Intelligent Algorithm for Efficient Use of Energy Using Tackling the Load Uncertainty Method in Smart Grid

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ABSTRACT

In this paper, I am developing a unique optimization based real-time inland load management algorithm that takes into account load ambiguity in order to minimize the energy payment for each residential user, as well as reduce the Peak to Average Ratio to overcome the drawbacks in the stability of Electrical Grid. By categorizing the all residential load in different classes i.e. must run, Interruptible and Uninterruptible appliances I used the Real Time Pricing scheme for load management. However, Real Time Pricing creates the peak profiles when the energy demand is too high that’s why I used the combination of Real Time Pricing and Inching Blocks Rates model to improve the grid stability by reducing the Peak to Average Ratio. A Simulation results show that the proposed algorithm efficiently and effectively reduced the overall residential energy cost as well as Peak to Average ratio of our model for data provided.

KEYWORDS

Demand side management, peak to average ratio, energy cost, user comfort, smart grid.

INTRODUCTION

The advanced technologies in communication, distributed generation, cyber security, and advanced metering infrastructure of smart grid enhance the efficiency, reliability, and flexibility of the power grid [1]. Due to preset fashion and behaviour of suppliers and consumers, smart grid improves the competence, reliability, economics and sustainability of the fabrication and distribution of electricity. Due to different protocols, self remedial and intelligent communication sharing transportation, smart grid provides different techniques and algorithms to use energy more sensibly and effectively at demand side [2]. Demand Side Management encourage and assist the user to shift their load from peak time slots (where the demand of energy is too high) to off peak time slots (where the demand of energy is low) [3]. Recently, one of the crucial DSM activities is demand response (DR), it is presumed that DR is a subset of DSM in broader aspect. Demand
response is defined as the tariffs or program established to influence the end users to reshape their energy consumption profile in response to electricity price [4]. Among different techniques i.e. direct load control and smart metering encourage the user to shift their load [5]. Demand management algorithm using the net metering techniques in which customer are encouraged to install renewable sources at demand side and extra generation will be sent back to utility [6]. Real time demand response also a model used in when real time data is provided by the customer to utility [7]. Game theoretic model, Incentive based Energy consumption algorithm, Autonomous three layered structure model and Vickrey Clarke Groove Mechanism are the techniques of demand side management that manage the consumption in different prospectus [8]. Game theoretic method is also method implemented to get discussed results [9]. Some heuristic policies are also introduced to manage the energy consumption when it exceeds the threshold point [10]. Some techniques minimize the energy cost while some reduce the peak to average ratio but in limited amount. We planned the algorithm that reduce the overall energy payment for user and reduce the peak to average ratio PAR in greater amount. Our algorithm will consider the user comfort as well. A new model of RTP will be introduced in coming sections in which a user will have to sufficient time to schedule the operation of household load.

