighting

Activity 3. Analyze Trends Across Sample of Customers - Quality Group Limited

- Recommendations:
  - Close vents that are not needed for air conditioning
  - Use efficient lighting
  - Use air doors to reduce infiltration
  - Consider creating air-barrier in the atrium



Activity 3. Create System Load Profiles



Total Annual Consumption by TANESCO Region from AMI Data

Activity 4. Conduct Energy Analyses of DSM Measures

- Customer Classification: Construct prototype facilities
- Create a list of energy efficiency measures
- Conduct energy savings calculations for the selected energy efficiency measures

Activity 4. Customer Classification

- Ideal Approach
  - Ideally, we would start with the common subsector building types for each of the residential, commercial and industrial sectors
- Challenges
  - No classification for clients
  - No annual load shape data
- Alternative approach
  - Classified representative customers based on electricity consumption rate class instead of subsector building types
  - Disaggregate electricity use based on consumption level

Activity 4. Customer Classification – AMI Analysis by Rate Class- T1

- To estimate the number of residential vs. commercial customers
  - Create consumption bins:
    - Average Consumer Under 33rd Percentile
    - Average Consumer Between 33rd and 66th Percentile
    - Average Consumer between 66th and 95th Percentile
    - Average Consumer in top 5th percentile
  - Removed outliers for examples electricity use of less than 100kWh per year
  - Categorize based on consumption bin as residential if they were fall under bins 1 & half of 2 and the rest as commercial. This is to reconcile with the report created by Hatch.

Activity 4. Customer Classification – AMI Analysis by Rate Class- T2

- To estimate the number of industrial vs. commercial customers
  - Create consumption bins:
    - Average Consumer Under 33rd Percentile
    - Average Consumer Between 33rd and 66th Percentile
    - Average Consumer between 66th and 95th Percentile
    - Average Consumer in top 5th percentile
  - Removed outliers for examples electricity use of less than 500kWh per year
  - Categorize based on consumption bin as commercial if they were fall under bins 1 & 2 and the rest as industrial

Activity 4. Customer Classification – AMI Analysis by Rate Class- T3

- All industrial

Activity 4. Customer Classification – AMI Analysis by Rate Class- D1

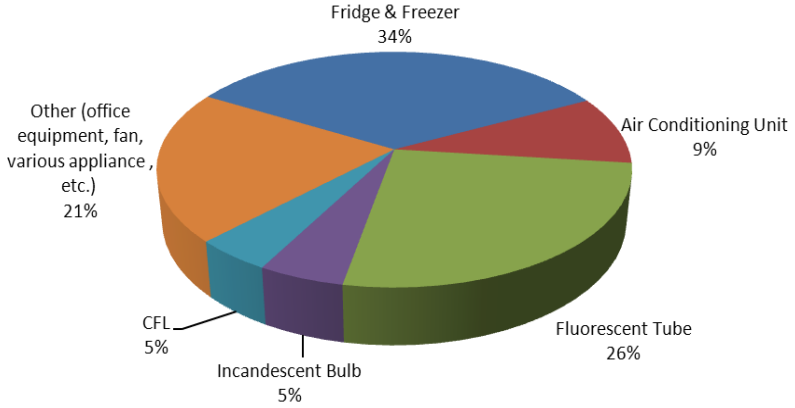
- All residential

Activity 4. Customer Classification – Aggregate consumption and number of Customers

