Development of Simulation Model for Electrical Microgrid System

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ABSTRACT

This paper presents a model simulation for electrical microgrid system. This model can balance whole electrical microgrid system, It is a electricity management system, used system for supporting electricity system in the future. The simulation model is used for examining and monitoring the status and amount of electricity consumption and generation balance in whole grid system instant. At the same time, this simulation model also can be used to calculate the net electricity charge instant appearing in the whole system.

Keywords: *Electrical Simulation, Microgrid*

1. INTRODUCTION

Nowadays the energy consumption ways are increased continuously. Another side, the proportion of fossil energy in total energy consumption is gradually reduced. This is a serious problem not only in Thailand but also in the world. In the future, the renewable energy utilization will be changed to produce electricity from renewable energy. The houses, buildings, and offices are the producers (supply source) and the consumer (Demand Source) at the same time. As a result, this utilization, is able to gather the electricity generated from various renewable energy sources, into to a grid net system exchanging and sharing between, in the system, one energy consumer can buy electricity from grid and also can sell the electricity which produced by itself into grid system. Because different solar radiation value in different time of a day, the electricity generated by PV cell is not stable in every minutes. Another side, the electricity demand in daytime is different as in night time. Moreover the amounts of electricity demand inexactly too.

For balance the electricity system for small batch and allover image more difficult, that problem researcher becomes a barrier. If we use the information system to manage units electricity, record electricity amount produced and used, and administrate the system to balance renewable energy electricity. This enables a examination for the different conditions of real time system. Therefore, the system is more stable and we can use electricity worthily.

2. MATERIALS AND METHODS

To develop the technology of power quality maintenance for electrical microgrid system which is composed by decentralized power source and exist grid, the researcher has to study the different electricity consumption models and system of renewable energy together. The methods of research are to collect the data of performance, and the data is available in the production. (All the reference data for concept model design and development are com from School of Renewable Energy Technology (SERT) at Naresuan University.) In addition, the balance of electricity is handled with management data system, load balancing for small batch and allover image system. In this research, it is limited 6 systems of simulation model to show how to calculate, algorithm, the status and graphs in the microgrid system.

2.1 Load simulation

The measuring equipment was installed adjacent to the electricity meters of the customers. The power demand of each systems was recorded every 5 minutes for at least one year. As a result, the purpose of the analysis work of analysis is to create statistical demand curves for a forecast model. It is assumed that information is available in regard to the composition of the customers group of such as household, offices and industry.

The average power demand (P_{mean}) was calculated based on the total power demand for all day. E the total energy for all day, T total unit time for calculated per day [1].

$$E = \int_0^T P(t)dt \quad (1)$$

$$P_{mean} = \frac{\int_0^T P(t)dt}{T} \quad (2)$$

2.2 Electrical simulation

The main electrical production simulation is interest in Photovoltaic System at SERT, because there is measuring equipment to collect data of solar radiation value every 5 minutes (at the same time of power demand). Total plane of array irradiance in kWh/m^2 was calculated base on meteorological data from SERT and consequent calculated the Reference Yield (Y_r) and DC of electrical output was calculated by the Array Yield (Y_a) [2]. The calculation Photovoltaic system performance in this simulation software was followed IEC Standard 61724 [3]. Three of the performance parameters of IEC standard 61724 were used in this paper and calculated by the equations below;

2.2.1. Reference Yield (Y_r)

$$Y_r = H_T / G_{STC} \quad (4)$$

2.2.2. Array Yield (Y_a)

$$Y_a = E_a / P_O \quad (5)$$

2.2.3. Final Yield (Y_f)

$$Y_f = E_{PV} / P_O \quad (6)$$

Where

P_O = Peak Power (W_p)
H_T = Mean daily irradiance in array plan (kWh/m^2.d)
G_{STC} = Reference irradiance at STC (1 kW/m^2)
E_a = Array output energy (kWh)
E_{PV} = Energy to Grid (kWh)

2.3 Load balancing system algorithms

After the system finished load and produce simulation, load balancing system may be divided into 3 modes, which are demand, supply and island mode. In simulation model, there is a load balancing algorithm to calculate net metering for each household (it will be shown in block diagram below). For example, if power production is more than power load, the status of system will show the

electrical supply mode. It means there is electricity supply exiting in the grid. When finish the calculation, each household can know the electrical status of system. First, simulation software will calculate the net electricity units of each household, and then it will calculate the whole net units of electricity for whole microgid system. The system will report the electrical unit of each household. If load balancing unit is a subtract value, the electrical status will show the demand mode. It means the system need to outsource electric from existing grid to balance the system [4,5].

