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An Improved Load Scheduling and Load Shedding Power Supply

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Abstract
India's century-old electrical grids brought the nation inexpensive, abundant power and changed the way the country worked filling homes, streets, businesses, towns and cities with energy. What they also did was pay little regard to the environment. Unidirectional by nature, the grids were designed to distribute power, not to manage a dynamic global network of energy supply and demand. The result is, today India's grids account for some of the highest transmission and distribution losses in the world, at around 27%. This inadequacy could possibly become an obstacle to the country's progress in the years to come. Regardless, a report earlier this year on the top 10 smart grid countries by the research firm Innovation Observatory ranked India No. 3 behind the U.S. and China. Smart grid refers to an improved electricity supply chain using digital technology.

It enables monitoring, analysis, control and two-way communication between the electrical delivery system and the consumer end. Smart grids use sensors, digital meters and controls and analytical tools to automate, monitor and control flow of energy and hence provide detailed and timely information on energy consumption. In this paper the proposed system with effective solutions for multiple problems faced by India's electricity distribution system such as varying voltage levels experienced due to the varying electrical consumption, power theft and transmission line fault for single phase electricity distribution system also various techniques used for the energy optimization along with the consumption scheduling. In these paper we propose a mechanism for load scheduling.

Load scheduling is nothing but a smart option for load shedding. We propose a home based mechanism. Here we classified hone appliances into three categories according to their working and power consumption mechanisms. Using the power consumption we switch on or off these home appliances. These all things are done by considering the hourly load consumption.

Index Terms
Demand Side Load Scheduling, Smart Grid, Energy Optimization Technique, Non-Shiftable, Time-Shiftable, Power -Shiftable Appliances.

I. INTRODUCTION
Load shedding strategy is applied when there is not enough electricity available to meet the increasing demand of consumers, and an electricity supply or utility company stops the energy supply to certain areas. It is a last option to balance electricity supply and demand. Most of the utility companies try to do it on the timely basis of load shedding schedules to enable their customers to be better prepared in the event of load shedding, which is also known as rotational load shedding. Rotational load shedding is more common in developing countries, like India in our case. because the electricity grid is underfunded, outdated or the electrical power system infrastructure is not properly managed. However, it can happen in developed countries as well to balance the load demand. This rotational load shedding may caused due to high demand for the power at the operational times. The blackouts are taken place fairly and rapidly so that no area had to spend more than one hour without power.

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To balance the availability and the requirement of electricity the concerned authority has to execute the load shedding process. The process is more prone to human errors as an operator has to manually switch the load ON/OFF. If we can design an efficient and economical solution to perform this operation automatically from a one centralized location, we will be able to replace the manual system with a sophisticated centralized automated system. "An approach to automated city load shedding management using embedded technology" implements the application of the embedded system technology which has covered almost all areas of the world. This helps in reducing the implementation cost and also makes it simpler and easier to install a fully automated system both at the controller and transformer side.

An ARM processor is one of the CPUs based on the RISC (Reduced Instruction Set Computer) machine architecture ISSN(Online): 2320-9801 ISSN (Print) : 2320-9798 International Journal of Innovative Research in Computer and Communication Engineering (A High Impact Factor, Monthly, Peer Reviewed Journal) Website: www.ijircce.com Vol. 6, Issue 10, October 2018 Copyright to IJIRCCE DOI: 10.15680/IJIRCCE.2018. 0610009 8508 developed by Advanced RISC Machines (ARM) itself. The proposed approach for designing this system is to implement microcontroller based control module that receives its instructions and command from an ARM processor and accordingly shed the particular load as per the program. The ARM processor then will carry out the issued commands and transfer the control to relays which will shed the interfaced load accordingly. The load shedding is interpreted by the ARM based module and instruction is given to the hardware i.e. relays which perform the action of turning ON/OFF of the load.

II. RELATED WORK

This section describes the existing power management techniques. The overall work is divided into two sub-sections:

Conventional Load Shedding Techniques

Conventional Load Shedding techniques are still used to meet demand and supply imbalance in many developing countries. Automated under frequency Load Shedding methods are based on the frequency drop or rate of frequency change. This techniques are simple to execute but time delays makes their response considerably slow. Additionally it may result in tripping of distributed generation source. Another advanced PLC based load shedding technique being automated and technologically equipped provides many advantages over under frequency based technique. It provides fast response or increases power consumption. However, it has its own disadvantage including excessive load shedding during transient responses, absence of dual communication ability and predefined or non flexible power limitations.

