Estimating Electrical Load Characteristics of Households using A Naive Engineering Appliance Saturation Technique: Case of Uganda

Presentation by

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Background

- Understanding the behavior of electricity consumers is vital prior to planning, operation and expansion of power system networks.

- The development of the load pattern and understanding consumers' power usage can help to define important parameters.

- Justification of this research is against the need to have organized consumption pattern to help in power systems studies and analysis.

- The scope of the research is focusing on domestic electrical users.

Introduction

- According to *Yibeltal et al (2024)*, load profiles of communities tend to differ significantly across locations, sectors, and time.

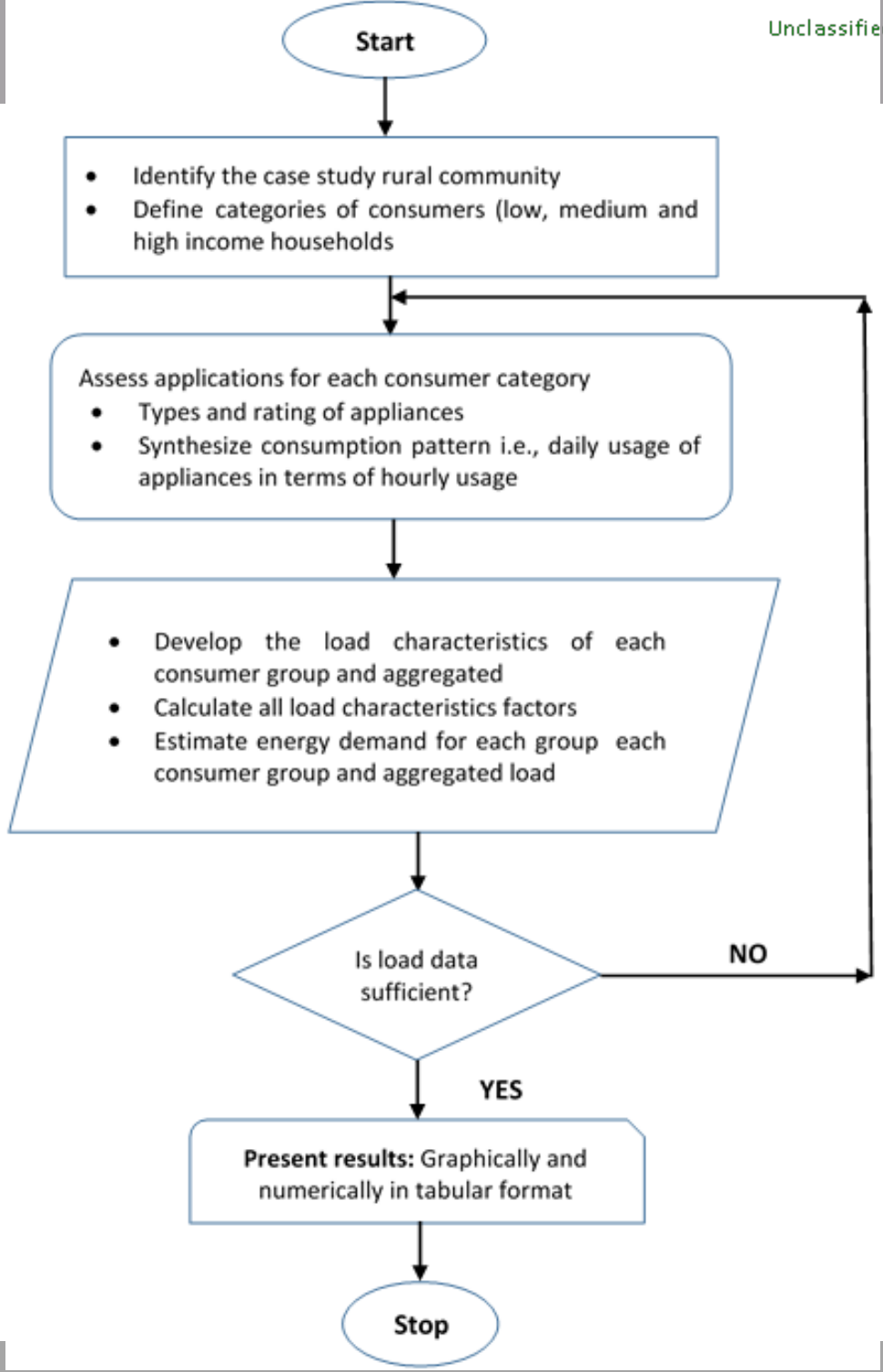
- The research presents a naive methodology to characterize daily load profile of domestic electricity consumers using synthetic data for communities in developing countries as a case study (Uganda).

