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PHENOMENOTECHNICAL CRITICISM OF THE AUTOMATION OF ACTIVE POWER SAMPLING AT THE GECAMINES KAMBOVE HIGH-VOLTAGE SUBSTATION

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Abstract: **In this article, we are talking about a preliminary project for the implementation of an automatic sampling system for active power measurements at the HV substation of Gécamines Kambove. Since the existing substation is used for the distribution of electrical energy to the facilities of Gécamines Kambove and at the same time it supplies the mining companies located in different parts of the city. In view of the importance of the above, the new direct debit system aims to guarantee a continuous service to the watt man who takes the measurements manually from different feeders and facilitates the operation of the network and (which is remote supervision and control and telemetry). To get there. Based on the results obtained, it is shown that the automation of active power sampling is the solution for distribution networks. The results of the present study provide necessary information on the inlet voltage of the substation, the high voltage; the current and power factor as well as the frequency that characterize them.**

Keywords: **Phenomenotechnical criticism, substation, automation, sampling, digital, measurements, meter, intelligent.**

I. INTRODUCTION

Technological innovations are leading to many social and anthropological transformations. With ubiquitous digital technologies, we live, speak, and act under the threat of the loss of what makes up the fabric of our humanity, our human relationships, and our society. We live under the threat of the loss of what irrigates our lives. Our words and actions attest to the permanence of lack and therefore of threat. These can be seen in the spaces of construction, processing, and transmission of knowledge that contribute to the understanding of the future of societies, humans, and the world. In the pedagogical society promoted by materialism, digital technologies are displacing the place of concentration of knowledge, saturating the pyramidal pedagogical model and virtualizing the physical body of the teacher. What worlds, culture and pedagogy do digital technologies endowed with machine intelligence, called artificial intelligence, build? Can we sketch out what is at stake? The pedagogical society refers to a society where the media, digital techniques and technologies, artificial intelligence, and social networks compete with the educational institution for the monopoly of the production and transmission of knowledge as well as education. (Emmanuel, 9/2023)

A phenomenotechnical device is a technical matrix that makes possible the production, organization and mediatization of a set of phenomena. This is the case of the pedagogical society in which technical means, such as the printing press, the

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media, the computer, the Internet, artificial intelligence and social networks, function as media for the transmission of information, knowledge, science and pedagogy. the nerve, the brain, and every numinous reality." (2020 : 26).

The computer and the Internet are the central technologies of the pedagogical society. By penetrating pedagogy, they have reversed the flow of knowledge and all education. If, up to and including the twentieth century, the learner ran physically in search of knowledge, the reversal brought about by the computer, the Internet and the global accessibility of the Web, "global memory and collective encyclopaedia of humanity» leads to the opposite movement. Knowledge is available everywhere and comes to the learner at any time (Serres, 2001)

Methods and tools that are more effective than electrical engineering are already on the market, but the difficulty is such that their use is not granted to all those concerned due to lack of resources. It is in order to circumvent the problem of reducing measurement errors within certain positions that do not have sufficient means to obtain the necessary tools.

The evolution of technology in the world is no longer to be demonstrated, given the impact of technology on the entire field of social and professional life. And above all, the impact of IT in software and software in the technical field is of paramount importance. IT is linked to the automatic system through the management and supervision of various coded technical information provided by the processes.

Many of today's processes are handled by automatic machines, making the task easy for the savvy operator. The rational operation of an industrial installation implies for the operator the need to have at all times information giving him accurate knowledge of the state of the unit's constituent system and of the means of acting on it within a minimum time. Hence the objective of our scientific work is to provide all researchers with a useful and necessary computer tool for the model of sampling the digital loads of HV substations.

The aim is to exploit the physical quantities measured by the various sensors on board a station; Thus it is possible to visualize in graphical form the different data received by the receiver, and connector to a PC via its serial port. The signal that we will receive will be in the form of a bit stream, it is a matter of retrieving this signal, storing it in a computer file in the form of raw data to be able to visualize it afterwards.

II. METHODOLOGY

1.1. Data collection

1.1.1. Job Profile Diagram

The high-voltage substation is located in the Gécamines Kambove facility in the central group of Gécamines, about 25.6km long from the town of Likasi, in the province of Haut-Katanga in the Democratic Republic of Congo.

