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ROLE OF SMART METERS IN COMBATING ELECTRICITY THEFT: AN ANALYTICAL AND CRITICAL STUDY

Bhavesh Acharya [a, *]
[a] *Research Scholar, Maharashtra National Law University Nagpur, Maharashtra (India).*

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ABSTRACT
Over the years, the Government of India has undertaken various methods to combat and deal with electricity theft. The introduction of Section 135 which penalizes electricity theft was the first attempt at creating a deterrence for electricity theft. Furthermore, the law has also resorted to imposing harsh penalties & punishments, creation of special courts, and some state governments have even created special police stations to deal with electricity theft. Despite these steps, electricity theft continues to be an issue in the country which is a major contributor to the T&D losses and has led to a very poor financial health of the distribution companies. The installation of smart meters is expected to help in providing a long-term solution to the problem of electricity theft. This research paper attempts to discuss the nature and working of smart meters. Thereafter, it lists the advantages of installing smart meters especially in preventing and detecting electricity theft. India has started its journey towards incorporation of smart meters and the paper elaborates upon this journey by reflecting upon the latest available data and the issues and challenges that the states are facing in this journey. The paper has also deliberated upon the issues that may arise in the future. Having identified the issues, the paper concludes with a comprehensive discussion on suggestions to resolve existing issues and to resolve future issues as well. Much focus has been put upon data privacy in this paper. Through this paper, the author intends to provide a detailed study of the technical and legal aspects of smart meter installation and to study and predict its positive as well as negative effects. The author also desires to provide solutions to the negative effects discussed in the paper.

I. Introduction

Electricity theft is a peculiar problem in India. Over the years, the mode and manner of committing electricity theft have evolved which in turn forces the detection mechanisms to be evolved as well. India is in the list of top countries where T&D losses are significant. As of 2013, the T&D losses accounted for 20% at the generation stage itself.[1] According to the data as available in 2018, the T&D losses at the distribution stage were at 22%. However, in some states, the losses accounted at almost 40% or higher. Odisha, Madhya Pradesh, and West Bengal were the worst sufferers.[2]

Corresponding author
>>***E-mail:** arybhavesh@gmail.com (Bhavesh Acharya). https://orcid.org/0009-0006-9695-7019
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According to PricewaterhouseCoopers (PwC) India estimates, theft, meter tampering, billing problems, and leakage due to defective equipment cost India's power companies around a fifth of the electricity they supply, or about USD 10.2 billion annually. The World Bank estimates that in 2011, the debt incurred by India's power sector amounted to INR 3.5 trillion (about USD 77 billion), or 5% of the nation's GDP. Approximately 25% of the electricity produced in the nation is either misplaced or lost during transmission.[3]

The most basic form of identification of electricity theft is to account for the difference between the electricity supplied and electricity consumed. This is what electricity meters perform. Therefore, good and efficient metering technology can play a significant role in combating electricity theft. The algorithms of machine learning that have developed over time can contribute a lot in improving the metering system in India. The algorithm can aid in determining the predictability of customers' normal and malicious consumption patterns and provide a high and adjustable performance with a low sampling rate by applying the proper classification and clustering techniques, transformer meters, and anomaly detectors in tandem.[4]

Smart meter technology

A smart meter consists of two components: a metering device which is in the custody of distribution company or utility company and a display unit which is installed at the place of electricity consumption, that is, with the consumer. These smart meters are capable of one-way communication and can help the distribution companies in identifying cases of unusual consumption. Even minor deviations are easily identified and hence, it is very effective even in places where electricity theft is prevalent and manual identification is difficult. Additionally, these meters have an automatic shutdown feature for households or consumers who have failed to disburse the payment for a certain period of time.[5]

The smart metering systems will store huge amount of data and will also enhance the accuracy of the data. All in all, it will no doubt assist in identification of electricity theft in lesser time and with more accurate date for deciding upon culpability. Additionally, the data stored and transmitted by these meters has limited accessibility meaning that it cannot be altered or removed by any person other than those authorized. Another advantage of energy consumption data collection for consumers is that they can manage their electricity consumption. Smart meters can also help them in monitoring and controlling their appliances.[6]