**Table 1. Heuristic Techniques**

<table>
<thead>
<tr>
<th>Techniques Names</th>
<th>Aims and objectives</th>
<th>Descriptions</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid technique (GA and PSO) [11]</td>
<td>Minimization of cost and (PAR)</td>
<td>Distributed energy resources and energy resources system in HEMS</td>
<td>User comfort is ignored</td>
</tr>
<tr>
<td>EA [12]</td>
<td>Cost reduction</td>
<td>Energy optimization in household, commercial and residential consumption areas</td>
<td>System complexity is increased</td>
</tr>
<tr>
<td>ILP [13]</td>
<td>Cost and (PAR) reduction</td>
<td>Categorizing/classification of household contrivances using day ahead pricing model</td>
<td>PAR is not considered</td>
</tr>
<tr>
<td>DP [14]</td>
<td>Cost and (PAR) reduction</td>
<td>Energy consumption behavior optimization with high penetration of renewable sources</td>
<td>System complexity is increased, user comfort is ignored as well</td>
</tr>
<tr>
<td>GA [15]</td>
<td>Cost reduction and user comfort</td>
<td>Division of operation period, as a result cost reduced and energy is optimized</td>
<td>System deals with large number of contrivances in multiple sectors results in enhancement of system complexity</td>
</tr>
<tr>
<td>GA, BPSO, ACO [16]</td>
<td>Cost and (PAR) reduction with limited user comfort</td>
<td>Using satisfaction and Renewable sources integration considered, Schedule the load</td>
<td>System complexity and computational time are increased</td>
</tr>
<tr>
<td>GA [17]</td>
<td>Cost reduction and user comfort</td>
<td>Energy consumption behavior optimization using renewable incorporation</td>
<td>PAR is ignored and challenges in considering renewable sources are not addressed</td>
</tr>
<tr>
<td>Hybrid technique (LP &amp; BPSO) [18]</td>
<td>Cost reduction and user comfort maximization</td>
<td>Interruptible contrivances are considered for schedule the operation under day ahead pricing umbrella</td>
<td>PAR is not considered</td>
</tr>
<tr>
<td>FP [19]</td>
<td>Electricity cost reduction</td>
<td>Cost efficient model under distributed energy sources and</td>
<td>PAR and user comfort are not considered</td>
</tr>
</tbody>
</table>
In time varying pricing tariffs, the proposed operation is divided into different time slots. The price of electricity varies according to different time slots. The prices are mainly higher from 6 p.m. evening to 10 p.m. night and lower at 12 a.m. night to 5 p.m. evening. Different pricing schemes as discussed in paper [26] are implemented by the utility on consumer. Real time pricing RTP is one of the major pricing schemes mainly used in European countries, in which the prices of electricity are declared after every hour for the next coming hour. Day ahead pricing can be more effective because consumers can get sufficient times to plan their electricity consumption schedule, while hourly pricing can be boring for consumers. The Real Time Pricing RTP can prove to be the most efficient pricing scheme, benefiting every stake holder involved and optimized by using the automated control system for the load [27]. The further type of RTP is Day ahead pricing (DAP), in which prices of next 24 hours are defined day ahead. Second pricing scheme is Time of Use pricing (TOU), which is mainly used in Indo-Pak region. In TOU pricing the prices are usually high at peak hours because high demand of energy, and low at off peak hours because low demand of energy. The more complex type of Time of Use pricing is seasonal TOU pricing in which prices varies according to season (two or more times in a year). Another important type which is considered to be more essential for Demand Response is Inclining Blocks Rates IBR. Inclining block rates structures charge a higher rate for each incremental block of consumption. As the consumption of energy increases, the rate of energy per kWh increases [28].

From all above previous literature we can draw a conclusion that:

- In all previous work, the RTP model is used in which prices are changed after every hour, as a reset and user struggle and have not a sufficient time to schedule the operation of his household load.
- No one method was proposed previously that takes into account all of three particulars i.e. energy cost minimization, PAR Reduction and user comfort. We proposed a model in which takes into account all of three particulars cost minimization, PAR reduction and user comfort without any complexity in system.
We proposed an algorithm that uses small number of contrivances to schedule the operation. In our system we take into account all of three particulars cost minimization, PAR reduction and user comfort. Our model will be simple and less complicated.

The rest of this paper is organized as: The system model is introduced in Section II. Problem formulation and algorithm description are presented in Section III. Simulation results are provided in Section IV. The paper is concluded in Section V.

SYSTEM MODEL

In this section, we present overall contribution towards this paper. We will define peak to average PAR according to parameters and its complete profile and impact on overall Electrical system. Then we discuss of Real time pricing (RTP) and pricing function (PF) for our proposed model. Our system model is different from [29,30,31], because in [29,30,31] the Real time pricing RTP is to be implemented in such a way that prices are changed after every hour so that customer have insufficient time to schedule their load. In my system model I implemented such a real time pricing RTP model that prices are not change more than three times in a day. In such a model a customer have sufficient time to schedule the operation of their load according to demand.

Household Load

Let us consider the residential setup that consist of 5 devices with variable energy consumption and categorized as in Table 1. Must run and controllable devices that are interruptible and non- interruptible controllable devices. Must run start operation immediately at any time e.g. PC, TV. Interruptible load is a controllable load. In this load it is not only possible to postpone the operation but also to interrupt the operation and restore later on e.g. Plug in electric vehicle (PEV) [32,33,34]. Interruptible load further classified into two categories sequential load and non sequential load. The operation period of sequential load is same for whole given 10 days e.g. if it operation time is 5 a.m. to 6 a.m. then it will remain same. While the operation period of non sequential load is not in sequence, it becomes active any time in given period. In Non interruptible load the control unit may only delay its operation. For example Air conditioner timer and washing machine etc. They complete their operation in specific time without interrupting or delaying their operation. The intended period of time for which I am going to develop algorithm is 10 days. Each hour is marked as one time slot and 1 day is equal to 24 hours means 24 time slots \( t_s \) so total numbers of time slots \( T \) are \( 24 \times 10 = 240 \) time slots.

