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Electricity Demand Model Generation Using Malaysian Typical Load Profile

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ABSTRACT –This paper presents an approach to stochastically generate load profile for residential consumers. The aggregated load profile from transformer side that situated in substation is used to model the individual load profiles. Each load profile represents the daily power consumption of a household with 5-minute time interval. The generated load profiles have the similarity index that need to be minimized. In order to minimize the objective function of load profile and find the optimum aggregation load profile, the Water Cycling Algorithm (WCA) has been utilized in this paper to maximize the similarity index of the profiles compare to existing typical aggregated load profile. This paper models Malaysian residential distribution network using OpenDSS power flow engine with integration of Matlab scripts in iterative manner. The results of this paper show that the aggregated load profile has acceptable similarity index with typical Malaysian residential load profile.

1. INTRODUCTION

Considering the diversity of the consumers' demand profiles in the network modelling [1] is very important for strategic network planning to better represent the demand characteristic. In contrast to other research works by [2] and [3] which only consider the aggregated demand profiles and a relatively small number of LV consumers. The residential demand profiles modelling tool developed by Centre for Renewable Energy Systems Technology (CREST), Loughborough University, UK [4] is used by many researchers to generate load profiles. However, this tool needs excessive initial data inputs such as household appliances type, time of use, maximum demand and etc. The CREST tool has been applied for UK which is not suitable to be performed for other countries due to different geographical locations and weather as well as different type of appliances. Hence, the modelling of different type of consumer is the main challenge in this paper. It can be highlighted that the stochastically load model generation for unlimited load profile in residential sector is proposed in this paper. In other words, this paper introduces the methodology to generate the load profiles for unlimited number of consumers that are connected to the same substation. Hence, an optimization problem with Objective Function (OF) is introduced to be optimized using a meta-heuristic evolutionary algorithm called Water Cycling Algorithm (WCA) [5]. This algorithm has been used for many constraint optimization problems [6], [7] to find the optimum points of corresponding OF. The Open Distribution System Simulator (OpenDSS) software used as time series power flow engine to calculate the parameters of the network and extract the results in form of excel (.csv) files. The Matlab software has been connected to OpenDSS to run optimum power flow in iterative manner. Figure 1 shows the main flowchart of load profile generation that has been applied in this paper. The After Diversity Maximum Demand (ADMD) of each consumer type was obtained from Tenaga Nasional Berhad (Malaysian Utility Company) guidebook [8] as shown in Table 1. As Malaysia is located in a tropical region without seasonal weather variation, the consumer demand patterns are relatively similar throughout the year for a given consumer type [9].

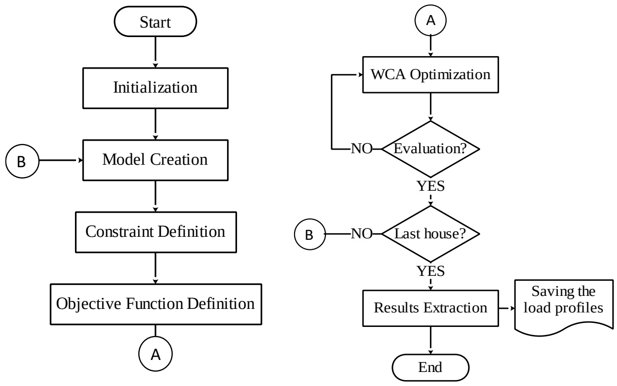

Figure 1 Stochastically load profile generation using WCA

The following shows the steps of modelling and performing the mentioned above methodology for load profile generation in this paper.

