v. 2, n. 4, 2022

Journal of
Engineering
Research

REAL-TIME MONITORING OF ELECTRICAL POWER TRANSFORMERS FOR HOMES

Marcos Moreira de Albuquerque

Wenndell Queiroz Rufino da Costa

Luciana Coelho da Silva

Christian Raphael Viana

Alan Barroncas Maia

Charlisson de Jesus Aguiar

André Henrique dos Santos

Luciana da Silva Reis

Abstract: The project's objective is to build a functional prototype, which allows for a quick response in the activation of teams, related to the maintenance of electrical networks, within the urban fabric. It is entitled SRREU – Rapid urban energy reconnection system. The prototype was based, using Arduino programming pillars, once the CH340 USB adapter was used, the ESP8266 module was programmable by Arduino. The module is the communication that manages the energy of the phase failure relay, and transforms it into a wifi signal, which in turn, communicates with the Zabbix platform, the energy interruption assigned to it. The SRREU is installed at the output of 13.8 KV three-phase transformers, widely used for urban energy distribution, however, for defense purposes, it will be powered by a 5 Vdc bivolt source. Obtaining the results occurs through data analysis and processing, together or a system used for the due purpose, having satisfactory results in terms of time and ease in completing the activity to be carried out with energy service providers in the urban fabric of Manaus. , the result of the tests, provided a more direct response at the locations of each occurrence in a time satisfactory to the provider, dynamizing the containment action and thus contributing to social well-being. For future propositions, it is planned to use a more effective method of fabrication so that the prototype is more refined and can be made available on a larger scale, enabling a greater structural reception network, allowing a larger region to be hosted by the management tool.
Keywords: SRREU, Reclosing, Zabbix, monitoring.

INTRODUCTION

According to Law Number 10,438, of April 26, 2002, ANEEL created rules for the universalization of the public electric energy service throughout the country. According to these rules, distributors have deadlines to carry out, at no cost to the consumer, new connections of consumer units that fit certain characteristics.

Currently, only 14 distributors continue to implement universalization plans: CEA, Celg, Celpa, Cemar, Cerr, Coelba, Eletrobras Distribuição Acre, Eletrobras Distribuição Alagoas, Eletrobras Amazonas Energia, Eletrobras Distribuição Piauí, Eletrobras Distribuição Rondônia, Energisa Mato Grosso, Energisa Mato Grosso do Sul, Energisa Tocantins. Adapted from ANEEL (2010).

Interruptions in the electrical distribution system are routinely common for a variety of reasons, many of which the concessionaire has no control over, such as: vegetation, unauthorized human action, climatic variations and equipment corrosiveness. Interruptions in the supply of electricity every year cause several economic and social losses. Despite the interruption by external agents, service providers do not paralyze or reduce energy generation capacity, thus being a wasted resource for not using it. Is there real-time monitoring of electrical energy transformers for homes?

Real-time monitoring of electrical energy transformers for homes is a way to reduce the response time of the concessionaire's operational area and, consequently, avoid various losses, guaranteeing greater agility in the service provided by the provider, today carried out by connecting the consumer affected by the interruption. energetic. For this, the real-time monitoring of electrical power transformers for homes, using the Open Source, Arduino and Zabbix platforms, through a 2.4Ghz 802.11b/c LAN network, comes to dynamize the system. The objective was to create an electronic device using the Arduino platform, assigning an ethernet address via wireless to the device and monitoring its availability by the Zabbix

platform. In the absence of one of the phases or neutral, the device is deactivated and the Zabbix system stops receiving the signal, generating an immediate alert, with a delay of up to 2 minutes for power interruption and 20 seconds for re-establishment, which can be seen on the website. Zabbix client even received by automatic email generated by the incident. Alerts are immediately available to field teams and are recorded for auditing purposes and for defending civil claims for reimbursement.

After the construction of the device called SRREU, we monitored the phase failure system in an urban grid as the device was installed, reduced response time to calls due to system interruption through alarms triggered by the SRREU and contributed information to the power plant through the Zabbix system. It is common knowledge that electrical energy is of paramount importance for economic and social development and the improvement of the population's quality of life, there are greater concerns about its generation, transmission, distribution, and especially with the electrical energy consumed. However, currently, there is no concern or even interest in monitoring interruptions in the supply of electricity. When there is an interruption of electricity in the consumer unit, whatever the problem, the consumer is subject to inform the same.

