VIEW POINT

TIME OF USE ELECTRICITY TARIFF – A KEY ENABLER FOR RENEWABLE ENERGY USAGE

Abstract

Many countries around the world are working towards achieving net zero. This has shifted their focus towards adopting renewable energy sources and reducing their dependence on power generated through fossil fuels. In order to make this initiative successful, demand management of electricity consumption is equally important. The responsibility does not rest solely with governments and their ability to generate more renewable power. Households must plan their consumption too so that they can absorb the renewable power generated to the maximum extent possible. Time of use (TOU) is an electricity tariff mechanism that can encourage consumers to make this shift towards using renewable power.

This paper discusses TOU, its implications on renewable energy consumption, and the challenges in implementing TOU tariffs. It also provides suggestions and the course of action for distribution companies, manufacturers, and consumers to fast-track the adoption of TOU tariffs.

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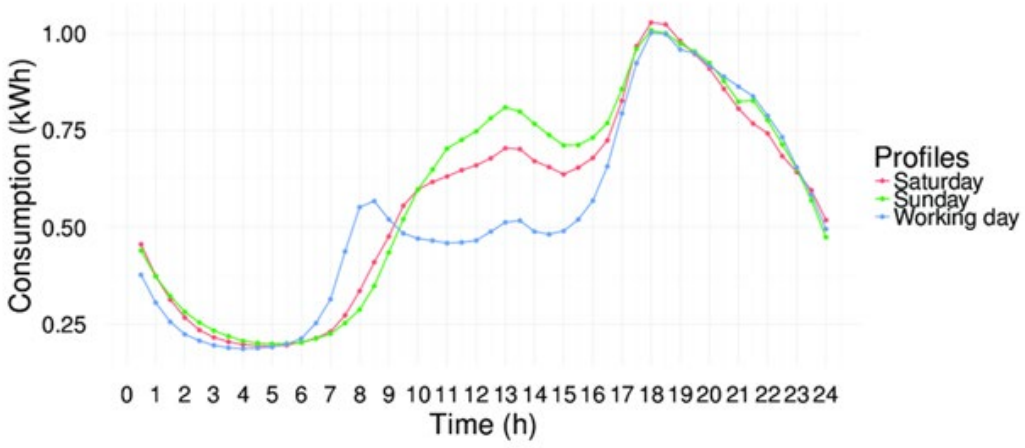
Introduction

As the demand for electricity increases globally, it is important to use less fossil fuel to generate power and to promote the use of renewable energy sources such as solar and wind power. A significant challenge with solar energy is that it is intermittent, i.e., not constantly available throughout the day. Storing solar power in reserves to use at night involves high costs, Moreover, this process is at a very nascent stage. Hence, solar energy needs to be consumed quickly.

However, a typical electricity consumption pattern as shown in Figure 1 reveals a spike in electricity consumption in the morning when offices, colleges, and schools start their operations. This is followed by a spike in the late afternoon as students return home from college and school while businesses, manufacturing facilities, and offices are still functioning. Lastly, a peak in electricity consumption is observed during the early evening hours as working adults head home from their offices. Throughout these peak hours, coolers and air conditioners run in full swing during summers in households, and similarly, geysers and heaters operate during winters.