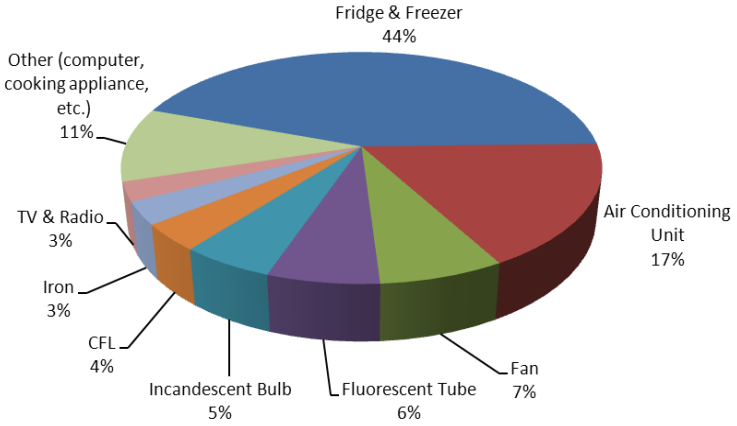
Customer class	No. of customers	Units Sold GWH	Source
D-1	453,409	2467	Calculated from difference of EWURA from T1, T2, T3
T-1	232,119	1,171	Representative Meter Data
T-2	1,512	411	Meter Data
T-3	440	2,573	Meter Data
Total		6,621	EWURA cost of service study

Activity 4. Customer Classification – Energy End-Use Disaggregation

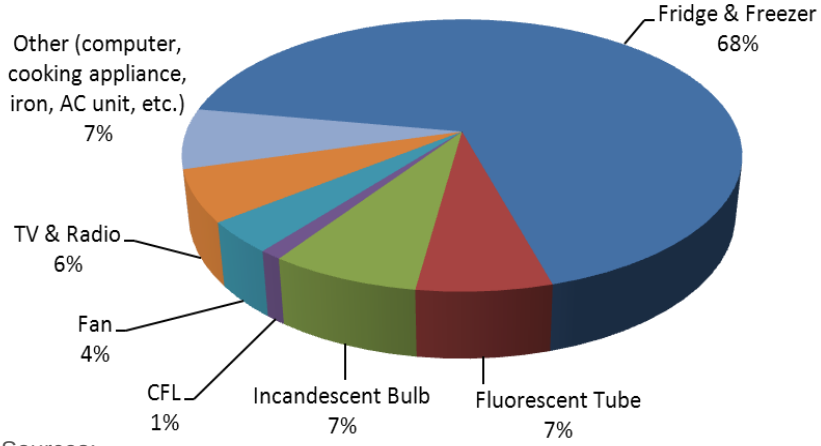
T1 Commercial Customer



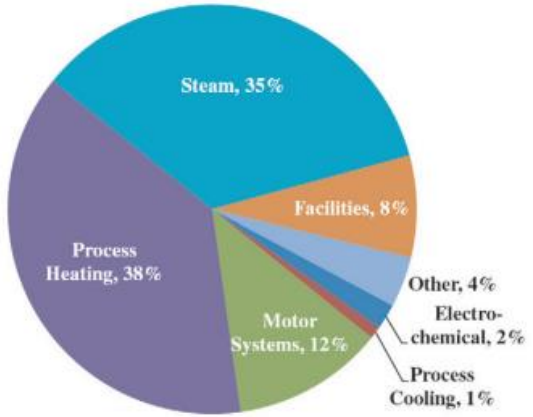
T1 Residential Customer



D1 Residential Customer



T3 Industrial Customer



Sources:

Hatch report for D1, T1 residential, and T1 commercial; GEA, 2012: Global Energy Assessment - Toward a Sustainable Future, Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis, Laxenburg, Austria.

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Activity 4. Create A List Of Energy Efficiency Measures (Appendix)

- Residential measures categories : 5
- Residential measures: 20
- Industrial measures categories: 40
- Industrial measures: 408
- Commercial measures categories: 24
- Commercial measures: 235
- Sources:
  - Hatch report
  - ICF Industrial Measure Database
  - ICF Commercial Measure Database
  - ICF Trip to Tanzania

Activity 4. Conduct Energy Savings Calculations For The Selected Energy Efficiency Measures