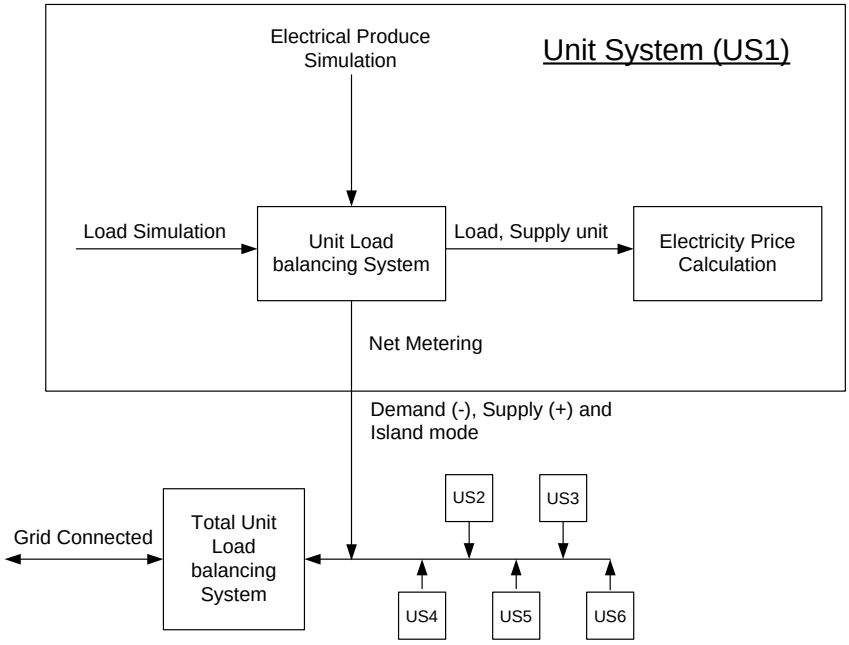


Fig. 1 Block diagram of the load balancing algorithm

3. RESULTS AND DISCUSSION

The result of simulation in this paper will be show only 1 day as example. It calculates from 00:00 am to 23:55 pm every 5 minutes and need parameters for calculate such as household, peak power load, type of load, peak power production, starting dates and ending dates. The table below shows the example data for calculation in simulation software.

Table 1 Example of parameters for calculate the electrical microgrid simulation software

House No.	House Name	Load Type	Peak Load (kW)	Peak Produce (kW)	Start Date	End Date
1	House1	Household	9	15	1/25/2008	1/25/2008
2	House2	Industry	9	5.5	1/25/2008	1/25/2008
3	House3	Office	10	3	1/25/2008	1/25/2008
4	House4	Industry	11	20	1/25/2008	1/25/2008
5	House5	Office	8	8	1/25/2008	1/25/2008
6	House6	Household	9	11	1/25/2008	1/25/2008

Remark : All related daily radiation data for power production calculation in this paper are collected in SERT.

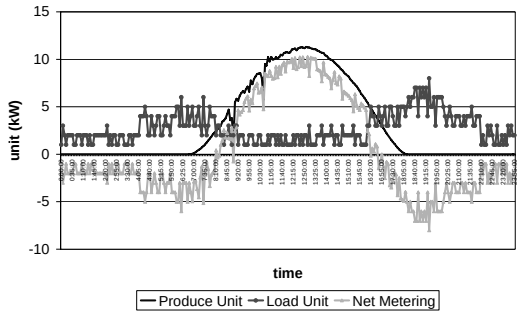
The table 1 will show the detail data as different types, such as load peak load and peak produce. It can show the ratio of the peak load and peak produce, which is different from each system. There are two important data concerned load balancing system. These two data are the load and power production. When the data are correct, the simulation software will generate power load and power production every 5 minutes on starting date and then it will calculate load balancing at the same time. After that, it will save data as the power load, power production and power of net metering for each household into database. The table and graph below show the result of simulation.