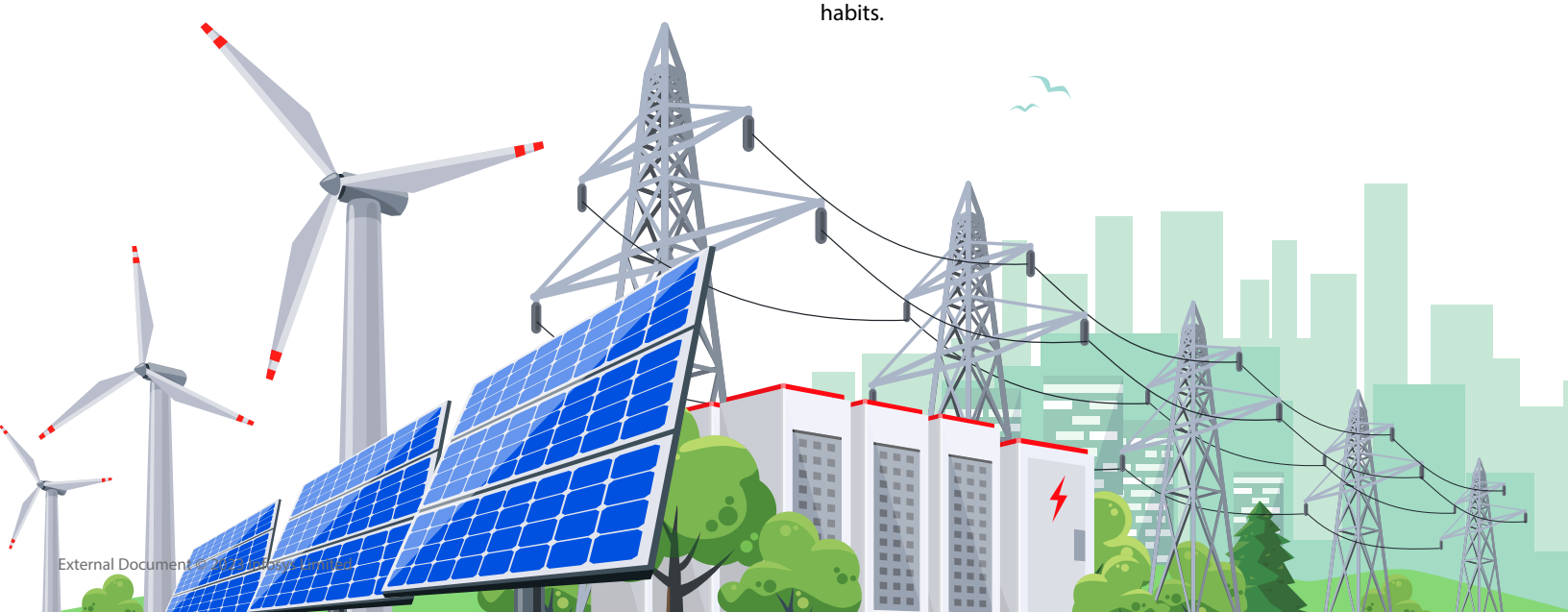
Figure 1 – Typical electricity consumption pattern



(Source: "A Dedicated Mixture Model for Clustering Smart Meter Data: Identification and Analysis of Electricity Consumption Behaviors" by Fateh Nassim Melzi, Allou Same, Mohamed Haykel Zayani and Latifa Oukhellou)

To maximize utilization of solar power, it is essential to bring a behavioral change in consumers by incentivizing them to use renewable energy during the day and reduce the usage after sunset during the evening peak hours. This will shift part of the demand for electricity from peak times to non-peak times and enable the utilization of renewable energy to the fullest.

Imagine a scenario where we pay less for electricity if we meet our electricity needs - such as charging our electric vehicles or using the washing machine – during the day, and pay more if we consume electricity at night. This dynamic pricing mechanism is known as time of use (TOU) electricity tariff. This form of pricing can encourage consumers to change their electricity consumption habits.



Challenges Due to Peak Electricity Demand

Power generating companies (gencoms) and transmission companies face multiple challenges due to unexpected surges in demand for electricity.

• **High cost of raw material to meet unexpected demand:** Gencoms use coal procured from markets as raw material to generate electricity. While most contracts with the coal supplier are long-term deals, there could be short-term deals too. Striking a short-term deal with the coal supplier during unexpected peak electricity demand increases the bargaining power of the coal supplier, and significantly increases the cost of the raw material (coal) for gencoms. This increases the cost of producing electricity. Gencoms cannot always pass on the rise in the cost of raw materials to their customers as electricity is subsidized in many countries. Therefore, this method of operation is not economical for gencoms.

