

An Energy Fraud Detection Scheme for Power Utilities

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Abstract

Energy fraud is when the consumer deliberately tries to deceive the utility. A common practice is to tamper with the meter so that a lower reading of power use is shown than is the case.

This paper develops an automated energy fraud detection scheme for power utilities.

In the scheme, when the mains is switched ON, input and output signals are compared to check for any discrepancies. When no discrepancy is recorded, a green LED will be ON until a discrepancy occurs. When a discrepancy is recorded, a red LED at the substation turns ON to notify the operator after which the consumer data will be recorded. The nearest substation is then notified after all the data have been taken and the mains are turned OFF.

The scheme saves time as well as helping to maximize profit margin for power utilities working in electrical distribution network.

The scheme also assists utility companies to keep a constant eye on its customers.

Keywords: Energy fraud, Utilities, Discrepancy, Commercial losses, Energy meter, Technical losses, Distribution charges, Billing irregularities.

I. Introduction

Energy fraud is an art of tempering with utility meters to disorganize the billing information. It can also be a direct connection to the power system without energy meters [8].

The financial impacts of fraud are reduced income from the sale of electricity and the necessity to charge more to consumers. Energy fraud is closely related to governance indicators where higher levels are recorded in countries without effective accountability, political instability, low government effectiveness and high level of corruption.

Power fraud can be in the form of theft (meter tempering), stealing (illegal connections), billing irregularities and unpaid bills.

Commercial loads are usually difficult to measure because of lack of information on the commercial and legitimate loads in the systems which results into insufficient inputs for any meaningful calculation of energy losses. The current results of commercial losses measurements are often inaccurate because the figures rely majorly on the records of detected cases, instead of by actual measurements of the electrical power systems [[10], [9]].

The illegal electricity usage may indirectly affect the economic status of a country. The planning of national energy may be difficult in case of unrecorded energy usage.

Power System Losses.

Losses occur in all levels from generation transmission and distribution to the consumer and the meter. At the distribution level, majority of avoidable losses occur. All electrical power distribution companies operate with some accepted degree of level. Losses are of two types [2].

- Technical losses and
- Non-technical losses.

Technical losses are naturally occurring losses (caused by actions internal to the power system and consist mainly of power dissipation in electrical system component such as characteristic lines, power transformers and measurement systems etc.

Technical losses are possible to compute and control, provided the power system in question consist of known quantities namely resistance, reactance, capacitance, voltage, current and power. They are routinely calculated as a way to specify what component will be added to the systems. Loads are not included in the losses before they are actually intended to receive as much energy as possible[3].

Technical losses in power systems are caused by the physical properties of the components of power system. Such as I^2R loss or copper loss in the conductor cables, transformer switches and generators.

The instantaneous power loss, $P_{loss}(t)$ in a transmission line can be expressed as [1]:

$$P_{loss}(t) = P_{source}(t) - P_{load}(t) \quad (1)$$

Where $P_{source}(t)$ is the instantaneous power that the source injects into transmission line and $P_{load}(t)$ is the

instantaneous power consumed by the load at the other end of the transmission lines. The energy loss, W_{loss} is given by:

$$W_{loss} = \int_a^b P_{loss}(t) dt \quad (2)$$

Where 'a' and 'b', are respectively the starting point and ending point of the line intervals being evaluated. To make a reliable prediction of W_{loss} , a fairly accurate description of $P_{loss}(t)$ as a function of time is always needed.

Commercial losses are losses that are independent of technical losses in the power system. Two common examples of sources of such losses are component breakdowns that drastically increase losses before they are replaced and electricity theft. Losses incurred by equipment breakdown include losses from equipment struck by lightning, equipment damaged over time. Other causes of commercial losses are [3].

- Non – payment of bills by customers.
- Errors in technical losses computation.
- Error in accounting and record keeping.
- Inaccurate or missing inventories of data on customers

The most prominent forms of commercial losses in Nigeria are energy fraud and non – payment of bills. Non – payment refers to cases where customers refuse or are unable to pay for the electricity used [4].

Non – technical losses can also be viewed as undetected load. When an undetected load is attached to the system, the actual losses increase while the losses expected by the utilities remains the same. The increased losses will show on the utilities accounts and the costs will be passed to customers as transmission and distribution charges.

Commercial losses arising through energy theft is a universal problem in the electricity supply industry. The causes of such a loss may include meter tempering, illegal connection, billing irregularities and unpaid bills [[5], [7]].

Electricity use is said to be illegal if electrical energy is consumed without legal agreement between the providers and consumers.

It is also illegal if the consumer does not comply with the agreement clauses for the consumed energy such as entirely or partially not measuring the energy consumed and intentionally enforcing an error to the watt – hour energy meter [6].

II. Materials and Method.

The following procedural steps were taken to design the power fraud detection scheme for power utility.

- a. Development of a mathematical model for energy fraud.

III. Mathematical Model for Energy Fraud

The instantaneous power loss $P_{loss}(t)$ in a transmission line is expressed as:

$$P_{loss}(t) = P_{source}(t) - P_{load}(t) \quad (1)$$

Where $P_{source}(t)$ is the instantaneous power that the source injects into the transmission line and $P_{load}(t)$ is the instantaneous power consumed by the load at the other end of the transmission line.