The application of the SRREU was a way of monitoring interruptions in the supply of electricity, thus increasing the efficiency of the existing traditional system.

REFERENTIAL THEORETICAL

NETWORK CLASSIFICATION

According to ABRADEE, conventional aerial distribution networks are the most used in Brazil. They are composed of bare conductors (without insulation), supported on ceramic insulators fixed horizontally on wooden or metal crosspieces in medium voltage circuits (primary networks) and vertically in low voltage circuits (secondary network). Still in its structure, other equipment can be identified, such as: lightning rods, public lighting arms, distribution transformers, capacitor banks, disconnecting switches and communication infrastructure. (NAKAGUISHI & HERMES, 2011).

According to ABRADEE (Brazilian Association of Electric Energy Distributors), the distribution networks are composed of high, medium and low voltage lines. The basic network consists of transmission lines with a voltage equal to or greater than 230 kV. The Other Transmission Installations (DIT's) are lines with a voltage lower than 230 kV, which, when operated at a voltage between 69 kV and 138 kV, are normally operated by distribution companies. In addition to high voltage lines, electricity distributors also operate medium and low voltage lines, known as primary and secondary networks. Primary networks operate with voltages between 2.3 kV and 44 kV, while secondary networks operate with voltages that can vary between 110V and 440V. The primary aerial networks (medium voltage) are composed of three aerial conductor wires supported by crossheads on poles. The secondary aerial networks (low voltage) use the same fixing pole as the primary networks, but are located at a lower height, with the electrical energy received in homes and small businesses being conducted from the secondary networks through standardized connection branches. (ABRADEE, 2021).

It is common, nowadays, for the lack of energy to happen because of accidents in these types of network, with several factors contributing to this, with balconies, buildings, trees and scaffolding built close to the network it becomes conducive to accidents. The conductors of the conventional aerial

network are not shielded conductors, but bare conductors, who end up having an even greater risk of fatal accident through accidental contacts of workers near the network. The network is also completely unprotected from the environment, that is, any object that touches the network, such as tree branches, can cause an interruption in the power supply. (ABRADEE, 2021)

Although this type of network is cheaper, it has a much higher maintenance cost, due to the frequency and characteristics of the occurrences. This space dispute between the environment and the airline network can cause inconvenience to society, among them:

- Short-circuit in medium and low voltage;
- Loosening of connections and fixings;
- Burning of domestic and industrial appliances;
- Excessive expenses with corrective maintenance and emergency pruning; and
- Burnout of transformers, due to the constant number of shorts.

TYPES OF TRANSFORMERS AND CHARACTERISTICS

Current transformers have two main types of services: metering and protection. With this, we have two main types of classification. (Bovolato, 2004)

Current transformers for measurement services are used for measuring currents at high voltage, they have characteristics of good accuracy (0.3% to 0.6% measurement error) and low saturation current - 4 times the rated current. It is an equipment that needs high precision in the transformation of the secondary current, as it feeds meters, often billing. (Bovolato, 2004)

Current transformers for protection services are used to supply substation protection equipment and isolate the primary circuit from the secondary. They require a linear characteristic up to the secondary voltage that corresponds to the maximum fault current flowing in the connected load. Used to protect high voltage circuits, they are characterized by not requiring high precision (10% to 20% of measurement error) and by the high saturation current, on the order of 20 times the rated current. The figure below shows typical saturation curves for protection and measurement current transformers. (Bovolato, 2004).

DATA SURVEY

Emergencies are computed in minutes monthly and represent a set of consumer units. (ANEEL, 2016).

Below is a list of the main indicators of possible occurrences:

- Average Preparation Time (TMP);
- Average Travel Time (ATM);
- Average Execution Time (TME);
- Number of Emergency Occurrences (NUMOCORR);
- Number of Emergency Occurrences with Electricity Interruption (NIE).

The times informed by the concessionaire are always taking into account only the effective measures that are taken after the knowledge of the emergency. This situation hides then that there is a time beyond those set by the concessionaire: the time between the actual occurrence of the emergency and where the Average Preparation Time (TMP) is.

- Individual Interruption Frequency per Consumer Unit (FIC) which measures the number of interruptions occurred for each unit or connection point;
- Maximum Duration of Continuous Interruption per Consumer Unit (DMIC) which measures the longest interruption time in a consumer unit in hours.