The Gécamines substation is currently supplied with 110 kV by the NRC line and the 220kV-COMIKA line, a three-phase R, S, T overhead line in accordance with the SNEL representation, attached to the porcelain insulators on the metal pylons with ribbon armament and the line was connected as such claim in June 2020. (KVE/ELEC, 2023)

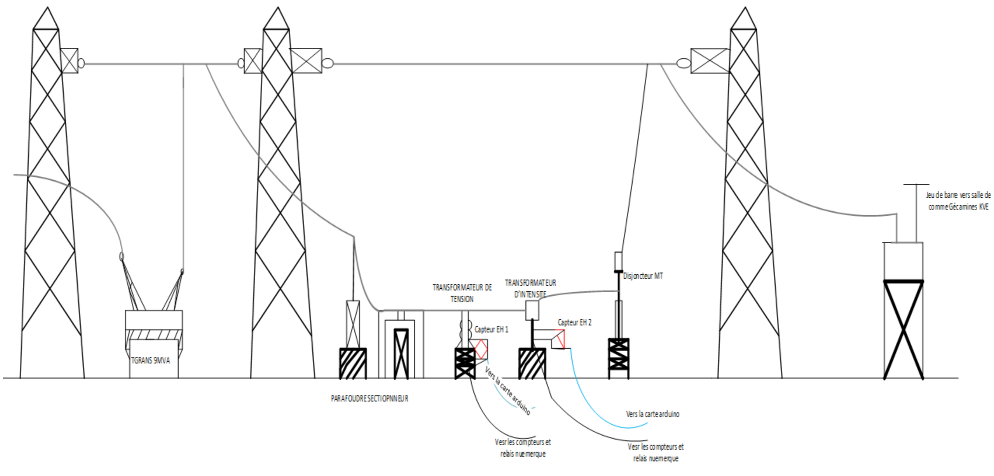

Figure 1: Job Profile Diagram

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Sampling current and voltage from the main busbars, to determine the active power, the latter acts on the frequency by:

$$Cos\varphi = \frac{P}{S} \quad \textbf{(I.1)} \quad P = UICos\varphi \quad \textbf{(I.2)} \quad P = \sqrt{3}\,UICos\varphi \quad \textbf{(I.3)}$$

This is a flow cell measuring and counting from the Gécamines substation.

1. T.I Current Transformer

The current transformer used has two secondary windings, one for measurement and the other for protection. T.I: Brand: SIEYUAN 500 250/ 5A. (Estaca, 2006)

2. **The Potential Transformer**

The potential transformer used is 110kV/ 5V and 250/√3, the Brand:

The watt operators monitor the substation and take measurements per hour on each inlet and inlet of the substation upstream and downstream of the transformer, the arrival of the transformer by a SNEL relay where the MW power of arrival is taken in 110 KV NRC COMIKA, which together with it, a monthly power consumption report must be made (KVE/ELEC, 2023).

Before decentralization, Gécamines would take care of all domestic consumption, so after decentralization, today Gécamines, the domestic houses and other houses in the Gécamines region.

1.1.2. **Sampling of active power**

Consumption refers to the amount of energy because, in addition to power, it involves the time factor. Electrical energy is symbolized by the letter W or E, but in terms of consumption, this energy can also be symbolized by the letter C. Because of the importance of the values, kilowatt-hours (kWh) or megawatt-hours (MWh) are used to quantify consumption or energy consumption. (Jacop.JP, 1968)

Being in the time domain, it is therefore very important to know the consumption to get an idea of the satisfaction of the market, whether the power supplied is actually used or whether the use actually receives the desired power. It is partly on the basis of consumption that the customer pays his bill to the SNEL distributor.

Table 1 of the levy of 07/07/2023

N°	Date Time	MW between substations	INT TFO 9MVA	INT R14	THIRD-PARTY MW	MW GCM	INT LUB	FREQ	TENSION	INT R1
1	07/07/2023 12:00'	4,3	27	120	2,15	2,15	0	50	6,7	210
2	13h00'	2,4	24	120	2,15	0,25	0	49,9	6,8	0
3	14h00'	3,9	25	120	2,15	1,75	0	50	6,6	175
3	15h00'	4,2	27	110	2,06	2,14	0	50	6,6	200
4	16h00'	5,9	38	135	2,29	3,61	0	50	6,5	225
5	17h00'	5,8	30	120	2,24	2,06	0	49,9	6,6	230
6	18h00'	5,4	27	130	2,33	2,07	0	50	6,6	185
7	19h00'	5,9	27	140	1,88	2,32	0	50	6,7	220
8	20h00'	5,8	27	90	1,83	2,37	0	50	6,8	225
9	21h00'	5,4	27	85	1,83	2,07	0	50	6,8	220
10	10:00 p.m.	5,0	25	85	1,83	1,97	0	50	6,7	220
11	11:00 p.m.	4,8	25	85	1,78	1,92	0	50	6,7	190
12	24h00'	4,4	24	80	1,78	1,42	0	50	6,8	170
13	01h00'	3,9	21	80	1,78	1,82	0	50	6,7	210
14	02h00'	4,0	24	80	1,78	1,82	0	50	6,8	170
15	03h00'	4,1	24	80	1,78	1,72	0	50	6,8	200
16	04h00'	3,9	23	80	1,88	1,82	0	50	6,8	200
17	05h00'	4,0	26	90	1,88	1,82	0	50	6,7	200
18	06h00'	4,8	31	100	1,73	2,83	0	50	6,7	220
19	07h00'	4,9	32	120	1,97	2,75	0	50	6,8	195

20	08h00'	4,0	25	110	2,15	1,94	0	50	6,6	150
21	09h00'	3,8	24	110	2,06	1,74	0	49,9	6,7	155
22	10:00 a.m.	3,8	24	110	2,06	1,74	0	50	6,6	150
23	11:00'	3,7	24	120	2,15	1,55	0	50	6,8	125

1.1.3. Status of the active power downstream of the substation

For this approach, we can only look at the voltage and current, as well as the frequency and the power factor per hour indicated by the table.

