TYPE AND NATURE OF ELECTRICITY THEFT:
A CASE STUDY OF GHANA

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ABSTRACT

Theft of electricity is a severe problem affecting the energy sector and continues to escalate. It results in the loss of large amounts of revenue due to the energy company, part of which is passed on to consumers in the form of higher tariffs. A sizable number of energy meters in Ghana are analogue post-paid. The two utility companies in Ghana, Electricity Company of Ghana (ECG) and the Northern Electricity Distribution Company of the Volta River Authority (NEDco-VRA) have begun deploying prepaid smart energy meters to households and businesses in some parts of Ghana to curb energy theft and ensure the payment of accurate bills. By installing a prepaid meter, the utility companies hope to reduce and potentially eliminate non-technical losses perpetrated by persons who have been taking advantage and tampering with meters to hide their actual consumption. The deployment of the prepaid meters has rather worsened the situation. Our objective in this paper is to identify the techniques that are employed in tampering with meters to steal electricity in Ghana. By identifying the tampering techniques and the actors involved, it will enable the subsequent implementation of methods to track and minimise electricity theft.

Keywords: Electricity theft, Smart meter, Tampering, Theft, Non-technical loss, Prepaid

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1. INTRODUCTION

Power theft is on the ascendency and has become a drawback to the energy sector [1] culminating in huge revenue losses and the cost passed on to consumers through increased tariffs. Electricity in Ghana is distributed by two companies, ECG who is in charge of the southern part of the country with about 56% of access and NEDco-VRA in charge of the northern part of the country with 44% access. The two energy suppliers revealed that financial losses in the form of theft and non-payment of bills have greatly affected their profitability culminating in government’s desire to privatise the ECG. These huge revenue losses have affected the ability of the utility companies to procure modern machinery to upgrade their services. In 2011, the Electricity Company of Ghana (ECG) listed 2.4 million customers with distribution loss of 31.82%, technical loss of 10.38% and commercial loss of 21.45% [2]. Due to the widespread power theft, the utility companies introduced a pre-paid metering system to curb it. The ECG believed that despite the successes chalked with the pre-paid meters, a quarter of their yearly revenue is still lost due to theft. NEDco-VRA also discovered that majority of electricity theft are perpetrated by their customers who use prepaid meters [27]. They further revealed that prepaid customers tamper with their meters if they don’t have enough credit and this has resulted in the eminent collapse of the utility company. One of the reason for tampering with energy meters in Ghana is to lower electricity consumption readings in order to reduce the amount to be paid. Electricity theft is seen by the utility companies as a non-technical loss which accounts for significant part of the losses incurred by the companies.

Theft of power which is a non-technical loss (NTL) is a major issue in developing countries and tracking it has been difficult and occurs when electrical energy is being transmitted [3]. Corrupt officials of the utility companies connive with fraudulent individuals and companies to dupe them by under reporting energy consumption thereby attracting lower bills. It came to light during the investigation that about 30 per cent of power supplied by the ECG is lost through theft and other illegal activities. With the expected large scale deployment of smart prepaid meters by the ECG, the identified actors in the energy sector (consumers, ECG staff and accredited agents) will still device ways to tamper with the meters. A smart energy meter records in hourly intervals or less electric energy consumption and communicates information to the energy provider for subsequent billing and monitoring. A smart meter has the benefit of ensuring that consumers pay accurate bills, monitor and manage their energy consumption. Hacking meters is attractive to perpetrators due to the financial benefits accruing to them [4].

In this research, we aim to characterise the type and nature of attacks which could be experienced by analogue post-paid and smart prepaid energy devices in Ghana. This will eventually lead to the development of a system to track such crimes for prosecution and also to prevent such attacks. Major actors in energy theft in Ghana were identified as consumers, staff of ECG and accredited agents. Old analogue meters and smart meter were used in the study, the actors were interviewed and literature on smart meters was also surveyed.

