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Demand Side Management for Reducing Rolling Blackouts Due to Power Supply Deficit in Sumatra

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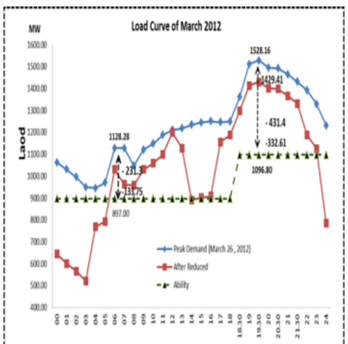
Graphical abstract



Abstract

When the high electricity demand growth is not matched by growth in generating sufficient capacity, deficit cannot be avoided. In Sumatera, power outages of up to 6 hours per day are part of the power crisis experienced. To date, deficits experienced by Sumatera require better management strategy and operation of electric power systems, taking into account the security system, reliability and customer service. This paper briefly discusses the impact of rolling blackouts on the community's economy and proposed demand-side management strategies as short term measure to overcome the power supply deficit in Sumatera. From the analysis, electricity savings in household equipment can save energy consumption by 98.79 MW at peak load and 97.55 MW for off peak load time.

Keywords: Deficit; supply-side management; demand-side management; retrofitting economic community

Abstrak

Apabila pertumbuhan permintaan elektrik yang tinggi tidak sepadan dengan pertumbuhan penjanaan kapasiti yang mencukupi, defisit tidak dapat dielakkan. Di Sumatera, gangguan kuasa sehingga 6 jam setiap hari adalah sebahagian daripada krisis kuasa yang dialami. Setakat ini, defisit yang dialami oleh Sumatera memerlukan strategi pengurusan dan operasi sistem kuasa elektrik, dengan mengambil kira sistem keselamatan, kebolehpercayaan dan perkhidmatan pelanggan. Kertas kerja ini membincangkan kesan ketiadaan bekalan elektrik terhadap ekonomi masyarakat dan strategi pengurusan berasaskan permintaan yang sesuai dicadangkan untuk mengatasi defisit bekalan kuasa di Sumatera. Penghematan lelektrik oleh peralatan rumah tangga boleh menjimatkan penggunaan tenaga sebanyak 98.79 MW pada saat beban puncak dan 97.55 MW pada saat di luar waktu beban puncak.

Kata kunci: Defisit; pengurusan sebelah bekalan; pengurusan permintaan; perkuatan, komuniti ekonomi

■1.0 INTRODUCTION

Since the last few decades, the electricity consumption per capita worldwide has shown significant increase due to the growth in population as well as the rise in living standards [1]. In some countries, it has caused imbalance between the electrical energy reduction and demand which results in energy deficit. In places like Sumatera, Indonesia, rolling blackout is common due to significant energy deficit. Power outages cannot be avoided and caused discomfort among people. The electric utility in Sumatera, Perusahaan Listrik Negara (PLN), has experienced significant electrical energy deficit due to its less power generation capacity than the peak load demand. Furthermore, the average age of most of its generation power plants is 30 years [2]. In Sumatra, the energy deficit has resulted in rolling blackouts for 2 to 3 hours, or even 6 hours. The enforced blackout created a lot of problems to consumers. As the blackout can occur at any time of a day and at any duration of time, consumers find it very difficult to cope with the situation. Industrial consumers, in particular, will find it very difficult to plan their activities. They may have to install their own generating set, thus increasing their operating cost. Furthermore, the unreliable and unstable power system can also cause short life span of many appliances.

To reduce rolling blackout, Sumatra may have to look beyond the traditional utility planning process. The government must now consider both supply and demand options. Various studies have shown that demand-side management (DSM) is one of the many options to solve the energy deficit problems.

