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ELECTRIC VEHICLES ON LOW VOLTAGE NETWORKS – IMPACTS ON THE QUALITY OF ENERGY DISTRIBUTION

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Abstract: One of the main challenges of sustainable development is global climate change, resulting from the intense consumption of oil and coal derivatives. The transition towards a carbon-free world will be a challenge for this and future generations. The electrical energy sector, due to its renewable sources of energy generation, such as photovoltaics (PV) and wind, becomes one of the main agents in the decarbonization of the global economy. In this context, electric vehicles (EV) gain great importance, as the transport sector is currently responsible for emitting around a quarter of total greenhouse gas emissions, therefore, EVs can be seen as being a potential solution. This article seeks to analyze, through a simulation in the OpenDSS software, plug-in electric vehicles connected to low voltage networks, aiming to identify how they can influence different aspects of distribution networks, mainly regarding the drop-in power. voltage, active losses and transformer overload, through the different charging modes (slow, intermediate and fast), so that it can be seen that there was an influence on the worsening of quality levels.

Keywords: Quality levels; Electric vehicles; Low voltage network; Distributed generation; Qualities of the service and product.

INTRODUCTION

In recent years, the topic of sustainability has gained notable relevance in all social and economic sectors in the world, so that several countries and companies have been making high investments in areas related to the subject, ranging from achieving "seals of excellence", to the large-scale implementation of renewable energy sources, whether through tax incentives or changes in current legislation, but the major focus since the beginning of the century has been vehicles powered by electricity. The constant search for sustainable development has found electric vehicles to be the best cause for reducing the consequences generated by combustion engines, through their high efficiency, low local emission of pollutants and low operating costs, according to Su et al. (2012) and thus, encourage nations to invest in alternative energies in order to improve their respective carbon footprint, as it will generate clean energy. However, the rapid integration of such transport has required studies in the most diverse areas, from new technologies for energy storage to the impact and behavior of these new loads, which are characterized by both temporal and spatial unpredictability, as theircharging is at different current levels, times and locations, thus presenting several scenarios to be analyzed.

From this point on, the distributors' current objective is tosearchunderstand how these vehicles will influence positive or negative aspects, firstlyin low voltage networks, and thus process data related to energy quality in order to obtain characteristics, secondly, they will bring new perspectives to concessionaires in terms of making changes mitigating negative impacts, in addition to using this technology to the benefit of both for itself and for the consumer, through analyzes and case studies.

With the aim of carrying out simulations of the operation of charging centers and storage systems in the low voltage distribution network, with the aim of understanding the consequences that will be generated, programming software with an emphasis on distribution systems called OpenDSS was used, operating with real data from the network, and setting up scenarios.

ELECTRIC VEHICLES

CONCEPT OF EVS

According to Hussain (2003), at the beginning of the 20th century, vehicles powered by steam and electricity were sold more than those powered by internal combustion engines (MCI), the scenario changed over the years with the presence of vehicles powered by MCI which dominated the automobile industry in the 20th century. A new alternation in this field is being witnessed nowadays with the insertion of hybrid vehicles, powered by both combustion and electricity, and purely electric vehicles, since since the growing "wave" of sustainability in the 1990s, these types automobiles have once again gained importance and various studies have been and are being carried out so that they can be socioeconomically viable, both in terms of the economic factor focused on the price of their components, such as batteries and power electronics, as well as the social factor, determined how society will interact with a new type of infrastructure as discussed by Kempton and Tomic (2005), among other actors, who analyze everything from the constructive aspects of cars (storage systems, engines and power electronics), to the connection of these in the networks aiming at the loading characteristics and the behavior of these loads in the distribution networks.

However, it is necessary to highlight that there are variations in the configurations of these vehicles, as can be seen in figure 1 (Castro; Ferreira, 2010). The purely electric vehicle is the basis of this study.

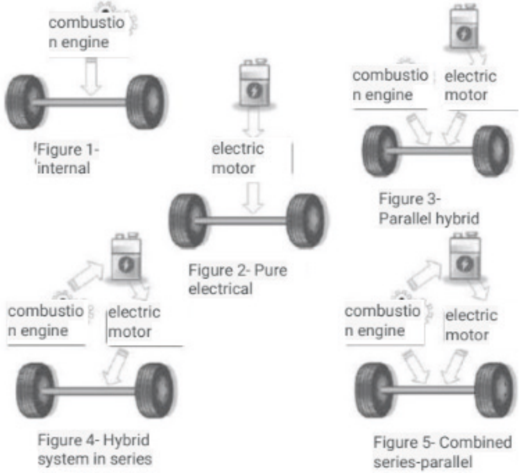


Fig. 1 Types of electric vehicles.