So the proposed system, when the emergency occurs due to interruption of supply, the distributor would be immediately

Tempos médios de atendimento						
AME – MAY / 2020						
Set	Code	NIE	NUMOCORR	TMD	MTE	TMP
ALTO SOLIMÕES	12584	170	193	139,48	44,35	137,16
APARECIDA	13002	136	212	39,06	27,14	91,52
CACHOEIRINHA	15799	95	159	40,23	33,22	95,68
CIDADE NOVA	13004	517	760	38,92	22,12	92,19
DISTRITO INDUSTRIAL I	15800	22	42	32,69	37,05	94,86
DISTRITU INDUSTRIAL II	13006	170	234	38,27	28,46	59,22
FLORES	13007	247	437	42,29	42,75	97,05
MARAPATÁ	15798	127	179	42,50	29,84	83,20
MAUÁ	13008	125	185	43,76	32,84	69,31
MEDIO E BAIXO AMAZONAS	12581	1119	1460	29,20	54,32	456,30
MÉDIO SOLIMÕES E JURUÁ	12583	364	424	20,08	57,59	279,40
PONTA NEGRA	13009	263	399	41,47	26,46	79,98
PURUS E MADEIRA	12582	210	331	31,81	63,93	510,80
REDENÇÃO	13010	216	307	43,71	28,35	89,58
RIO NEGRO E BAIXO SOLIMÕES	12585	785	1035	42,36	81,73	372,15
SANTO ANTÔNIO	13011	479	694	55,10	48,13	94,29
SÃO JOSÉ	13012	458	666	44,21	25,09	78,46
SERINGAL MIRIM	13013	110	184	41,50	64,68	93,60
V8	13014	222	327	41,69	19,62	114,27

Amazonas Energia's Average Emergency Response Times for May 2020.

Source: Average service times – ANEEL, (2016).

informed, that is, it would create an Average Time of Knowledge (TMC) and it would always be close to zero because the system is all computerized and automatic. With the immediate information of the interruption, the gains can be:

- Elimination of the need for a human factor in the notification;
- Elimination of time intervals between emergency and TMP;
- Reduction of the sum of total average times;
- Elimination of generated and not consumed electricity waste;
- Reduction of complaints and lawsuits from dissatisfied customers;
- Improved supply quality and safer mapping of locations with recurring problems

METHODOLOGICAL ASPECTS

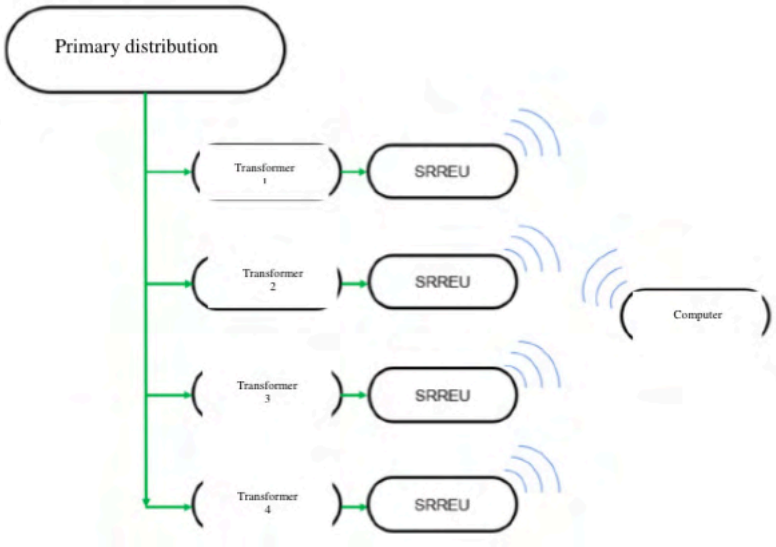
APPROACH METHODS

It is about the use of the inductive method of purposeful character to the construction of a prototype device that will generate qualitative-quantitative data when reporting the interruptions of the electric energy supply. Based on the data generated, it is possible to make deductions of results regarding the continuity and quality of the service.