• **Adding capacity for rare spikes in peak demand:** Transmission companies supply the electricity generated from the main power station to substations across the country. They set up the infrastructure to ensure consistency when electricity demand increases. For this reason, they need to add new capacity to cater to moments of peak demand. But this peak demand can be just for a few days in a year such as during holidays. Transmission companies must still add capacity to ensure an uninterrupted supply for this seasonal peak demand. For the remainder of the year, the newly added capacity is unused. Hence the return on investment makes this unviable.

• **Managing sudden surges in demand:** A surge in peak demand puts an immense load on the entire electricity supply value chain. This results in a deterioration of the system load factor.

A smooth demand curve can protect gencoms from a sudden spike in the cost of producing electricity and help transmission companies reduce the capex costs of setting up new infrastructure to cater to peak seasons. Lastly, a predictable demand curve can improve the system load factor by reducing the demand on the system during peak periods.

Traditional Billing – Fixed/flat Tariff

In the traditional billing system, a consumer is charged a fixed/flat electricity rate at all times of the day. The total invoice depends only on the number of units consumed. As the number of units consumed increases, the electricity bill also increases. This pricing mechanism is followed in most countries including India, Australia, and Germany.

The problem with fixed rate tariff

A fixed tariff rate does not provide any monetary incentive to consumers to change their electricity consumption habits. Consumers use electricity as needed and no conscious decision-making plays any role in their usage pattern. For example, a person charging their electric vehicle after sunset (during peak demand time) will incur the same cost that they would if they charged the vehicle in the morning (during off-peak demand time). The time of the day does not impact their electricity consumption behavior. Therefore, the typical electricity consumption pattern explained in Figure 1 stays the same.

Time of Use (TOU) Tariff – An Alternative to Fixed Rate Tariff

In this method of billing, instead of the same flat rate at all times of the day, the price of electricity varies according to the time of the day. There are two types of TOU tariffs – static TOU tariff and dynamic TOU tariff.

Static TOU tariff

This tariff applies to usage over continuous time blocks of several hours, where the time for each block is determined in advance and remains constant. In a static TOU tariff, the day is divided into three parts: normal hours, solar hours, and peak hours.

- **Normal hours:** Normal hours usually span the time between midnight and daybreak. During normal hours, consumers are neither incentivized nor penalized for consuming electricity. The tariff rate set for this period is typically considered the reference rate, against which tariffs for solar and peak hours are set.
- **Solar hours:** Solar hours typically span 8 hours a day when the sun is out. Throughout this time, the tariff is lower than the tariff during the normal hours. Compared to normal hours, the tariff of solar hours is usually 10% to 20% lower. Since solar power is cheaper than that generated from coal or other fossil fuels, the tariff during solar hours is less. This is beneficial to the consumer.
- **Peak hours:** Throughout peak hours, the tariff is higher than the tariff during normal hours.
  Compared to normal hours, the tariff of peak hours is usually higher by 10% to 20%. During this period, non-renewable energy sources such as coal and natural gas are used to produce electricity. The cost of producing power from these sources is higher than that of solar power. Coal power is four times costlier than solar power. This rise in cost is passed on to consumers.

Dynamic TOU tariff

Under the dynamic TOU tariff mechanism, rates are determined in real time and the tariff varies at short notice. These rates are defined based on the actual system conditions driven by supply and demand. Just as a company's stock price changes in real time within the same day based on investor demand, so too it is with dynamic TOU tariffs. Armed with the knowledge of the cost of electricity at any given time, consumers can manage their electricity consumption accordingly.

For example, let us assume that on a Friday evening, from 17:00 hours to 17:30 hours, the household consumption of electricity ramps up due to a surge in demand. From 17:30 to 18:00 hours, the consumption further increases (compared to the period between 17:00 and 17:30 hours), leading to a peak. Based on this pattern, dynamic pricing would assign a higher price tariff (say 'x' per unit since the consumption increases fast during this period) from 17:00 hours to 17:30 hours and an even higher price tariff (say 'x + n' per unit) from 17:30 to 18:00 hours.