Modern Load Shedding Techniques

Modern Load Shedding techniques are more progressive towards micro grid or smart grid technology. It shows all the communications and electricity flows connecting each domain and how they are inter related . Recent research in this field mostly focuses on intelligent load shedding management systems. However, there is very little research is done on load priority based intelligent load shedding systems. It's an efficient technique which can be used in future smart cities. Drawbacks include limited categorization of loads and decision making within defined limits of power are used to shed the load which results into excessive or malicious load shedding [1]. Since there is no sufficient work done to address the need of future power distribution in the cities, we need to address practical solutions that are not focused to a limited boundary or a specific user. We have to simultaneously address this issues for domestic and commercial end users. Therefore we have to propose a new and more generic approach in the field of power management techniques.

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III. LOAD SHEDDING

Load shedding is the last step to prevent the collapse of the country's entire power system. When there is not enough power station capacity to supply demand (load) of all consumer, electrical system becomes unbalanced, which can cause it to travel out of the country-wide (a blackout), and that can take days to recover. When the power is not enough, the electricity utility company may either increase supply or reduce demand to bring the system back into balance [2]. The utility usually takes a sequence of steps to ensure a stable system and to avoid the burden of shedding the demand/load. The first step includes asking for large consumers to reduce their demand/electricity consumption on voluntary basis. However, if the deficit is sudden, the utility may go directly to load shedding to prevent the system from becoming unstable. Methods to solve the problem of inadequate supply have been raised in previous studies [3-4]. Many methods introduced are for solving temporary shortage of supply caused by unplanned cuts.

Total energy deficit is not large, so the load reduction can be made in various ways such as frequency control, voltage control using a variety of computing intelligence techniques. However their impact is limited and cannot be used in cases where energy deficit is significant. In such cases, the direct and effective way is to delete the load in rotational basis. In other words, the consumer is taken out of service, and then reinstated, by way of rotation. The main challenge is to develop a method of outage schedule that is fair and efficient. A good schedule should make sure the user experience minimum electricity outage period, blackout divided evenly on each user, different time every day and so on [5-6]. The schedule should also be prepared in advance with a supply outage notice to enable users to plan ahead. From a survey conducted in South Korea, due to a serious imbalance in the supply and demand, causing a blackout in 2011, researchers estimated the cost of the difficulty of a sudden rolling blackout is 3,900.67 KRW (3.56 USD) per month for each household, while a rolling blackout with early notice to be at 3,102.95 KRW (2.83 USD). The study shows that the cost can be reduced nationwide by providing advance notice of planned rolling blackouts (Load Shedding Schedule) to consumers [3]. Thus, it is important for the schedule to be published in advance so that consumers can know the day and time when they would be compromised if load shedding became necessary. Furthermore, the schedule must be simplified to make the schedule easier to understand and remember, improve the utility ability to comply with the planned schedule and improve the consistency and predictability of schedule.

IV. THE CONCEPT OF SCHEDULING

In literature, scheduling methods is widely used for solving computer processing problem. Some of the methods that commonly used are Priority Based, Shortest Job First (SJF) and Round Robin Scheduling [7,8]. In Priority Based Scheduling, each process will be given priority to be decided by any needs. The process with the highest priority will be executed first and so on. Shortest Job First (SJF) is a set of strategies to implement the process with the least processing time first. Round Robin (RR) was one of the oldest scheduling algorithms, the simplest and most equitable and the most widely used. Each process is allocated with processing time socalled quantum. Each process will be executed oneby-one on rotational basis.

For load shedding scheduling problem, the process to be executed in computer processing problem is substituted by the load/consumer to be shed. Therefore, based on the Priority Based Scheduling, load with the highest priority will be deleted first. In the case of power system, the loads which are critical such as hospital may be given lowest priority whereas loads which are not so critical such as residential homes may be given the highest priority in shedding. For Shortest Job First (SJF) scheduling, load with the lowest demand will be shed first followed by the next load with next lowest demand until the energy deficit problem at that particular hour is solved [9-10].