A. Initial inputs

1) *Maximum demand:* The maximum demand of each household is taken from [10] as shown in Table 1.
2) *Probability of household:* The types of the households in Malaysia premises is used in this paper to distribute the houses. This distribution is based in Table 1.
3) *Data resolution (144 data) for 10 minutes*
4) *Minimum base load (2% of the maximum demand)*
5) *Typical load profile:* The targeted load profile after aggregation of individual load profiles.
6) *Constraints:* The following shows the constraints of the load profile generation.

   a) Energy consumption per day (kWh)

The house energy consumption per day should be between the minimum and maximum energy consumption from the initial inputs. For this paper the minimum and maximum daily energy consumption is grabbed from the Malaysian household electricity bill average for different type of the houses. Table 1 shows the utilized minimum/maximum energy consumption for different type of the houses in Malaysia. To generate this table, 100 houses are studied to extract the average values.

$$Min_{energy} \le E_{house/day} \le Max_{energy} \quad (1)$$

   b) Basic load violation

The basic load of each houses is assumed 2% of the maximum demand of the houses. In other word, the minimum power consumption of each household is considered in this paper as basic load of load profile. This is one the constraints of the optimization problem that need to be minimized.

$$Min_{AP_i} \geq Min_{P_{base}} \quad (2)$$

c) Maximum Power limit

Another constraints of the optimization problem is Maximum Demand (MD) limitation for load profile. The MD of aggregation load profile should be less than the MD of typical load profile that can be written as follows.

$$AP_i \leq Max_{TP_i} \quad (3)$$

d) Similarity average

The typical load profile is divided to 10 sessions, get the average of each session and normalized it. On the other side, the aggregation load profile should be divided to the same as typical load profile sessions and normalized one is compared with the corresponding session. The similarity index is one the constraints that can be written as follows:

$$S(i)_{TP} - [5(\%).S(i)_{TP}] \leq S(i)_{AP} \leq S(i)_{TP} + [5(\%).S(i)_{TP}] \quad (4)$$

B. Objective function:

Objective Function (OF) of load profile optimization problem can be defined as minimization of the similarity index of the aggregation load profile compare to typical load profile. The subtraction of these two elements should be minimized to reach the best possible similar load aggregation compare to typical load profile.

$$Min.\{OF = |S_{TP} - S_{AP}|\} \quad (5)$$

Table 1: The probability of load distribution and Maximum Demand as well as Energy assumption premises type

			Energy (kWh)	
Type of the house	Probability	MD	Max	Min
single storey	0.2	3	150	250
Double storey	0.2	5	250	350
Single storey, semi-detached	0.2	7	350	450
Double storey, semi-detached	0.2	10	500	700
Bungalow & 3-room condominium	0.1	10	500	700
Double storey bungalow & luxury	0.1	15	800	1000

2. RESULTS AND DISCUSSION

This paper considers 300 households in residential area as a case study to generate the load profile for per houses. The given load profile for residential area in Malaysia is shown in [11]. It assumed that 300 consumers are connected to the same substation and the aggregated load profile is expected to be as much as possible similar to the typical load profile. Figure 2 shows the individual load profiles of houses and the aggregation load profiles is shown in Figure 3.

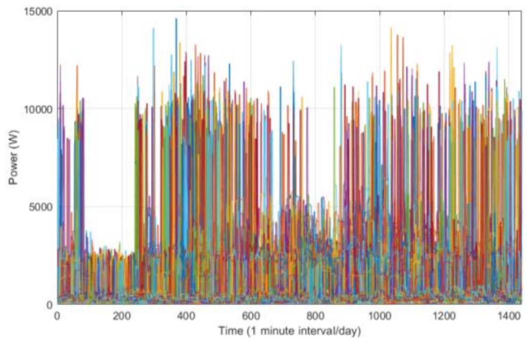

Figure 2 The generated individual load profile

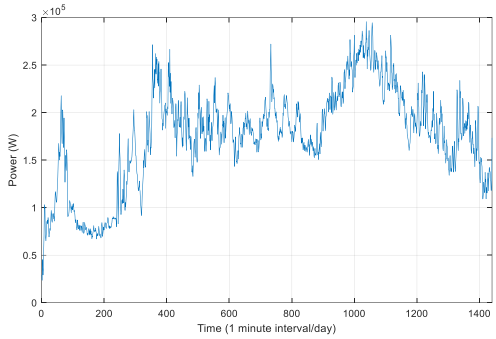

Figure 3 The aggregated load profile

3. CONCLUSION

In conclusion, this paper proposed a method to generate the load profile per individual based on the typical load profile. The result shows that the obtained aggregation load profiles of the houses are similar to Malaysian residential typical load profile.

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