IoT and smart meters

In the fight against electricity theft, even the Internet of Things (IoT) can help. Smart metres with IoT capabilities can help with overall electricity management by detecting issues such as power outages, manipulated meters, and general monitoring, in addition to electricity theft and aberrant use. The ability to send real-time data is the most significant advantage of IoT connected smart meters. Consumers and distributors can both benefit from this real-time information. Real-time data will assist consumers because they will be able to track their electricity usage and receive a cost

estimate ahead of time.

The benefit of application of IoT to smart meters, in terms of electricity theft is that the meters can be attached with theft detection systems. This is done through Advance Metering Infrastructure (AMI) which will report anomalies in real time. Thus, the manual practice of analysing consumption data will be done away with which will in turn make the enforcement mechanism stronger and faster. Some prominent examples of AMI are meter tampering alarms which raise alarms when meters are tampered or hacked, automated control and cut off which can cut off supply as soon as theft or any other fraudulent activity is detected, accurate consumption analysis which will help in spotting leakages caused by electricity theft, etc.[7]

Apart from electricity theft, the IoT enabled smart meters can also help in combating other electricity problems like technical power losses, peak power deficit, effective energy management, efficient use of grid resources, focusing on renewable energy usage, and better monitoring by load forecasting.[8]

Steps taken in India

In furtherance of this objective, the Government of India established the National Smart Grid Mission (NSGM) in 2015 so as to enable acceleration of Smart Grid deployment in India. As of April, 2021, 2,392,137 smart meters have been established across India in pursuance of this mission.[9] These smart meters are capable of handling the menace of theft of electricity. However, much depends on the efficient, timely, and effective deployment of these smart meters which is in turn dependent upon the infrastructure.[10]

According to the official website, smart grid has been defined as "an Electrical Grid with Automation, Communication and IT systems that can monitor power flows from points of generation to points of consumption (even down to appliances level) and control the power flow or curtail the load to match generation in real time or near real time".[11]

In April, 2021, Tata Power DDL launched India's first Narrow Band-IoT (NB-IoT) enabled smart meter in Delhi. The NB-IoT is 4G and 5G enabled and is claimed to ensure efficient performance irrespective of congestion and will also increase the number of remore meter readings.[12]

India has aimed at replacing all conventional meters with smart meters by 2022. For achieving this mammoth goal, the Smart Meter National Programme (SMNP) has been started by the Energy Efficiency Services Limited (EESL). The aim is to replace almost 25 crore conventional meters to smart meters across India. EESL signs MOUs/Agreements with the States for installation of smart meters.[13] As of December, 2021, smart meter installation has started in the states of Uttar Pradesh, Bihar, Haryana, Rajasthan, and Delhi. Furthermore, in Jammu and Kashmir, Arunachal Pradesh, West Bengal, and Gujarat the discussion is going on.[14]

Smart Meters and Electricity (Rights of Consumers) Rules, 2020.

The Electricity (Rights of Consumers) Rules, 2020 were issued by the Central Government on December 31, 2020, in exercise of its powers under Section 176 of the Electricity Act, 2003. These have been issued with the goal of ensuring excellent delivery of consumer services by

establishing the rights of electrical consumers to basic quality standards. Various rules have been adopted under the Rules in respect to metering, invoicing and payment, disconnection and reconnection, and standards of performance for distribution licensees, among other things.

Rule 5 of the Consumer Rules stipulates upon metering. At the outset only, it has been clearly stated that, "No connection shall be given without a meter and such meter shall be the smart prepayment meter or pre-payment meter." Any deviation from this mandate must be approved by the Commission and the reasons for doing so are required to be recorded.