Now consider the same situation on a weekend, Saturday, from 17:00 hours to 18:00 hours. This is when many people come out of their homes to stroll in the park or visit a cinema hall. Now, since household electronic equipment and appliances are idle, and, consequently, there is no rise in electricity demand, the principle of dynamic pricing would assign a price tariff that is lower than the tariff for the same time on Friday (say 'x-p' per unit) from 17:00 to 18:00 hours. Note: The rate of 'x-p' per unit would still be higher than the tariff during solar hours.

On the other hand, the static TOU tariff mechanism would have assigned the same tariff rate (let us say 'y' units, where 'y' is higher than the solar hours tariff) on both the days – Friday and Saturday – in the time-slot mentioned earlier (17:00 hours to 18:00 hours). This is because the rates under static TOU are predetermined and do not change in real time.

Benefits of Time of Use Tariff

Several nations around the world are implementing TOU tariffs. Countries that follow TOU tariffs include the USA and 17 European countries such as France, Sweden, and Finland.

In addition to the obvious advantages of driving consumers towards utilizing renewable energy and helping businesses achieve their net zero targets, other benefits of the TOU tariff system include:

- **Savings on electricity bills:** As indicated earlier, consumers receive price signals in the TOU system. Based on these, consumers can manage their load optimally according to the tariff. They can plan more activities during solar hours, when tariffs are lower, to reduce their power costs. This helps cut electricity bills and effectively utilize the TOU tariff mechanism.
- **Faster energy transition:** The TOU tariff incentivizes demand increase during high renewable energy generation hours. This ensures better grid integration of renewable energy sources, facilitating a faster energy transition.

Challenges in Implementing Time of Use Tariff

As with any change, implementing the TOU tariff system has its own set of challenges that must be overcome.

Consumers are not interested in managing their electricity consumption: Most consumers believe that they should use electricity when it is needed and not have to wait for the right time for it to become cheaper. Also, consumers perceive that the savings made using the TOU tariff mechanism would be insufficient and insignificant.

Implementing smart meters is causing a hindrance: Smart meters are devices that automate the process of accurately recording the electricity consumption in real time. These devices constantly relay the reading to the electricity supplier, that is the power distribution companies (discoms). This reading can also be synchronized with an app, so consumers can see the units they consume in real time. Smart meters are a prerequisite to implementing the TOU tariff. But deploying smart meters in every home has been an uphill task due to the following reasons:

- The time taken to integrate smart meters with the legacy billing software of the distribution companies is excessive.
- The global shortage of semiconductor chips, which are an integral component of smart meters, has led to a production slowdown.
- The initial investment for deploying smart meters is high. Installing smart meters is highly capital-intensive for both consumers and suppliers. The average cost of a smart meter unit is somewhere around US $100 to $500, whereas a traditional meter costs around US $10 to $30. Also, it is unclear who, consumers or distribution companies, would bear this additional cost. Governments in various countries have assured discoms that they will provide subsidies. But cash-strapped and debt-ridden discoms are apprehensive about putting their skin in the game. This is further delaying the implementation of TOU tariffs.