<table>
<thead>
<tr>
<th>Household Devices</th>
<th>Power Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device 1</td>
<td>2000 Watts</td>
</tr>
<tr>
<td>Device 2</td>
<td>1000 Watts</td>
</tr>
<tr>
<td>Device 3</td>
<td>746 Watts</td>
</tr>
<tr>
<td>Device 4</td>
<td>150 Watts</td>
</tr>
<tr>
<td>Device 5</td>
<td>60 Watts</td>
</tr>
</tbody>
</table>

Prices are defined for peak time and off peak hours i.e. 13 PKR/kWh for peak time and 7 PKR/kWh for off peak time. Fist all calculation is to be done on given data without any consumption control unit CCU. CCU is nothing but a smart meter that has a digital two
way intelligent communication infrastructure, and is responsible for DSM at consumer side. The whole system model is summarized such as:

- We develop narrative optimization based inhabited model which reduce the energy cost for each residential consumer and reduce the PAR as well. Each device send operation signal towards CCU, CCU decides, signal could be acceptable or not according to demand of customer.
- We draw suitable management profile for controllable load in the sense of economically for the consumer and the electrical system.
- At last, we will make analysis on simulation results obtained from proposed algorithm. We see whether our algorithm effectively reduces the cost and PAR for overall aggregated load.

**Peak to Average Ratio**

Peak to average ratio (PAR) is the ratio of maximum aggregated load consumed in a certain time frame and the average of the aggregated load. Peak to average PAR informs about the energy consumption behaviour of the consumers and the operation of the power grid. As we employed only the Real time pricing RTP, at peak hours when demand is high the peak to average ratio PAR mainly increase which result in destabilization of electrical power grid. While reduction in Peak to average ratio PAR, simultaneously enhance the stability and reliability of power grid and reduces the electricity bill of residential consumers. The peak to average ratio PAR does not change as the customer does not respond to change the parameter which is defined in next sections. Mathematically, representation of Peak to average ratio PAR for a residential unit as [35]:

\[
L_{\text{peak}} = \max_{t \in T} E_T(t_s) \quad (1)
\]

\[
L_{\text{avg}} = \frac{\sum_{t=1}^{T} E_T(t_s)}{T} \quad (2)
\]

Where, \( L_{\text{peak}} \) and \( L_{\text{avg}} \) show the maximum aggregated load and average load in a time frame\( (t_s) \). While \( E_T(t_s) \) represents the total energy consumption of devices in a time slot for intended operation. Peak to average ratio is given by:

\[
\text{PAR} = \frac{L_{\text{peak}}}{L_{\text{avg}}} = \frac{\sum_{t \in T} E_T(t_s)}{\sum_{t=1}^{T} E_T(t_s)} \quad (3)
\]

**Real Time Pricing**

Let \( P_t \) is the total household power consumption in current time slot “\( t_s \)”. We define a pricing function \( \varphi_{t_s} \) with a combine model of Real time pricing RTP and Inclining Block Rates IBR, which represent the wholesale payment in time slot “\( t_s \)” as a function of user’s power consumption.

\[
\varphi_{t_s}(P_{t_s}) = \begin{cases} i_{t_s}, & \text{if } 0 \leq P_{t_s} \leq P_{th} \\ j_{t_s}, & \text{if } 0 \leq P_{t_s} \leq P_{th} \end{cases} \quad (4)
\]
Where, \( i_{ts}, j_{ts} \) and \( P_{ts} \) are the fixed parameters, and we have \( i_{ts} \leq j_{ts} \). Discussed in next sections that combine model of Real time pricing RTP and Inclining block rates IBR can effectively avoid load harmonization.

**PROBLEM FORMULATION**

Let suppose “\( D \)” represent the set of all devices present in this household unit. While “\( d \)” represents the current device on which operation is to be performed. Then each device \( d \in D \) must act as either must run or controllable (Interruptible or Non-Interruptible). The real time data is given in the form of 0 or 1 respectively for all devices. We define a dual variable \( y^d_{ts} = \{0, 1\} \) as a representation of status of device \( d \in D \). We set a variable \( y^d_{ts} = 1 \) if the device \( d \) is active in current time slot. In other case we set \( y^d_{ts} = 0 \).