2. PROBLEM DEFINITION AND SCOPE

Electricity theft in Ghana and other developing countries has reached an alarming proportion requiring urgent solutions to protect the utility companies who are losing large parts of their revenue which is due them. There are different methods employed in stealing electricity in different jurisdictions. In the estimation of [1] getting electricity through illegal means could be done by bypassing the meter, tampering, hooking up to the grid illegally, not paying bills and irregularities in billing consumption. It is the allusion of [22] that illegal connections and meter bypass are the main techniques employed in electricity theft in Jamaica. In the
estimation of [23] directly tapping electricity from the main feeder and tampering with the meter by using magnets to interrupt the rotation of the disc is a common method employed in electricity theft. In Pakistan, bypassing the meter, hooking directly from the main lines, opening the meter to reverse the meter counter to alter consumption readings, the use of a magnet and changing the meter’s direction to halt the movement of the rotating disk are the commonest methods applied in electricity theft [24]. Tapping electrical connections from distribution lines directly, swapping the input and output connections and neutral wire grounding are identified by [25] as methods employed in electricity theft. Electricity theft could also be perpetrated by damaging the rotating coil [26], this prevents the meter from reading accurately. In the year 2011, the Electricity Company of Ghana uncovered 2929 connections that were illegitimate and a recovery of Ghc 5.6 million was made, in 2012 3,425 illegal connections were identified and Ghc9 million was recovered and in 2013, 2,242 were also identified and Ghc11.8 million was recovered [21].

The power company therefore decided to deploy smart prepaid meters. As users are connected digitally to the service provider, these meters can be remotely connected or disconnected, an automatic alert can be sent if a meter in a particular location has been tampered with. The meters are fitted with dual pole relay sensors which send alerts to a control room when the meter is tampered with through an illegal connection. Consumption is reported automatically to the central repository and it helps in the regulation and monitoring of consumption by consumers. They can be instrumental in reducing bills in the household. These meters help to reduce bills as one is able to monitor the consumption of lights, appliances and gadgets in a household. In Spain Javier Vidal and Alberto Illera who are experts in security discovered that smart meters are also susceptible to hacking [11], just like the old analogue meters. The pair were able to send spoof messages to an electricity company from a smart meter after they hacked into its encryption system.

The scope of this study is to find the techniques employed in stealing electricity in Ghana. Customers and staff of the utility company are interviewed in the study alongside analyzing documents at the utilities premises. The ECG who have 56% of electricity access and based in the southern part of Ghana are used for this study.

3. METHODOLOGY

In characterising the type and nature of attacks that could be experienced by energy devices, the research methodology used included a combination of both qualitative and quantitative. Existing documents (qualitative) at the office of the utility company detailing cases on persons arrested for electricity theft and how they perpetrated it were analysed and tallied. Energy theft cases documented at the Criminal Investigations Department of the Police Service following the arrest of offenders and documentation of responses to their interrogations were also perused. Interviews, document analysis and observation (quantitative) were also used to learn from ECG personnel, customers, ECG contract meter readers how meters were hacked. The actors who perpetrate fraud in the energy sector were identified to be domestic and industrial consumers, staff of the utility company and their accredited agents. It was assumed that in gathering data energy consumers would be most corporative since they are the hardest affected by energy theft as some cost is eventually passed on to them. They will therefore be interested in seeing the curbing of theft in the energy sector so they would provide responses that are genuine and honest. It was further assumed that on condition of anonymity, staff of the utility company and their accredited agents would also provide genuine and honest responses. A major limitation was the unwillingness of some of the actors to be interviewed as they were not sure if they will be arrested later and prosecuted for stealing.
4. IMPLEMENTATION OF SOLUTION PROCEDURE
Data that was used for this research came from records of persons apprehended and documented at the Ashanti Regional Office of the ECG, the sample size is two thousand nine hundred and twenty (2920). This data is mainly from the Ashanti Region and involved documented arrests spanning from January 2015 to February 2017. The tally was based on the method employed by the culprits in the theft. The reason is to rank the type of attacks to know the type of attack that is more prevalent or least prevalent.