N°	Date Time	INTENSITY	TENSION	COS PHY
1.	07/07/2023 12h00'	27	6,7	0.8
2.	13h00'	24	6,8	0.8
3.	14h00'	25	6,6	0.8
4.	15h00'	27	6,6	0.8
5.	16h00'	38	6,5	0.8
6.	17h00'	30	6,6	0.8
7.	18h00'	27	6,6	0.8
8.	19h00'	27	6,7	0.8
9.	20h00'	27	6,8	0.8
10.	21h00'	27	6,8	0.8
11.	10:00 p.m.	25	6,7	0.8
12.	11:00 p.m.	25	6,7	0.8
13.	24h00'	24	6,8	0.8
14.	01h00'	21	6,7	0.8
15.	02h00'	24	6,8	0.8
16.	03h00'	24	6,8	0.8
17.	04h00'	23	6,8	0.8
18.	05h00'	26	6,7	0.8
19.	06h00'	31	6,7	0.8
20.	07h00'	32	6,8	0.8
21.	08h00'	25	6,6	0.8
22.	09h00'	24	6,7	0.8
23.	10:00 a.m.	24	6,6	0.8
24.	11:00'	24	6,8	0.8

1.2. Proposed solution

In this part of the technological approach on the automation of active power picking, we will present a numerical model of the sampling under a computer system by a microcontroller (by actuators and pre-actuators).

The proposal can be summarized downstream of the 9 MVA transformer, which Gécamines considers to take the different measurements, In the present case, the consideration is to make the measurements by automatic system to determine the losses of the transformer, i.e. the transformer provide a power that flows through a surge arrester, a disconnect switch a TP, TI (smart meter or digital relay) circuit breaker analysis to the main busbar at the control center a This is the function of monitoring the network, its operation, the metering of power, current, voltage and other electrical quantities on the networks.

The control of the active power sampling system will operate as follows:

Once the time reaches the right limit peak, a signal light lights up to indicate that you are in automatic operation. Since there are three points of measurement of the power, the voltage, the current and the power factors c, therefore the control of the sampling must be done using the sensors at Effel hall Eh1 which, being connected to the power transformer, takes the voltage 6.42 kV

$$V_s = k_h x I x B x sin\theta \quad \textbf{(I.4)}$$

$$I = \frac{V_s}{k_h x B x sin\theta} \quad \textbf{(I.5)}$$

So that it picks up the current 25.24 A approximately, it sends an electrical signal to the PLC to the digital meter and the latter understands this is given permission to the microcontroller to store the measurement and visualize by a computer so

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the Eh2 sensor captures the current per hour. An alarm sounds for 1 minute to alert the wattmans who monitor the substations, that they are fully measured and the H1 and H2 lamps light up and mark the voltage and current measurements, and thus an H3 lamp lights up after 1min showing the normal operation of the substation. As a result, once we reach 59 Minutes, the sensors send a signal again to the microcontrollers to sample the power. (A.Fabre, 1996)

1.2.1. System Block Diagram

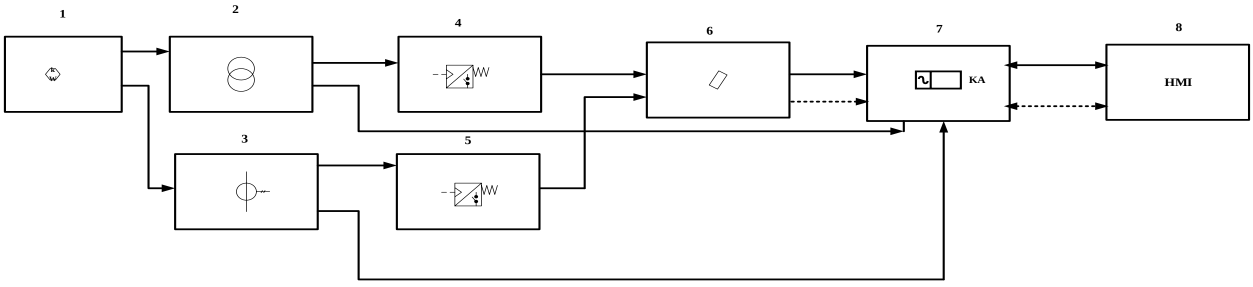

Figure 2 System Block Diagram

With:

1. Secondary inlet power supply 9 MVA transformer of the Gécamines Kambove substation;
2. Voltage transformer;
3. Current Amperage Transformer;
4. Hall effect sensor for voltage measurement;
5. Hall effect sensors for current measurement;
6. The Arduino UNO microcontroller;
7. Digital relay (smart meter);
8. Human-machine interface (computer monitoring).

