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Detection and Solutions for Non-Technical Losses in Cameroon Electricity Network

[1]Lekini Nkodo Claude Bernard, [1]Ndzana Benoît, [1]Oumarou Hamandjoda and [2]Fippo Fitime Louis

[1]*National Advanced School of Engineering, University of Yaounde I, Cameroon*
[2]*Computer Science Laboratory, University of Paris 13, UMR CNRS 7030, France*

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Corresponding Author:
Lekini Nkodo Claude Bernard
National Advanced School of Engineering, University of Yaounde I, Cameroon
Email: grhuang@126.com

Abstract: The purpose of this study was to provide a tool to detect NTLs and subsequently, discuss the establishment of a prepaid system in Cameroon. The conception of a prepayment system for electric power or other utility commodity distribution using Wi-Fi and GSM to store and transfer value (money or KWh, meters reading indexes) from the client module to cut-off module then to platform of the system and deliver power to the customer from the power distribution system. This system is also used as fraud detection model for the Cameroon National Electricity Company.

Keywords: Fraud Detection, Prepaid System, Meters, GSM, Non-Technical Losses

Introduction

Non-Technical Losses (NTLs) of energy in an electricity distribution system result from unregistered energy consumption. These losses result from energy theft or counting and profiling errors. In the electrical industry, knowledge on electricity consumers is important, as it provides an understanding of their consumption behaviour. With this knowledge, electricity suppliers can develop a new business strategy and offer services based on customer demand. One of the most commonly used methods of acquiring knowledge about customer behaviour is the load profile, which is defined as the electricity consumed by a customer or group of customers over a given period. Load profiles have been used for many years by utility companies for tariff formulation, system planning and marketing strategy development. Power companies record customer data histories, such as contract details, billing procedures and consumption indexes in various customer databases. However, the information that exists in the IT platform is often too complex to allow the human mind to make strategic and effective decisions or draw effective conclusions. In addition, this information is often inaccessible and takes a long time to retrieve, because of the problems associated with data archived in complex database systems.

Due to the NTL problems faced by electricity companies, different methods for an efficient management of NTLs in the electricity distribution sector have been proposed. The most effective method currently used to reduce NTLs is the use of smart electronic meters. However, although their installation is beneficial, their costs are high and new infrastructure is required for data collection. In this study, we provide a tool to detect NTLs and subsequently, discuss the establishment of a prepaid system in Cameroon at same moment.

Electricity Sector in Cameroon

Cameroon has a high exploitable hydroelectric potential of 19.7 GW, of which only 3.72% is currently being used as presented by Lekini *et al*. (2017). Electricity production has witnessed a steady growth from 2006 to 2016, despite a slight drop in 2009 and 2012. In addition, the commissioning of Emergency Thermal Power Plants in 2013 helped to increase electricity generation by 9.15% in 2013 compared to 2012. However, losses due to transmission, distribution and non-technical aspects have not ceased to increase from 2006 to 2016.

Cameroon plans to become an emerging country by 2035, which requires the development and consolidation of its industrial fabric. This requires adequate production and distribution of energy, considered essential for the smooth functioning of enterprises and the economy and for improving the living conditions of the population.

In this regard, Cameroon has enormous energy potential. In fact, its geographical location allows it to have the second highest hydroelectric potential of sub-Saharan Africa, after the Democratic Republic of the Congo.

This potential only needs to be used to meet an ever-increasing demand and to reduce the imbalance that exists in this sector. Aware of this challenge, the authorities have launched an extensive program to increase the supply of electricity through the construction of several hydroelectric dams (the Lom-Pangar, Memve'ele and

Mekin dams), the Kribi gas-fired power plant, boreholes for the production of thermal energy and even the exploitation of new and sustainable sources of energy.

The objective is not only to fill the national deficit, but also to export electricity. To absorb the energy deficit, in the same publication as presented by Lekini *et al.* (2017), Cameroon is engaged in several projects, such as:

- The Dibamba Power Developer Company, responsible for producing electricity from a thermal power plant with a capacity of 86 MW
- Construction of the reservoir dam of Lom Pangar in the Department of Lom and Djerem with a production capacity of 30 MW
- Construction of Memve'ele Hydroelectric Generating Station on Ntem in the Southern Region with a capacity of 201 MW
- Construction of the Mekin Hydroelectric Dam with a production capacity of 15 MW
- Construction of a gas-fired power plant in Kribi in the Ocean department, with a capacity of 216 MW, which is extendable to 300 MW
- The commissioning of the emergency thermal program through the installation of thermal power stations in the cities of Bamenda, Ebolowa, Mbalmayo and Yaoundé. These plants operate with light fuel oil and have a total capacity of 100 MW, i.e., 20 MW in Bamenda, 10 MW in Mbalmayo, 10 MW in Ebolowa and 60 MW in Yaounde (Ahala)

The total demand and evolution between supply and demand are presented in Fig. 1 and 2.

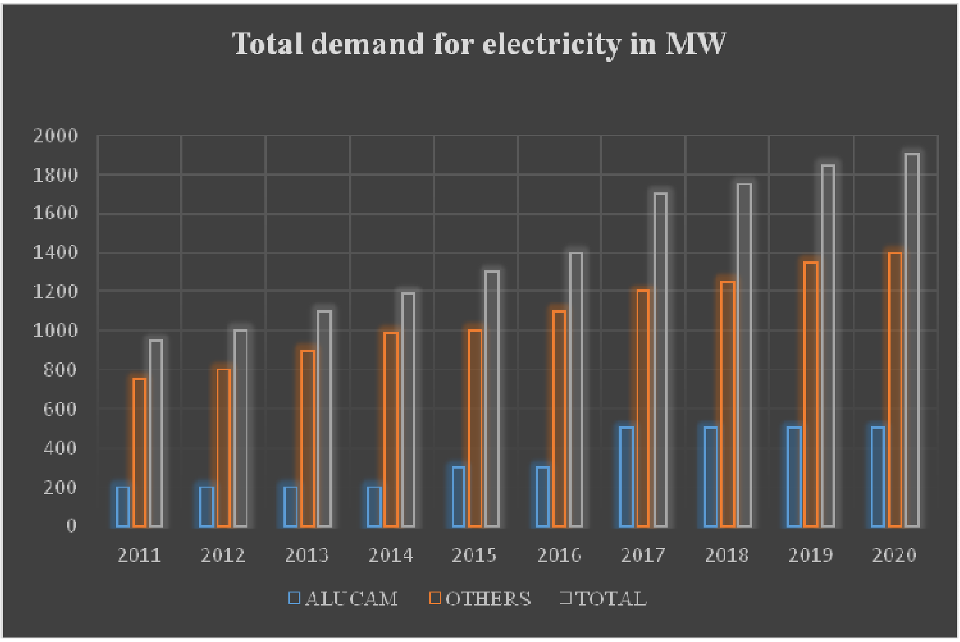

Fig. 1: Total demand for electricity in MW

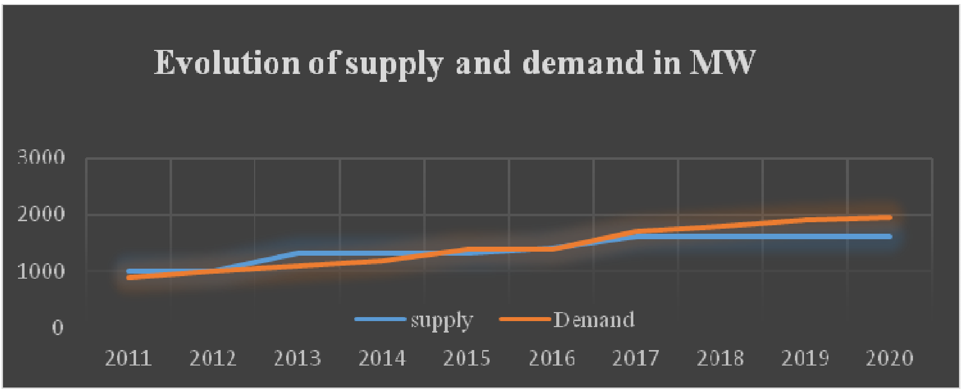

Fig. 2: Evolution of supply and demand in MW

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Related Work and Literature Review

The use of electronic token prepayment metering has been widely used in the UK for customers with poor payment record. Shwehdi and Jackson (1996) presented the Digital Tele-wattmeter System as an example of a microcontroller-based meter. The meter was implemented to transmit data on a monthly basis to a remote central office through a dedicated telephone line and a pair of modems; it was a stand-alone metering system.