Furthermore, Rule 5(5) also stipulates that, smart meters must be read remotely at least once a month. Consumers will have access to data on energy consumption via a website, mobile app, SMS, or other means. Consumers with smart pre-payment meters may also be provided data access in order to monitor their usage on a continuous basis.

Even though there is only one provision that talks about consumer protection aspect of smart meters, the aspect has no doubt been acknowledged. Thus, over time, more detailed provisions regarding this aspect can be expected.

Impact on tariff

The majority of families in India pay a "flat-rate" tariff based on recorded consumption volume over a long period of time (e.g. monthly, seasonal, yearly). However, the cost of energy supply is determined by a number of factors that may or may not be consistent with this fixed price. Thus, imposition of a flat rate of tariff for all consumers across all segments of the society may not be economically efficient, neither for the consumer nor for the DISCOM. Installation of smart meters and the data available through smart meters can solve this problem by allowing for the introduction of dynamic tariffs on electricity.

The NITI Ayog in a report on Electricity Distribution in India demonstrated how smart meters can be useful for DISCOMS to increase demand flexibility. In simple terms, demand side flexibility in electricity refers to the capacity of loads on the demand side to alter the consumption patterns on a regular basis. Tata Power has conducted automated demand response (ADR) trials in Delhi and Mumbai so far, focusing on a small number of commercial and industrial customers.[15] BESCOM, a utility in Karnataka, chose to power irrigation pump sets during the day in a way that closely mirrors solar generation trends. As a result, they can better serve the morning and evening peak loads.[16]

Increasing demand side flexibility will help the DISCOMS in lowering the average cost of supply of electricity. Furthermore, demand flexibility allows for imposition of dynamic tariff or Time of the Day tariffs, which in turn will help both the consumers and DISCOMS. Electricity suppliers need to know about the demand-price relationship, consumers' willingness to pay for electricity, and demand projections in order to manage their supply and tariff structures. Electrical load scheduling can help consumers save money on their bills by increasing consumption when costs are low and decreasing consumption when prices are high. Demand patterns and elasticity differ from one user

to the next, hence segmenting the power market might be beneficial. Suppliers can provide appropriate pricing schemes in a timely manner.[17]

The scenario in the United States

For the purpose of a comparative analysis, the laws of the United States may be apposite to be considered. The United States' objective is to encourage, "time-based pricing and other forms of demand response, whereby electricity customers are provided with electricity price signals and the ability to benefit by responding to them" according to Sections 1252(e) and (f) of the Energy Policy Act, 2005. Furthermore, it also states that, "Deployment of such technology and devices that enable electricity customers to participate in such pricing and demand response systems shall be facilitated, and unnecessary barriers to demand response participation in energy, capacity and ancillary services markets shall be eliminated". To aid in the implementation of this new demand response policy, the Act establishes new demand response requirements for electric companies and states.

The EP Act seeks to achieve these objectives in two ways,

- **a.** By educating and making consumers aware about the technology of the smart meters and the advantages of dynamic and demand-driven pricing.
- **b.** Working with the different States and the Utilities in order to overcome any barriers that may come across in the working of smart meters.

Advantages of dynamic tariffs

Such dynamic and demand-driven pricing is beneficial for both the consumers and the Utilities. Customers can benefit from dynamic pricing in terms of cost reductions. It may be beneficial to electricity suppliers due to lower peak capacity investments, better planned operations, and cost-reflecting prices. By shifting peak loads from peak to non-peak hours, dynamic pricing might assist producers postpone investment choices.[18]

With the introduction of smart meters, dynamic and demand driven tariffs is a viable option in India. However, there is a dire need of data to understand and implement the same.

Advantages of smart meters

The data relating to electricity theft would reveal the areas that are most problematic and the means that are mostly employed for committing theft. This in turn will allow the distribution companies to focus on these areas that have high risk of theft.[19] The affluent and non-affluent areas both commit theft. Certain researches have demonstrated that the people in affluent areas usually commit theft of greater intensity since the theft is mostly committed in factories, industries, and commercial places. Additionally, in non-affluent areas like the slums, the intensity of theft is less since theft is committed mostly in residential places. (BRDC, 2000). Thus, the study has shown that theft occurs in all places, it is just that the power stolen in affluent areas is more in comparison to that stolen in non-affluent areas.[20] Unfortunately, despite stealing more, the people in affluent areas get away with it and inspection is often targeted against the poor persons.