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While effectively solve the problem of energy deficit, both Priority Based and Shortest Job First Scheduling cannot provide a fair schedule to all consumers since the same consumers may be repeatedly being shed as compared to others. In Round Robin scheduling, every consumers/load will be shed one-by-one on rotational basis. As all loads will be affected and participated in the shedding, the method is fair and more favorable. Round Robin method requires the quantum size of each hour to be the same. The quantum size in this problem is the electricity demand size of each load that must be the same [11]. Every load is unique and it is changing all the time thus it is impossible to get similar load demand at each hour.

V. THE PROPOSED LOAD SHEDDING SCHEDULING

The proposed scheduling for load shedding is described as follows.

A. The steps

Step 1: Grouping the loads/consumers

In order to apply Round Robin method for load shedding, the load-quantum size of all grouped consumers of a particular hour must be approximately the same. The quantum size can be different at different hour. This ensures that the amount of electricity demand that being shed at any particular hour remain approximately the same even though demand from different group is shed [12]. Once the consumers have been grouped, the number of grouped consumers $Ngroups$ can be obtained.

Step 2: Determining number of daily time slots

The number of time slots in one day depends on the total duration for load shedding in one day and the duration of each shedding for each grouped consumers. The number of daily time slots can be calculated as follows:

$$N_{slots} = \frac{T_{affectedhours}}{T_{shedding}} \quad (1)$$

Where $Taffectedh\ ours$ is the total affected hours in one day while $Tsh\ edding$ is the duration of each load shedding. For example, if the affected hours is 24 hours and the duration of each shedding is 2 hours, then there will be 12 slots. To avoid the same consumer being shed at the same time slot every day, then the following rule is applied: $Nslots \neq Ngroups$

Step 3: Develop Round Robin Scheduling

Distribute the grouped consumers in the time slots base on Round Robin. For example, if there are grouped consumers A, B, C, D, E and 4 time slots in one day, the consumers will be distributed as illustrated in Table 1.

Table 1 Development of round robin scheduling

	D_1	D_2	D_3	D_4	D_5
t_1	**A**	**E**	**D**	**C**	**B**
t_2	**B**	**A**	**E**	**D**	**C**
t_3	**C**	**B**	**A**	**E**	**D**
t_4	**D**	**C**	**B**	**A**	**E**

Step 4: Develop Round Robin Sub-Scheduling

If the energy deficit is not solved in particular/some time slot/s, sub-scheduling inside the scheduling in previous step is developed [13]. In this sub-schedule, the grouped consumers are distributed again using Round Robin approach. The allocated grouped consumer at each time slot must not the same as the grouped consumer in the earlier schedule (from previous step). For example, if the energy deficit is not solved at time slots t_3 and t_4, a new sub-schedule will be introduced at t_3 and t_4 as follows:

Time Slots	D_1	D_2	D_3	D_4	D_5
t_1	**A**	**E**	**D**	**C**	**B**
t_2	**B**	**A**	**E**	**D**	**C**
t_3	**C,B**	**B,A**	**A,E**	**E,D**	**D,C**
t_4	**D,C**	**C,B**	**B,A**	**A,E**	**E,D**

This step is repeated until all energy deficits are solved

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VI. CASE STUDY: SUMATRA POWER SYSTEM

A. Background of The System

The electrical power system in Sumatra consists of Northern Sumatra, Middle Sumatra and southern Sumatra electrical systems. Power outages in northern Sumatra are still continued to occur due to the high electricity demand growth is not matched by sufficient generation capacity. Among the contributing factor to the problem is the delay in several power plant projects such as steam power plant Nagan Raya in Aceh, PangkalanSusu in North Sumatra, and TelukSirih in West Sumatra. Also there are delays in geothermal power plants in Tapanuli Utara and hydropower power plants in Lampung. Another contributing factor is due to shut down of some generation plants to aging machines and damage.

Figure 1 show the yearly peak load recorded in Sumatra from year 2000 until 2012. The highest peak load is recorded in March 2012 at 1528.2 MW. The highest numbers of blackout events is recorded in the year 2012 in December as many as 33 times with duration between 2 to 3 hours for each blackout and some cases reaching up to 6 hours. Figure 2 shows the hourly load demand and hourly supply ability on March 26, 2012 with an installed power capacity of 2280.6MW. The highest peak load was 1528.16 MW with deficit of - 431.4MW at 19:30 pm and supply power ability at 1096.8MW. Outside peak load, the highest load was 1128.28 MW with a deficit of 231.3 MW at 06:00 am and supply power ability of 897.0MW