Zhang *et al.* (1998) utilized a digital signal processor DSP-based meter to measure the electricity consumption of multiple users in a residential area. A Personal Computer (PC) at the control centre was used to send commands to a remote meter, which in turn transmitted data back using the power line communication technique. However, this system could not detect tampering by consumers.

Kwan *et al.* (2002) suggested a system design that can be used for data transmission between the PC and the smart card. The device transmits data in the half-duplex mode. They designed, modelled and simulated an intelligent prepaid energy meter using MATLAB/SIMULINK tools. Koay *et al.* (2003) designed and implemented a Bluetooth energy meter where several meters are in close proximity and communicated wirelessly with a master PC. Distance coverage is a major setback for this kind of system because Bluetooth technology works effectively only within a close range.

Scaradozzi and Conte (2003) viewed home-automation systems as multiple agent systems. They proposed a home automation system whereby home appliances and devices are controlled and maintained for home management. However, this system does not measure the amount of energy consumed by users. Hong and Ning (2005) proposed the use of Automatic Meter Reading (AMR) using wireless networks. However, some commercial AMR products use the Internet for data transmission.

Stanescu *et al.* (2006) presented the design and implementation of SMS-based control for monitoring systems. They proposed three modules involving a sensing unit for monitoring complex applications. SMS is used for status reporting such as power failure. However, it does not consider issues related to billing systems for electricity board usage. Prepaid meters can also make use of state-of-art technologies such as WiMAX owing to the idea of centralized accounting, monitoring and charging. It brings telecommunication to the core of its activities to support more smart grid applications such as demand response and plug-in electric vehicles (Khan *et al.*, 2007). Prepayment polyphase electricity metering systems have also been developedand consist of local prepayment and a card reader-based energy meter (Ling *et al.*, 2010).

Malik *et al.* (2009) mainly focused on controlling home appliances remotely and providing security when the user is away, using SMS-based wireless home appliance control. Maheswari *et al.* (2009) aimed to develop an energy-efficient and low-cost solution for street lighting systems using the global system for mobile communication (GSM) and General Packet Radio Service (GPRS). The whole set-up enables the remote operator to turn off the lights when not required, regulate the voltage supplied to the streetlights and prepare daily reports on glowing hours.

Sharma and Shoeb (2011) suggested a method that utilizes telecommunication systems for automated transmission of data to facilitate bill generation at the server end as well as to the customer via SMS or Email. Amit and Mohnish (2011) suggested a prepaid energy meter that behaves like a prepaid mobile phone. The meter contains a prepaid card analogous to a mobile SIM card. The prepaid card communicates with the power utility using mobile communication infrastructure. Once the prepaid card is out of balance, the consumer load is disconnected from the utility supply by the contactor. The power utility can recharge the prepaid card remotely through mobile communication based on customer request.

Others factors contributing to NTLs activities such as:

- Unauthorized line tapping; tampering with meters so that meters record lower rates of consumption
- Unauthorized line diversions; stealing by bypassing meters or otherwise making illegal connections
- Inadequacies and inaccuracies of meter reading
- Inaccurate customer electricity billing
- Poor revenue collection techniques
- Arranging billing irregularities with the help of internal employees, such as making out lower bills and adjusting decimal point position on bills
- Non-payment of electricity bills
- Losses due to faulty meters and equipment
- Loss or damage of equipment/hardware that is, protective equipment, cables, conductors, switchgear etc
- Inaccurate estimation of non-metered supplies that is public lightning, agricultural consumption, rail traction etc

The below table gives us an overview of research carried out in this area between 1953 and 2017 as presented in Table 1.

Methodology for the Design of a Prepaid System for NTLs

In this part, we present the prototype allowing us to eradicate the PNT in the Cameroonian electricity network as presented in Fig. 3.

Table 1: Overview of research carried out in this area between 1953 and 2017

Years	Authors	Titles
1953	Courant and Hilbert (2008)	Methods of mathematical physics
1979	Vapnik and Chervonenkis (1974)	Theory of pattern recognition
1982	Devijver and Kittler (1982)	Pattern recognition: A statistical approach
1987	Fletcher (2013)	Practical methods of optimization
1992	Birch and Ozveren (1992)	An adaptive classification for tariff selection
1993	Fisher *et al*. (1993)	Applying AI clustering to engineering tasks
1995	Vapnik (1997)	The nature of statistical learning theory
	Kohavi (1995)	A study of cross-validation and bootstrap for accuracy estimation and model selection
	Benjamini and Hochberg (1995)	controlling the false discovery rate: A practical and powerful approach to multiple testing
1996	Benessahraoui (1996)	Le contrôle des pertes non techniques d'électricité
1997	Scholkopf (1997)	Support vector learning
	Friedman (1997)	Knowledge discovery and data mining
1998	Brossette *et al*. (1998)	Association rules and data mining in hospital infection control and public health surveillance
1999	Lavrac (1999)	Selected techniques for data mining in medicine
	Platt (1999)	Fast training of support vector machines using sequential minimal optimization
	Karypis *et al*. (1999)	Chameleon: Hierarchical clustering using dynamic modeling
	Ray and Turi (2000)	Determination of number of clusters in k-means clustering and application in color image segmentation
	Bjornar and Chinatsu (1999)	Fast and effective text mining using linear- time document clustering
	Chen *et al*. (1999)	Implementation of the load survey system in taipower
2000	Steinbach *et al*. (2000)	A comparison of document clustering techniques
2001	Halkidi *et al*. (2001)	On clustering validation techniques
2002	Han and Kamber (2012)	« Data mining: Concepts and techniques
	Zakaria and Lo (2002)	Load profiling in the new electricity market
2003	Maulik and Bandyopadhyay (2002)	Performance evaluation of some clustering algorithms and validity indices
	Chang and Lu (2003)	Load profiling and its applications in power market
2004	Duarte *et al*. (2003)	Data mining techniques applied to electric energy consumers characterization
	Chang and Lu (2003)	Load profiling and its applications in power market
	Duarte *et al*. (2003)	Data mining techniques applied to electric energy consumers characterization
	Gerbec *et al*. (2003)	« Determination and allocation of typical load profiles to the eligible consumers
	Markou and Singh (2003)	Novelty detection: A review — Part 1: Statistical approaches
	Ghajar and Khalife (2003)	Cost/Benefit analysis of an AMR system to reduce electricity theft and maximize revenues for electricite du liban
	Gerbec *et al*. (2004)	Determining the load profiles of consumers based on fuzzy logic and probability neural networks
2005	Lo and Zakaria (2004)	Electricity consumer classification using artificial intelligence
	Verdu *et al*. (2004)	Characterization and identification of electrical customers through the use of self-organizing maps and daily load parameters
	Smith (2004)	Electricity theft: A comparative analysis
	Fourie and Calmeyer (2004)	A statistical method to minimize electrical energy losses in a local electricity distribution network
	Filho *et al*. (2004)	Fraud identification in electricity company customers using decision tree
	Doorduin *et al*. (2004)	« Feasibility study of electricity theft detection using mobile remote check meters
	Kou *et al*. (2004)	Survey of fraud detection techniques
	Ren *et al*. (2004a)	RDF: A density-based outlier detection method using vertical data representation
	Ren *et al*. (2004b)	A vertical outlier detection algorithm with clusters as by-product
	Cabral *et al*. (2004)	Fraud detection in electrical energy consumers using rough sets
	Hodge and Austin (2004)	A survey of outlier detection methodologies
	Gerbec *et al*. (2005b)	Allocation of the load profiles to consumers using probabilistic neural networks
	Chicco *et al*. (2005)	Emergent electricity customer classification
	Figueiredo *et al*. (2005)	An electric energy consumer characterization framework based on data mining techniques
	Gerbec *et al*. (2005b)	Allocation of the load profiles to consumers using probabilistic neural networks
	Chicco *et al*. (2005)	Emergent electricity customer classification
	Figueiredo *et al*. (2005)	An electric energy consumer characterization framework based on data mining techniques
	Yao and Steemers (2005)	A method of formulating energy load profile for domestic buildings in the UK
	Espinoza *et al*. (2005)	Short-term load forecasting, profile identification and customer segmentation: A methodology based on periodic time series
	Gerbec *et al*. (2005a)	Actual load profiles of consumers without real time metering