Collection of data relating to theft is an extremely important way of identifying the causes of theft,

demarcating areas more prone to theft, and in general to formulate means of countering electricity theft. The introduction of smart meters will enable the collection of consumption data. However, the analysis of such huge volumes of data would require an algorithm that helps in continuous and accurate analysis of the data that is collected through the smart meters.

The algorithm will keep track of the general consumption of the consumers. The general or average consumption is dependent upon the nature of the consumer (residential/ commercial/ agricultural), time of the day (morning/ afternoon/ evening/ night), weather (summer/ winter/ rainy), financial status of the consumer (bigger houses might consume more electricity), number of users per connection, and various other factors.

After this, the algorithm will identify the irregularities. However, all irregularities cannot amount to electricity theft or unauthorized use since some irregularities may stem from the change in surrounding circumstances. Thus, there will be a need to classify the irregularities into categories based on the origin of the irregularities. The irregularities that occur without a reasonable explanation may be considered to be owing due to electricity theft, unauthorized use, or any other such illegal factors. Such complex analysis and calculations can be performed effectively and efficiently through High Performance Computing.[21]

Corruption is another major problem in cases of electricity theft. The inspectors often take bribes from the offenders and let them go. Thus, the employees of the distribution companies themselves are also at fault and also contribute to electricity theft indirectly.[22] India is a huge country and electricity connections are spread far and wide. The number of inspectors is also huge which makes the management and monitoring very difficult. Most employees get away with corruption and altering bills because of the sheer volume of connections and the mismanagement on the part of the distribution companies.[23]

The far reach of electricity and the mismanagement at central level allows the employees not just a position of authority but also allows for grater exercise of discretion at their end. Most employees then misuse this authority and discretion. They have the authority to decide important considerations like who will get connection, when the connection will be provided, time of power outages, bill payments, etc.[24] Since the employees are more likely to get illegal money from affluent areas, they have no incentive to go into the problems of the poor or less affluent areas.

Smart meters will not require such people to inspect the electricity usage manually. It will now be regulated by the smart meter itself and hence, the middle-men who are most likely to be involved in corruption are now eliminated. Furthermore, even those who oversee the functioning of the smart meter will not be able to control or alter its data since only a few personnel will be allowed access to the data. Thus, smart meters will also help in regulating corruption in the long run.

Issues and complications in smart meters installations

Several states have already started with the installation of smart meters for few lakhs of

consumers. On a limited scale of installation, certain problems have cropped up. For example, in Uttar Pradesh, almost 6,000 consumers have sought permanent disconnection complaining system faults and have expressed their dissatisfaction with smart meters. In Bihar, consumers have expressed recharging issues regarding pre-paid meters and the compatibility of these meters with payment applications.[25]

Yet another point of concern is the issue of data privacy. Since the smart meters are capable of transmitting real time data to the Distribution Companies, the consumer's privacy can be a concern. However, this is not a major roadblock since the receiver of the data can be controlled. However, in absence of such data control mechanism, consumers may not trust these smart meters for fear of privacy infringement.

Another issue that has come up in Uttar Pradesh, Rajasthan, and Bihar is with respect to who will bear the cost of installation of the smart meters: consumers or Distribution Companies. Earlier Uttar Pradesh had said that the cost will be collected from the consumers. However, the government then changed the policy and decided to charge additional tariff for collection of the cost of installation. The distribution companies, owing to their delicate financial health, do not wish to bear the cost of smart meters and they are arguing that it is the consumer who is the ultimate beneficiary of these meters and hence, they should be the one bearing the cost of installing smart meters.[26]

However, according to NITI Ayog, installing smart meters in all areas may not be suitable. This is especially for areas where the consumer concentration is low and also in areas where billing efficiency is already very good.

