Energy Tariff Control Using IoT on Domestic Households

G. Bhavani a,*, R. Dravid Rahul b, V. Gurudev b, T. Sridharan b, H. Neeraj Kumar b

ABSTRACT: Dynamic pricing of electricity can provide numerous benefits to utilities and customer alike by lowering the need for expensive peeking capacity and reducing power cost. This focus on the design for the tariff control based on IoT. The consumers can plan for the consumption according to their usage of electricity. This cause the decrease in the conventional energy resources Consumers can schedule their consumptions according to their usages, which will be beneficial to both suppliers and consumers. To reduce the high energy consumption in residential buildings, the appliances are divided into priorities, which control through IoT.

Keywords: IoT, Domestic Households,

1 Introduction

Tariff is a duty to be paid for the amount of consumption used. In India till now we are paying a constant amount per unit is been charged. Whereas in many other countries the unit charge is varied for time period. In future India will also undergo such progress, charge based on time period. In which literally it reduces the tariff, but the high consuming appliances at the peak time will cause huge tariff. INDIAN ENERGY EXCHANGE (IEX) is providing reports of the daily energy charges, which vary for every 15minutes. Above the particular unit consumption the INR/unit varies.

A. Dynamic tariff

For decades, dynamic tariffs, in combination with customer engagement and price-responsive technologies at the point of consumption, have been an important avenue for managing electricity supply and demand balance. As an example, in conjunction with construction of relatively “inflexible” large-scale nuclear power generation capacity in the 1970s and 1980s, utilities in France established a nighttime discounted rate and distribution companies installed electric water heaters that would automatically switch on during these low-rate periods–thus providing a load for the power and allowing the high capacity operation of the plants. The overall effect of this coordinated tariff and technology system flattened overall demand, shifting load from daytime peak periods to night time low-demand periods; it provided greater alignment between electricity generation and consumption. Further utilities around the world have tested the impact of price based customer feedback system on consumer behavior for at least four decades. Such studies can directly motivate the energy conservation through consumer behavior.

B. Tariff Determination in India

The terms and conditions for tariff setting in India are generally guided by the principles contained in the

Fig.1. Load curve for a typical day
Electricity Act 2003. Though the legislation under the act provides for differentiation of tariffs, even among the same category of consumers (according to, e.g. basis of load factor, power factor, and even the time at which supply is required), the tariff currently set by State Commissions is mostly at fixed rates (barring a few instances where ToD tariff is being implemented for bulk consumers). The main reason for this is a lack of information and communication technology in the Indian distribution network for capturing consumption data in near real time. All this is set to change with implementation of smart grid technologies in the Indian distribution sector.

2. Related Works

A. Power System Challenges in India:

In order to meet the enormous power needs in the coming decades, the Government of India (GoI) has launched various initiatives such as the Ultra Mega Power Projects (UMPPs), facilitating increased private sector participation via IPP in power generation by allotting projects under tariff-based competitive bidding routes. UMPPs are very large projects, with approximately 4000 MW each using super critical coal technology and involving an estimated investment of about US$ 4 billion. As a result, the share of private sector in Generation installed capacity is set to increase from 19% in the Eleventh plan to around 57% in the Twelfth plan. To improve performance of distribution companies, the smart grid in India will aim at:

- Reducing aggregate AT&C losses and bringing them to around 5-7% matching with the benchmark losses across the best utilities around the globe
- Ensuring minimum lifeline supply for all, ensuring there are no power cuts
- Managing and reducing peak power demand
- Utilizing the abundant potential of renewable power by integration of renewable/ distributed generation to the Grid efficiently
- Enabling proliferation of presumes using rooftop solar PV generation.

B. Consumer Concerns

A. Consumer Concerns about benefits

- Utilities seek to justify their smart metering approach without any analysis of alternative means to obtain DR results from residential customers: direct load control works and is less costly; do not need AMI for this technology.
- Utilities typically do not include customer costs to actually bring the usage data into the home or connect to any appliance: in-home devices and new appliances are not cheap!

Benefits -

- Using dynamic pricing tariff operational cost will be saved because elimination of jobs re meter reading and field operation.
- Using dynamic pricing tariff consumption of energy will reduce and energy will conserve.

B. Consumer Concerns about costs

- Utilities often seek separate tracker to assure cost recovery outside of a base rate case: consumers bear full responsibility for actual costs as they occur.-Potential for higher bills for low use and low income customers [1].
- New technologies: who bears risk of wrong choice? [VCRs vs. DVDs vs. DVRs] [1].
- Smart Metering proposals may be only a down payment on unknown future Smart Grid investments [1].

3. Consumer Concerns
C. Consumer Concerns about security

- Utilities typically couple smart metering with the functionality of remote connection and disconnection of the meter; disconnection for non-payment should be accompanied by a premise visit and attempt to contact the customer to avoid disconnection \(^1\).

- These new meters may give rise to a host of degraded service options, e.g., prepayment (pay in advance and automatically disconnect when meter is not fed); service limiters \(^1\).