- Average consumption and stochastic load profile of a single household and a sample community during weekdays, weekends, and holidays are analyzed with 30 minutes resolution and implemented using excel.

Methodology

Steps followed to execute the research are summarized in a flow, procedure to achieve the objectives chronologically

Domestic electrical consumers were grouped into: low, medium, and high income groups (to formulated to reflect both income and consumption levels).



Methodology …

Demand: average load over a defined period, calculated by dividing the energy consumed during the interval to the number of hours in the interval.

$$Demand = \frac{Energy\ during\ the\ interval, Wh}{interval\ range, hours}$$

Demand factor: the ratio between the peak demand and the connected load, i.e. between really measured peak and maximum theoretical peak; this ratio is usually considerably less than 1.

$$Demand\ Factor, DF = \frac{Peak\ or\ maximum\ demand, W}{connected\ load, W}$$

Methodology …

Load Factor: the ratio between average demand and peak load in a given period. It is an indicator of which peak value level is maintained during the period under study (usually a day, a season or a year).

$$Load\ Factor, LF = \frac{Total\ energy\ during\ period, Wh}{Peak\ or\ maximum\ demand, kW\ \times period, hours}$$

Diversity factor: the ratio of the sum of individual maximum demands of various subdivisions of a system to maximum demand of the whole system.

$$Diversity\ Factor, DF = \frac{\sum(individual\ maximum\ demands)}{maximum\ demand\ f\ aggregated\ load\ or\ system\ load}$$