PROCEDURAL METHODS

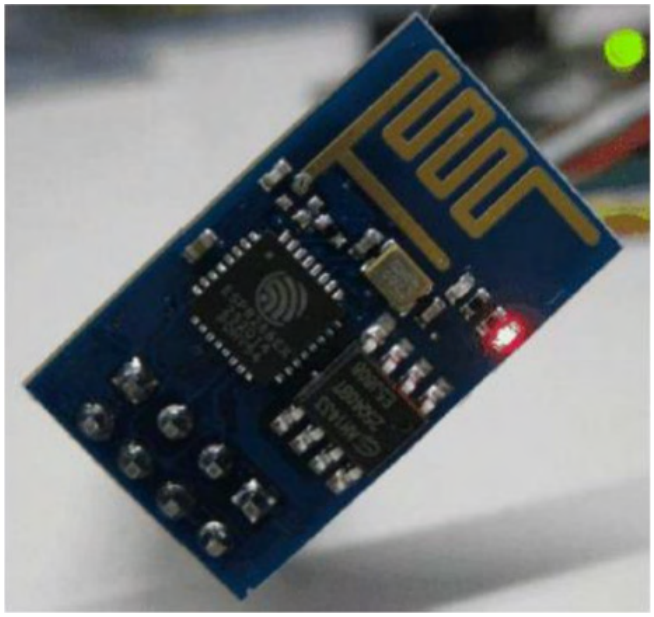
Below is the processing chain of the solution exemplified in the figure below, the progress and passage of steps for the expected result.

Today the motto is connectivity and mobility. We are seeing things that are increasingly mobile and connected, especially



Project processing chain.

Source: Own authorship.



ESP8266 MODEL ESP-01.

Source: ESP8266 Model ESP-01 – curvello, (2017), apud Espressif, (2017).

when it comes to the internet. And among the numerous modules that have recently emerged to explore the wave of the Internet of Things (IoT), the one that stands out the most is the ESP8266, from the company Espressif, whose model ESP-01. (André Curvello, 2017, embarked.com.br).

Zabbix is a monitoring tool for networks, servers and services, designed to monitor availability, user experience and quality of services. The Zabbix architecture and the flexibility of the modules allow the tool to be used for conventional monitoring (live/dead on/off), application performance monitoring, user experience analysis and root cause analysis in complex environments, through the server. Zabbix and the correlation rules. The Zabbix network monitoring tool offers a 100% web interface for data administration and display.

Zabbix monitoring system alerts can be configured to use various methods of communication, such as SMS, email and opening tickets in helpdesk systems. The system also allows automatic actions, such as restarting services, to be executed based on events.

Zabbix allows agentless monitoring for various protocols and has auto-discovery (automatic item discovery) and low level discovery (metric discovery on monitored items) functions. (4linux.com.br,2021)

Zabbix was born as a distributed network monitoring tool with a central web interface where it is almost possible to be monitored. (VACCHE, LEE, 2015, p. 44).

The first element of the prototype according to the electrical diagram was a three-phase circuit breaker having the protection function, not acquiring any logic function. In sequence, we have the phase failure relay that receives the three phases (R, S and T) and the neutral (N), supplied by the electricity distributor after the secondary of the transformer. The model RPS-FF 380V from the company CCA Eletrônica was selected. The relay switches the 5V power supplied from a bivolt source, through the NA+C contacts, where the device only remains on after the detection of phases R(L1), S(L2) and T(L3). In the figure below we can see the selected model, the source and the controlled device.

The ESP8266 module and the CH340 adapter were powered by a 5Vdc source. This device was chosen because it was the cheapest model that would meet the project requirements.

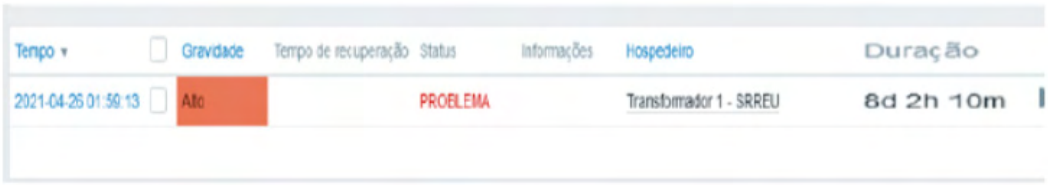
The model is simple, low power consumption and compact as shown below.

The equipment was assembled and housed inside a hermetic box for electrical commands, since the idea is for the prototype to be attached to residential transformers subject to sun exposure, rain and weather. The box selected was the model Box-20x15x9 from the manufacturer Bombaplasti.

Once the assembly is carried out according to the electrical diagram below and after all the elements have been defined, we house all the equipment inside the selected hermetic box.