**Without Consumption Control Unit**

**Schedule estimation:** According to given data the ON or OFF state for each device \( d \in D \) with respect to time slots and days is given in the given figure 1. From figure 1, we analyze that device 1 is ON in each time slot in 10 days. For device 2 it can be seen that it is ON for all days in time slot 18 and for 7 days in time slots 12, 15 and 21. Device 2 is also ON for 4 days in time slots 6 and 9 and for 3 days in time slots 5, 7, 8, 10, 12, 13, 19 and 22, while at time slots 1, 2, 3, 4, 11. In this way we check the device ON and OFF status in each time slot. Similarly, the ON and OFF status of all other devices can also be known easily by analyzing the figure 1.

![Figure 1. ON/OFF status of household load with respect to time slots and days.](image-url)
that it remain ON for 3 days in time slots 7, 19 and 23, while in remaining time slots it remain OFF.

**Devices frequency:** According to predefined variable $q_{t}^{d} = \{0, 1\}$, the state of ON or OFF and operation of overall load in given 240 time slots is defined. From figure 2, tells us the overall frequency profile (on status) of each appliance for our monitoring system for all 240 time slots. We have 240 time slots in 10 days. From the figure 2, we can easily analyze that the device 1 is on in all time slots, device 3 is on in 130 time slots in 10 days, and device 5 is on in 120 time slots.

![Devices Frequency](image)

Figure 2. Devices Frequency.

While device 4 is on for minimum time slots i.e. 20 time slots for 10 days. In this way we check each device frequency for specific period of time in given days. And then estimate the overall household consumption for real time data and vice versa.

**Load estimation:** Let us denote the whole intended operation period for all devices is $T$. We are going to calculate the power consumption of each device in their intended operation time slot cycle i.e. $t_{5} \in T$. For that purpose we categorize the given household residential load into several classes that are given below and have been discussed in previous section as well:

- Must Run Load
- Interruptible Load
- Non-interruptible Load

After categorizing the overall household load, we consider a system without CCU deployment, where each device $d$ is assumed to start operation right after it becomes awake at its nominal power $\alpha_{d}$.

Figure 3 shows the variation in electrical demand over particular period of time. In figure 3 we can see that wattage consumed curve of device 1 is a straight line because it remains on for all 240 time slots and does not show the variation in demand for a specific time due to must run property.
Similarly we can see in second interruptible device that it consumes maximum power 7500 watts in time slots 18 for whole period 10 days and consume 5500 watts for time slots 12, 15 and 21. Device 2 consumes 3000 watts in time slots.

**Bill calculation:** We note that the operation of different devices is influenced by the preference of user. Different parameters of our model may be considered to capture different types of preference. In time differentiating pricing tariffs, the intended operation period is divided into several time slots, and the price of electricity varies across different time slots. For example, the prices may correspond to off peak, mid peak and on peak hours. We have different rates for energy consumption in real time pricing. In Real Time Pricing RTP rates are defined at different levels of time slots i.e. off peak hours where the energy rates are kept low because consumption is low and on peak hours where the rates are kept high because consumption increased during that time slots.

For above profiles the intended period of operation is divided into Peak time and off peak time. Peak hours from 5 p.m. to 10 p.m. and the off peak or rest hours for the day are off peak hours (12 a.m. to 4 p.m. and 11 p.m.). According to Real time pricing RTP the prices varies with time. We defined the prices i.e. 13 PKR for peak time and 7 PKR for off peak time. According to that data we calculate the overall cost of all devices. From
figure 4, we can see that each device is consuming different power so the energy cost for each device is different. The device which has greater energy consumption bill in PKR represents that it start operation many times during peak time slots because during peak time slots energy rates are high i.e. 13 PKR per kWh.

So the total energy cost after summing energy cost of all devices is 3269.65 PKR that is great amount by the way due to lack of energy consumption control unit CCU with our system. After calculating overall cost of consumption of all the devices in given 240 time slots (off peak and peak time), we move forward on the load estimation of our system. In our load estimation section we define how the load damages the overall system performance as well as in economical point of view of consumer. We discuss how we shift the load from peak time slots to off peak time to give incentive in economical point of view to the consumer and best for the community growth and infrastructure.

**Load curve:** Figure 5, explains the load curve for all devices collectively. In this way, we easily analyze the electrical demand in each time slot. This figure also shows the maximum and minimum electrical demand over a specific time for all the devices collectively. In figure we can see that the load is maximum at peak time slots and minimum at off peak time slots of total slots. As the consumption increases the calculated load increases, as a result the peak to average ratio PAR of a system increases and damage the system’s performance.