Results

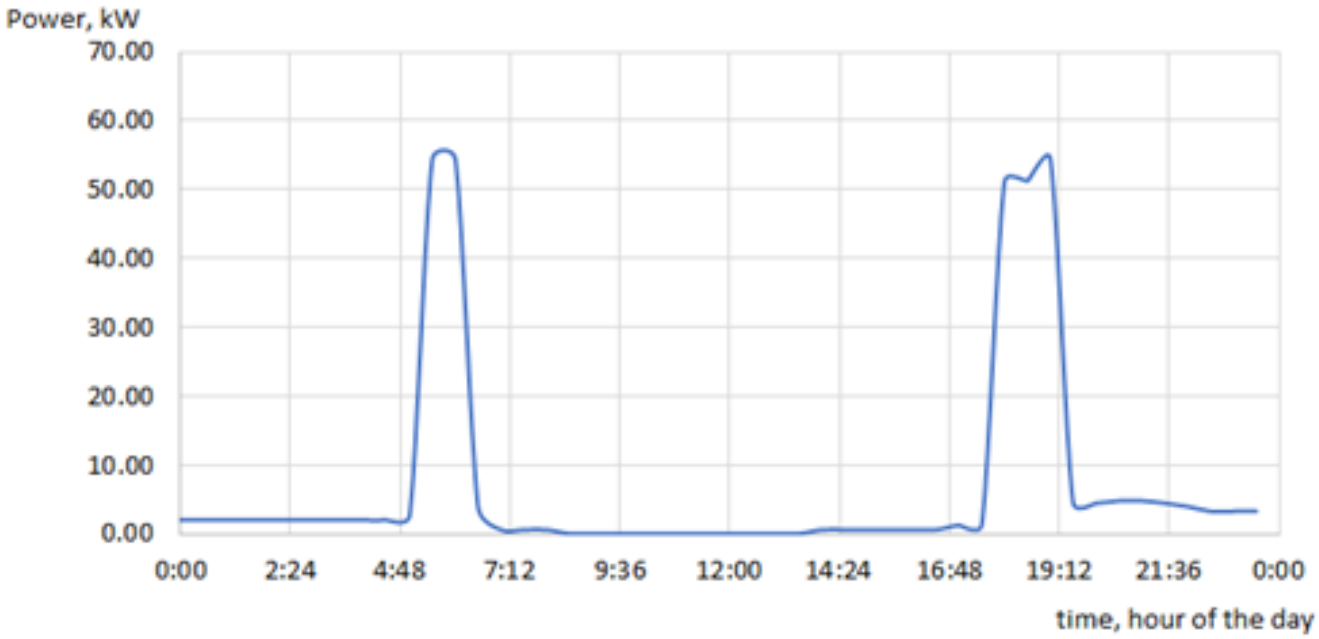


Figure 1. Load Curve of the proposed 50 Load Consumer Households

Table 1: Load Curve Parameters of Low Income Household Group

Parameter	Value	Unit
Daily electrical energy consumption per household	3,304.50	Wh/day
Daily electrical energy consumption for 50 households	165.23	kWh/day
Average Demand for the 50 households	1.16	kW
maximum demand for the 50 households	54.50	kW
Load Factor for the total demand	12.63	Percentage
Demand factor for the total demand	97.71	Percentage

Results ...