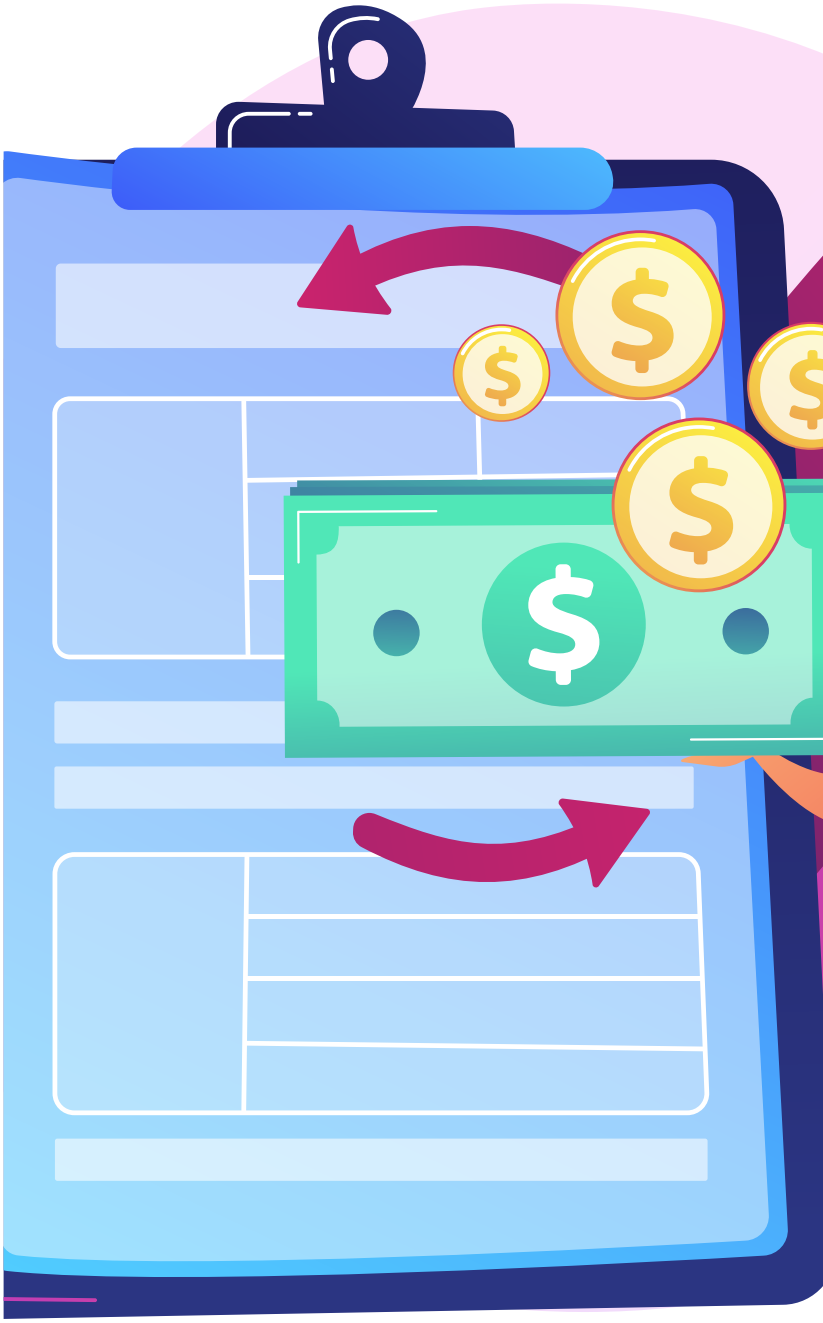
Recommendations to Accelerate TOU Tariff Adoption

Governments, power corporations, and consumers can undertake several measures to accelerate the adoption of TOU tariffs with consequent long-term benefits for all stakeholders.

Financial support from the government

Governments can provide subsidies to discoms for procuring smart meters and installing them, thus helping ramp up their deployment. Discoms should actively cooperate with the government and utilize the subsidies for their benefit. With smart meters, these companies can reduce electricity theft and increase bill collection efficiency, improving revenue and profitability as a result.

Governments can also propose production-linked incentives for smart meter manufacturers. This will help manufacturers scale up their operations and bring down the per-unit cost of a smart meter through economies of scale. Production-linked incentives for associated businesses such as semiconductor chip industries will also help smart meter manufacturers procure raw materials domestically. This will bring down the cost of importing chips and assembling them, thereby bringing down the overall cost of production.



Adopting smart appliances and automation

Smart devices can automate the process of actively monitoring the change in tariffs and responding to it, thereby sparing consumers from performing this activity manually. A few startups and other companies are already exploring the possibility of developing smart devices that can react to changes in price signals in real time. Automating existing appliances or purchasing smart devices requires consumers to spend more money, leading to a reluctance to buy these devices. However, consumers must understand that in the long term, the money saved on electricity bills will outweigh the initial spending. The smart appliances market is growing at an unprecedented rate because there is a rise in interest in smart appliances and gadgets, especially among millennials and Gen Z.