Fig. 2 Sample screen shots from electrical microgrid simulation software

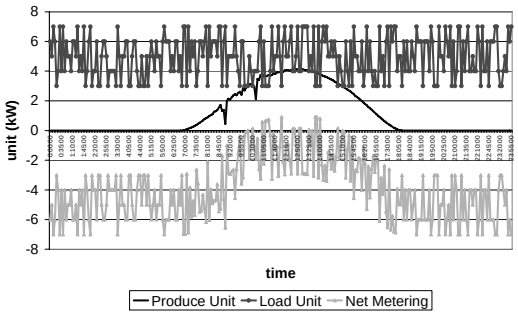
On the screen, it shows the frequency of real-time simulation is every 5 minutes. During the night from 00:00 – 06:00 am, the power electric of household comes from exist power grid because there is no solar radiation. From 07:00 am – 6:00 pm, the household can produce the electrical power from photovoltaic system and the household have to consume electrical power at the same time. The system is need to balance the load and produce, to calculate the net metering from load and produce system and show the electrical status for the each household. However, the unit of load, type of load and produce system are very different from each household. The algorithm of microgrid simulation is using units of load balancing before and after then it will balance total from load together. Continuously from 6:00 to 23:55 pm, the household will only use the electricity from existing grid.

The report of simulation software will display the static such as starting date, name of household, maximum of produce system, type of load, the real-time , solar radiation value, the total of load and produce unit, net metering and the electrical status. The software also can display the graph of each household (the graph will show below).

The graph shows the curve of power load, power produce and net metering after finish simulation for each system.



(a)



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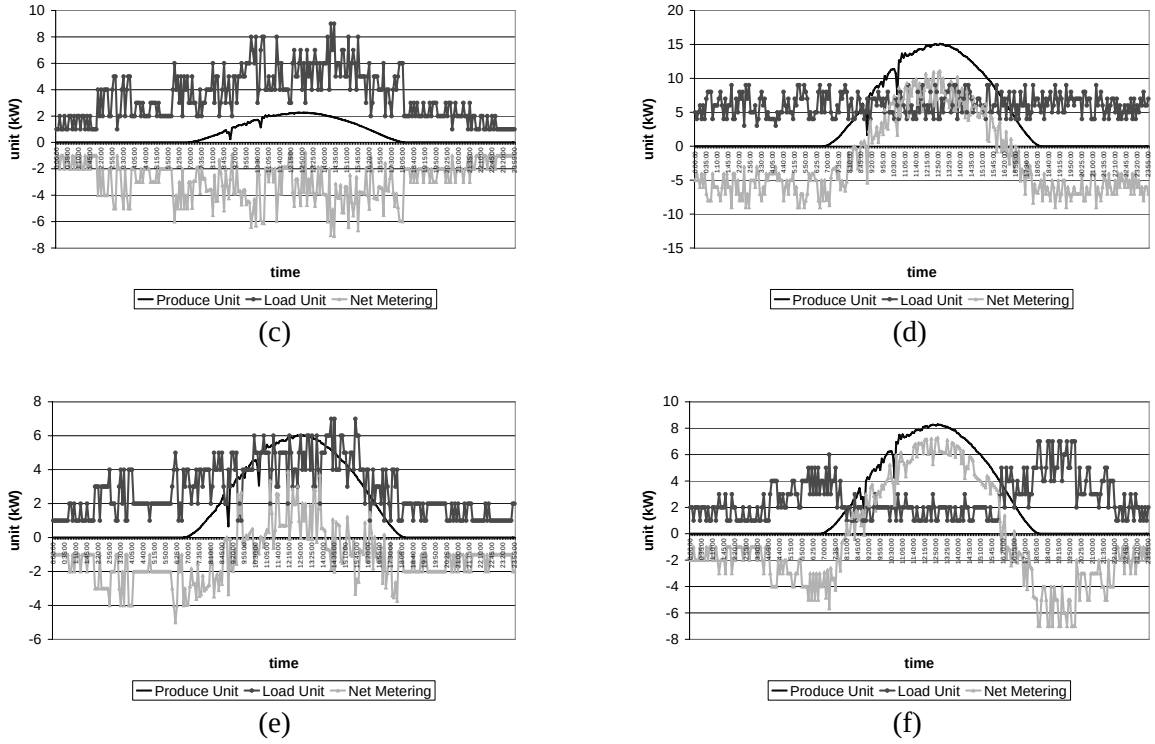