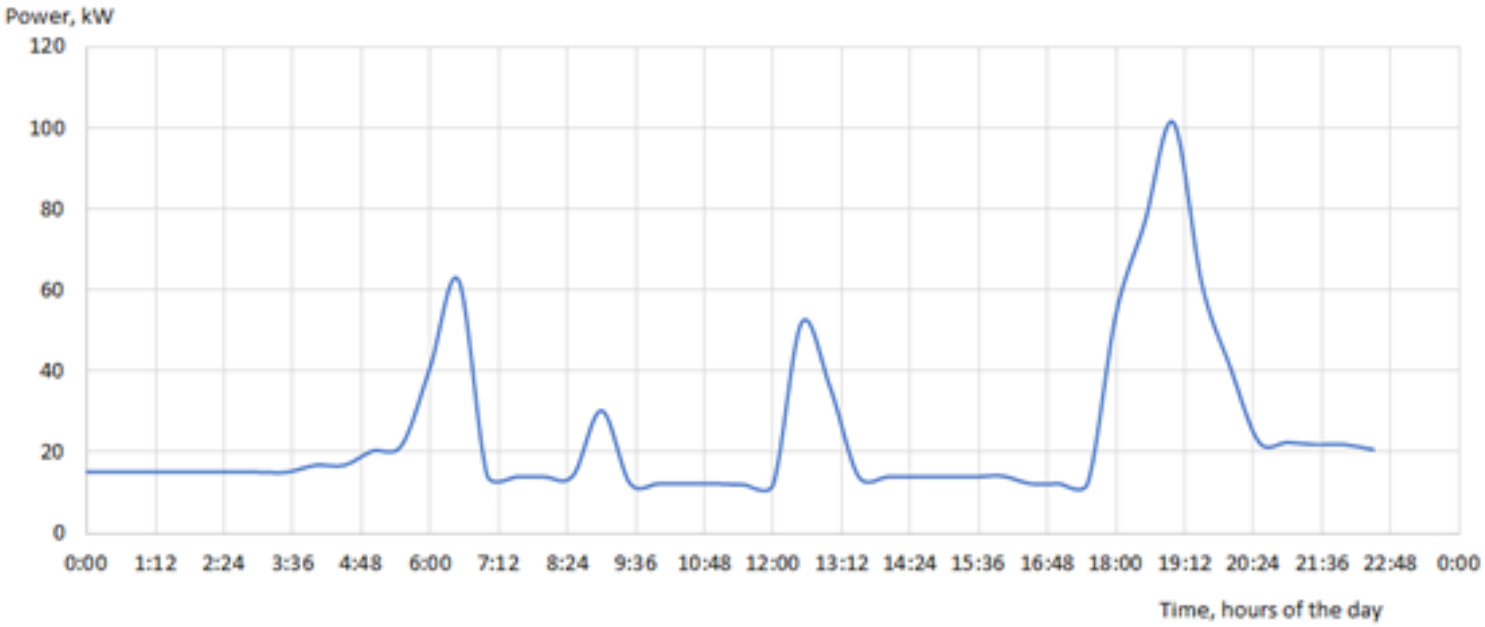


Figure 2: Load Curve of the 40 medium income households

Table 2: Load Curve Parameters of Medium Income Household Group

Parameter	Value	Unit
Daily electrical energy consumption per household	14,083.30	Wh/day
Daily electrical energy consumption for 40 households	563.33	kWh/day
Average Demand for the 40 households	2.98	kW
maximum demand for the 40 households	101.35	kW
Load Factor for the total demand	23.16	Percentage
Demand factor for the total demand	70.82	Percentage

Results ...

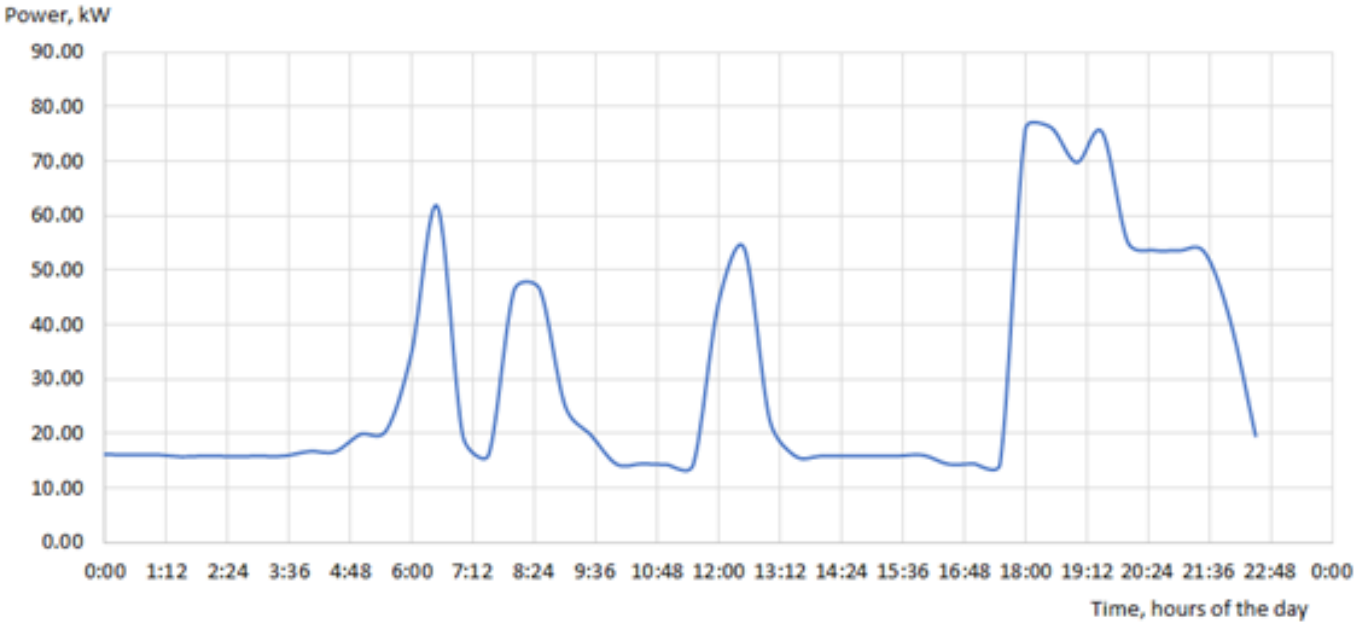


Figure 3: Load Curve of the 10 high income households

Table 3: Load Curve Parameters of 10 High Income Household Group

Parameter	Value	Unit
Daily electrical energy consumption per household	68.035	kWh/day
Daily electrical energy consumption for 10 households	680.36	kWh/day
Average Demand for the 10 households	2.95	kW
maximum demand for the 10 households	76.22	kW
Load Factor for the total demand	37.19	Percentage
Demand factor for the total demand	53.86	Percentage

Results ...