![LOAD CURVE Bars](image)

**Figure 5.** Histogram of PAR when only RTP is applied without CCU.

Recall from Eq. 3 that, Peak to average ratio PAR is the ratio of the maximum aggregated load consumed in a certain time frame and the average of the aggregated load. PAR informs about the energy consumption behaviour of the consumers and the operation of the power grid. In figure 5 we can see that the load is consuming more power at time 18, 19, 20 and 21 during peak time slots (5 p.m. to 10 p.m.), where energy tariffs rates are high, which is not better for economical point of view for consumer. During these time slots the PAR is high which overload the electrical grid system and its performance slow down. Our aim is to minimize the peak to average ratio PAR to improve system performance for run smoothly. We also aim to shift the peak load to off peak time slots because the rates during off peak time slots very low as compared to peak time slots to make economical use of energy in smart grid system.
Proposed Strategy Description

1) DSM through (CCU) deployment with (RTP): When consumption control unit (CCU) is deployed with respect to Real time pricing (RTP) at demand side, the result in the form of demand side management (DSM) minimize the energy cost for residential user.

2) DSM through (CCU) deployment with (RTP+IBR): When DSM is done through (RTP) the results in reduction in cost, but increases the peak to average ratio (PAR), which damages the grid stability. For this purpose a combine model of (RTP) and (IBR) is implemented.

Figure 6 is a block diagram of basic demand side management (DSM) scheme. From figure 6 it is clear that consumption control unit (CCU) has not any type of physical connection with must run load. It only schedules the controllable (interruptible and non-interruptible) household load according to the circumstances.

With Consumption Control Unit

When we deploy the consumption control unit (CCU) the operation signal is received from the device. Initially the load will be either must run or controllable. If the load is must run, the consumption control unit (CCU) ignore it. When the load is shift-able (controllable), the consumption control unit accept the operation signal, once the operation signal is accepted the device starts its operation immediately. From figure 7, in must run device it is in OFF mode it remain OFF but when the operation signal is accepted it becomes ON and activate itself without any delay and finish operation. If the device is non-interruptible then again if it is in OFF mode the obviously it remain OFF.

Figure 7. Different operating states of proposed algorithm.

If it turns ONN then a second inactive mode is developed. It goes to inactive mode with delay greater than zero and then active mode or directly from ON mode to active mode with zero delay and then finish the entered operation. If the device is interruptible controllable load, again if it is in OFF mode then it remains OFF. When it goes to OFF
mode to ON mode it goes to inactive state. Now two states are developed, it performs dual operation between inactive and active modes or directly ON state to active state and then finished the operation.

Cost minimization: By deploying of consumption control unit (CCU), the load at the peak time slots mainly 5 p.m. to 10 p.m. are shifted to off peak time slots to reduce the energy cost for residential users. Thus, we formulate a scheduling problem that minimizes the expected energy payment of the user with respect to demand uncertainties. In each time slot $t_s$ as the demand information of the device is updated, the operation schedule of each controllable device can be rescheduled and the optimum power scheduling can be identified in real time as the solution of the following optimization problem for the minimization of expected cost from the current time slot $t_s$. In figure 8 we can see that by deploying of energy consumption control unit (CCU) the energy is minimized i.e. 2771 PKR.

![Figure 8. Cost minimization by deployment of CCU.](image)

Combination of RTP and IBR: When Real time pricing (RTP) is charged then during peak time when the demands of energy are usually high, the peak to average ration (PAR) of a system has been disturbed which obviously disturb the overall system’s performance. To overcome this drawback and increase the peak to average ratio (PAR), a combine model of Real time pricing (RTP) and Inclining block rates (IBR) is implemented. According to Islamabad Electric Supply Company (IESCO), Pakistan, the Inclining block rates (IBR) are according to [36] as in Table 2:

<table>
<thead>
<tr>
<th>Tariff category/Particulars</th>
<th>Prices per kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>001-100 Units</td>
<td>8.70 PKR</td>
</tr>
<tr>
<td>101-300 Units</td>
<td>10.20 PKR</td>
</tr>
<tr>
<td>301-700 Units</td>
<td>14.00 PKR</td>
</tr>
<tr>
<td>Above 700 Units</td>
<td>16.50 PKR</td>
</tr>
</tbody>
</table>

Peak to average ratio reduction: Let the demand information of the device is known ahead of time. Awakes devices in the upcoming time slots $k > t_s$ that are currently sleeping, only the probability with which each device becomes awake at each time slot is before the operation cycle begins.
Where, $q_d$ denotes the probability that device $d$ does not become ON at any time within the DSM operation period.

$$\sum_{t_d=1}^{T} p_{t_d} + q_d \quad (5)$$

In figure 9, we can see that after deployment of energy consumption control unit (CCU), the bar line at peak time slots is shifted to off peak time slots. When the load from more energy consumption slots is shifted to less and reliable slots, then we have reduction in peak to average ratio (PAR) of overall aggregated load which improves the overall system’s performance.