1.1 Electrical Power System of Sumatra

The electrical system in Sumatra as shown in Figure 1 consists of northern Sumatra (North Sumatra Province and the Province Nanggroe Aceh Darussalam), Middle Sumatera (West Sumatra province, the province of Riau, Jambi, Bengkulu Province) and southern Sumatra (South Sumatra Province, the Province of Bangka Belitung, Lampung Province) electrical systems. Northern Sumatra's operation system is under the control of load arrangement unit, in which the system operator is under PLN Distribution and Load Control Centre of Sumatra. The electrical system of northern Sumatra is interconnected with 150 kV of Acheh and isolated subsystem of 20 kV distributions. The northern Sumatra's electrical system is also interconnected with other power systems, namely 275 kV system of PT Inalum.

Figure 1 Sumatra's power transmission systems

Power outages in northern Sumatra is still continue to occur due to the high electricity demand growth that is not matched by sufficient generation capacity. One of the main contributing factors to the problem is the delay in several power plant projects, such as steam power plant Nagan Raya (PLTU 2 x 100 MW) in Meulaboh-Aceh, Steam Power Plant Pangkalan Susu (PLTU 2 x 200 MW) in North Sumatera, and Steam Power Plant Teluk Sirih (PLTU 2 x 112 MW) in West Sumatera. Furthermore, delay in 330 MW geothermal power plants or Sarulla Geothermal Project in Tapanuli Utara, delay in construction of Asahan 3 hydropower (PLTA 170 MW) and PLTU Tarahan (2x100) in Lampung are also contributing factors. Another contributing factor is the damage of some generation plants, such as Steam Power Plant Labuhan Angin (PLTU 2x115 MW), due to aging machines and in Belawan (PLTU 40 MW) caused by the damage of its unit 1 engine steam power plant.

Table 1 shows the monthly peak load recorded in Sumatra from year 2000 until 2012, while Figure 2 shows the yearly peak load recorded for the same years. The highest peak load was recorded in March 2012 at 1528.2 MW. The highest numbers of blackout events was recorded in the year 2012 in December, which was as many as 33 times with the duration between 2 to 3 hours for each blackout and some cases reached up to 6 hours. Figure 3 shows the hourly load demand and hourly supply ability on March 26, 2012 with an installed power capacity of 2280.6 MW. The highest peak load was 1528.16 MW with deficit of 431.4 MW at 19:30 p.m. and power supply ability at 1096.8 MW. Outside peak load, the highest load was 1128.28 MW with a deficit of 231.3 MW at 06:00 am and power supply ability of 897.0MW. This condition occurred due to some plants that were not functioning properly, namely PLTU Belawan U1, PLTGU Belawan GT 1.1, 1.2- out of service, PLTGU Belawan ST 1.0- experienced problems and PLTGU Belawan GT 2.1, 2.2 due to emergency. Besides that, some plants do not conform to their installed power capacity [3-7, 9-10].

Table 1 Peak load during the year 2000 to year 2012

Month		**Peak Load Year 2000 up to 2012**											
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
January	742.3	768.0	849.7	835.0	866.5	971.3	1032.4	1017.3	1050.5	1171.2	1202.0	1352.4	1456.97
February	766.9	838.3	865.8	843.0	846.5	959.6	958.2	1029.9	1098.9	1168.2	1240.0	1383.0	1503.60
March	793.7	827.8	846.2	838.6	975.7	938.6	994.9	1039.1	1125.2	1206.3	1315.5	1424.76	1528.20
April	754.3	835.8	866.7	937.4	938.8	1047.5	1051.1	1010.4	1087.5	1232.8	1332.1	1418.62	1453.91
May	787.2	841.7	877.8	943.7	981.7	990.8	1003.0	1023.5	1076.6	1233.2	1301.5	1437.4	1494.90
June	800.1	834.9	883.6	955.6	949.8	1010.7	1007.6	1031.6	1090.4	1227.5	1309.5	1404.65	1519.40
July	800.8	823.5	892.3	831.5	980.2	946.0	1000.9	942.3	1130.7	1234.5	1306.8	1427.73	1524.40
August	838.0	824.6	809.5	930.9	999.6	976.2	972.6	1028.1	1129.3	1207.6	1350.6	1432.14	1510.90
September	850.2	805.5	805.3	922.4	1006.5	992.7	1002.7	1044.6	1183.7	1225.4	1332.6	1444.32	1513.30
October	865.7	776.5	816.8	929.8	998.8	998.9	1025.9	1030.7	1167.9	1197.2	1366.0	1438.21	1519.00
November	828.4	802.5	818.3	971.5	967.2	1021.7	858.7	1022.8	1163.6	1169.4	1315.7	1467.51	1523.82
December	827.5	808.5	838.0	937.7	1016.0	1070.2	999.6	1063.4	1138.5	1174.3	1326.9	1471.85	1523.90