1.2.2. **Functional Specification Grafcet**

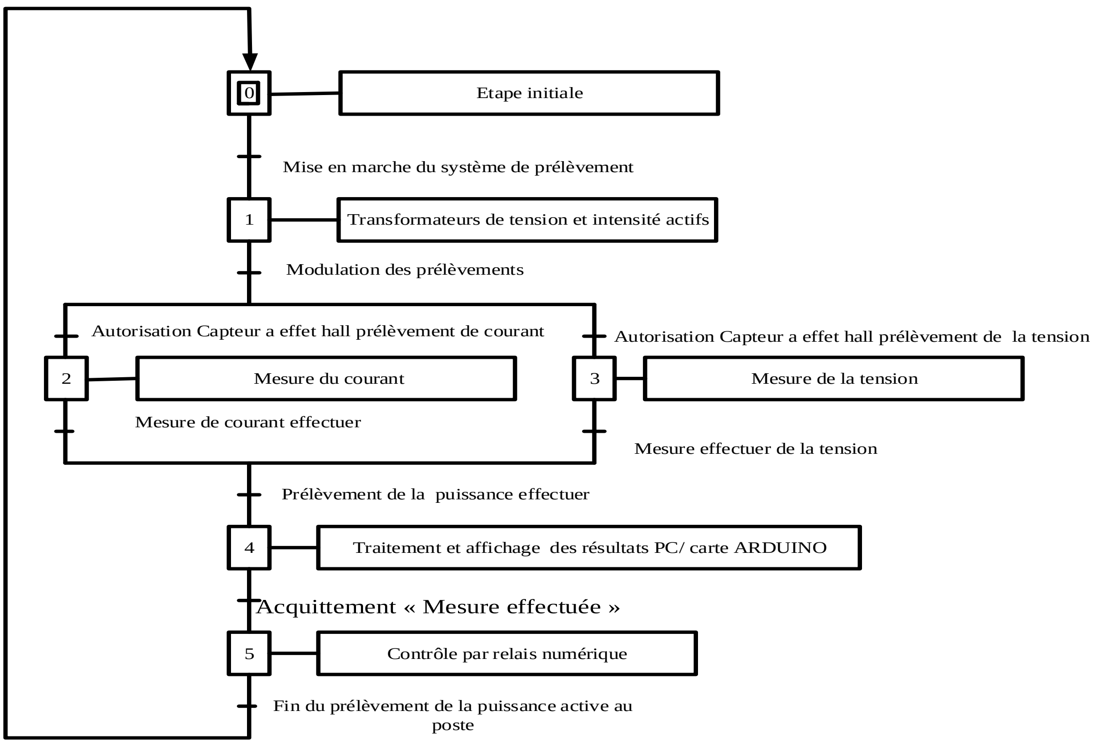

Figure 3 Functional Specification Grafcet

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1.2.3. Technology Specification Grafcet

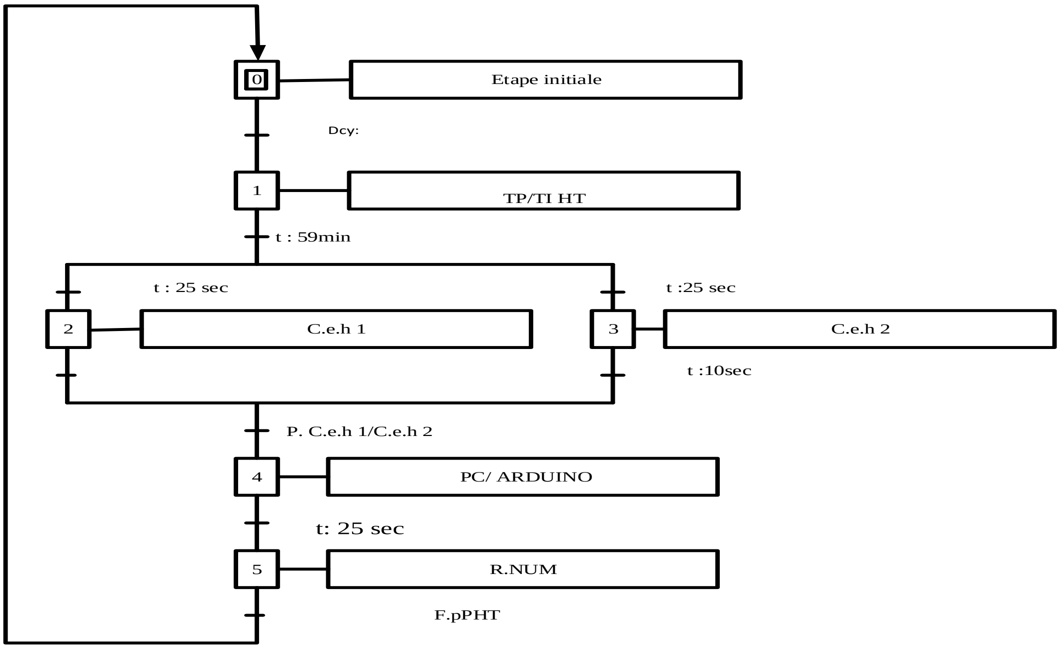

Figure 4 Technology Specification Grafcet

— 59 minutes = time required to start up the measurement sampling system at the station