5. RESULTS AND DISCUSSION

5.1 Actors in Electricity Theft
The investigation identified consumers, staff of the utility company and accredited agents as the perpetrators of energy theft as depicted in figure 1.

   i. Consumers
Investigations revealed that consumers in household and businesses tamper with meters with the aim of paying lower bills.

   ii. Staff
Unscrupulous members of staff also charge consumers various sums of money and tamper with the meters. In the conventional meters, staff who are detailed to take meter readings take money and other gifts and under report the actual energy consumed. They are normally assigned to a particular area for a long time. When the time is due for them to be posted to another area they again collect money and destroy the meter to avoid detection. They then ask the consumer to report to the office of the utility company and a new meter is issued after confirmation that the old one is faulty.

   iii. ECG accredited agents
Meter readings in some areas have been given out on contract to agents. The agents then recruit people to work for them. Investigations revealed that where these agents feel that their remuneration is inadequate, they collect money from consumers to tamper with the meters to under report consumption. These people later abscond and cannot be traced as background checks prior to employment are poorly done in Ghana.

Figure 1 Actors in Energy Theft
5.2 Reasons for Energy Theft:
One is tempted to assume that people with low incomes are the main perpetrators of energy theft, this is not the case in Ghana as businesses, churches, schools and middle income households have all been cited in energy theft. A technical team from the ECG undertook an exercise to check illegal electricity connection, at a police barracks in Tema and they found that the consumers by-passed the meters and connected the cables direct and they were consuming energy free without paying for it [5]. Two (2) persons were also arrested and sent to court for by passing a meter and stealing power worth GH¢205,303 for a company, they were charged with power theft and inference with the ECG distribution system without being authorized [6]. The investigations revealed that the under mentioned reasons partly account for the theft of electricity in Ghana.

i. Poor service conditions of employees
The morale of some workers at the utility company is at low ebb as a result of stagnant income for some years and high cost of living. In order to earn extra income some unscrupulous workers of the utility company approach consumers to assist them to lower their consumption rate so as to pay lower bills for a fee.

ii. Poor service to consumers
Erratic power supply has resulted in businesses and domestic users losing a lot of money and equipment. There is often low voltage during peak times and this frustrates consumers who do not see the reason to pay full cost for the exorbitant tariff.

iii. Billing mistakes
The ECG is well known for billing customers erroneously. The ECG itself confirmed that after introducing new billing software in May 2016 there has been over billing of 7,823 representing 0.09% error out of a total of 8.5 million bills [7]. They acknowledged numerous complaints of overbilling by customers which they promised they were resolving. Customers who are victims of such overbilling find ways to steal electricity since they believe the energy company is also stealing from them.

iv. Estimated bills
During the investigation it came to light that the utility company concedes that electricity bills calculated on estimates are unacceptable. Estimated bills should only be given when customers receive new meters and it takes about three months to get actual consumptions. Estimated bills are also to be given by the ECG when meter readers are not able to gain entry to the house or when there are faulty meters which are earmarked for replacement. All these notwithstanding, residents complain that they receive huge estimated bills accompanied by threats of disconnection which is sometimes carried through causing discomfort to consumers.

v. Delay in Sending Bills
The ECG delays in sending bills to consumers. Consumers receive bills after 3 months to 1 year, they are given few days to pay the outstanding bills of between 3 to 12 months. They are compelled to connect illegally when they are disconnected because they feel cheated by the energy company. The public outcry compelled The Public Utilities Regulatory Commission (PURC) to issue a statement to consumers not to pay the bills when it is delayed for up to a year [8].
5.3 Methods employed in Tampering with Meters in Ghana

There are two types of meters currently in use in Ghana, these are analogue postpaid meters as shown in Figure 2 and digital prepaid meters shown in Figure 3 below.

![Figure 2 Analogue Domestic Meter](image1)

The analogue meter shown in Figure 2 is an electro-mechanical induction device and it is widely used in Ghana, it has a moving dial and an electromagnetic (induction) motor. It uses eddy current to regulate the rotation of the dial depicting the actual electricity consumption. Prepaid meters deemed to be smart have as shown in figure 3 have currently been deployed in some urban areas in Ghana to curb electricity theft. These prepaid meters are operated using smart cards by purchasing credit and transferring it to the meter by inserting or passing the card in front of the meter. As pointed out by [9], smart meters are deployed to help fight the menace of theft faced by utility companies. In spite of the deployment of these prepaid meters to combat electricity theft, organised and widespread theft which retards the progress of the Electricity Company of Ghana still persists. The cards are assigned unique numbers and a central database contains information on all issued cards.

