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Demand Side Management Program for Residences in Iran

***Abstract**. In General residential sectors are the major consumers responsible for the peak load in Iran. However, the consumer satisfaction in residential area is important but there needs a method to control the peak load by using smart load controllers. In this work, a load control system is designed and applied in relation with the Iranian Social structure to reduce the intensity of the peak load.*

*Streszczenie. W artykule analizuje się komunalną sieć zasilania energią elektryczną. Na przykładzie takiej sieci w Iranie proponuje się metody zapobiegania przeciążeniom sieci. (**Zarządzenie komunalną siecią energetyczną na przykładzie wybranej sieci w Iranie**)*

Keywords: Demand Side Management, Load control, Load management.
Słowa kluczowe: przeciążenie sieci, komunalne sieci elektryczne.

1. Introduction

The demand side management principles have been defined for thirty years now. Since then there have been many countries in the world to implement various programs of DSM so that the load shifting; peak clipping, valley filling, strategic conservation, and strategic load growth [3]. Few years later, the DSM activities were initiated in three main categories: Network, Market and Environmental-driven [4, 12 and 16].

Based on international studies, there are many advantages with the DSM programs including: power utilization optimization, service reliability, economical, employment and environmental [1, 6, 9 and 10].

One of the most important challenges before the countries was how to reduce the peak load practically. Considering the fact that a major portion of the problem in Iran is related to residential sectors, proposing a DSM program can modify the peak load by minimizing residential consumptions.One way of reducing the peak load is to use a direct load control program [15], this will cause consumer dissatisfaction especially in the night peak hours. In this work a load control system is designed to limit the residential consumptions.

The paper is organized as follows: in section 2, the international experiences are described. In section 3, the existing potentials and challenges for implementing DSM programs in Iran are described. In section 4, we are proposing a load limiter in residential sector and in section 5, the results of applying the load limiter program for homes in the city of Hamedan are analyzed.

2. General Approaches

Analysing the potentials and the barriers of DSM are the most important factors for applying the program successfully and it should be the first stage to implement.

There have been some international studies; In June 2003, a study carried by Chinese scientists were estimated that it can be saved almost 60 GW of power till 2020 in China by improving the energy efficiency standards for major industrial equipment and domestic appliances [4]. There are some barriers to DSM: Lack of legal basis, Lack of adequate funding, lack of reasonable pricing and unreal prices.

Other studies show that technical infrastructures such as advanced communication technologies and measurements (AM) play important roles in advancing the programs, for example; the LIPAedge project [4].

The ILUMEX Program (CFL lamps) has been implemented in Mexico funded by the World Bank [5]. Also Golden Carrot program for the refrigerators used improved electric motors and compressors in the USA.

The US Department of Energy data shows a reduction of 23,000 MW to 30,000 MW and energy saving of 54,000 million KWh to 60,000 million KWh due to energy efficiency programs initiated by the utilities" [4]. There are other types of savings; reduction in demand due to the appliance efficiency standards, actions initiated by individual the consumers, tighter norms for construction of buildings or the load management programs. Moreover, nearly two-thirds of the peak as well as energy saving comes from residential and commercial (non-industry) consumers [7, 8].

3. Potentials and Challenges in Iran

In our previous paper, the potentials were fully discussed [1]. Table 1 shows statistically, different group of consumers in Iran [11]:

As it can be seen in the table, a big portion of the consumption and the peak load belong to the residential. The peak load reduction must be highlighted for residential areas. The international experiences and activities in this regards are:

- Educate the consumers how to use the electricity.
- Setting correct regulations to justify the DSM programs practically.
- Replacing energy intensives and low efficient appliances, such as CFL lamps.
- Using smart power consumption management systems
- Shifting the high power consumption times by proposing some incentives.

There are several challenges encountered with applying DSM programs in Iran:

- However, in recent years there have been major restructuring/updating the system but yet the structure of Iran's power industry is traditional.
- Existing unacceptable peaks in Iran´s daily load curves either in residential or in the industry, for example there are high peaks of consumption at night has been increasing steadily since 1996.
- In normal and standard conditions, there should be 20 to 22 percent power saving, but Iran it is only 7 to 8 percent and of course it multiplies the necessity of reducing consumptions on peak hours.
- Lack of economical motivations

In Iran the government subsidizes for electricity, so the consumers are charged less. If the charge is calculated A, the real price should has been calculated as: A+B

B is the amount of money that the government subsidies to utility company for that particular bill. B is usually 6 folds higher than the A.

$$B \approx 6A$$

It means that the government pays almost 6 times more than the amount showed on the customer's bills. In this situation, there will not be enough motivations to apply DSM programs for the on consumers. So applying any DSM program causes two new problems:

a. Only government carries the program expenses
b. Some limitations to the consumers causing additional dissatisfactions.