— 25 seconds = time required for sensor authorization

— 10 seconds = time needed for measurements

— 25 seconds = time required for processing and acknowledgment of measurements

1.2.4. *System Detail Diagram*

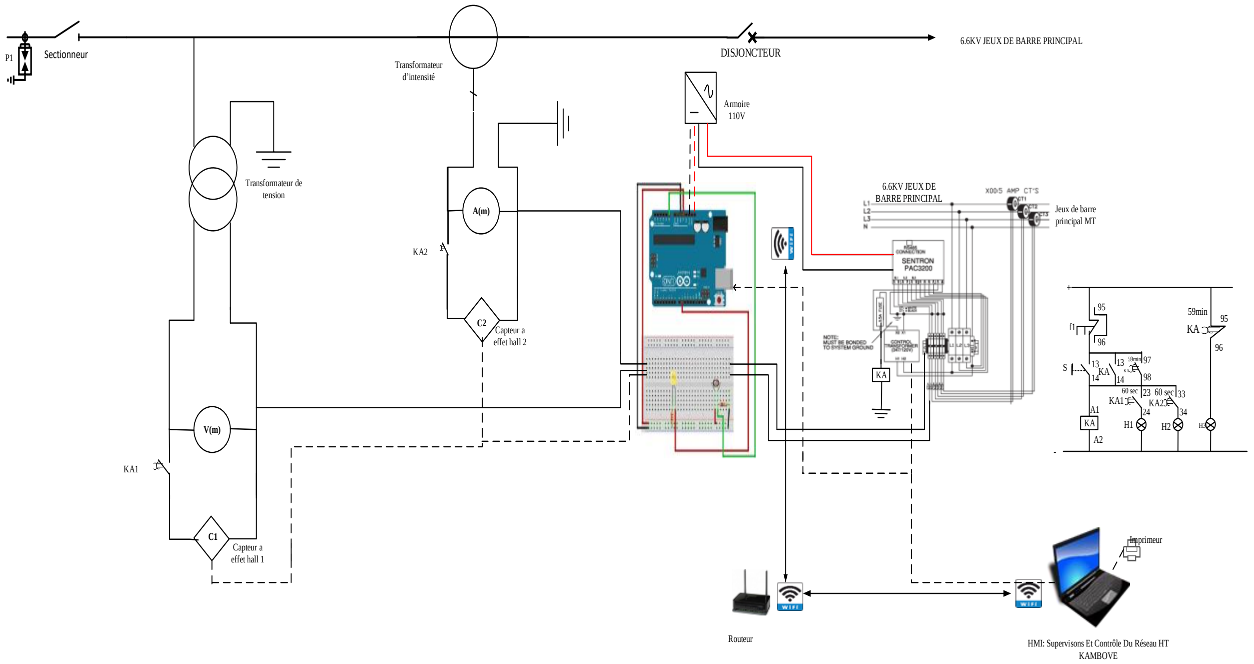

Figure 5 System Detail Diagram

1.3. Simulation

The simulation is done on the basis of the results found and sampled by the computer system, starting from the phenomenotechnical critique. We realized that the digital system is more useful than the analog system, the latter reduces measurement errors and this is done in an automatic way.