Table 1: Continue

	Lozano and Acufia, (2005)	Parallel algorithms for distance-based and density-based outliers
2006	Nizar *et al*. (2006a)	Load profiling method in detecting non-technical loss activities in a power utility
2009	Mabrouka (2009)	Caractérisation aveugle de la courbe de charge électrique: Détection, classification et estimation des usages dans les secteurs résidentiel et tertiaire
	Birch and Ozveren (1992)	An adaptive classification for tariff selection
	Mathias (2009)	Perte d'énergie dans les réseaux de distribution d'électricité
2010c	Nagi *et al*. (2010c)	NTL detection of electricity theft and abnormalities for large power consumers in TNB Malaysia
2012	Rengarajan and Loganathan (2012)	Power theft prevention and power quality improvement using fuzzy logic
2013	Sheriff and Maguire (2013)	Ranking distribution of environmental outcomes across population groups
2014	Creedy (2014)	Interpreting inequality measures and changes in inequality
	Dangar and Joshi (2014b)	Normalization based K means Clustering Algorithm
	Dangar and Joshi (2014a)	Electricity theft detection techniques for distribution system in GUVNL
	Christopher *et al*. (2014)	Distribution line monitoring system for the detection of power theft using power line communication
2015	Sahoo *et al*. (2015)	Electricity theft detection using smart meter data
	Zhou and Chen (2015)	A dynamic programming algorithm for leveraging probabilistic detection of energy theft in smart home
2016	Glauner *et al*. (2016)	The challenge of non-technical loss detection using artificial intelligence: A survey
2017	Lekini *et al*. (2017)	Evaluation of customer behaviour irregularities in cameroon electricity network using support vector machine

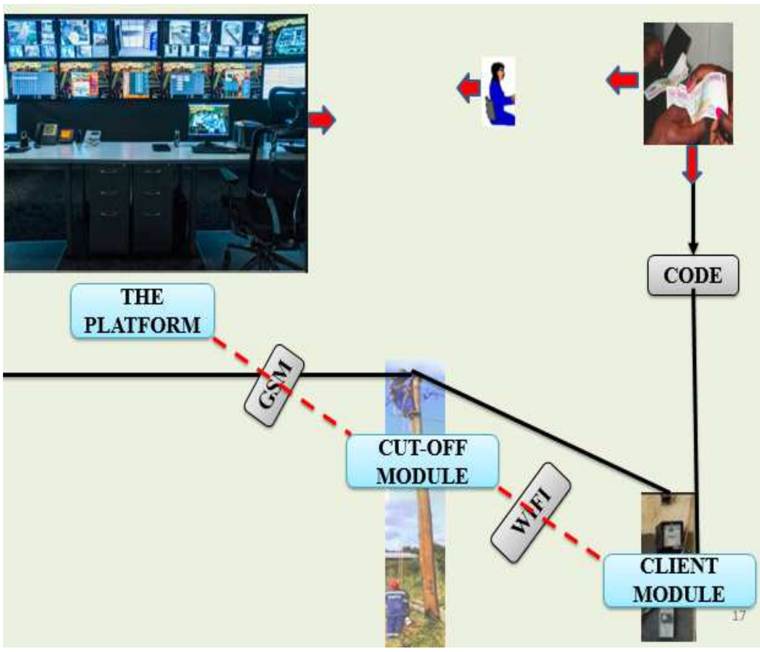

Fig. 3: Prototype design

How does the System Work?

- The user enters a code corresponding to the amount of energy he wants to consume. After validating the code, the system gives the user access to the network, measures the customer's consumption and puts the customer off the grid once the energy consumed is equal to the energy purchased
- The prototype to be designed consists of an electronic module installed on the meter, an electronic module installed at the pole on which the customer is connected and a customer management platform
- The module installed on the meter reads the customer's consumption and communicates it to the module on the pole to which the customer is connected. This module also allows the charging and display of the payment procedure
- The module on the pole has the role of evaluating the consumption at the post, acting on the cut and inform the platform on the consumption at the pole

and consumption at the meter. In the case where consumption at the pole is greater than consumption at the client meter the system detects fraud and the customer is cut off

Description of the System Modules

The system of prepaid billing and computer monitoring of real-time consumption of customers in its most general view is one that combines several resources available and easily mobilized. In our case, we have a prepaid meter installed at the customer, a cut-off module installed on the electricity pole closest to the meter and a platform.

Module Installed at the Client

The customer's electricity meter measures energy consumption and compares it with prepaid energy. This prepaid counter consists of a display screen, an alphanumeric keyboard, a wireless communication module and a metering and consumption evaluation system. As presented in Table 2.

Module Installed on the Electric Pole

The cut-off module receives the customer's consumption and the cut-off order coming from the prepaid meter installed on the customer's premises via the Wi-Fi. It acts on the line disconnector when the cutoff is activated. This module also counts the electrical energy that passes through the pole to the customer. Electrical energy consumption at the customer and consumption at the pole are transferred by GSM to the control platform.

The s*et al*lows us to detect fraud, compare consumption at the customer level and at the pole. As presented in Table 3.

The Platform

The role of the platform is to generate customer codes and decodings, but also to receive, store and process the data transmitted by the module installed on the pole.

Generating the Recharging Code

For the generation of the recharge code we need to:

- The volume of consumption
- The number of the meter
- A serial number

The volume of consumption kilowatt hours of charging is defined according to the cost per kilowatt hour when purchasing the code number.

The number of the counter that associates the generated number has a single counter

A serial number is a number which is incremented with each new invoice. Thus each invoice is unique. This ensures that a recharge code is only used once.

NOTE: The meter number and the unique identifier ensure that a code is used only once on a meter. Its three pieces of information that are combined and then encrypted with a key that is kept private.

For encryption, we can use proven algorithms such as AES which is 128-bit encrypted and DES which is 64-bit encrypted.

This would ensure that the code structure remains protected. So without the encryption key, it is very difficult to generate a valid code. As presented in Fig. 4.

Decoding the Recharge Code

After reading the code by the device set up, it is to decipher by the same algorithm used for coding with the same key used this time for decryption. This key is stored in the device's memory and after decoding we can extract:

- The volume of consumption stored in the code
- The number of the meter for which the code is intended
- The unique number associated with the code

Table 2: Client modules

Module	Constituents	Role
Prepaid counter	Supply circuit	Adjust the voltage level across the electrical components of the system.
	Module for acquiring data related to the reading of client indexes	Extract the customer's electricity consumption from the meter.
	Client-counter communication interface	Allow code entry and display of the charging procedure.
	Communication interface with the cutoff module	Transfer consumption and cut-off order.

Table 3: Pole module

Module	Constituents	Roles
Cut-off module	Supply circuit	Adjust the voltage level across the electrical components of the system.
	Module reading indexes on the pole.	Allows reading of the indexes on the column.
	Communication module with the prepaid counter (transfer of customer indexes)	Receive consumption and cut-off order.
	Communication module with the platform	Transfer the data to the platform.
	Cutoff circuit	Act on the line disconnector.