Therefore, it becomes impossible to design and implement any comprehensive DSM programs unless the subsides are canceled.

Table1.Consumption Share of Peak load, Amount of consumers up to the end of 2000

Type of consumer	Share of Peak load(%)	Number of consumers	Consumption
Residential	50.8	13072000	34.5
Industrial	18.6	86000	32.1
commercial	12.6	1896000	6.6
Public	6	465000	12.5
Agricultural	7.6	60000	10.1
others	4.4	-	4.2

4. Proposed load limiter

Based on DSM potentials in Iran, using a control scheme in residential sectors would be quite helpful to reduce the peak load. The Iranian households power consumption patterns are seasonal and very much depend on the geometry or area climate and it may vary from one area to another in the country because of different social and cultural behaviors. So, using specific appliances in hot season such as the air-conditioning systems usually require lots of electricity for long hours and therefore, huge amounts of loads will be imposed on the power network. Then, majority of peak load problems are experienced from the mid June to mid August between 7 pm to 11 pm. In the winter, in some areas many electrical heating systems and appliances like electrical stoves are used for long hours. So we are witnessing an increase in consumption during the winter as well. The most excessive utilization of the electricity belongs to summer in Iran because of frequent usages of different cooling systems by consumers. Therefore, controlling the consumption patterns in different seasons is very important especially in hot season and in residential sectors.

One way of managing the consumptions in residential areas is to use of smart buildings. Constructing such buildings requires lots of capital and time. So we need to reduce the energy consumptions in a short time, especially in peak loads.

In order to decrease the peak load, a system was designed to control and prioritize the consumption lines in the building for cutting off the excessive usages during peak load according to set point adjustment. The set-point signal will be send from the controlling operator through a communication system to our local system. When the consumption is more than its defined values, the proposed system controller starts to cut off the feeders based on adjusted priorities until it becomes equals or less than the given values. Therefore, the whole electrical power in the household will never be cut out in any times. This brings higher consumer satisfactions and good motivation for implementing these types of systems in Iran.

4.1 Structure of the Load limiter

The system introduced in this article controls and restricts the consumptions and easily can be installed in any residential building. The proposed controller acquires lower cost and needs less time for its installation in comparison to constructing a smart building. This system controls the peak loads and complies with regulations in the country.

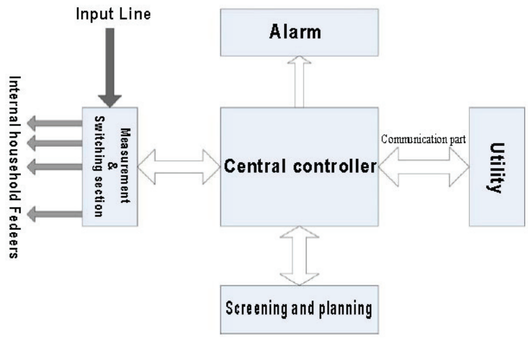

Fig.1. Schematic of the proposed load controller

Electrical regulations in Iran must enforce construction companies to install different feeders for various usages in fuses cabinet in every household. For example, the lights in living room and bedroom should be separately connected to any specific feeder. Large loads like coolers, washing machines and dishwashers need to receive power from different feeders.

There are some proposals in various articles suggesting the control schemes in regards with cutting off the big loads such as air conditioning systems in the peak times, when it is required [15]. In the our system, Fig. 1, a central controlling system is responsible for sampling the signals from the feeders and compare them with the information received from Utility communication system (GSM in this case), Then the system controls consumption loads based on the customer's own pre-setting. The controller consists of hardware, software and the communication parts as below:

Hardware:

The hardware of the proposed load controlling system includes the following components:

- Central controller
- Measurement section
- Switching section
- Screening and planning
- Communication section
- Alarm

Software:

The software for this system designed in a way to fulfil all customer requirements without limiting the whole consumption, thus it provides good service in customer satisfaction. The software has 8 sectors:

- System clock
- Lines switches controller
- Instantaneous power consumption Calculator (P).
- Instantaneous energy consumption (W) and the price Calculator.
- Data transmitter and receiver via RS232 port.
- System Performance scheduler (by power utility or local operator)
- Monitoring panel controller.
- Data storage.