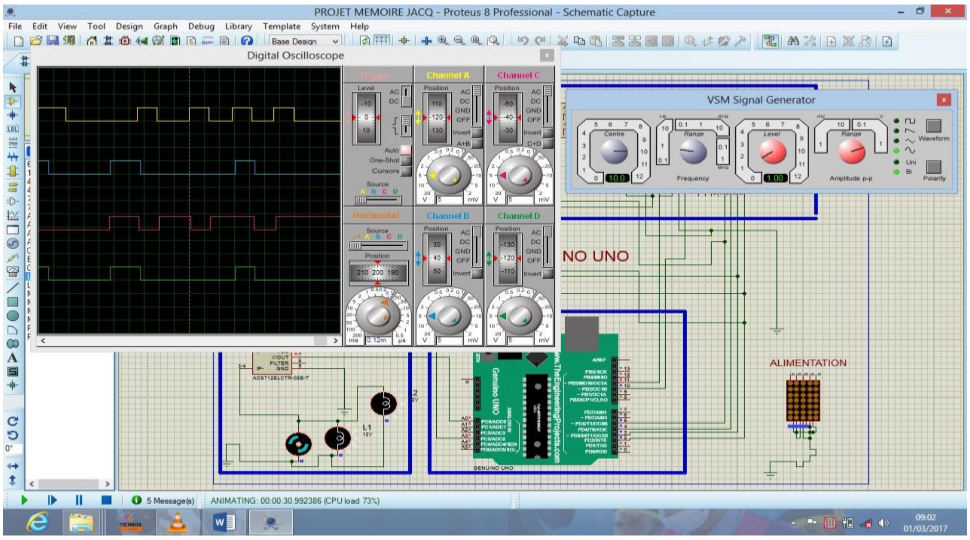

Figure 6 Practical implementation of direct debit

III. RESULTS & DISCUSSION

a. Analysis of the sample

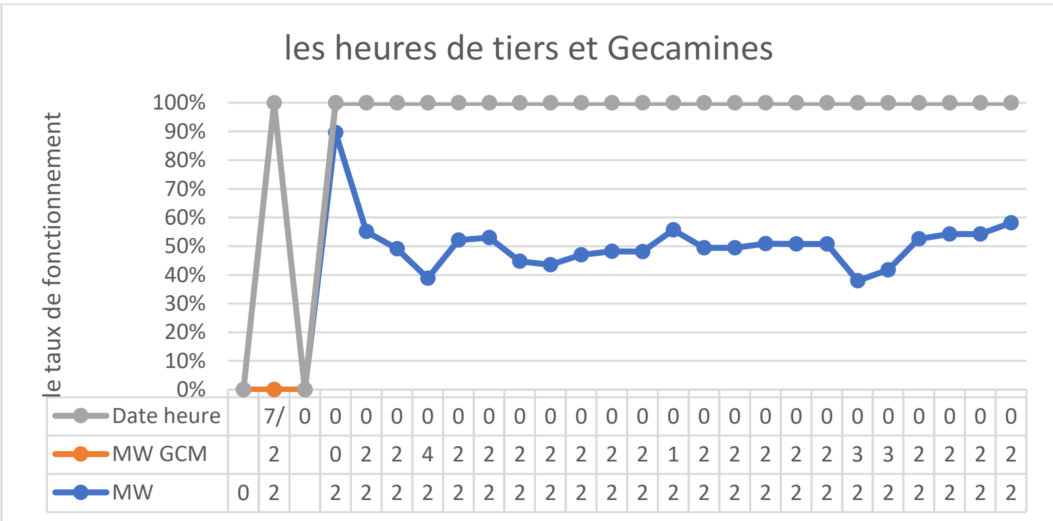

Figure 7 Substation operation as a function of TIERS AND GCM in active power

On this graph we can see the power curves of the partners SNEL and Gécamines, the green curve that changes pace and shows the daily consumption represents the subscription which corresponds to the power divided by the two sponsor SNEL and the orange line powers consumed by Gécamines and so the grey line corresponds to the consumption stub which represents the consumption per hour. Here the minimum consumption is around 40% at 1 p.m., in this case, we see some power exceedances, which will be invoiced by SNEL, so it would always be useful to control these two powers to make a difference in power at the end of the month to avoid the overages of SNEL Gécamines and its partners' billing. This analysis of the sn curves is important to know the consumption in detail, to detect the drift in order to correct them and to reduce the energy bill.

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b. Status of the active power downstream of the substation

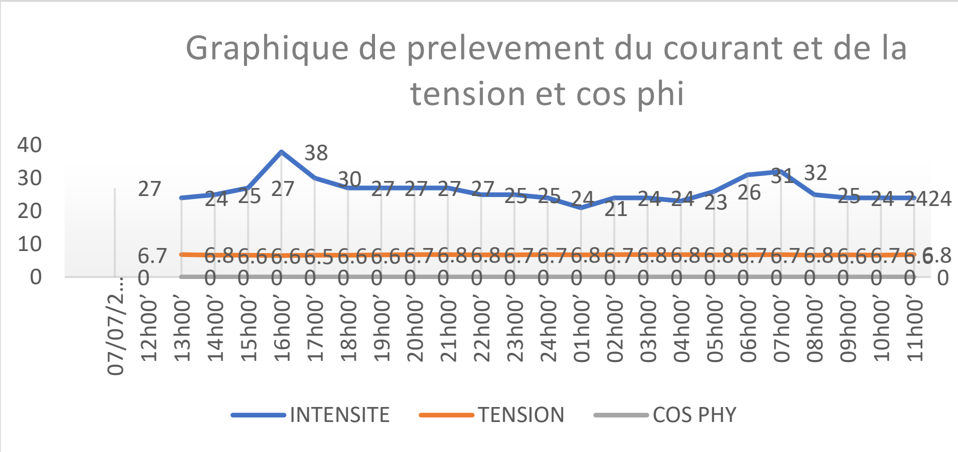

Figure 8: graph of the evolution of I, cos phi and U

This graph shows the daily energy loss to show us which time of day is high consumption, and over which period of day consumption is high. It is clear and observable that electrical energy is highly consumed between 10 a.m. and 4 p.m., moderately consumed between 00 a.m. and 8 a.m., and it is that at 00:00 that low consumption is recorded following the slowdown of industrial and domestic activity, the peak of consumption was reached at 4 p.m., while the low at 6 a.m. On average.