Examples of using automation to adopt TOU tariffs

Figure 2 demonstrates a simple automation algorithm for an electric heating appliance.

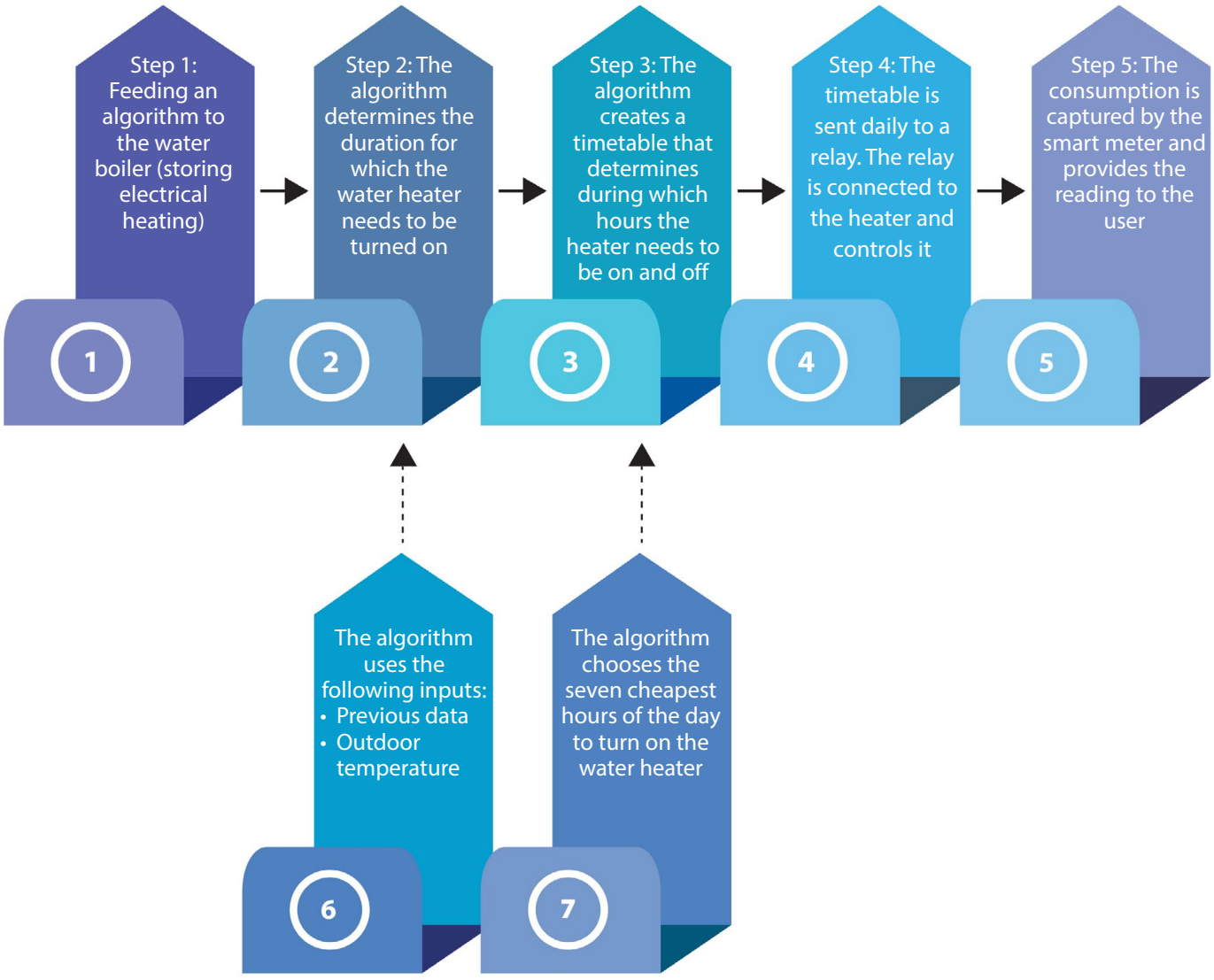


Figure 2 – Automation algorithm for a heating device

Figure 3 demonstrates the development of an Alexa-based application that can make any home appliance smart. The user just needs to provide a command such as "Hey Alexa, turn on my washing machine when the power tariff is cheapest."