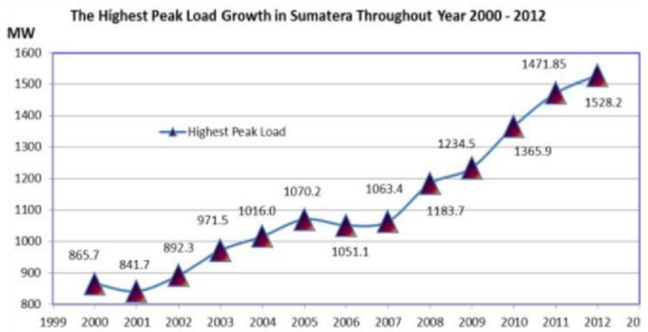

Figure 1 Peak Load Growth in Sumatra (2000 - 2012)

B. Application of the Proposed Load Shedding Scheduling On Sumatra

Figure 2 shows the total system demand profile for Sumatra and its generation capacity for 24 hours on Monday, 1 February 2010. It can be seen that the generation capacity unable to meet the demand at every hours. The energy deficit is highly significant from time 1800 until 2200. To simplify the analysis, it is assumed that similar demand quantum size at each hour has been achieved by properly grouping the consumers in Sumatra. Also, t is assumed that the consumers have been grouped into 20 big groups (named here as G1, G2…. G20). The affected hours are 24 hours while each time slot lasted for 2 hours. Thus, there will be 12 time slots in one day. Applying the proposed load scheduling method will result in schedule (for 3 days) presented in Table 10.

Note that sub-scheduling is applied twice at time slot t_{10} and t_{11} to solve the significant deficit problem from 1800 until 2200. Also, it can be seen from the table that the grouped consumers are distributed fairly in the schedule. Figure 3 shows the deficit comparison of the system between no load shedding, load shedding without sub-scheduling, with sub scheduling 1 and sub-scheduling 2. It can be seen from the figure that energy deficit problem at most hours can be solved without using sub-scheduling [14]. 2 times subscheduling is needed to solve energy deficit problem from 1800 until 2200. Due to demand quantum size, the amount of demand that being shed during these hours is above the required amount. This however can be solved by using smaller demand quantum size. Doing this may increase the number of sub-scheduling.

The problem has been simplified to demonstrate the application of the proposed method. The daily load profile of another day may be slightly different from the one used in the study. This can be solved by using average or slightly above average daily load profile as a reference for the scheduling [15].

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Also, different schedule for weekends or public holidays may be recommended since and their demand profiles significantly different for weekdays.

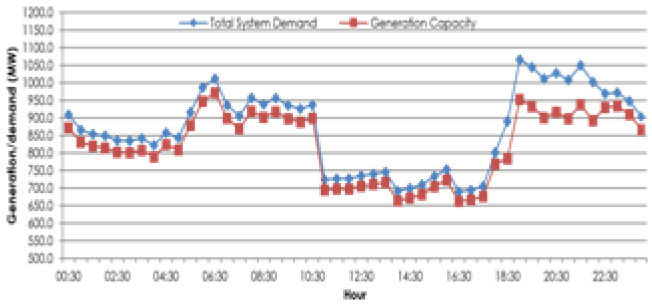

Figure 2 Total system demand and generation capacity profile for one day of Sumatra (Monday, 1 February 2010)

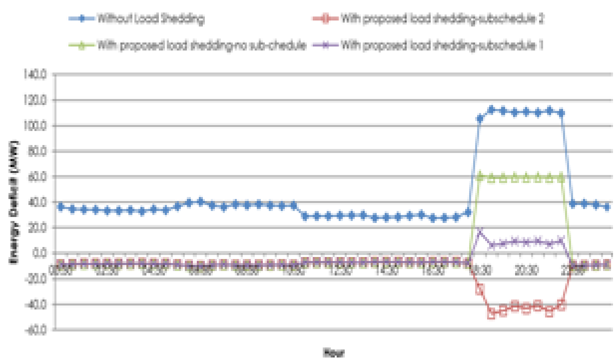

Figure 3 Energy deficits without load shedding and with load shedding scheduling

VII. CONCLUSION

This paper has presented an improved Load Shedding Scheduling base on round robin approach to solve energy deficit problem especially in cases where generation capacity of a power system unable to meet the demand at all time. The proposed method has been illustrated and tested on actual load profile data from Sumatra electrical system. The results showed that the method is fair, systematic and importantly is able to solve the energy deficit problem.

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