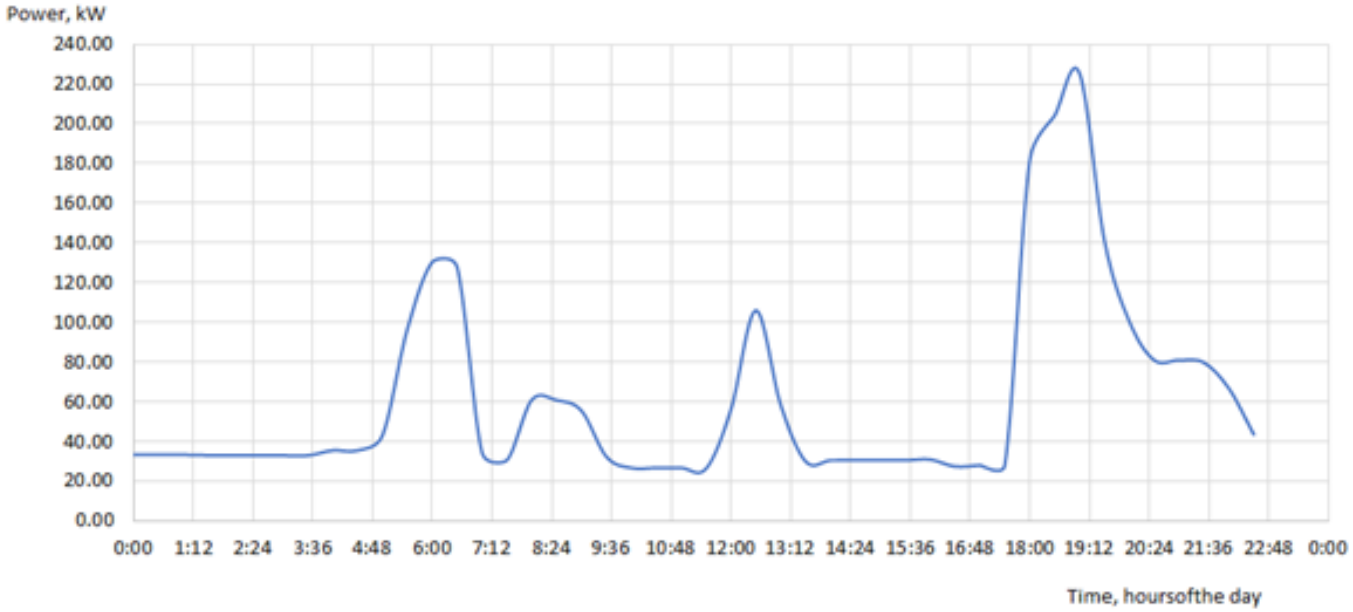


Figure 4: Load Curve of the aggregated Load combining all groups

Table 4: Load Curve Parameters of the community (aggregated load)

Parameter	Value	Unit
Demand Factor for the entire community	66.25	Percentage
Load Factor for the entire community	25.90	Percentage
Load diversity factor for the community	1.0288	Unit less
Average Demand for the entire community	7.09	kW
Maximum demand for the community	225.54	kW

Results ...