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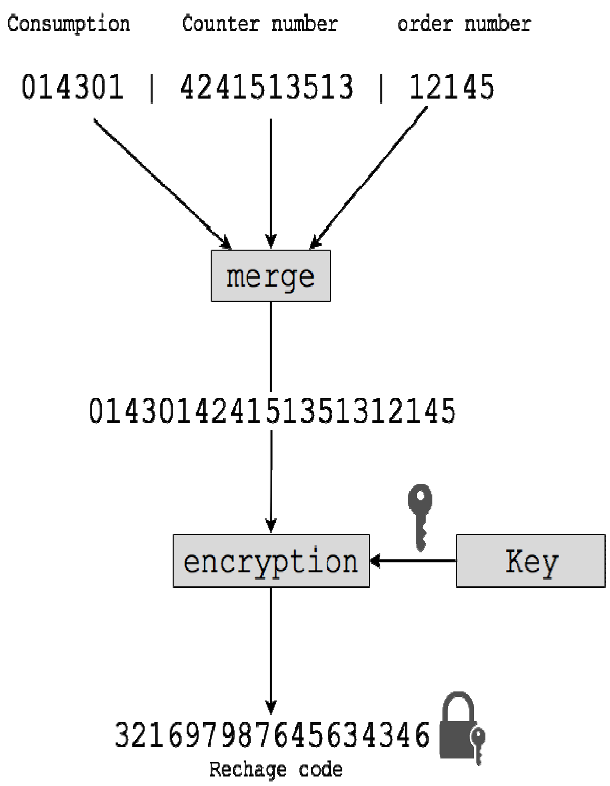

Fig. 4: Generating the recharge code

But before you save some checks are done:

- We check if the unique code already registered by the device prevents the same code from being used several times
- It is checked whether the number of the counter present in the code corresponds to that of the counter which was previously registered in the device

If one of the checks fails the code will be rejected by the device.

If against this one is passed all the checks, the code is considered valid. The volume of consumption present in the code is recorded in the device which will decrement it as the meter records the consumption until it is zero and the power supply is cut off.

In order to prevent the code from being used a second time, the unique code is saved. So this code recharge will not pass the verification because the device remembers that he has already seen. As presented in Fig. 5.

List of Materials to Use

The material needed for the realization of our prototype is given in the Table 4.

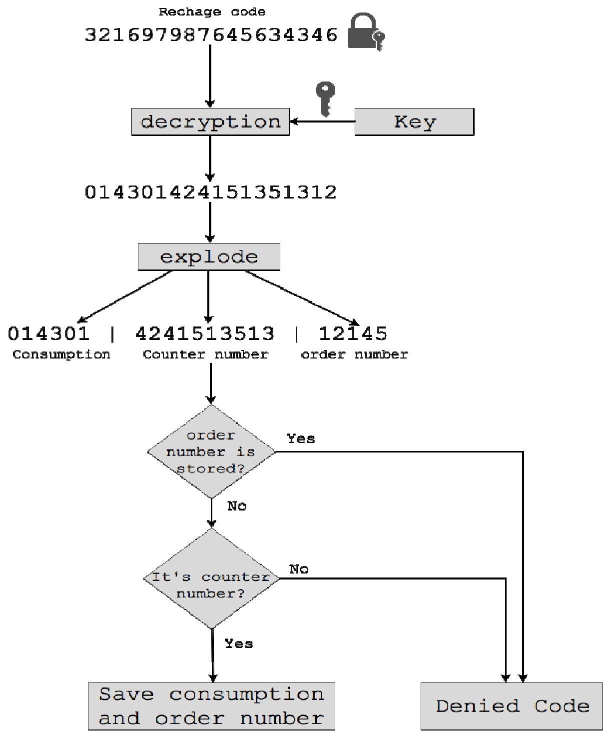

Fig. 5: Decodings the recharge code

Table 4: List of equipment used to implement prototype

Materials	Quantity
Arduino Uno R3 card	2
5V Relay module	2
WiFi module	2
Plexiglass support	2
Connection Cable Pack	2
Test plate	5
LCD screen 20*4	1
Photoresistor	5
Pack de Resistor	1
Terminals	10
Transformer220/12	2
Digital meter	2
Drawing-board	2
GSM module A6	2
Numeric keyboard	1
1000u Capacitor	4
Graetz Bridge	4
Transistor 2N2222	4
Regulator 5V	4

Circuit Diagrams of Modules

Communication Module

The communication module exists for the client module only for the module cut, as such we have: Communication interface with the cutoff module Communication module with the prepaid counter as presented in Fig. 6.

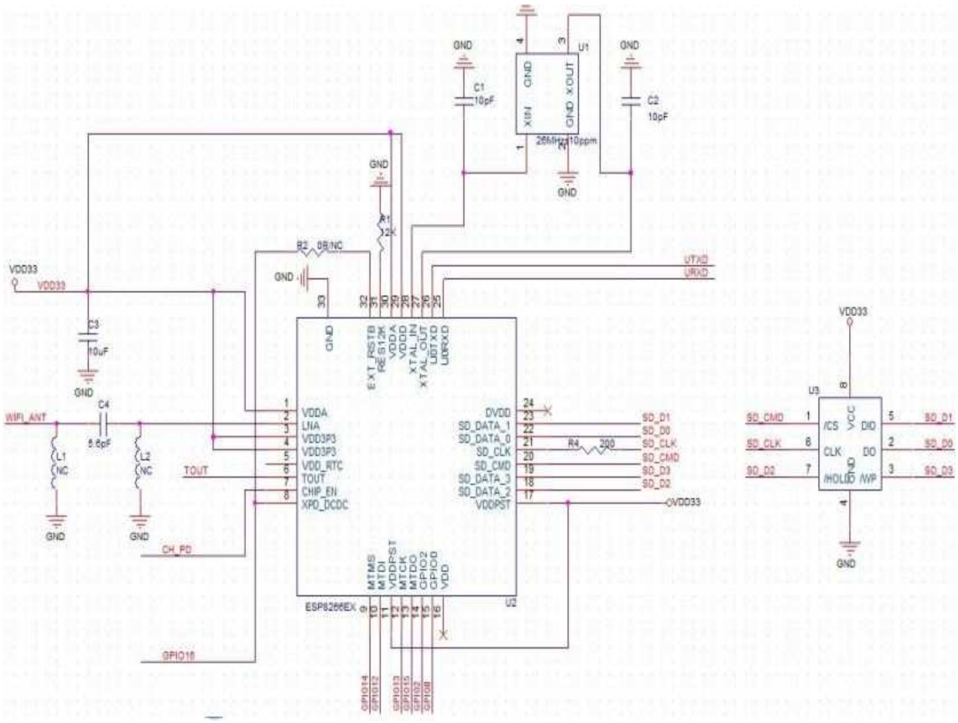

Fig. 6: Sub communication module between the cutoff module and the customer meter

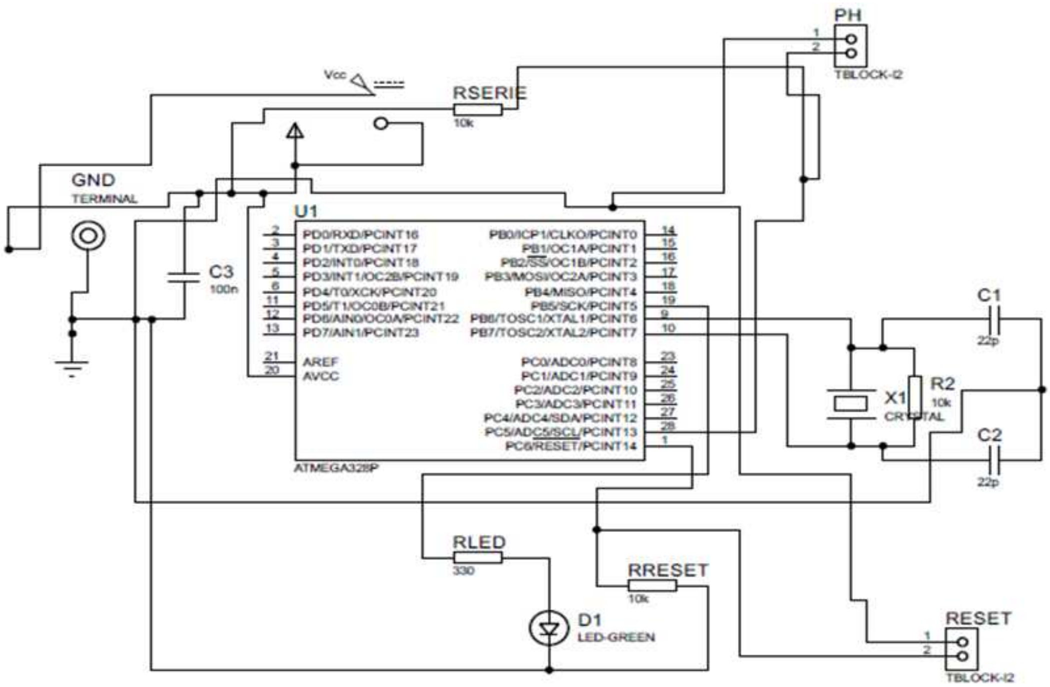

Fig. 7: Sub indexes reading module on customer and pole meters

Its role is to transfer indexes related to the customer's consumption but also to act on the order of cut in case of fraud or insufficient credit in the customer account. The design is presented in Fig. 8.