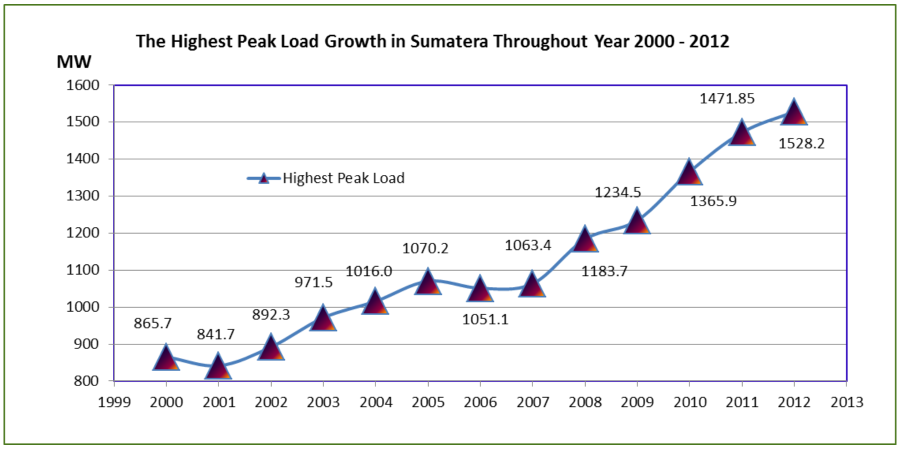


Figure 2 Peak load growth in Sumatera (2000-2012)

1.2 Impact of Rolling Blackout on Economy and Community

Rolling blackout carried out by PLN in almost all parts of Indonesia is one of the characteristics of the national energy security's fragility. This condition would be ironic for a country that has a wealth of energy resources, not just oil, coal and gas, but alternative energy resources such as renewable geothermal, wind, solar cells, wave and water. Due to frequent power outages, anxiety began to haunt the people and industry on a national scale.

From the social standpoint, various effects of rolling blackouts had been imposed since 2008. Power outages are often without prior notice and have negative impacts on customers/consumers. The problem of household electrical equipment damages are often the topic of complaints. In the employment sector, possibilities of employment dismissal are very large due to the decrease in productivity. Besides that, swelling of the employer's industry has caused the turnover number to not meet the daily production target. Moreover, there are even some companies/small industries that had to close down. In addition, sales of generators also potentially triggered jealousy in the community because it will further widen the economic gap between the poor and the rich. The rich can still do activities with the help of energy generators while the poor are not able to do much during power outages. Power outages greatly impact the economy. PLN policy with power cuts reaching 2-6 hours a day caused a big blow for most businesses as they heavily rely on electricity.

1.3 Demand Side Management

Demand-side management (DSM) is the process of managing energy consumption, generally to optimize the resources planned and implementation. DSM refers to utilized activities that can affect customers' electricity usage and ultimately produce a change in the utility's load shape. It has been traditionally seen as a way for the utility to delay the expansion of generation capacity. DSM actions include planning, monitoring and implementation of changes in time pattern or magnitude of a utility's load. The purpose of DSM is mainly to minimize energy (kWh) consumed by end-user and reduce the maximum demand (kW) for energy.