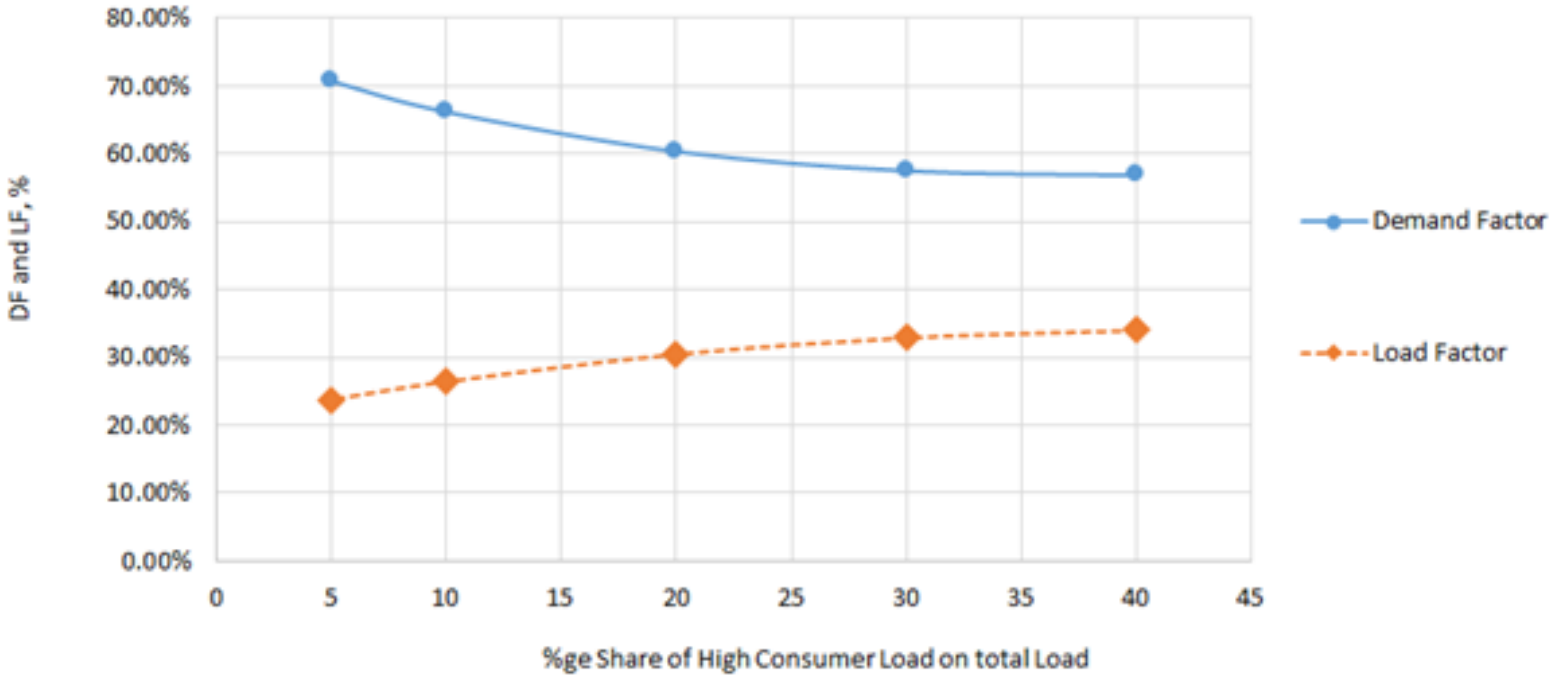


Figure 5: Plot of Load Factor and Demand Factor against percentage share of aggregated load by the HIH in the community

- The demand factor is inversely proportion to the demand level as the number of high consumer groups increases the demand factor decreases.
- Load factor increases with portion of high consumer groups.
- Also the diversity factor varies in an inverse manner, it decreases otherwise.

Conclusions

A naïve engineering appliance saturation methodology to develop electrical load characteristics and electrical energy consumption of residential electrical consumers is presented based on synthetic data.

Appliances considered are: lighting (in- and out-door) and thermal needs (cooking, water heating, micro-wave, air fryer, ironing etc.). Lighting and thermal applications are the most dominating needs.

Load curves generated for three groups of consumers: low-, medium- and high-consumer households, and later into an aggregated load profile using population of each consumer group.

Load curve parameters used to explain the behavior of the consumption pattern (high electrical energy consumers operate at low diversity factor and high load factor).

Recommendation & future research

Recommendations

- A detailed survey to establish the possible range of consumers income and consumption levels can be accomplished
- The dynamics or stochastic behavior of consumers can also be investigated

Future research

This research has focused on household electricity consumers, similar research can be implemented to include non-household users e.g., commercial and industrial consumers

Acknowledgement

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Asante … Danke … Arigato …

Okuhepa kinene …

Thank you

***for* your attention**