Indexes Reading Module

The indexes reading module of the meter installed at as well as that installed on the post is given by the diagram of Fig. 7.

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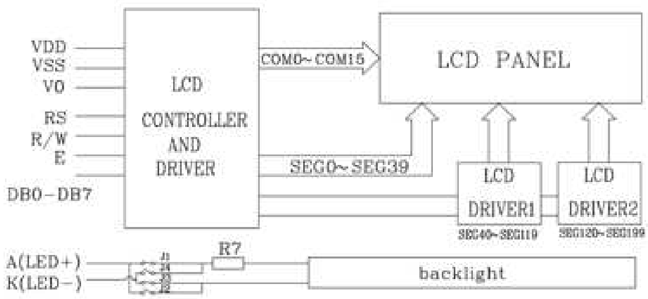
Screen for Entering Codes

For the acquisition of data related to the recharge of the consumption of the customer we have designed the diagram presented in Fig. 8 and 9.

Le Wi-Fi Module or Esp8266 Module

The ESP8266 module is a grouping of multiple components, in the form of a mini-electronic board, with 8 connection pins as presented in Fig. 10.

Fig. 8: Sub code entry module and recharging procedure



Pin no.	Symbol	External connection	Function
1	V_{SS}	Power supply	Signal ground for LCM (GND)
2	V_{DD}		Power supply for logic (+5V) for LCM
3	V_0		Contrast adjust
4	RS	MPU	Register select signal
5	R/W	MPU	Read/write select signal
6	E	MPU	Operation (data read/write) enable signal
7~10	DB0~DB3	MPU	Four low order bi-directional three-state data bus lines. Used for data transfer between the MPU and the LCM. These four are not used during 4-bit operation.
11~14	DB4~DB7	MPU	Four high order bi-directional three-state data bus lines. Used for data transfer between the MPU
15	LED+	LED BKL power Supply	Power supply for BKL (V=+5.0V)
16	LED-		Power supply for BKL (GND)