Communication part:

There are different ways to communicate with the utilities like wireless networks [14]. In this work, GSM type communication is used because its infrastructural availability in Iran and the cost effectiveness.

5. Case study

1. Automatic meter readings and bill payments

In comparison with traditional operation within the utilities, this control system save money and time for the utilities and the consumers by instant reading of electrical usages and communicate the cost information through the system for the costumers. Items are showed in the Table 2. below for Hamedan utility:

2. Factors influencing in system performance

To control the consumption level, a reduction factor needs to be calculated. Reduction factor depends on the number of people participating in the plan and power product deficiency. The deficiency could be calculated by the total power produced minus predicted consumption according to data from previous years.

For example, if are you want to reduce "a" percentage of the average consumption in a residential unit for four hours at night, then:

$$\text{Maximum control level} = \frac{\sum U}{4} \times a$$

$\sum U / 4$ is the average consumption per residential unit

a is the percentage of consumption reduction calculated by dividing the power deficency over produced power.

This predetermined control level is at maximum. In normal condition, total consumption will be less than of the control level.

3. Participation rates in the plan

Participation in our control system is optional and for higher consumer satisfaction there is no obligation for any individual costumer for being involved in the plan. So there must be a factor which can raise the participation rate for the consumers in any control scheme:

$$P_{after} = P_{total} - P_{\text{disaffilia tion}}$$

P_{after}: Max. consumption of the group affiliated in the plan
P_{total} : Total consumption before implementing the plan and
$P_{disaffiliation}$: Consumption of group disaffiliated in the plan.

The consumption level for members which are not participating in scheme plan is proportional to their population. n_d is the number of disaffiliated members.

$$P_{\text{Disaffiliation}} = \sum_{i=1}^{n_d} P_{n_d}$$

In general, there are two types of consumers in a disaffiliation group: $n_d=b_1+b_2$

- Consumers which exceeding their controlled consumption levels occasionally (b_1).
- Consumers with no interest in participating (b_2).

Reducing some subscribers from group b_2 through TOU (time of use) tariffs is possible and it is a function of social issues [13].

Table 2: Reduction in expenses for automatic meter reading and bill payments

expenses	Annual expenses (Rls)	When using load limiter	amount of savings
Cost of Meter Reading	1,243,107,000	184,800,000	1,058,307,000
Cost of Bill Distribution	621,553,500	92,400,000	529,153,500
sum	1,864,660,500	277,200,000	1,587,460,500

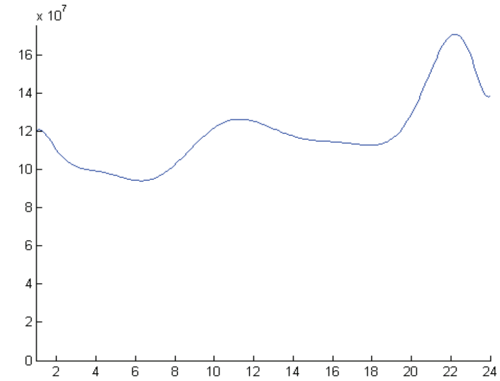

Fig.2. Average daily power consumption for Hamedan's residential sector

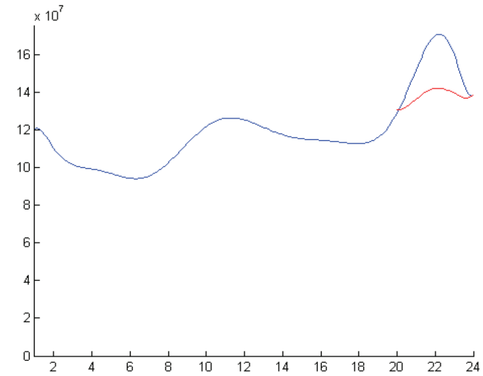

Fig.3. Amount of peak load reduction in the city of Hamedan using proposed controlling system (100% participation).

Number of the subscribers in group b_1 could not be changed because in some occasions such as; the family gatherings, religious and marriage ceremonies, their consumption rates are higher than set point levels.