**RESULTS ANALYSIS**

When we implemented only Real time pricing, the energy cost is minimized but unfortunately we get increase in peak to average ratio of overall household load. But when involved Inclining block rates we get reduction in Peak to average ration as well. In this section we describe the impact of involving IBR with RTP model.

**Blow of Involving IBR**

As in figure 10 and 11, In Real RTP when pricing parameters changes from $i_{t_d}$ to $j_{t_d}$, the peak to average ratio of the system disturbed. When $i_{t_d} = j_{t_d}$ then there will be no issue with PAR of the system. When it shows dual behaviour $i_{t_d} \neq j_{t_d}$ then IBR must be a part of our system. Simulation results for the average daily payment of the user as well as the average PAR of the system for different values of parameter are depicted in figure 10 and 11. Intuitively, when parameter is equal to one, i.e. when $i_{t_d} = j_{t_d}$ for all time slots $T$, the performance of our proposed method is the same as the one in which effect of IBR is ignored. However, by increasing the pricing parameters, the payment increases, as the user has to pay more every time that its load exceeds threshold $p_{th}$ as in figure 10. In figure 11, increasing pricing parameters improves the peak to average ratio (PAR) of the
system. Surprisingly, results shows that greater the consumption, greater the cost and Peak to average ratio (PAR) reduction. So here we draw a statement that Demand Side Management (DSM) encourages the user to use the power more wisely and effectively by shifting the load from peak time to off peak time. In my simulation model I set the $p_{th}$ (threshold power consumption level) 23.5 kW for 24 time slots. As the load exceeds the threshold point (23.5 kW), consumption control unit (CCU) shifts behind to off peak slots results in reduction in peak to average ratio.

Figure 10. Difference between two profiles of Peak to average ratio and cost without and with (CCU).

Table 4. Concluded results of cost and PAR reduction

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Without (CCU)</th>
<th>With (CCU)</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>3269.65 PKR</td>
<td>2771.9 PKR</td>
<td>15.22 %</td>
</tr>
<tr>
<td>PAR</td>
<td>$2.80 \times 10^4$ W</td>
<td>$2.35 \times 10^4$ W</td>
<td>16.07 %</td>
</tr>
</tbody>
</table>

CONCLUSION

In this paper, I developed a residential Demand side management (DSM) algorithm in presence of load uncertainty. I measured the benefits for both residential customer and utility via minimizing the energy cost as well as Peak to average ratio (PAR). I formulated an optimization problem to minimize the electricity payment for residential users in the situations where only an estimate of the future demand is available. I focused on a scenario where Real time pricing (RTP) is combined with Inclining block rates
(IBR) to balance residential load to achieve reduction in Peak to average ratio (PAR). Scientific contributions of work have covered different areas. A simulation results shows that a unique model of Real time pricing (RTP) provides a sufficient time to schedule the operation more easily, in which prices are changed only 2 to 3 times in day instead of hourly fluctuation. In fact, proposed model of Real time pricing is a new shape of RTP in class of dynamic pricings. A results show that the proposed algorithm reduces the energy cost for users, encouraging them to participate in Demand side management (DSM) scheme. Exploiting Inclining block rates (IBR) with Real time pricing (RTP) tariffs can help to avoid load synchronization, and the combination of general Real time pricing (RTP) method with my algorithm reduces the Peak to average ratio (PAR) of the total load. The latter provides incentives for utilities to support implementing the proposed algorithm. So this is proper intelligent algorithm for economical use of energy in smart electrical network system.

In future I have aim to integrate the renewable sources for more expendiency of residential consumer. This will provide automatic switching to user during peak time slots. My system model can be extended to scenarios when a user faces deep trouble during load shedding. In this case of constraint of renewable sources can help to tackle this situation.

REFERENCES