Fig. 9: Data acquisition screen

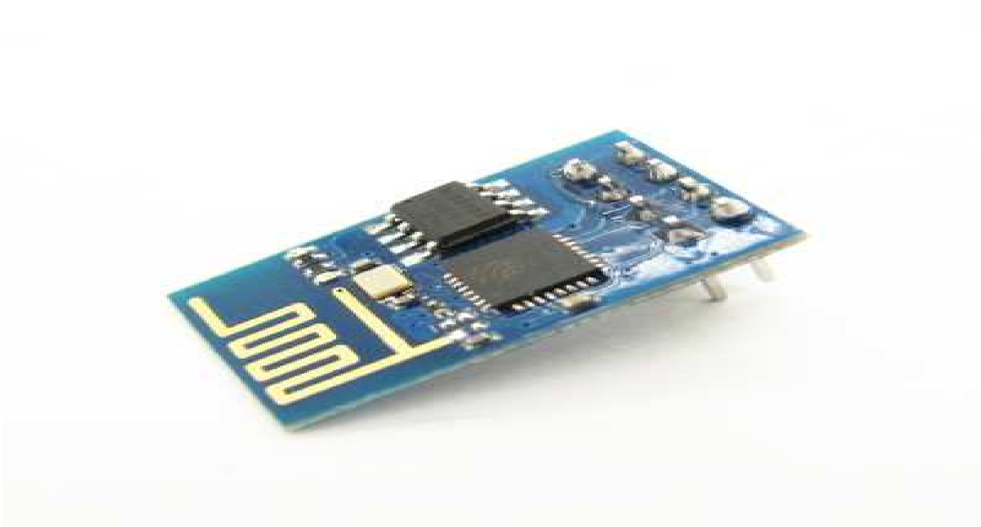


Fig. 10: ESP 8266

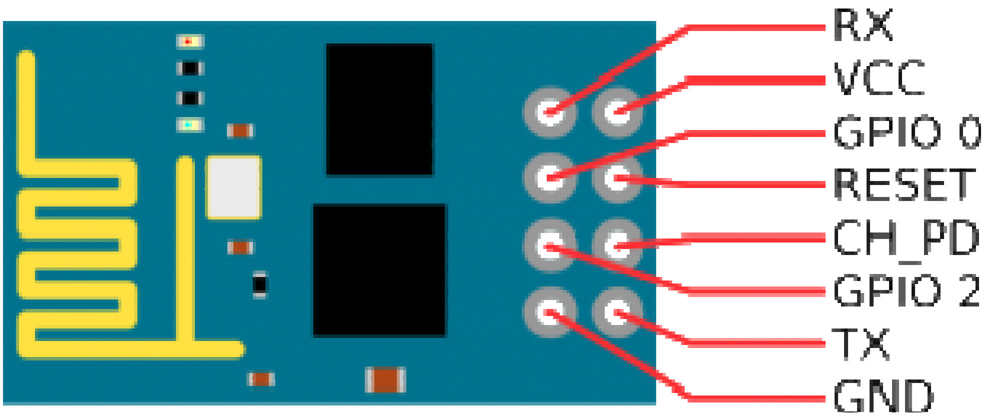


Fig. 11: Sub Wifi module

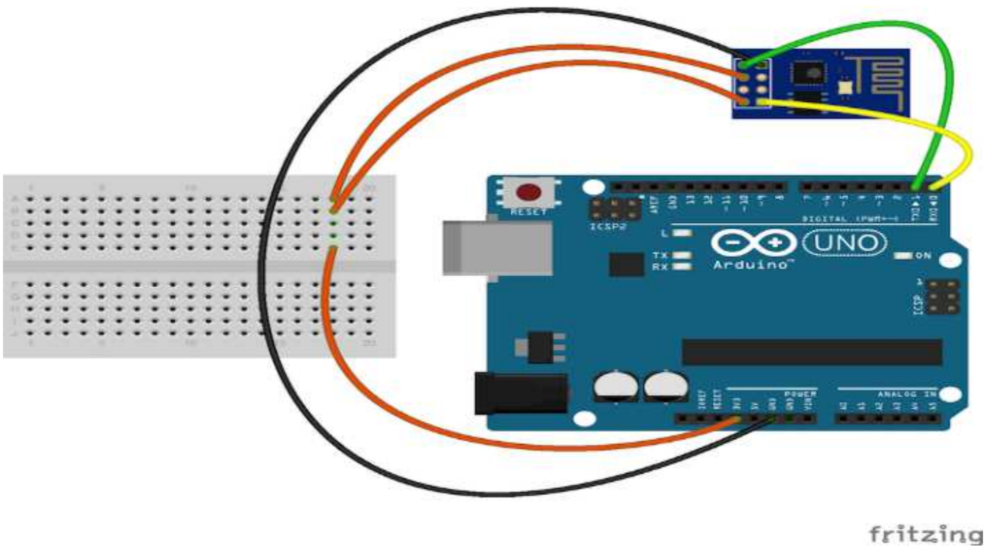


Fig. 12: Connexion du module Wifi

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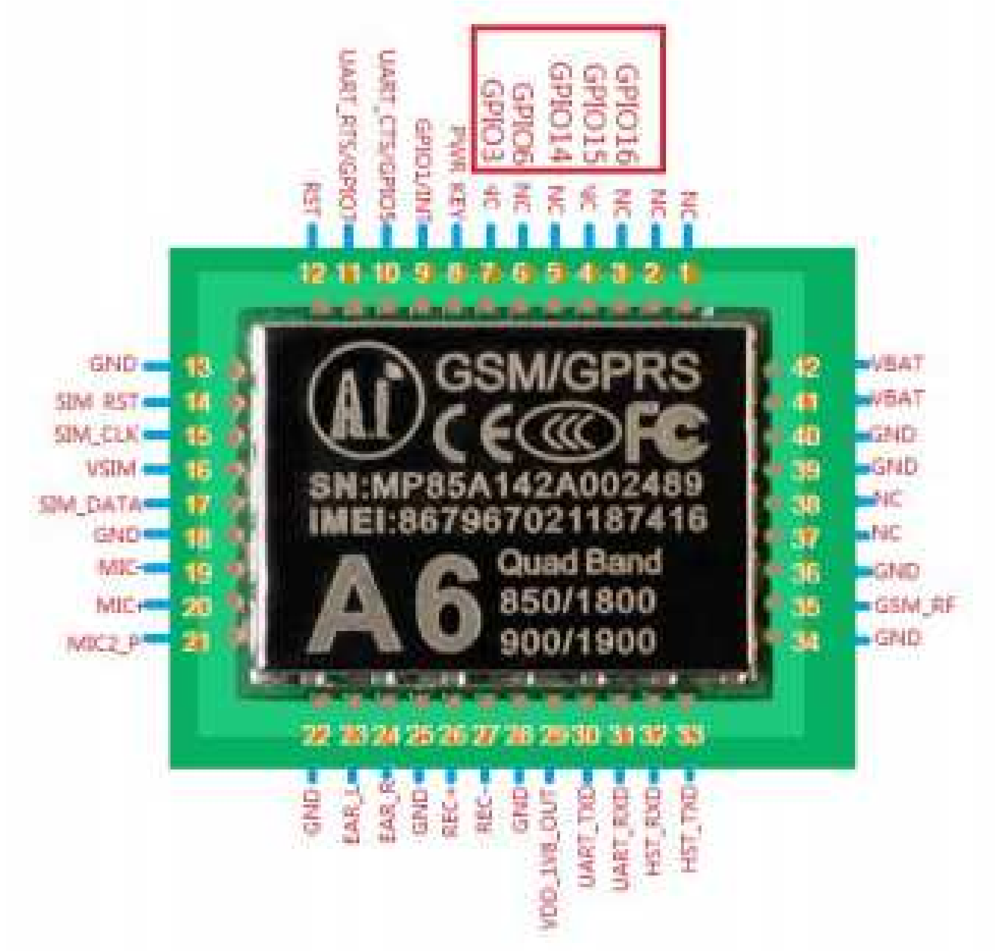

Fig. 13: Diagram of the pins of the GSM modem A6

This module measures 2.5×1.5 cm and allows you to connect to a Wi-Fi point to communicate in client/server mode (be client or server) but it can also be defined as a Wi-fi point. The details of the connections are given in Fig. 11 and the design is presented in Fig. 12.

- UTXD: This is the output of the ESP8266 data. This signal will be 3.3V and will be easily recognized by the Arduino, without the need for a logical level conversion
- CH_PD ("chip power down"): Must be at 3.3 volts to allow operation of the module
- RST ("reset"): When this pin is connected to ground, this results in a reset (restart) of the module
- Vcc: Power supply of the module: 3.3 V
- GND: Ground
- GPIO2: "General Purpose Input Output"
- GPIO0: Set to 3.3 volts in normal use (connected to GND when you want to update the firmware of the ESP8266)
- URXD: Data entry, which must be at a logic level of 3.3 volts

GSM Module

The communication between the cutoff module and the computer platform will be done through a GSM modem A6 whose is presented in Fig. 13.

GSM: Global System for Mobile Communication (GSM) (historically "Mobile Special Group") is a second-generation digital standard for mobile telephony. GSM is the most used standard in Europe at the end of the 20th century, supported in the United States. This standard uses the 0.9 GHz frequency band in Europe. In the United States, however, the frequency band used is the 1.9 GHz band. For example, mobile phones that can operate in both Europe and the United States.

In a GSM network, the user's terminal is called a mobile station. A mobile station, in this case, a GSM modem, is composed of a Subscriber Identity Module (SIM) card, enabling the uniquely identifiable use of a mobile terminal.

Terminals (devices) are identified by a unique 15-digit identification number called International Mobile Equipment Identity (IMEI). This code can be protected using a 4-digit key called PIN code.

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The SIM card thus makes it possible to identify each user, independently of the terminal used during the communication.

The GSM modem is actually an integrated circuit with the ability to communicate with a GSM antenna and a SIM card (called a chip by misuse of language), thanks to certain commands that can come from a microcontroller or a PC.

GSM has the advantage of being not only far-reaching (several kilometers), to have a wide geographical coverage, but also to be wireless, so flexible.

The operating principle is given by the Fig. 14.

Cut Off Circuit Module

The cut-off circuit makes it possible to act on the customer's electrical power supply line by cutting or not through a controlled relay.

The electromagnetic relay consists of a multi-coil tower, wound on an iron core, to form an electromagnet. When the coil is excited, by the current flowing through it, the core becomes temporarily magnetized. The magnetized core attracts the iron frame. The articulated armature operates one or more sets of contacts. When the coil is de-energized the armature and contacts are released. The relay can generate a very high voltage across the coil when it is turned off. This can damage other components in the circuit. To avoid this, a so-called freewheel diode is connected across the coil. The Relay has five points. On both operating points one is permanently connected to the 5 DC power source and the other point is connected to the collector section of the power transistor. When the power transistor is saturated, that is to say the coil of the excited relay, it is magnetized and attracts the iron frame. The iron plate moves from the Normally Connected position (NC) to the Normally Open position (NO).

Thus, the line disconnector closes and allows the passage of electrical energy. When a fraud is detected or prepaid energy consumption is reached, the disconnector opens and prevents the passage of electrical energy.

Its module is presented in Fig. 15 and 16.

Counter Module

It is given by the following diagram presented in Fig. 17.

Power Module

It is present in the customer and pole modules and its role is to adapt the voltage level to the terminals of the electrical components of the system his design is presented in Fig. 18.

Overview of the Prototype

After presenting the various modules and sub-modules and their roles, we present in Fig. 19 the overall diagram of our prototype.