After the electrical and physical assembly was carried out, we loaded the source code through the Arduino IDE to the ESP8266 module with the help of the CH340 adapter. The software used was Arduino v1.8.13. Below we visualize the algorithm embedded in the ESP8266 information flow and processing progress below, this flowchart has the role of connecting the ESP8266 with the WI-FI network, as well as monitoring the device's power.

Then the ESP8266 was connected to the wireless network of the HP TL-WR841HP router. The choice of this router was made because it belongs to the HP series which means High Power, so we can better simulate



Zabbix alert for a Transformer with a problem for 08 days, 02 hours and 10 minutes.

Source: Own authorship.

Dashboard of a running Zabbix server.

Source: What`s New in Zabbix 4.0 LTS–Zabbix.com, (2021).

Steck Circuit Breaker Series SD63 –40A –Three-pole –Curve C.

Source: Steck Circuit Breaker Series SD63 –40A –Tripolar –Curve C –PROESI electronic components, (2021).

Phase Loss Protection Relay.

Source: Phase Failure Protection Relay Model RPS-FF 380 V -Electronic CCA.

5Vdc transformer bivolt source.

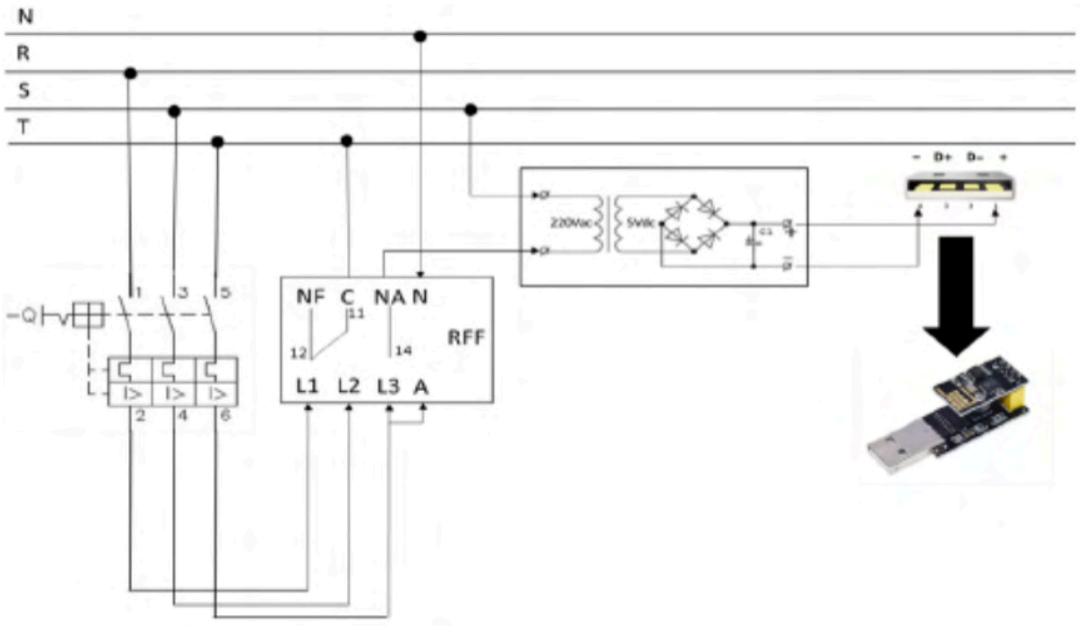
Source: 5Vdc bivolt source -Mercadolivre.com.br, (2020).

Arduino ESP8266 coupled to the CH340 USB Type A module.

Source: Esp-01s Wifi Esp8266 + Serial USB Adapter CH340G Arduino –Mercadolivre.com.br, (2020).

Bombaplasti red box.

Source: PVC Control Panel Box 285x208x125mm Ip67 Tableplast –Mercadolivre.com.br, (2020).