> "The case for smart meters is easier to make in areas where the billing efficiency is low, or in the case of high-tension consumers (where time-of-day (ToD) tariff can make a significant difference)."[27]

Another area of concern is the data protection and privacy. The Forum of Regulators had released a Model Smart Grid Regulations in 2015 as a guide to power sector regulators. The document clearly stipulated that the Distribution Companies or any other such agency would be responsible for ensuring consumer protection and privacy in terms of the data that is received from the smart meters. However, the document lacked clear guidelines as to how this data protection and privacy is to be achieved.[28]

Thereafter, certain states like Telangana, Assam, Tripura, Karnataka and Haryana framed Smart Grid Regulations that had certain points mentioned in relation to handling data and maintaining its privacy.[29] In 2020, the Ministry of Power framed the Standard Bidding Document that contained detailed guidelines on various aspects of the smart meter installation.[30] However, the provisions pertaining to data privacy were framed with reference to the Information Technology Act and not the recent Data Protection Bill. In future, the guidelines may have to be amended to be in consonance with the Data Protection Act. Overall, it appears that the relevant regulatory authorities and the Ministry have not deliberated sufficiently upon the data privacy aspect of the smart meters.

Conclusion and Suggestions

Of all the solutions available, installation of smart meters seems to be the most viable in the long term. However, this comes with the issue of data privacy. On one hand smart meters help in providing real time data, collection of data for analysing irregularities and can also help consumers in electricity consumption management. On the other hand, the major issues that plague the smart meter mechanism is the installation itself and the issue of data privacy. The issue of data privacy becomes more pronounced owing to the Data Protection Bill that may be enacted into a legislation.

The installation of smart meters is a mammoth task and is likely to bring about huge changes in the electricity sector. The effectiveness and efficiency of this smart meter system is dependent not just upon the Distribution Companies but also upon the consumers themselves. For example, the Distribution Companies will have to update their technical systems and the integration of the new mechanism with the existing technology. On the other hand, the consumers will have to get adapted with the app-based system and pre-paid bills. They will also have to learn and be aware of all the nuances of the new system.

The replacement of meters in India has taken up great speed. The entire mechanism stands upon the assumption that "the future benefits will cover the costs that are incurred now".[31] However, for this assumption to convert to reality and also to win the confidence of the consumers who are indirectly paying for this replacement, the entire cost-benefit needs to be tracked right from the installation time. The cost-benefit assessment must be done in a transparent manner, that is the formula for calculation must be revealed and the data arrived at using the formula must be made available to public for verification. It is also essential that this approach be uniform across all states.

There is also a need to make it clear as to who is the ultimate cost-bearer of the smart meter installation: the Distribution Companies or the consumer. In this regard, it would be appreciable if a uniform practice is adopted throughout the states so that what happened in the state of Uttar Pradesh does not happen in other states.[32] Rajasthan on the other hand have developed plans that will result in the consumer paying the cost of installation through the tariffs. Furthermore, Bihar has not yet decided upon who will bear the cost. Such non-uniform practice will cause harm not just to Distribution Companies who are unable to conduct a proper cost-benefit analysis but would also affect the consumers.

There is also need for focusing upon protecting consumer interests and making the consumers aware of the advantages of the smart meters. This will help in building consumer confidence in the smart meters and ensure that consumers do not resort to disconnection.

One problematic aspect of the smart meters is that consumers will face disconnection upon non-payment (in case of post-paid connections) or upon exhaustion of credit limit (in case of pre-paid connection). It is not clear whether such disconnection will take place immediately or whether the consumers will be given some warning or notice prior to disconnection.[33] This is important

especially during the nascent stages because consumers will have to learn to adapt to the new system and hence, immediate disconnection without notice would not be appreciable.