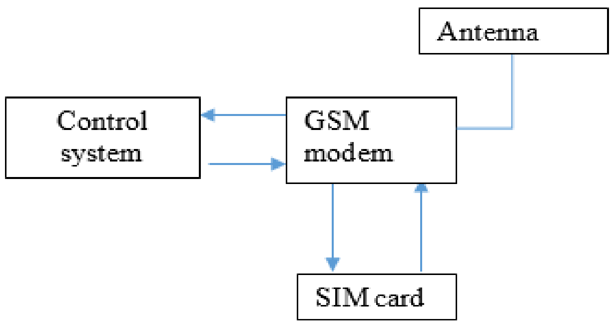

Fig. 14: The general operation of a GSM modem

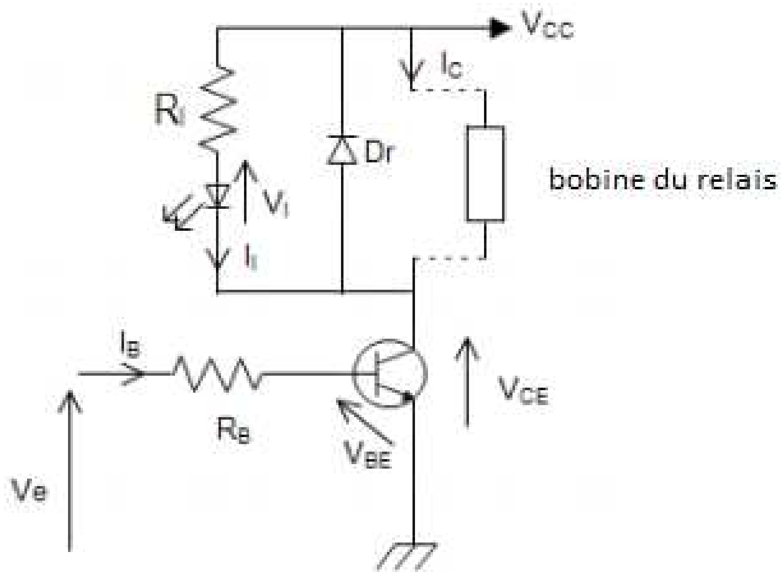

Fig. 15: Control diagram of the cutoff circuit

DOI: 10.3844/ajeassp.2018.166.185

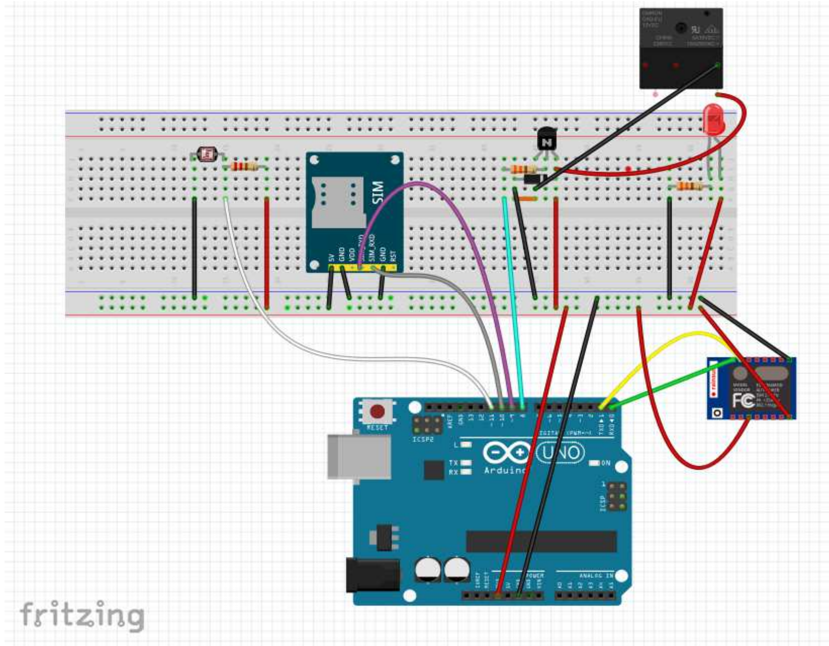

Fig. 16: Cutoff module representation

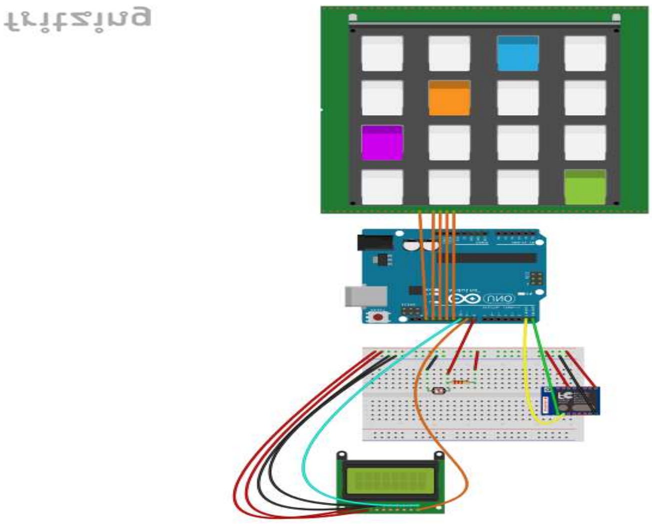

Fig. 17: Counter module representation

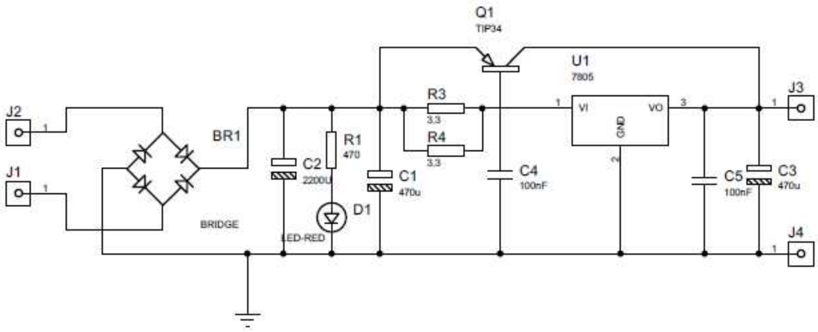

Fig. 18: Electrical diagram of the supply circuit

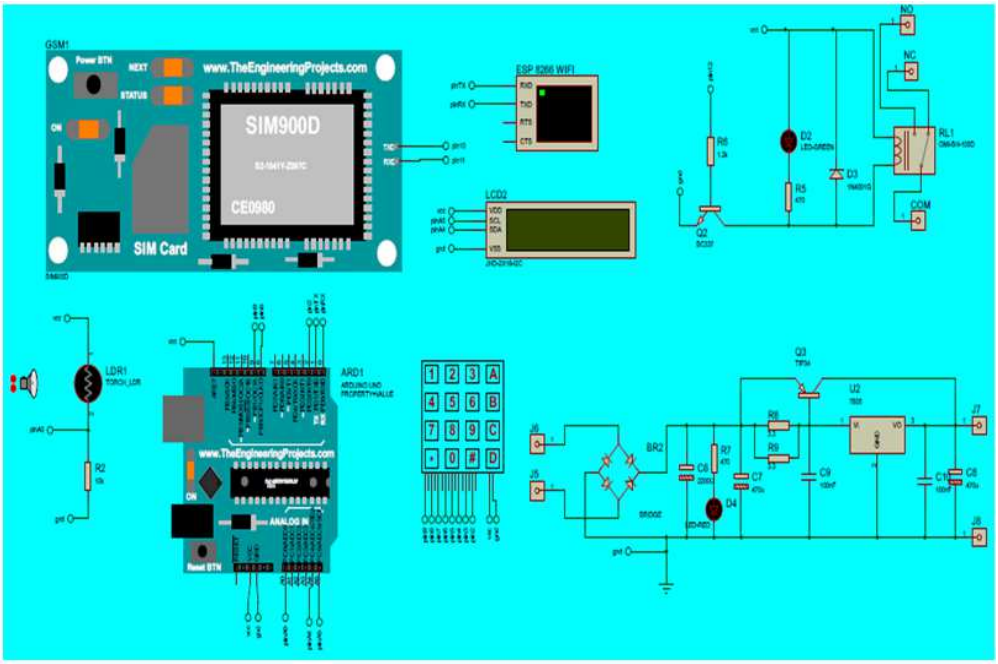

Fig. 19: Overall electrical diagram of our prototype

Results and Discussion

Results

In this part we present our prototype, we have from the left to the right the client module and the cutoff module and down, we have the different screens of our platform: the home screen, the generation codes screen and the control screen as presented in Fig. 20. Our prototype brings several answers for the eradication of the nontechnical losses in the Cameroonian electricity network namely:

- Cost of meter readings
- Lack of access to meters
- Cash delay problem
- Litigation management
- Losses on non-payments
- More unpaid bills from tenants

Because it makes it possible to do remote metering, the management of the flows of consumption, the control of the consumptions and increase of the invoicing rate of the company in charge of the distribution but also a huge gain in terms of energy to 10% of the total production of Cameroon in 2020 is 300 MW. This result is obtained on the combining of the work of this research with those carried out in our previous works on the Evaluation of Customer Behaviour Irregularities in Cameroon Electricity Network using Support Vector Machine published in American Journal of Engineering and Applied Sciences in 2017.

Table 5: Evaluation of MW cost in cameroon

Projects	Power in MW	Cost (Billions)
Memvele	200	503
Hydromekin	15	25
Lom pangar	30	500
Natchigal	420	690
Makay	350	500
Nyong power H	250	500
Song ndong	270	375
Total	1 535	3 093
Cost of MW	2	Billion Xaf

Knowing that the MW of energy produced is evaluated as follows in Table 5, our prototype allows a gain in terms of investment in the order of 600 billion CFA Franc.