- New privacy concerns will become evident with the access to individual household usage information: Is anybody home?

- What appliances are being used? Who can access this data and for what purpose?

Implementing this system user can monitor the tariff changed with time and optimum utilization of household and home appliances as per their beneficial tariff rate. This proposed system can also influence the load demand increase during the off peak period and helps to maintain the load factor within the off peak period. This system helps to improve the overall economy per unit cost of electricity and also it will be beneficial to consumer rate of electricity utilization also \(^1\).

4. Proposed Systems:

A. Analysis:
Most people have a set routine and consume energy at the same time of day. The data that were collected show that domestic households have high usage of energy during morning (8-11am) and again in the evening (7-9pm). In future different tariff structures will encourage consumers to reduce their electrical loads during the peak hours. The meter used to capture the data can be considered as a ‘smart meter’. Smart meters come with an in-home display screen that shows you exactly how much energy you’re using in pounds and pence, in near real time and will bring an end to estimated bills. Pricing is one of the key components characterizing a retail offering (besides the billing options, the form and level of customer service, the type of electricity etc.).

Depending on the peak demand the unit price are fixed, by reducing the peak demand the unit price will also be reduced. To reduce the demand curve and to make constant demand the load should be shared equally for full time. While comparing to the commercial users residential users are more. So the major factor to reduce the demand curve is from residence. Since for commercial users they have some time limits other than their time they don’t use electricity. By focusing on the residence the demand curve can be gradually decreased and can make constant curve with some variations as shown in figure.

![fig2. Current unit charges in Tamilnadu](image.png)
B. Methodology.

A variety of pricing offers allowing maximum choice and the best fit for customers is crucial. Retailers prepare integrated electricity offers combining the three elements of the bill, i.e. energy, taxes and levies. While they effectively pass-through the network and taxes and levies charges, they have an option on how to design the energy component. Retailers should be able to propose to their customers a diversified price list that allows them to choose an optional exposure to price volatility corresponding to their flexibility potential and risk aversion. Such products may include fixed-price offers and different types of dynamic pricing.

To reduce the Tariff, the demand is to be reduced, the high appliances is to be operated in non-peak hours. By operating the high appliances in non-peak hours, there is an increase in the non-peak hour and a decrease in the peak hour. This will make the demand curve constant as shown in fig3.

C. Implementation.

The appliances are divided into priorities and at the low peak time the high appliances such as inverter charging, motor, electric car charging. The cost of production of conventional energy also can be reduced.

The household appliances to be divided into two categories:

Priority 1: The mandatory loads (Fan, Lights, Television, Fridge, and Oven) these appliances are to be used whenever user needs. This cannot be restricted.

Priority 2: The high-level appliances (Motor, Inverter Battery backup, Air conditioner, Car Battery charging in future). By restricting these kind of appliances in non-peak hours will reduce the demand.

The appliance under the category of priority 2 is to be manipulated and scheduled using microcontroller based on real time unit cost of electricity. As shown in block diagram, the present electricity price per unit is automatically fetched to microcontroller through internet using Ethernet shield. RTC (Real Time Clock signal) is a clock that keeps track of current time. It is used to access the current time and compare it with fetched data for manipulation and task scheduling for the priority 2 appliances. By collecting the information from RTC and IEX server, the microcontroller sends signal to switching and control circuit (i.e. relay) to control the switching operation of appliances.

fig5. Shows the statical data from IEX in which the price for every 15 minutes is plotted. The arduino atmega2560 microcontroller uses C program embedded with HTML as instruction language to process the scheduling of task. During the period of low demand in electricity this circuit will automatically turn on the
scheduled appliances in order to stabilize the demand curve, which results in lowering of maximum demand. This makes the impact on usage of non renewable resources.

5. Processing

The webpage for complete access and scheduling of electrical appliances has been designed using HTML embedded with C language using arduino. This webpage displays the statistical data fetched from Indian Energy Exchange (IEX) website in form of graph and also contains control and access keys in form of buttons along with check box and radio buttons to differentiate among priorities devices. The command is provided through this webpage and the data is transferred in digital form to arduino and is processed in the microcontroller itself. If the users want to operate the high appliance apart from scheduled time, the microcontroller compares the scheduled time and given input time from the users and notifies the user about the unit charges. Whenever the user attempts to schedule the task there will be a notification from the circuit which prompts the user about the optimum scheduling time. This process will take place only if the user needs the appliances for emergency time.

E. Merits:
- Increase the usage of renewable energy resources and reduce the usage of non renewable energy resources.
- The cumulative unit charge is reduced in individual.
- Stabilize the demand curve by decreasing the maximum demand.

6. Conclusion:

This proposed system enables user to monitor the tariff changed with time and optimum utilization of household and home appliances as per their beneficial tariff rate. It can also influence the load demand increase during the off peak period and helps to maintain the load factor within the off peak period. This makes an impact on usage of non renewable resources for energy generation and helps to improve efficiency. Future work could further link with emerging technologies such as Smart Grid and make associated operating changes.

References