c. Determination of Daily Power

$$In_{tfo\ 9\ MVA} = 631A\ \rightarrow 0.623\ KA\ /24h$$

$$Un_{tfo\ 9\ MVA} = 154.2KV/24h$$

This sampling even includes measurement errors. On the other hand, by comparing the ratio of power between that extracted from TIERS and that of Gécamines, we can estimate the net consumption of the subjects of our analysis:

$$P_{heure} = 6.11\ KW/h$$

$$P_{journalire} = \sqrt{3}x0.631x154.6x0.8 = 136.862\ KW$$

$$P_{TIERS} = 47.52\ MW$$

$$P_{GCM} = 47.65\ MW$$

Knowing the daily power, we can know the daily power of Kambove Mining.

$P_{kve} = P_{jr} - P_{TIER} - P_{GCM}$

$$P_{kve} = 41.6\ MW$$

$$P_{jr} = 136.862\ MW$$

$$r_{1\ jr} = \frac{P_{jr}}{P_{jr} + P_{GCM}} = \frac{136.862}{136.862 + 47.65} = 0.74166\%\ soit\ 0.75\%$$

$$r_{1\ Gcm} = \frac{P_{GCM}}{P_{jr} + P_{GCM}} = \frac{47.65}{136.862 + 47.65} = 0.2516\%$$

$$r_{2\ Jr} = \frac{P_{TIERS}}{P_{jr} + P_{TIERS}} = \frac{47.52}{136.862\ + 47.52} = 0.2577\%$$

$$r_{2\ tiers} = \frac{P_{jr}}{P_{jr} + P_{TIERS}} = \frac{136.862}{136.862\ + 47.52} = 0.742\%\ soit\ 0.75\%$$

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Knowing the power weighting ratio exploited at the Gécamines substation, noting that the SNEL partners consume a greater power than the Gécamines.

Table 3: Power Weighting Ratio

Reports	$r_{1\ jr}$	r_{2tiers}
$r_{1\ Gcm}$	75%	25%
$r_{2\ jr}$	25%	75%

d. Measurement errors

Knowing the accuracy classes of the device which is a factor in normal operation when the potential and current transformer which is characterized by the FS (safety factors) and the FLP (precision limit factor) it can be shown that we have defined the error on the active power measurements with the accuracy class of the voltmeter, ammeter and cosphimeter, all of which are analog devices:

→ Ammeter:

$$I = 0.631\ KA/24h \pm 1.5\%\ \ ou\ \ 631/24h \pm 0.15KA$$

$$X_{mesuree} = 26.29\ kA$$

$$I_n = X_{reel} = 50\ kA$$

$$E_{chelle} = 50\ kV$$

1. *Absolute Error*

$$\delta_x = X_{mes} - X_{reel} = 26.29 - 50 = -23.7\ \approx |-23.7| = 23.7$$

2. *Relative Error*

$$\delta_x = \frac{X_{mesuree} - X_{reel}}{X_{reel}} x100 = -87.4\ \approx |-87.4| = 87.4\%$$

3. *Device Class Uncertainty*

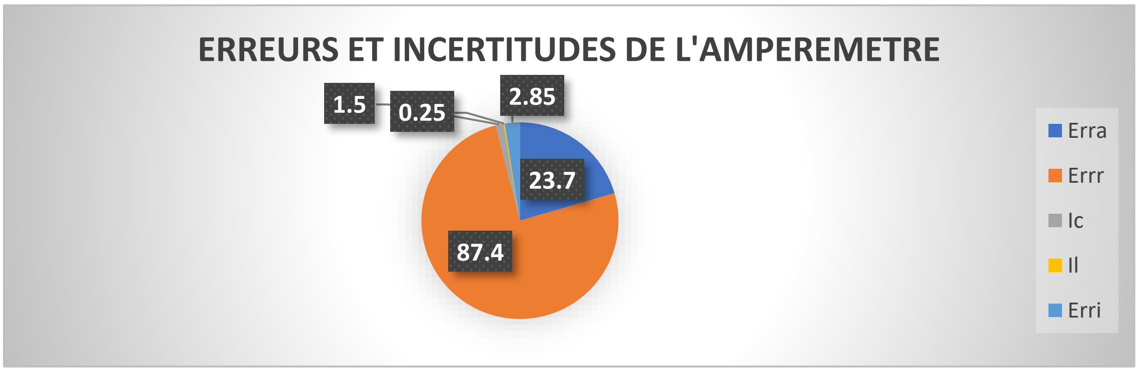
$$\Delta_{(x)inst} = \frac{X_{classe}\ x\ X_{calibre}}{X_{calibre}} = 1.5$$