Discussions

The work carried out in this research gives satisfactory results because it allows to detect and eradicate non-technical losses in electricity however some electrical power losses are inevitable, steps can be taken to ensure that it is minimized. Several measures have been applied to eradicate, including those based on technology and those that rely on human effort and ingenuity the overview of several research done concerning this topic are presented in Table 6.

Given the importance of electricity in the socio-economic development of populations, its key role in the fight against poverty and its accessibility to all, management, economy and the reliability of innovation in its recovery are a priority. If prepayment attempts to meet this priority, its practical exploitation presents deficiencies on both sides.

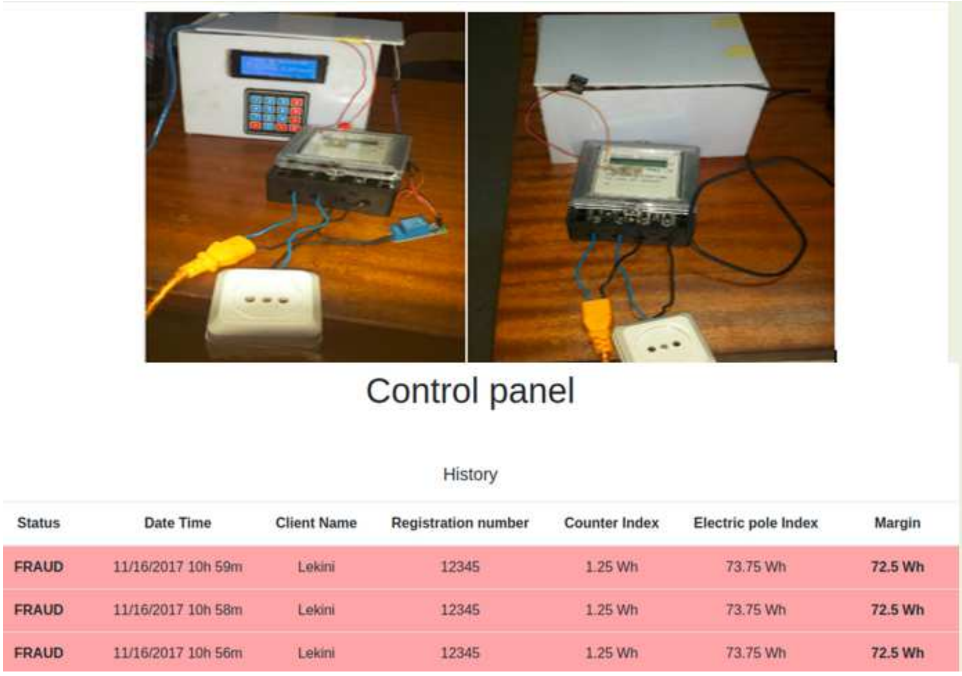

Fig. 20: Prototype

Table 6: Overview of relative works

Authors	Publication titles	Model used	Number of customers	Accuracy
Cabral *et al*. (2009)	Fraud detection system for high and low voltage electricity consumers based on data mining. Power and Energy Society General Meeting (PES'09).	SOM	2 K	0.93
Costa *et al*. (2013)	Fraud detection in electric power distribution networks using an ANN based knowledge-discovery process. Int. J. Artificial Intelligence Applic.	NN	22 K	0.87
Depuru *et al*. (2011)	Support vector machine based data classification for detection of electricity theft", Power Systems Conference and Exposition (PSCE), 2011.	SVM (Gauss) Bool rules Fuzzy rules SVM linear	1350 700 K 700 K 700 K	0.98 0.47 0.55 0.55
Muniz *et al*. (2009)	A Neuro-fuzzy System for Fraud Detection in Electricity Distribution		20 K	0.68
Nagi *et al*. (2008b)	"Non-Technical Loss analysis for detection of electricity theft using support vector machines. IEEE 2nd International Power and Energy Conference (PECon 2008).	SVM	Less than 400 K	0.53
Nagi *et al*. (2008a)	"Detection of abnormalities and electricity theft using genetic support vector machines. IEEE Region 10 Conference TENCON.	Genetic SVM	1172	0.63
Nagi *et al*. (2010b)	"Improving SVM-based nontechnical loss detection in power utility using the fuzzy inference system. IEEE Trans. Power Delivery, 26: 1284-1285.	SVM + Fuzzy	100 K	0.72
Nagi *et al*. (2010a)	"Nontechnical loss detection for metered customers in power utility using support vector machines. IEEE Trans. Power Delivery, 25: 1162-1171.	SVM Gauss	Less than 400 K	0.77
Nizar *et al*. (2006b)	"Customer information system data pre-processing with feature selection techniques for non-technical losses prediction in an electricity market. International Conference on Power System Technology (PowerCon 2006).	Decision tree	N/A	0.99

Table 6: Continue

Ramos *et al*. (2009)	"Fast non-technical losses identification through optimum-path forest. 15th International Conference on Intelligent System Applications to Power Systems (ISAP).	OPF SVM gauss SVM linear NN	736 736 736 736	0.90 0.89 0.45 0.53
Ramos *et al*. (2012)	"Identification and feature selection of non-technical losses for industrial consumers using the software WEKA. International Conference on Industry Applications, (CIA' 12).	SVM KNN NN	5 K 5 K 5 K	0.96 0.96 0.94
Sahoo *et al*. (2015)	"Electricity theft detection using smart meter data. IEEE Power and Energy Society Innovative Smart Grid Technologies Conference (GTC' 15).	Regression	30	-
Spiric *et al*. (2014)	"Using the rough set theory to detect fraud committed by electricity customers. Int. J. Electrical Power Energy Syst., 62: 727-734.	Rough sets	N/A	0.93

Nevertheless, these shortcomings can be minimized and this, if an increased policy accompanies the use of these meters. For example, the following recommendations can help minimize the negative aspects while improving the quality of service.

Advantages

Theoretical and practical studies have shown that prepayment is currently very successful, owing to the following advantages:

- Cash improvement as customers pay before using electricity
- Limiting collection defects because the customer does not receive electricity if he has not paid in advance
- Reduction in the cost of meter readings
- Reduction in fraud with appropriate facilities
- Anticipation of consumption
- Payment according to financial capacity
- Adjustment of consumption to the financial resources
- Avoidance of unpleasant surprises at the end of the month when faced with an unexpected bill

Disadvantages

Although prepaid meters have many advantages, the disadvantages cannot be neglected. These shortcomings, which more or less affect the supplier and the customers, are as follows:

- Saturation of the servers of the management units
- Spontaneous failure of the management and sales units
- Difficulties in recovering fixed premiums and royalty
- Difficulties in the supply of energy credits in certain branches, creating long queues
- Consumption of energy greater than that in the case of conventional meters
- Risk of sleeping without electricity for lack of units
- Difficulties related to the levying of the fee

Conclusion

After presenting the system for the detection of non-technical losses, a summary of a prepayment system for electric power or other utility commodity distribution using radio frequency identification tag technology to store and transfer value (money or KWh) from the retail vendor to the customer and deliver power to the customer from the power distribution system after the presentation of a fraud detection model for the Cameroon National Electricity Company, using support vector machines was implemented as solution. There are several well-known and generally accepted sources of evidence that prepaid electricity meters stop endless conflicts among customers, ENEO's collection departments, landlords and tenants over unpaid or sometimes rejected bills because they are considered overtaxed, which here constitute commercial or non-technical losses. In addition, this mode not only enables the supplier to solve collection problems, but also allows the customer to avoid unnecessary wastage of electricity and to better manage it according to their cash flow.

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Author's Contributions

Lekini Nkodo Claude Bernard: Contributed to research design, literature review, model development and manuscript preparation and revision.

Ndzana Benoît, Oumarou Hamandjoda and Fippo Fitime Louis: Contributed to conceptualization, manuscript review, revision and research supervision.

Ethics

The authors have no ethical issues that may arise after the publication of this manuscript and confirm that this work is original and has not been published elsewhere.

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