![Figure 3 Digital Prepaid Meters](image2)
The ECG provided a document on electricity theft that was perpetrated by domestic and commercial consumers who were apprehended. From analysing the document the ways in which electricity theft is perpetrated is shown in Figure 4

**Figure 4 Methods Employed in Stealing Electricity**

Corrupt ECG staff connives with consumers to adjust meters to slow them down so as not to function well. This results in under reporting of consumption culminating in lower bills. Meter readers of the utility company also understate the actual consumption of consumers by collecting money from them. This goes on for a long time until they feel that physical audits of the meters are to be carried out. They then destroy the meter so that data cannot be read from it. Others in order to enjoy free power tap electricity directly from the main power lines. In order to take electricity into the premises and to bypass the meter that filters and counts the usage of electricity, they connect the red live wire which has electricity direct to the live wire taking electricity into the premise. Consumers connect some of their gadgets without passing through the meter. Investigations revealed that electricity theft by an individual consumer in a house hold is about 6500 units a month. Some consumers also have huge outstanding bills, they are disconnected after a grace period. They reconnect the power directly bypassing the meter in the house after the technicians of the utility companies who disconnected them have left.

The analogue post-paid meters use aluminium dial, fraudsters interfere with its movement using large size magnets which they place at the sides of the meter directly thereby lowering the actual quantity of electricity consumed. Another method used to tamper with old meters involves drilling holes in the plastic case of the meter. The spinning aluminium dial is completely stopped or slowed down by inserting a needle in the hole that is created. During the investigation, it came to light that one of the largest distribution companies in Ghana is to be prosecuted for power theft by the ECG. They are said to have tampered with their meter and as a result they pay only a third of their actual consumption. They opened the meter and disconnected the cables which then affected the actual consumption readings making the ECG loose about two hundred thousand Ghana Cedis (Ghs200, 000.00). Sugar can also be inserted in the spinning aluminium dial to attract ants to it and thus slow its spinning. It was further revealed during the investigation that consumers turned the meters upside down to stop the meter. Another method used to alter electricity consumption readings is to by-pass the meter using jumper wires. The meter is by-passed for some days for the usage readings to be lowered and then restored to coincide with the visit of meter readers. The ways used in stealing electricity enumerated above is perpetrated through hardware. The only software based theft that was uncovered is workers with access to the database of the utility company who go into the database to edit cash received for a particular transaction into a lower value
and pocketing the rest of the money. They also receive monies from consumers and alter the quantity of electricity read for a period to reduce their bill for payment.

In identifying the techniques employed in energy theft and ranking them to know the method that is most used, a total of two thousand nine hundred and twenty (2920) cases were tallied. As shown in Figure 5 below, forty percent (40%) of the cases which ranked as the highest type of attack involved consumers who directly bypassed the meter and connected electricity directly to equipment in their premises. A total of 21.5% of the cases related to cases involving using jumper wires to bypass the meter and this ranked second method employed in attacking an energy meter.

![Figure 5 A Graph of the Type of Attacks on Meters](image)

Further, from Figure 5 14.9% of electricity theft that occurred were perpetrated by drilling holes into the meter case to interfere with the meter reading while 7.4% was done by inserting sugar into the meter to draw ants into it to slow down the spinning of the aluminum coil which resulted in paying lower bills. Another method employed in energy theft is the use of large size magnets and this accounted for 4.6% and placed sixth. Server side editing of data in the database which is perpetrated by highly skilled staff on behalf of clients accounted for 0.7% of cases and is the least method employed in energy theft. The three (3) dominant methods employed in electricity theft in Ghana are directly bypassing the meter, using jumper wires and drilling holes in the meter’s case.

6. CONCLUSION

In this research the type and nature of attacks which could be experienced by energy devices is characterised. Consumers, ECG staff and ECG accredited agents were identified as perpetrators of meter tampering. One motive of hacking energy meters in Ghana is to lower electricity consumption readings in order to reduce the amount to be paid. It was established through this research that the dominant techniques employed in electricity theft in Ghana involves directly bypassing the meter, using jumper wires and drilling holes through the meter’s case. As a future work we propose a model to extract evidence of electricity theft perpetrated using the techniques identified.
REFERENCES