4. *Reading uncertainty*

$$\Delta_{(x)inst} = \frac{1}{4} x \frac{X_{calibre}}{E_{chelle}} = 0.25$$

5. *Instrumental Error*

$$\delta_{instr} = \frac{X_{mesuree} - X_{reel}}{X_{reel}} \approx \frac{\Delta_{(x)inst}}{X_{reel}} = \frac{\Delta_{(x)inst} x\ X_{cali}}{X_{cali} x\ X_{mes}} = \frac{X_{classe}\ x\ X_{calibre}}{X_{mes}} = 2.85$$



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→ Voltmeter:

$$U = 154.2\frac{KV}{24h} \pm 1.5\% \;\; ou \;\; \frac{154.2}{24h} \pm 0.15kV$$

$$X_{mesuree} = 6.52\ kv$$

$$U_n = X_{reel} = 10\ kV$$

$$E_{chelle} = 10\ kV$$

1. *Absolute Error*

$$\delta_x = X_{mes} - X_{reel} = 6.52 - 10 = -3.58 \approx |-3.58| = 3.58$$

2. *Relative Error*

$$\delta_x = \frac{X_{mesuree} - X_{reel}}{X_{reel}} x100 = -35.8 \approx |-35.8| = 35.8\%$$

3. *Device Class Uncertainty*

$$\Delta_{(x)inst} = \frac{X_{classe}\ x\ X_{calibre}}{X_{calibre}} = 0.15$$

4. *Reading uncertainty*

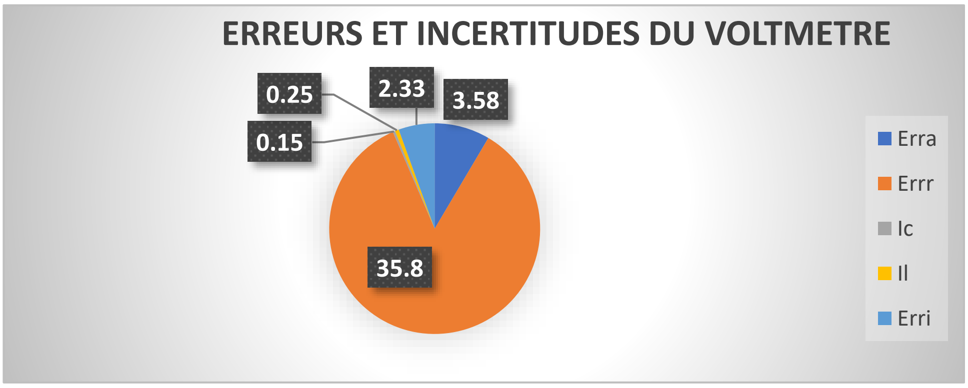
$$\Delta_{(x)inst} = \frac{1}{4} x \frac{X_{calibre}}{E_{chelle}} = 0.25$$

5. *Instrumental Errors*

$$\delta_{instr} = \frac{X_{mesuree} - X_{reel}}{X_{reel}} \approx \frac{\Delta_{(x)inst}}{X_{reel}} = \frac{\Delta_{(x)inst} x\ X_{cali}}{X_{cali} x\ X_{mes}} = \frac{X_{classe}\ x\ X_{calibre}}{X_{mes}} = 2.33$$

→ Cos phi:

$$Cos\varphi = 0.81\ \pm 1.5\% \;\; ou \;\; 0.81 \pm 0.15$$



After analysis and calculations, let's compare the different results on the active power $P = \sqrt{3}\ UICos\varphi$, by the voltage, the current drawn and the power factor.

The active power at the Gécamines Kambove substation under medium voltage can flow a power and includes errors, i.e. within 24 hours; by means of with a power factor of 80%. For the relative errors of the voltage which is taken from the voltmeter is as well as that of the current.

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IV. CONCLUSION

At this level, we put an end to the present work, which consisted in the study of the automation of the active power withdrawal of the high-voltage network at the Gécamines Kambove substation. Our concern was to make the phenomenotechnical critique by calculating the measurement errors and to opt the wattmans for a tool allowing them to better monitor the Gécamines Kambove HV networks and to take samples every one hour after the electrical measurements, in particular the active power. The results show that by modifying the measurement structure by digital and automatic sampling, we have a better gain in power and which reassures the proper functioning of the substation; This is the right equivalent for the operation of the high-voltage grid.

V. THE WAY FORWARD

The common and shared vision of the way forward. La Générale de Carrière et de Mines, Groupe Centre, KAMBOVE's headquarters, can only develop in its market, with serene working conditions and atmosphere, if its employees closely share the same vision of the path to follow and the objectives to be achieved. This is why, in the future, Gécamines, in partnership with the national electricity company, must provide the substation with the necessary and appropriate equipment for the electrical energy metering cells, and the protection cell (The new generation measuring devices such as: the digital relay and the installation at its substation of a Supervision and Numerical Control center.

To put it bluntly, all these can only be done with the will of all.

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