In a purely electric vehicle, its entire traction system is powered solely by an electric motor, so this model is equipped with an energy storage system, which needs to be recharged. As it only has an electric traction system, it requires shorter recharging periods and, depending on its use, higher power levels for recharging.

STORAGE SYSTEM

The storage system of an electric car is defined as a set of batteries (packs), these being sets of cells that may be connected in series, if a higher voltage is desired, or in parallel, increasing their nominal capacity. load, thus seeking the appropriate current and voltage levels for the operation to which it is assigned.

Manufacturers around the world research and develop batteries, in which these characteristics can be increased, that is, greater power, so that the volume and price do not increase substantially, consequently resulting in an improvement in their autonomy and performance. Therefore, the storage system becomes the biggest challenge for greater evolution and lower costs for EVs.

Two types of batteries are known, primary or non-rechargeable batteries and secondary batteries that allow recharging. Secondary batteries will be the ones discussed in this work, as these are the ones used in electric vehicles, and are characterized as such as long as they are capable of withstanding more than 300 complete charge and discharge cycles with 80% of their capacity.

Lithium ion batteries were responsible for replacing lead acid and nickel batteries, as these, although cheap, did not have specific energy and power for use on a large scale, in devices such as cell phones and notebooks. Developed in the early 1970s, due to their reactive characteristics with other materials, they were categorized as dangerous, however, with the advancement of studies, better functioning was made possible. These batteries are currently present in all notebooks and cell phones. Another application that will be seen in this work refers to its ability to store and supply energy to the distribution network in certain cases.

The battery management system (BMS - Battery Management System) becomes an important element capable of monitoring how the battery is being used in its discharge process, controlling the charging process through measurement and estimation of the battery parameters. This device is essential as a data aggregator, as it will be used at the charging center or by a smart grid to determine the levels of charging operations to which the vehicle will be subjected.

CHARGING CENTERS AND POWER ELECTRONICS

Currently there is a wide range of chargers, ranging from residential devices, to those that can offer up to three recharges at different levels (slow, medium or fast), reaching more advanced ones that are still under development, such as the inductive charger or wireless, which will not require a direct connection between the electrical energy distribution network and the EV, the variations of these technologies can be seen in figure 2 (Rodrigues et al. 2014). However, the two main branches that group these technologies are embedded or external.

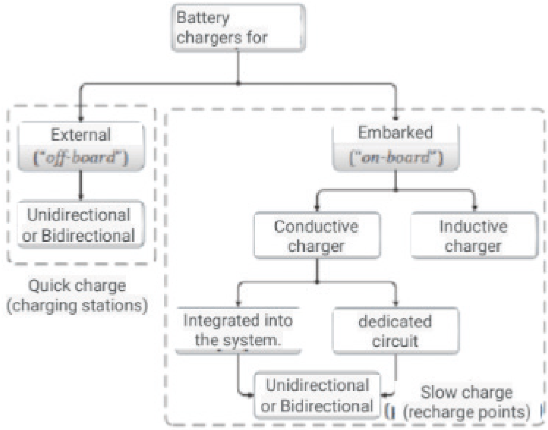


Fig. 2 Classification of battery chargers currently used in EVs.

The power electronics of a battery charger are based on an electronic circuit, consisting of an AC-DC converter, DC-DC converter and filter to eliminate harmonic distortions according to Arrabaça (2016). The charger can be either single-phase, more common in embedded alternating current (AC) technology, or three-phase, common in external direct current (DC) charging.

According to Rodrigues (2014), on-board chargers are associated with nighttime recharging, as they have a lower voltage level, so that rectification can be done in the car's own system, meaning recharges last longer. While the external type is related to quick charging stations, because due to the high voltage and current, more powerful rectifiers are needed, therefore they last less time. Therefore, the on-board charger is one in which the entire system is carried on board the EV, so the weight and volume restrict its use for faster recharging, as seen in figure 3 (Rodrigues et al. 2014). Of these types of chargers, the wallbox is its main representative. Used in homes to control the charging of electric vehicles, installing the wallbox is very simple, mainly requiring care regarding the sizing of protection devices, such as circuit breakers, and power cables.

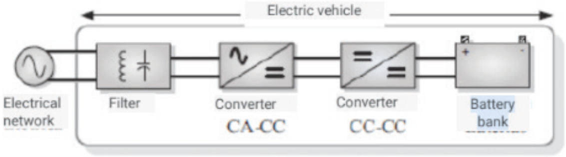


Fig. 3Battery charger for EVs - block diagram (typical circuits): on-board charger.