- A combination of engineering calculations and building energy modeling is used to model the various energy efficiency measures.
  - An example of simple engineering calculation: demand savings from going to CFL from incandescent bulbs is 60watts – 15watts= 45watts. Assuming the light bulb operates at 6 hours per day, the energy savings will be 99 kWh per year

Activity 5. Quantify System-wide DSM Potential

- Develop technical, economic, and market potential for demand and energy savings
- Estimate avoided utility costs
- Estimate current technology penetration and develop participation estimates
- Project energy savings over planning period through 2025

Activity 5. Develop Demand and Energy Savings Potential - Definition

- Technical Potential
  - is the amount of savings that would result from replacing all existing equipment that uses electricity with the most technically-efficient commercially-available equipment.
- Economic Potential
  - is the amount of cost-effective program potential that could be achieved absent program budget constraints.
- Achievable Potential
  - is the amount of cost-effective program potential that could be achieved given program barriers and program delivery effectiveness.

Activity 5. Develop Demand and Energy Savings Potential - Bottom-up analysis Approach

- Energy consumption disaggregated by various end-uses
- The disaggregated energy use was used as a constraint to ensure the product of energy consumption and number of measure units do not exceed the total consumptions.
- We also confirmed that the technical potential does not exceed the baseline energy
- Example: the number of incandescent bulbs * the energy consumption of the bulbs does not exceed the end use distribution of the lighting

Activity 5. Develop Demand and Energy Savings Potential - Bottom-up analysis Approach

- We estimate the savings potential for a measure on a per unit basis. For example demand savings from going to CFL from incandescent bulbs is 60watts – 15watts= 45watts. Assuming the light bulb operates at 6 hours per day, the energy savings will be 99 kWh
- Estimate the number of units affected. Divide appropriate end-use aggregated energy consumption for TANESCO by baseline energy consumption. For example, T1 end-use for incandescent light bulbs is 65 GWh. At 60 watts for each bulb this equates to around 495,000 light bulbs.
- Multiply number of units affected by energy and demand savings. For example, there would be 49 GWh and 22MW saved

Activity 5. Develop Demand and Energy Savings Potential - Measure Cost

- Cost of technology
  - Hatch report
  - African offices of Johnson Control
  - Conversion factor between North America and Tanzania for missing prices
    - USD to TZS
    - Shipping costs
    - Import Tariff
  - Missing information
- Cost of labor
  - World Bank report

Activity 5. Estimate Avoided Utility Costs

Avoided utility cost is the financial cost of additional infrastructure for a public utility to provide one more unit of power to an end-user.

Planning Year	Units	Avoided costs without inflation
2012-2035	per kW	$2,710 – nominal or total cost per unit of capacity.
2012-2018	per kWh	$0.06
2019-2035	per kWh	$0.09

Source: Power System Master Plan

Activity 5. Estimate Current Technology Penetration And Develop Participation Estimates

- Hatch report
- Work with research group or other departments at TANESCO
- Past experience of DSM studies in the region

Activity 5. Project energy savings over planning period through 2025 - Demand Response and TOU Rate Structure

- Demand savings potential from implementation of Time Of Use (TOU) rate structure is 244MW
- Technical potential from Demand Response is 126MW and the economic potential is 26MW. The programs could include:
  - Direct load control—utility-controlled switches on specific devices, e.g. water heaters, AC units
  - Curtailment incentives—customer curtails load on utility request, is paid for measured kW reduced during that period
  - Demand Response tariffs

	TOU			Demand Response	
	T1	T2	T3	T3	Total Demand Savings (MW)
Maximum Technical Potential	8	7	229	126	370
Economic Potential	8	7	229	26	**270**

Activity 5. Project energy savings over planning period through 2025 – Maximum Technical Potential

- Maximum Technical Savings Potential-Demand (MW)