Using an appropriate TOU tariff in conjunction with a suitable controlling system (set point) can attract high percentage of participation.

The city of Hamedan was selected because of its cold winter and occasionally hot summer located in the mountainous region, west of Iran with 140000 residential customers. The average daily power consumption in the city for four warmest months in the year (the highest peak load) is shown in fig. 2:

From Fig. 2, the load curve for Hamedan increases between 8 pm to 11 pm and reaches its peak at 10 pm. The Peak load at 10 pm is about 170MW. This peak may even reach higher level around 180MW in very hot summer days. The power consumption for different sectors (residential, commercial, offices and public lightening) is varied hourly. Between 2 pm to 8 pm, the highest consumption rate is belonged to residential and commercial sectors. At night, the highest consumption is for residential consumers [2].

With having all subscribers participate in the plan, the peak load will change as shown in Fig. 3 (The red section of the curve).

Fig. 3 shows that the peak load decreased by 16.21% (27.5 MW). Normally all subscribers do not participate in the plan, therefor the total reduction would be less than the amount showed in Fig 3.

Table 3 shows the peak load reductions for different contributions of costumers in the plan. For example for 75% participation, the peak load reduction is 12.2% (20.7 MW) and daily consumption will be at 40.1 MWh.

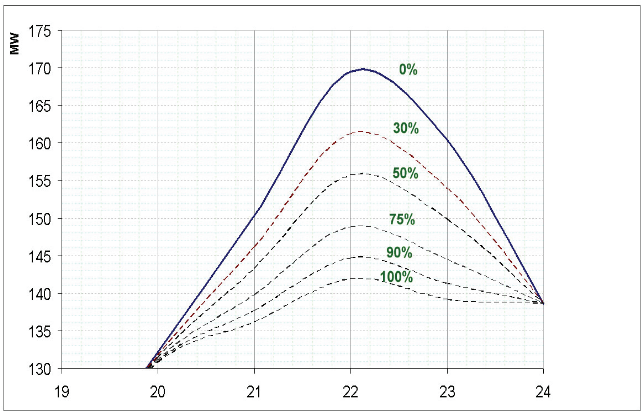

Fig 4: Peak Reduction for different Participation rates in Hamedan Residential sector

Fig.4 shows the peak load daily reductions according to the percentages of participation for 100, 90, 75, 50, 30 and zero. The maximum reductions were almost at 10 pm for all. Regional surveys demonstrated that more than 90% of residential subscribers would participate in the plan. Therefore the peak reduction will be around 15% (25 MW) and daily consumption reduction is expected to be approximately at 57.53 MWh.

4. Discussion

Results showed that any percentages of participations in the proposed plan will reduce the energy consumption and lower the costs and the future investments. Statistically, the numbers of participants interested in the plan were high and the worse scenario showed it is around 80% of the subscribers.

A research council from Iranian parliament estimated that the necessary investment for generating electricity by a gas power plant is about $400 per KW. For 100% participation in the plan, by adding 27.5 MW of the reduction from peak load to almost 3.4% of power loss reduction in the system (based on the report from Hamedan Utility Company, there is a 20% power losses in network system). Then the total power reduction will be around 34.38 MW (16.2+3.4=19.6%) and the savings would be $13,752,000. Therefore, in our proposed control system at the minimum saving of 15% in consumption, just for the four warmest months of the year, there will be a huge saving of gas consumptions plus an almost 14 million dollars for future investments to develop a new power plant.

Conclusion

In this research, a load controller was introduced for residential sectors for optimizing the peak loads. This load limiter can be installed easily on any available fuse cabinet in any households. With the help of an existing GSM communication system from utilities companies, the current spending for the plan will decrease considerably.

Using the controller in some residential areas in Hamedan estimated that there would be a significant peak load reductions with higher levels of customer satisfaction. The results are demonstrating that in any rates of participations, there will be huge amounts of power savings and daily cost reductions. Also applying this control system will save money and energy for construction of the new power plants.

Table 3. Peak values and percentages of reductions related to plan

Participation rates in plan (%)	reducing consumption in a day (MWh)	peak load reduction(MW)	reducing peak load (%)
100	63.9	27.5	16.21
90	57.53	24.7	14.6
75	40.1	20.7	12.2
50	34.8	13.8	8.1
30	18.3	8.27	4.9

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