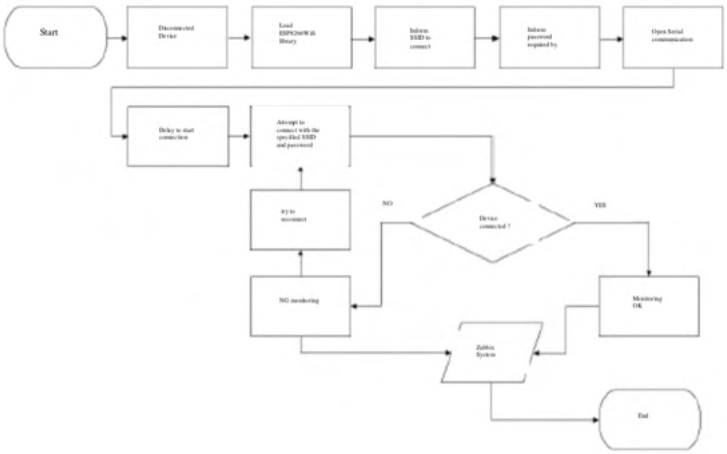


SRREU wiring diagram.

Source: Own authorship.

SRREU device.

Source: Own authorship.



Arduino language flowchart.

Source: Own authorship.

the performance of the device at greater distances.

The equipment was configured with a network with SSID 2.4Ghz of name UNIP with password engmec2021. The device created was obtained a fixed IP, but for the purposes of explanation we adopted the registration of four more cell phones, to simulate as if they were other devices. The addresses fixed by MAC ADRESS were as follows.

After the electrical assembly and physical equipment configuration steps, we now perform the Zabbix Appliance configuration. The Zabbix server ran from a virtual machine in Oracle VM VirtualBox Manager v6.1 software. The hardware configurations for the virtual machine created were as follows:

- Operating System: Red Hat 64-bit;
- RAM memory: 2048MB;
- Video memory: 10MB;
- HDD space: 10GB.
- IP: 192.168.0.9.

After the virtual machine configuration steps, we access the Zabbix server in the web interface through the IP 192.168.0.9 as we can see in the figure below.

After the login is performed, we create the "Transformers" Home Group that will control the monitored devices.

Next, we add to the Transformers group the IP of each device previously entered in the router settings, as shown in the figure below.

RESULTS AND DISCUSSIONS

RESULTS

After connecting the devices and connecting to the Wireless network, it was possible to monitor the created device and the other simulated ones. Once one of the devices was turned off, that is, missing at least one of the transformer phases, Zabbix notified its absence and listed it on the interactive dashboard. The interactive dashboard informed in a matter of seconds the problem of supply interruption in that region, enabling a faster response from the field teams for the restoration of service. Below is a picture as an example of all the "transformers" turned off.

When we click on one of the related problems, we can find out in the Time column the exact time when the supply was interrupted and in the Duration column, know the period in which there was a lack of supply. The downtime of the devices could be evaluated in detail and the incidence of cases. All the data generated was then exported and is easily and easily auditable.

It was also possible to establish the relationship between satellite maps and the monitored devices. This way, it was possible to insert the geographic coordinates of each device and facilitate its location by the technical teams of assistance of occurrences, the devices monitored on the map are icons that have the electronic address of geographic location and, when clicked, they lead directly to location apps such as GoogleMaps Waze, as we can see below, transformer 1 is turned off, where when clicking on the transformer in question, the platform directs the location page along with the system user's default navigation applications.

COST

The Zabbix and Arduino platforms are open source, so there will be no need to purchase software.

The following items will be used to make the prototype.

The router is already in the team's possession, it will not be necessary to purchase it.

FINAL CONSIDERATIONS

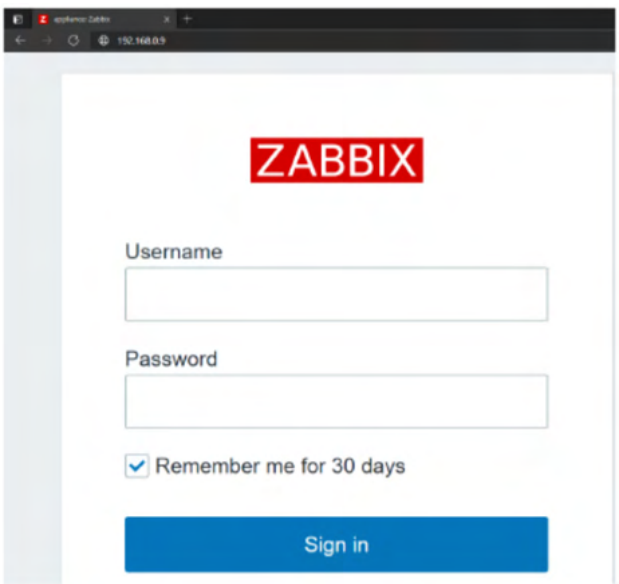
The SRREU project - Rapid Urban Energy Reconnection System, conceptually is a tool to speed up the passage of information after a lack of energy supply in a region after sending

Roteador HP WR841HP 1000mw 8dbi.