DSM's activities can be divided into two levels: i) Level I: Load shape objective, ii) Level II: End use. Load shape's objectives include load shaping measures that can change the time pattern and magnitude of utility's load. These measures include:

- Peak clipping which is generally considered as reduction of the system peak loads through direct load control.
- Valley filling which involves adding or building loads to the system during off-peak periods.
- Load shifting which is shifting loads from on-peak to off-peak periods.
- Strategic conservation results from load reduction in all or nearly all periods. It is a utility-induced program to reflect the modification in end-use consumption.
- Strategic load growth is a form of load building designed to increase efficiency in a power system. This load shape objective can be induced by the price of electricity and by the switching of fuel technologies (from gas to electric).
- Flexible load shape has the ability to modify utility's load shape on short notice. When the resources are insufficient to meet load's requirements, load shifting or peak clipping may be appropriate.

DSM reduces the generation margin, improves efficiency of system operation, transmission and distribution grid investment and operation efficiency, as well as manages the demand-supply balance in systems. DSM for customers is intended to control the growth of electricity demand by controlling peak load, temporary restrictions on the new connections in the critical areas that greatly affect the peak load increases and other measures on the customers' side. One of the strategies of DSM is energy savings, by reducing energy consumption in all sectors of customers especially during peak load. Electricity is a commodity that affects the lives of many people, therefore, provision for the public to be as economical as possible with due regard to quality and reliability. Load shifting is one of the most utilized DSM strategies that allow load consumption to be moved from on-peak periods to off-peak periods in most industrial and commercial establishments. The key effect of load shifting includes immediate cost saving where the process of buying or storing energy is done when the prices are low.

For the rolling blackouts in Sumatra, it is obvious that PLN needs to build more generation capacity. However, PLN and Sumatra authorities should also consider DSM as a strategic option to overcome the current dilemma. The potential benefit of DSM in reducing energy deficit in Sumatra is demonstrated in the following section.

2.0 DSM POTENTIAL IN REDUCING ROLLING BLACKOUT IN SUMATRA

2.1 Sumatra Electricity Customers

Electricity customers in northern Sumatra consist of social customer, household, business, industry, government office buildings and street lighting. In this case study, only household customers for 2012 are used for the analysis. The details are given in Table 2.

Table 2 Household customers' details for 2012

Details	No/MW
Number of customers (northern Sumatra and Aceh)	3,612,096 users
Installed capacity	2280.6 MW
Power supply ability	1096.8 MW
Deficit during peak load	-431.4 MW
Deficit outside peak load	-231.3 MW

2.2 Energy Savings Opportunities

Energy savings can be done on household equipments to lessen Sumatra energy demand and hence reducing energy deficits. There is 50% of household electrical energy consumption from air conditioners as well as several other equipments. Some household electrical appliances that were analysed in this paper are air conditioner, rice cookers, dispenser and lamps: CFL to LED. The energy consumption data of the electrical appliances are given in Table 3. Energy savings can be achieved by using the appliances more effectively (reduce wastage) and strategically (schedule their usage at proper time). The proposed strategy for each appliance is summarized as follows:

i) Air-conditioner

Use 2 units of ¾ HP, replacing the standard air conditioning to low Watt air conditioner. Usage hour is 8 hours with temperature of 25 ºC. Usage schedule: 2400 - 0300 *i.e.* before going to bed up to middle of sleeping. Even though the air conditioner is turned off at 3 a.m., the bedroom still feels cold until morning. The next usage schedule is the midday break or during hot temperatures (*i.e.* from 1400 to 1600). In this analysis, it is assumed that 50% of household customers do have air-conditioners. Thus, the potential energy saving is 252.847 MW per hour.