Fig. 3 Graph of the result of load, produce and balancing of each unit system
(a) house 1 (b) house 2 (c) house 3 (d) house 4 (e) house 5 and (f) house 6

Table 2 Result of the unit system from the electrical microgrid simulation software

House No.	Load in use (kWh)	Power production (kWh)	Load Charge (Baht)	Power production sell (Baht)	Net metering (kWh)	Net present value (Baht)
1	785	879.42585	2355	9673.68435	94.42585	7318.68435
2	1434	322.45614	4302	3547.01759	-1111.54385	-754.982405
3	1007	175.88517	3021	1934.73687	-831.11483	-1086.26313
4	1761	1172.56780	5283	12898.24580	-588.43220	7615.2458
5	812	469.02712	2436	5159.29832	-342.97288	2723.29832
6	753	644.91229	2259	7094.03519	-108.08711	4835.03519

Remark : 1) The net present value shows the subtract value, the money customers paying for Electricity Generating Authority of Thailand (EGAT) and the add value, which customer receives from EGAT.
2) For consuming electricity ("load in use" column) from EGAT, it costs 3 bath for one kWh electricity, and for supplying electricity ("power production" column) to EGAT, it will get 11 baht for each kWh electricity. [6].

After finish unit load balancing process, the software will calculate to net electricity unit and its direction. The report from simulation software can show the total load in use, total power production. The load and power production value which calculated based on electricity price calculation will be shown too.

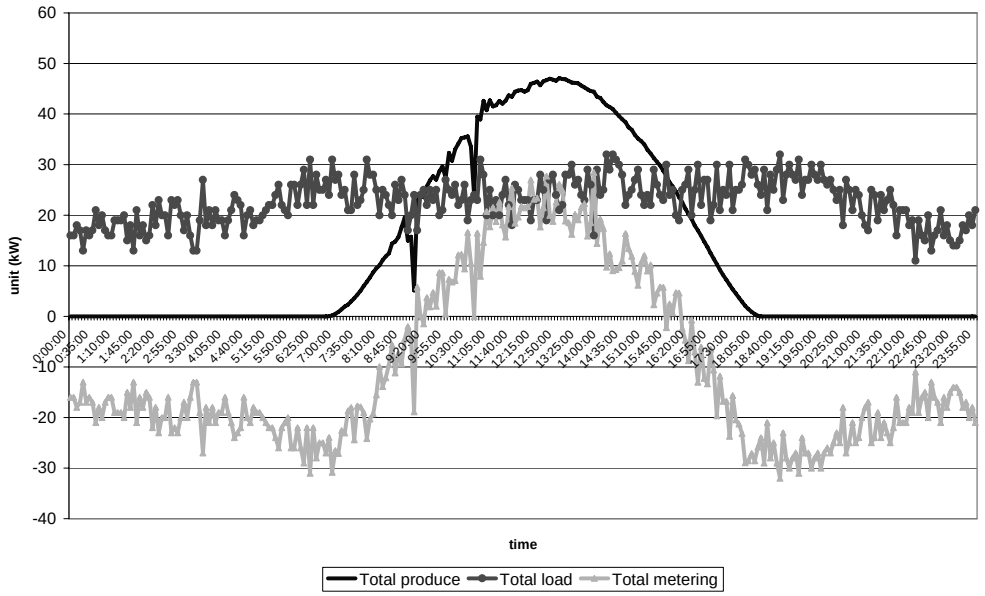

Fig. 4 Graph to show the result of total load, produce and balancing

4. CONCLUSIONS

Simulation software has been developed to calculate the load simulation, produce simulation and load balancing for unit and total system with graphic interface. The results show the algorithm for microgrid management system and effective the unit of electric energy. It allows the estimation of parameters of electric energy in the household. The user is guided step by step to input data for calculation process. When the data are correctly and completely entered, the software will start calculation automatically. The result shown on the screen and it can use to measure and predict.

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