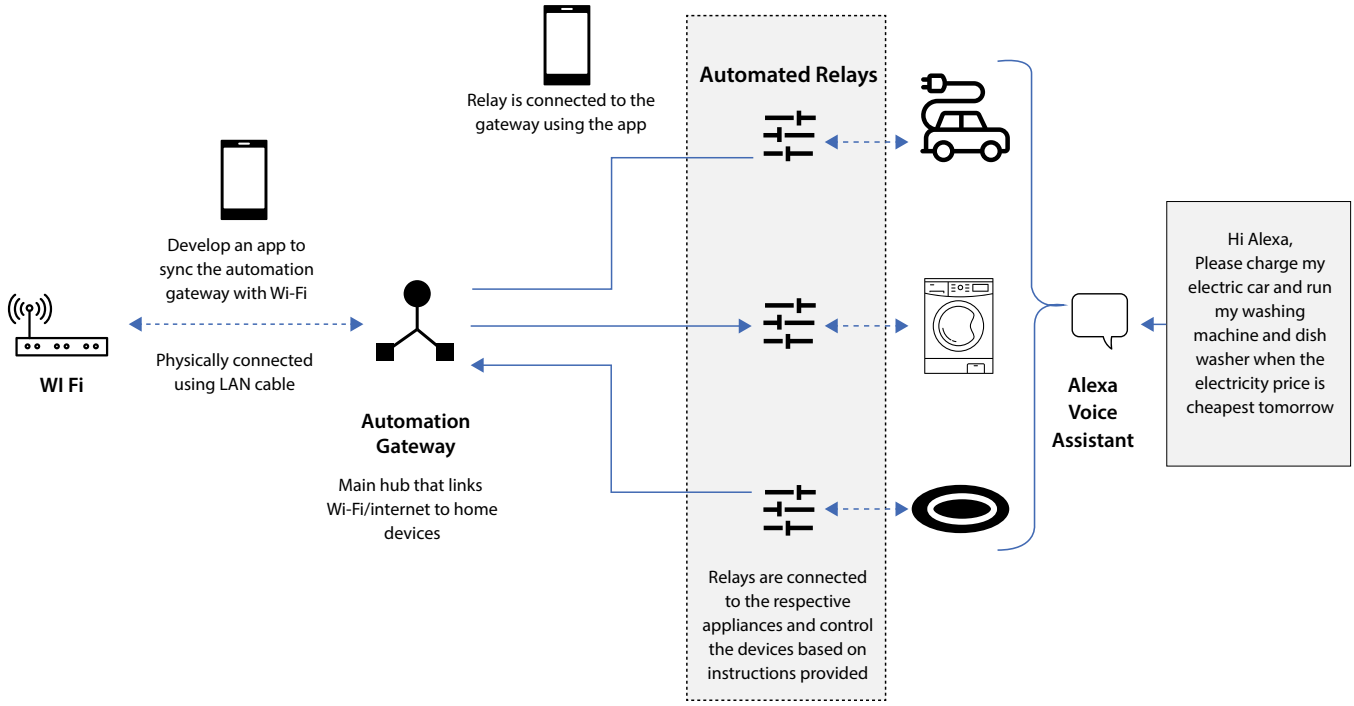


Figure 3 – Alexa-based application to figure out the best times to run home appliances

Upgrading the legacy billing software of discoms

The government can introduce a policy that proposes to have a single upgraded billing software in all the states across the country under a program such as 'one nation, one electricity billing software.' The government can consult with various industry experts, including smart meter manufacturers, and float a request for proposal (RFP). This can then be followed by a stringent bidding process where interested software solution-providers can participate. It is an excellent opportunity for software companies to provide modern technology solutions. Many web-based government applications have already been implemented across countries. For instance, in India, the software platform used in the Unique Identification Authority of India (UIDAI) program registers citizens and issues Aadhar cards (unique identity numbers), the Passport Seva Kendra portal onboards citizens to issue passports, and the Income Tax portal allows citizens to file their returns.