ii) Rice Cooker

Rice cookers are typically turned on for 24 hours straight; cooking for 1 hour and keeping warm for 23 hours. Cooking of 1 hour is equivalent to 465 Watt per hour of energy consumptions and 65 watt per hour for keeping warm. The savings can be made by simply ensuring the rice cooker is turned on only during cooking time. The energy saving is up to 72.887 MW per hour by 2,709,072 customers, while the energy wasted during the previous 23 hours is 253.129 MW per hour.

iii) Dispenser equipment

It is usually 2 hours of usage (250 Watts per hour) and turning off for 22 hours, with 1,806,048 costumers, which can save 10.84 MW of energy per hour.

iv) Lightings

By replacing light bulbs of CFL type with LED type, assuming the use of 15 hours a day for 3,612,096 customers, usage hour of 8 hours for 4 lamps (0000 to 0700) and 7 hours for 6 lamps (1800-2400), the potential savings is up to 86.690 MW for 4 lamps and 113 781 MW for 6 lamps.

Table 3 Data of selected household equipment [11-12, 16]

No	Equipment	Watt
1	Air Conditioner ¾ HP: Standard to Low Watt	600 - 530
2	Rice Cookers	465
3	Dispenser	250
4	Lamps : CFL to LED	22 -13

3.0 RESULTS AND DISCUSSION

Figure 3 shows the estimated hourly reduced load demand based on strategies presented in previous section. The results of the study showed air conditioner (AC) is able to reduce energy up to 252.847 MW per hour, rice cookers can reduce 78.89 MW, dispensers can reduce 10.84 MW and the use of 4 lights for 8 hours reduces lighting consumption by 86.690 MW, while the use of 6 lamps for 7 hours reduces the consumption by 113.781 MW (CFL to LED). It also can be observed from Figure 3 that the deficit during peak load has reduced to 98.79 MW, whereas during off peak load time was reduced to 97.55MW.

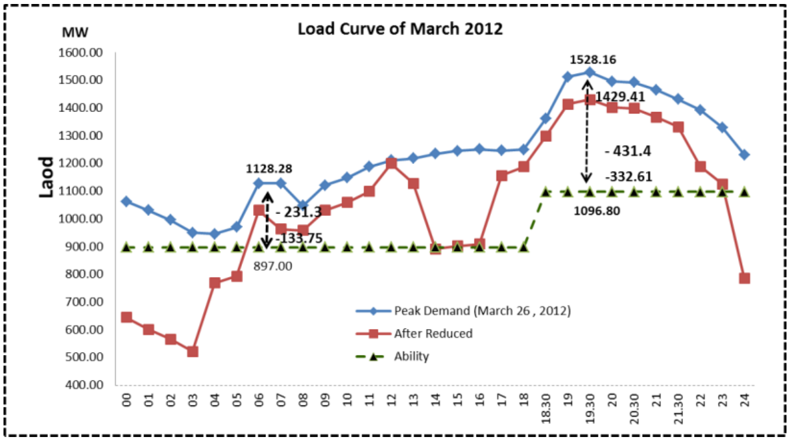


Figure 3 Load curve of March 2012

■4.0 CONCLUSION

PLN policy to conduct rolling blackouts still continues to nowadays, because some of the new plants do not go as planned and a few other plants are of old age, namely 0-10 years-14%, 11-20 years-61% and 21 - 30 years-25%. Outages have negative impact on economic activities of the community. Power outages which are implemented by PLN in almost all parts of Indonesia are a big question mark for a country that has abundant energy resources. An initiative by the government to develop the potential of abundant natural resources, especially in the provinces of North Sumatra and Aceh, is needed. Development of electricity based on renewable energy would be a real step for the government. This paper presents DSM strategy for electric energy savings in several household appliances. This strategy was carried out in an effort to reduce the load on the system, during power shortage, while awaiting completion of the new plant construction and repairs of damaged plants. The results of this case study showed that the strategies of energy savings in household equipment during peak load were 98.79 MW, while during off peak load time achieved a reduction of 97.55MW.

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