In relation to issues pertaining to data privacy, Prayas Pune has created a mechanism that will effectively deal with ensuring data privacy and still deliver the benefits of smart meters.[34] There are five key elements of this mechanism which are as under,

a. Limited purpose: This is probably one of the most cardinal factors that will assure the consumers that their data will not be misused. The framework governing smart meters must clearly lay down the purposes for which the data collected from the smart meters will be used. This will include boundaries as to who can collect, who can store, who can share, and for what specific purposes.

It is extremely imperative that the limited purposes defined be in line with the principals behind the provisions of the Data Protection Bill. Thus, the list for the purposes needs to be comprehensive and in consonance with the Electricity Act, 2003. It is also advisable to discuss these purposes with the various stakeholders involved. The list of purposes also needs to be categorized into those which require the consent of the consumers and those which are for reasonable purposes that do not require consent of the consumers.

b. Data storage and security: The Distribution Companies must ensure utmost data security and protection while the data is stored. The Distribution Companies would also be required to ensure the accuracy and the quality of the data. This would mean that personally identifiable data would need to be updated as and when required. The companies would have to ensure that the data is correct, updated, and still protected.

c. Consumer rights: Most state governments have agreed that the cost of installation of smart meters will be collected from the consumers. Furthermore, it is the consumers who will be ultimately affected by the data collection by smart meters. Thus, at all times, it is extremely important to keep consumer rights in mind. This will also be in line with the objectives and purposes of the Electricity Act, 2003.

Consumer rights will be in three forms: rights over their data, awareness regarding their data storage and sharing, and grievance redressal mechanism. The consumers must have access to their data, this will also ensure that the data is accurate and correct. Secondly, the consumers must be aware of how their data is being stored or if their data is being shared to third parties. Thirdly, the distribution companies must set up grievance redressal mechanisms and

dispute resolution mechanism to address grievances related to data.

d. Accountability: The Distribution Companies would be accountable in law for the data collected and stored. Thus, they will have to formulate comprehensive plans that address the collection, management, and storage of the data. These plans should be transparent and secure and available for the public for comments. These plans must also be subjected to periodic reviews.

e. SM data sharing tool: There need to be certain boundaries as to the sharing of data to third parties. Sharing of data to third parties must be strictly with the express consent of the consumer.

Thus, for the smart meter system to be successful, following are certain points that need to be kept in mind,

a. Continuous monitoring and data collection to enable effective cost-benefit analysis.

b. An iron-clad framework for data protection and privacy.

c. Uniform policy in relation to cost bearing.

d. Focus on consumer protection through awareness, inclusion, and grievance redressal.

Some of the states have amended their supply codes to define smart meters and to elaborate upon prepaid meters.[35] However, it has been argued that the amendments and regulations are silent about the procedure of installation of smart meters. It has been recommended that there is a need for detailed regulations relating to the application for smart meters, installation of smart meters, replacement of meters, grievance redressal, defining a timeline for the installation process, etc.

Furthermore, smart meters should provide some real benefits to consumers. One option is automatic compensation for power outages that last longer than a specific amount of time, as outlined in the Ministry of Power's Electricity (Rights of Consumers) Rules, 2020.[36] Of course, it is up to the state governments to implement the Rules. Some states, such as Maharashtra, have implemented automatic compensation via 'supply codes'. One good strategy to acquire consumers' buy-in for smart metering is to guarantee a consistent supply and compensation for disruptions.

Overall, the researcher believes that the installation of smart meters is a welcome step in India. Considering the advantages, it will no doubt help not just in a more efficient electricity theft detection mechanism but will also help in addressing certain root causes of electricity theft like corruption, poor quality supply, unpredictable power outages, billing irregularities, lack of data on electricity, etc. Thus, as a long-term solution for electricity theft, installation of smart meters is the most viable solution.

However, in looking towards the long-term positive impact, the short-term problems should not be avoided. The transition from traditional to smart technology is not an easy one and issues are bound to arise. In view thereof, the researcher believes that continuous monitoring, clear policies, uniformity, and transparency will make the transition a little smoother.

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