Measure	D1 Residential	T1 Residential	T1 Commercial	T2 Commercial	T3 Industrial	Total Demand Savings
Lighting Upgrade	12.75	1.11	15.25	0.45	-	29.56
Lighting Control	-	-	1.46	0.04	-	1.50
Split AC System Upgrade	-	-	13.35	0.65	2.55	16.54
Cooling Control	-	-	1.40	0.07	0.41	1.87
Air Sealing	-	-	3.07	0.15	0.89	4.10
Industrial Preventative Maintenance Measures	-	-	-	-	-	-
Motor System Upgrade (None-Air Compressor)	-	-	-	-	17.66	17.66
				Total Demand Savings (MW)		71.24

- Maximum Technical Savings Potential-Energy (GWh)

Measure	D1 Residential	T1 Residential	T1 Commercial	T2 Commercial	T3 Industrial	Total Energy Savings
Lighting Upgrade	9.31	0.81	11.14	0.33	309.80	331.38
Lighting Control	-	-	1.07	0.03	24.78	25.88
Split AC System Upgrade	-	-	22.83	1.10	6.60	30.53
Cooling Control	-	-	7.99	0.39	2.31	10.69
Air Sealing	-	-	17.49	0.85	5.06	23.39
Industrial Preventative Maintenance Measures	-	-	-	-	262.78	262.78
Motor System Upgrade (None-Air Compressor)	-	-	-	-	122.44	122.44
					Total Energy Savings (GWh)	807.09

Challenges and Recommendations for Future Studies

- Commercial and Residential building characterization
- Industrial sub-sector characterization
- Building and sub-sector baseline information about consumption and other energy features
- Market research about efficient available technologies including energy features and price
- End-use survey for residential, commercial, and industrial sub-sectors
- Appliance standards establishing minimum efficiency baselines, test procedures, and labeling.

Activity 6. Recommend DSM Tariff and Program Options

- Identify most promising programs and tariffs ranked by savings potential and cost-effectiveness.
- Work with TANESCO to gather program design consideration such as:
  - Marketing
  - Customer outreach channels
  - Administration process and cost
  - Monitoring and evaluation methods

A1 - Industrial Customer Classification

- Ammonia & Methanol
- Cement
- Chemical
- Fabricated Metal
- Food & Beverage
- Iron & Steel
- Jute
- Manufacturing
- Mining
- Non-Metallic Minerals
- Oil & Gas
- Petroleum & Refining
- Plastics & Rubber
- Potash
- Power Generation
- Primary Metals
- Pulp & Paper
- Sawmills & Wood
- Textile
- Transportation
- Water Treatment

A2 - Commercial Customer Classification

- Large Office
- Medium Office
- Small Office
- Warehouse
- Stand-alone Retail
- Strip Mall
- Primary School
- Secondary School
- Supermarket
- Quick Service Restaurant
- Full Service Restaurant
- Hospital
- Outpatient Health Care
- Small Hotel
- Large Hotel
- Midrise Apartment

A3 - Energy Efficiency Measures- Residential

- Lighting Upgrade
- Refrigerator upgrade
- Efficient Behavior
- Reduce Air Leakage