Advantages of a single electricity billing software

A single electricity billing software across the country has many advantages:

- **Reducing complexity and cost:** Consider a smart meter produced by a manufacturer A and used in two states, X and Y. If the billing software used in state X differs from state Y, the manufacturer must tune and calibrate the meter as per the software used in the particular state in which the meter is used. This process is time-consuming and raises the testing and software compatibility costs every time. It can delay the ambitious target of deploying smart meters across the country. Further, a rise in the cost of production of these meters will result in a higher selling price. A common billing software will reduce the complexity for manufacturers and keep overall costs low for consumers.
- **Ease of integration:** Similarly, discoms can publish the specifications and configuration of the billing software to all smart meter manufacturers that operate within the state for standardization. This makes it easy to integrate different smart meters used by consumers with the billing software.
- **Accelerating adoption:** If different manufacturers can successfully integrate their smart meters with the newly upgraded billing software of one discom, the practice can easily be emulated by other discoms across the country resulting in faster adoption of the TOU tariff system.

Introducing regulatory default options

The TOU mechanism can be made the default option for all consumers and consumers can have the option of moving out of it. Some countries where TOU has been made the default option are

Spain, Ontario, and Italy. Spain has set a good example in Europe. Nearly 40% of Spanish consumers are linked to the TOU mechanism which is higher than the average European participation. Opt-out schemes promote stickiness compared to opt-in schemes. This is the reason a large population in Spain continues to be on the default pricing mechanism. The enrollment rate in Ontario rose to 89% within a span of 4 years after the introduction of the opt-out scheme. In contrast, as per a statistical estimation model, the enrollment rate would be 20% had it been an opt-in model.

Case Study: TOU Tariff Success in the United States

ConEd, a utility company based out of the United States, launched a program in Illinois wherein consumers were allowed to participate in the TOU tariff scheme. Consumers initiated many electricity consumption pattern changes such as precooling the house during the early morning hours when the tariff is low and keeping the cooling system idle when the tariff is high. As a result of this program, consumers saved an average of 15% on their electricity bills.

There are many similar success stories about TOU tariffs. As consumers adopt this billing mechanism, they will begin to see the advantages for themselves.

Conclusion

As we target greater reliance on renewable energy, TOU electricity tariff can provide a good measure of the rate of progress. People can plan more activities during solar hours when the tariff is lower and save on electricity bills even as they contribute to making the planet greener.

However, any change brings its own set of challenges. Installing smart meters in households is a prerequisite to implementing the TOU tariff mechanism. We must investigate the technical and financial feasibility of implementing smart meters and incentivize manufacturers and discoms to drive adoption. The problem of legacy billing software can be overcome by moving to modern state-of-the-art billing software. Monetary incentives offered by the government can be of immense value in overcoming the financial burden on various stakeholders involved. These incentives can also help smart meter manufacturers scale up their facilities and reduce the unit cost of smart meters.

TOU tariff has been successfully implemented in several countries including the United States. This provides a path for other countries to emulate and implement TOU tariffs. However, all stakeholders such as smart meter manufacturers, discoms, consumers, and regulatory bodies must collaborate for successful implementation and rollout of this tariff system. This will ensure that energy produced from renewable sources is utilized to the fullest and our reliance on fossil fuels is reduced.

About the Author

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A consultant with Infosys Consulting and works with clients in the energy and utilities domain. He specializes in identifying and delivering business value to our clients through cutting-edge operating models and business transformation efforts. An avid follower of business trends, he provides helpful business insights to clients by better managing information.

Mrityunjay holds an MBA from the Indian Institute of Management, Indore, and a Bachelor's degree in Instrumentation and Control Engineering from the National Institute of Technology, Tiruchirappalli.

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