Source: TP-Link Router | Wireless | QoS | MPN: tl-wr841HP v2 – fourserv.com.br, (2021).

Device	Fixed IP	MAC Adress
Zabbix server	192.168.0.9	08-00-27-1D-9D-93
Transformer 1 - SRREU ESP8266	192.168.0.10	C8-2B-96-2F-71-3A
Transformer 2 - Cell 2	192.168.0.11	30-AB-6A-23-F0-90
Transformer 3 - Cell 3	192.168.0.12	70-FD-46-73-AB-24
Transformer 4 - Cell 4	192.168.0.13	98-60-CA-9B-B1-AB
Transformer 5 - Cell 5	192.168.0.14	00-B8-B6-3F-00-39

Device IP and MAC identifier table.

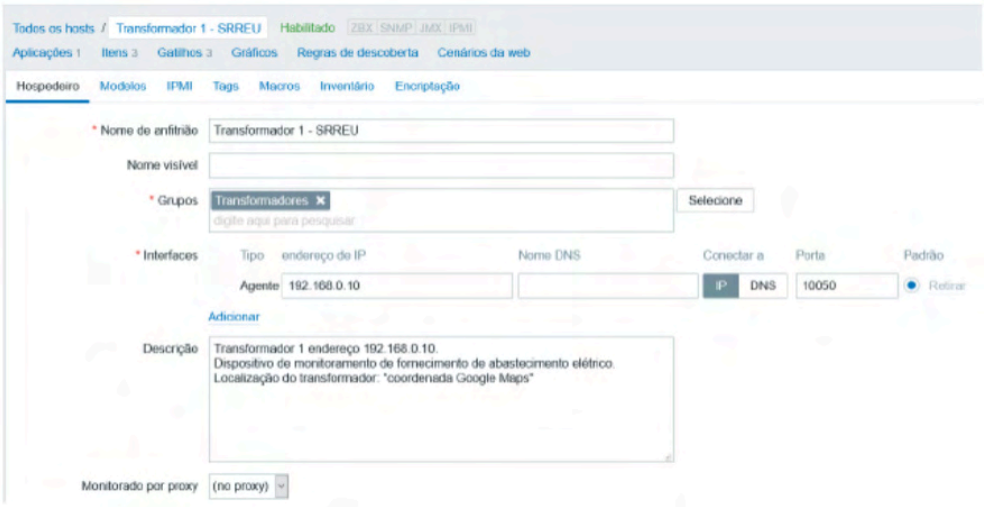


API Web Zabbix Appliance.

Source: Own authorship.

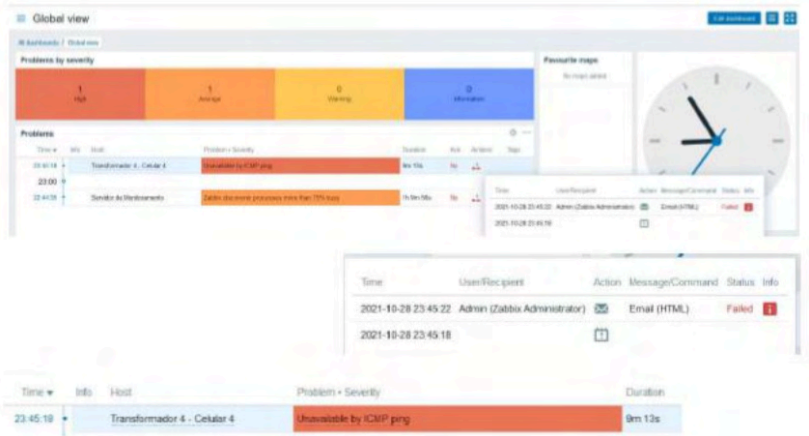
API Web Zabbix Appliance Shelter Groups.

Source: Own authorship.



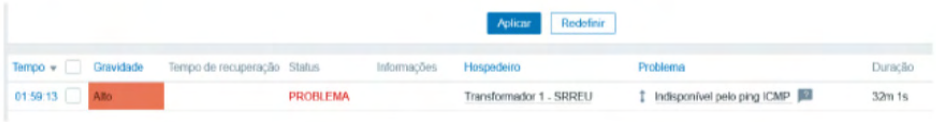
API Web Zabbix Appliance creation of Hosts and selection of Host Groups.