A4 - Energy Efficiency Measures-Commercial

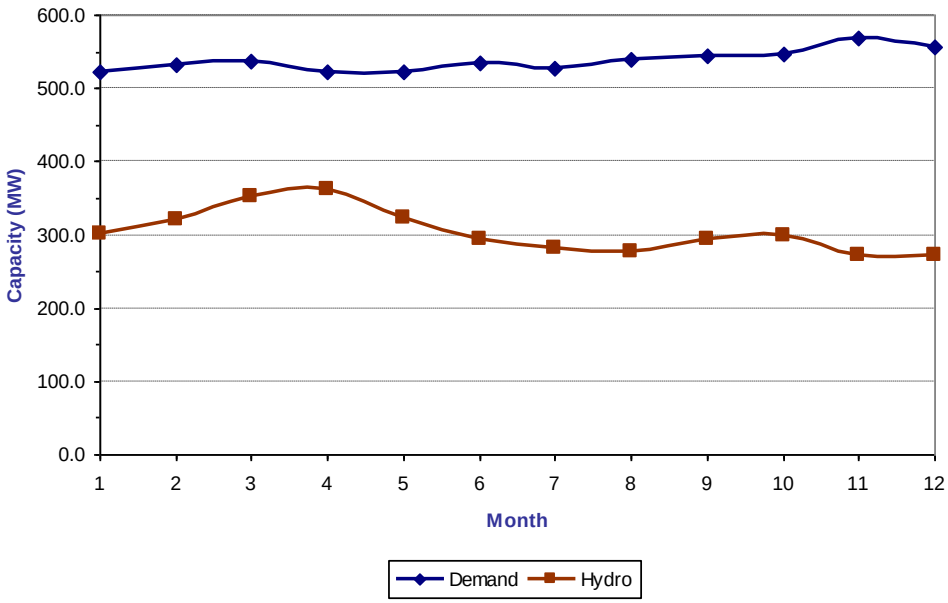
- Reduce Air Leakage
- Lighting Occupancy Sensor
- Air Conditioning Occupancy Sensor
- Lighting Upgrade
- Air Conditioning Upgrade
- Multi-VRF Air Conditioning System
- Window Films to Reduce Solar Gain
- Ceiling Insulation
- Efficient Behavior
- Efficient Water Heater
- Efficient Refrigerator
- Efficient Freezer
- Cold Drink Vending Machine
- Water Chiller Upgrade
- Beverage Machine Upgrade
- Efficient Ice Machine

A5 - Energy Efficiency Measures-Industrial

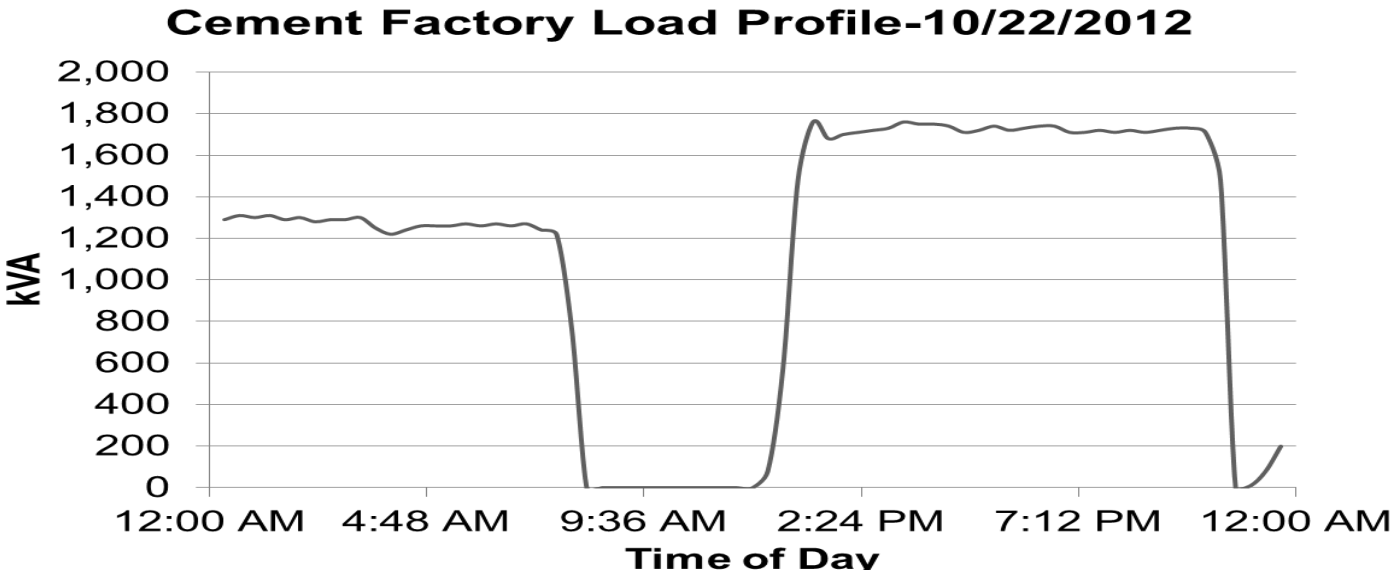
- Direct Load Control
- Interruptible Tariff
- Time of Use Tariff
- Power Factor Correction Program
- Motor Upgrade
- Variable Speed Drive
- Lighting Upgrade
- Lighting Occupancy Sensors
- Multi-Variable Refrigerant Flow System
- Lighting controls: occupancy sensors
- Compressed Air Storage
- Water Chiller Upgrade
- Air Compressor Upgrade
- Eliminate compressor air leaks
- Steam Trap Repair
- Doors, Covers and Curtains
- Improve insulation of refrigeration system
- Pump Impeller Trimming
- Energy Management Systems
- Reduce Air Leakage
- Air Conditioning Occupancy Sensor
- Ceiling Insulation
- Replace compressed air use with mechanical or electrical
- Efficient Lighting Design
- Refrigerator upgrade
- Minimize operating air pressure
- Preventative Pump Maintenance?
- Preventative Packaged HVAC Maintenance?
- Preventative Compressor Maintenance?
- Preventative Kiln Maintenance?
- Preventative Boiler Maintenance?
- Preventative refrigeration/cooling system maintenance?