The energy loss, W_{loss} is giving by:

$$W_{loss} = \int_a^b P_{loss}(t) dt \quad (2)$$

The power P in an electrical system is given as;

$$P = IV \cos \theta \quad (3)$$

The instantaneous current is also given as;

$$I(t) = I_m \sin(wt \pm \phi) \quad (4)$$

The input current to the meter is;

$$I_1(t) = I_m \sin(wt \pm \phi) \quad (5)$$

The output current to the meter is;

$$I_2(t) = I_m \sin(wt \pm \phi) \quad (6)$$

The input voltage relation is;

$$V_1(t) = V_m \sin(wt \pm \phi) \quad (7)$$

The output voltage relation is;

$$V_2(t) = V_m \sin(wt \pm \phi) \quad (8)$$

The output voltage V_o from the comparator is given as;

$$V_o = A (V_2 - V_1) \quad (9)$$

Thus

$$V_o = A [(V_{2m} \sin(wt \pm \phi)) - [V_{1m} \sin(wt \pm \phi)]] \quad (10)$$

$$V_o = A [(V_{2m} \sin(wt \pm \phi)) - [V_{1m} \sin(wt \pm \phi)]] = A (V_{2m} - V_{1m}) \sin(wt \pm \phi) \quad (11)$$

Equation (11) can be used for the comparison because for a purely resistive circuit, the phase will remain the same at both the input and the output.

Whenever input power is passing from supplier to the receiver and at that line, if the total amount of power is not received, then there is possibility of fraud of energy.

$$\sum P_{sent} = \sum P_{consumed} + \text{loss} = \text{No Fraud} \quad (12)$$

$$\sum P_{sent} = \sum P_{consumed} \quad \text{loss} = \text{Fraud occurs.} \quad (13)$$

Where $P_{sent} = P_{consumed}$ = Power measured by pole side energy meter.

- b. Receiving meter data of the measured power consumed by a customer.
- c. Receiving delivered power data that includes data of the power delivered to the customer.
- d. Determining the difference between the meter data and the delivered power data.
- e. Determining whether the difference between the meter data and the delivered power data is greater than a predetermined amount.
- f. Indicating a discrepancy if the difference between the meter data and the delivered power is greater than a predetermined amount.
- g. Providing a discrepancy notification through power lines.

IV. Discussion of Results

A digital energy meter measures a consumed power by load over a period and sends a data in proportion with consumed power to receiver via a wireless digital data transmitter. The receiver on the pole system receives the data sent by transmitter in a load side meter receiver and sends it to microcontroller. The energy meter on pole measures the power sent over the line and provides appropriate data to microcontroller.

The microcontroller now has two readings: One is power calculated on pole itself and the other is power consumed by the load. Whenever there is any tapping by any unauthorized person, there will be a difference between meter reading and the pole based reading.

The microcontroller compares these two values and if the measured value on pole is more than value sent by meter by some tolerance, then power fraud is happening on that line. This fraud signal generated on pole system can be transmitted to substation by power line communication techniques.

Tolerance for losses of line should be provided through programming of micro-controller because over a long period, there will be difference in reading of meter on load side and pole side due to loss of line between the pole load.

From equations 11, if the amplitude difference $V_{2m} - V_{1m}$ exceeds a predetermined value, then a fraud case will occur. This will be fed into a voltage-to-frequency converter to generate a periodic output wave form having a frequency proportional to the magnitude of an applied DC input voltage. The current in the system will vary for any discrepancies recorded. The input and output signals of the watt-hour meter is compared to check for any discrepancies when the mains is switched on, a green LED at the substation will be ON. When there is no discrepancy recorded, a red LED at the substation turns ON to notify the operator. The consumer data will be recorded after notifying the operator that a discrepancy has occurred. Among the relevant data recorded are the meter number, the time the problem started and the approximate location. The nearest substation is notified when all the data has been taken and the operation is stopped or the mains turned off. As shown in Figure 1. During this time, all the sensor devices in the comparison unit will be located along the low voltage power lines and along the machine voltage power lines since they are the main lines where theft can take place

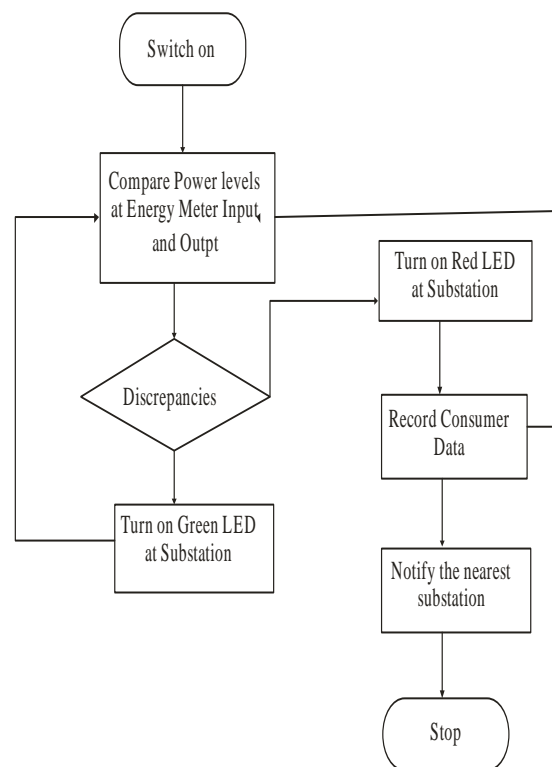


Figure 1:- Flow Chart of the Power fraud Implementation

Power line communication can be used instead of wireless data transmission techniques. In power line communication, data signal is modulated on power signal and sent through electrical distribution networks to reduce the cost for separate communication line.

V. Conclusion.

An automated energy fraud detection scheme for power utilities has been developed in this paper. The amplitude difference of the voltage is fed into a voltage-to-frequency converter to generate a periodic output waveform having a frequency proportional to the magnitude of an applied d.c input voltage. The nearest substation is notified when all the data has been taken and the operation is stopped or the mains turned OFF.

It saves time as well as helps to maximize profit margin for utility companies working in electrical distribution network. With this, utility companies can keep a constant eye on its customers.

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