Source: Own authorship.



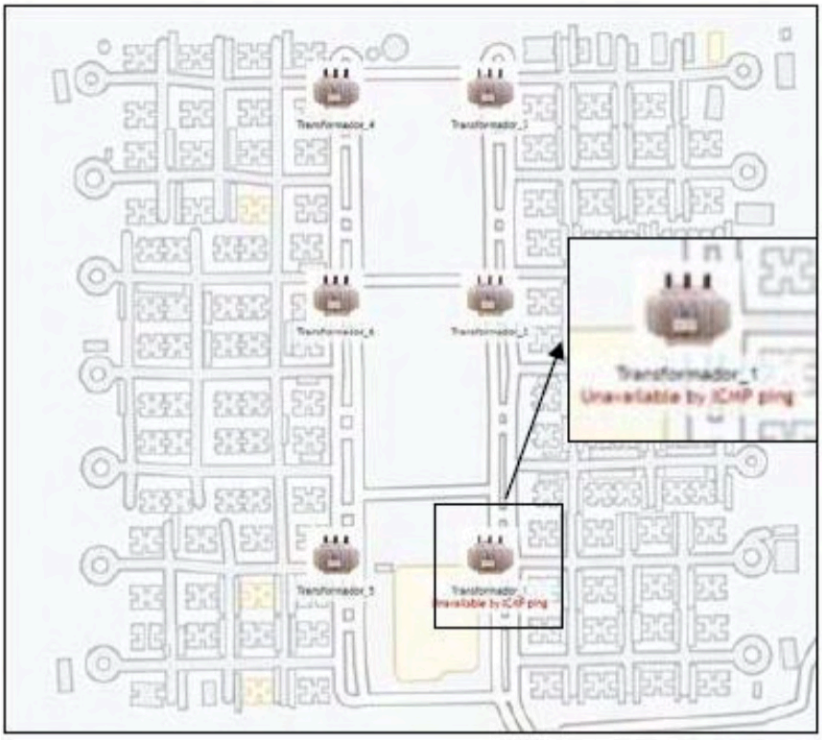
Zabbix Web Issues Dashboard.

Source: Own authorship.



Incident and problem report Transformer 1- SRREU.

Source: Own authorship.



Transformers monitoring satellite map.

Source: Own authorship.

Type	Description	Price
iron rail	Commando rail	R$ 14,00
wires	Lead wire 1.5mm2	R$ 15,00
microcontroller	ESP8266	R$ 19,90
Adapter	CH340	R$ 20,00
Hermetic box	Bombaplasti 20x15x9	R$ 24,99
5Vdc USB source	Google 5005BU5VDC	R$ 34,00
wires	Lead wire 4.0 mm2	R$ 40,00
Phase Loss Protection Relay	CCA RPS-FF	R$ 102,60
Circuit breaker	Steck SD63 50A	R$ 52,90
Total cost		R$ 323,39

alerts to the service provider, which already assigns a team to the site. of the occurrence.

During the prototype construction stage, the first stage being the choice of the embedded system, the ESP8266 used in the prototype, after it was completed, we started to evaluate the ZABBIX management platform, an open source platform, where it did not require financial resources to obtain software for management, being an indirect objective within the prototyping, making it more economically viable, not only in the short, but also in the long term. The third stage was directed at the assembly of the prototype in general without showing the aesthetic analysis of his. The listed phases were all successfully completed, allowing the team to go to the testing phase, which took place weeks before the delivery of the activity, in order to guarantee the correct functioning for the defense day. low in relation to the existing options in the energy management market, dynamism in the transfer of information, agility in the transfer of information, speed in the transfer of shares and ease of reading information on the platform.

During the process, some difficulties were encountered regarding the assembly in the electrical schematic of the device, which was resolved with the project supervisor. Another difficulty was related to the meetings of team members, as the construction was through restrictive measures to contain the health crisis of the coronavirus pandemic.

For the future of the project, it is decided to improve the current model, increasing some features such as a consumption measurement and even identification of deviations, and to define the model to serve the pilot public, located in the residential Eliza Miranda, another later point is the feasibility of the project in order to adopt the measure for the interior of the state, which is often poorly attended due to the communication difficulties found there.

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