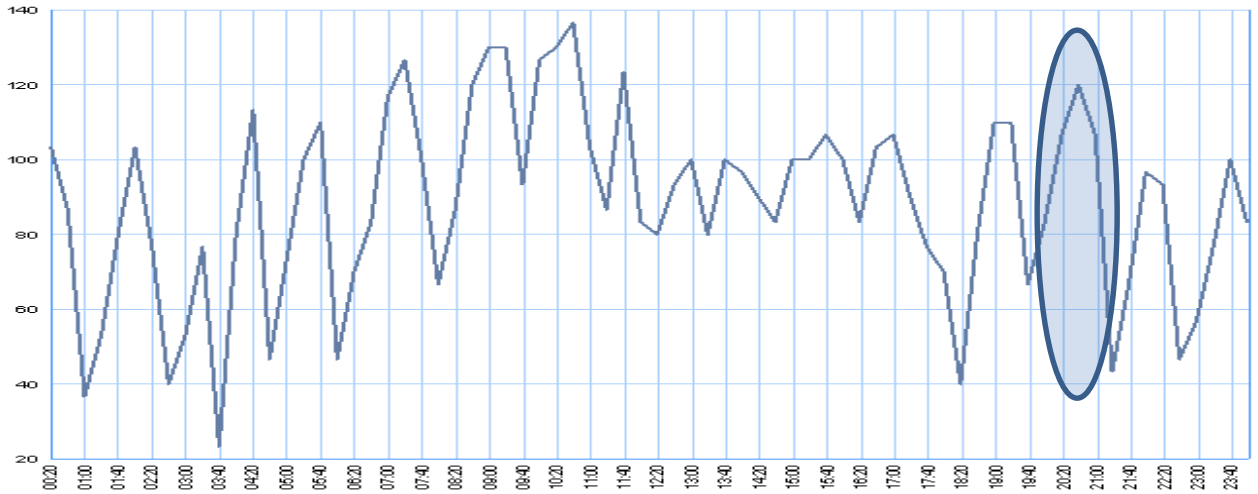
A6. DR Programs Applicable to TANESCO?

- Smart meters installed on 16000 of the largest customers
- Loading factor is low, that is peak demand is much greater than the average demand
- Generation is Hydro-Power dominant

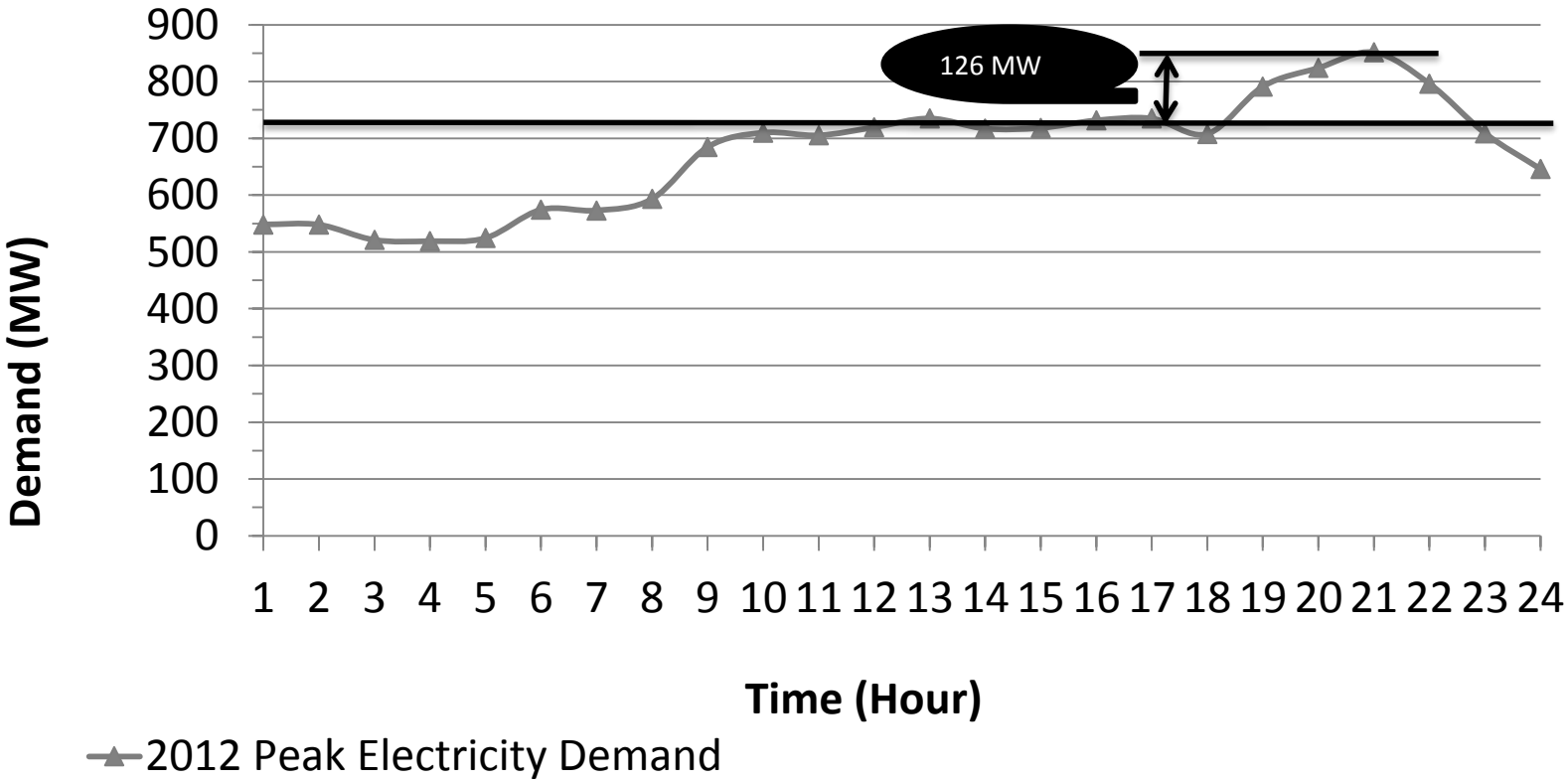


A7. Need for DR programs?





A8. impact of demand response programs



A9. Impact of DR Program