In an external charger, the entire recharging system will be located outside the EV, and the connection will be made directly to the battery already in DC, as this process is external, there is no concern about the size or weight of the recharging centers, soon higher power levels will be offered, as seen in figure 4(Rodrigues et al. 2014).

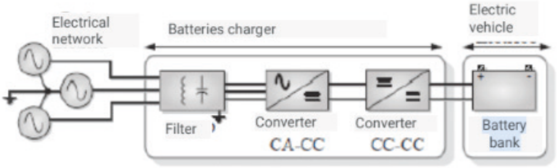


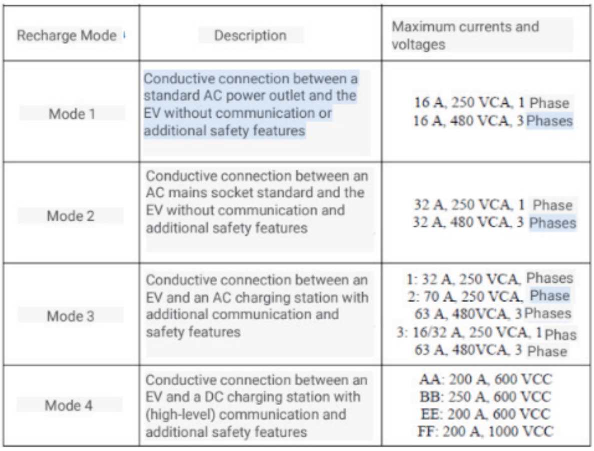
Fig. 4Battery charger for EVs - block diagram (Typical circuits): external charger.

Recharge centers are equipment with more complex power electronics, as they are capable of providing powers ranging from 22 kW to 250 kW, so more special filters and converters are needed, as the voltage, current and frequency levels are higher, so that recharges become semi-fast or fast, with durations that can range from 3 hours to 30 minutes.

The charger models will have their connectors having similar characteristics, from pins capable of monitoring and controlling current input into the storage system, to modes capable of controlling and monitoring redundancy subsystems, capable of offering greater security to the customer. These models are not standardized, so they have different types, depending on the manufacturer.

Connectors and power electronics that are being evolved, so that they can be used as a bidirectional system, that is, the storage system feeding the electrical grid on specific occasions, known as V2G (Vehicle to Grid), or vehicle to grid, However, there is still no legislation that makes this model viable.

Just like connectors, recharging methods will also have procedural standards, through specific standards, which will characterize the recharging level, its application, and the voltage and current levels. Another factor to be pointed out, as previously stated, is the waveform of this recharge, as previously stated for slower recharges the transfer of energy from the center to the car will be in AC, whereas in faster recharges this transfer is done directly. in CC. Table 1 shows the regulatory standards for these recharging methods (IEC's 61851, 62196 and 62752), according to Hanauer (2018), respectively:



Recharge Mode	Description	Maximum currents and voltages
Mode 1	Conductive connection between a standard AC power outlet and the EV without communication or additional safety features	16 A, 250 VCA, 1 Phase 16 A, 480 VCA, 3 Phases
Mode 2	Conductive connection between an AC mains socket standard and the EV without communication and additional safety features	32 A, 250 VCA, 1 Phase 32 A, 480 VCA, 3 Phases
Mode 3	Conductive connection between an EV and an AC charging station with additional communication and safety features	1: 32 A, 250 VCA, Phases 2: 70 A, 250 VCA, Phase 63 A, 480VCA, 3 Phases 3: 16/32 A, 250 VCA, 1 Phas 63 A, 480VCA, 3 Phase
Mode 4	Conductive connection between an EV and a DC charging station with (high-level) communication and additional safety features	AA: 200 A, 600 VCC BB: 250 A, 600 VCC EE: 200 A, 600 VCC FF: 200 A, 1000 VCC

Table1. Recharging methods per IEC's 61851,62196 and 62752

LEGISLATION AIMED AT EVS AND CHARGING CENTERS

In recent years, the government has been trying to develop public policies to grow the national market for these electric and hybrid vehicles. Aiming at the goals of reducing CO2 emissions, several incentives were created to encourage greater adherence, whether municipal, state or federal. Furthermore, Brazilian Senate Bill No. 304, 2017, can be cited, which says: "From January 1, 2030, the sale of new vehicles powered by fossil fuels will be prohibited in Brazil, and in 2040 no automobiles gasoline or diesel will be able to circulate in the country" (BRASIL, 2017).

The main regulatory legislation that was created for this new world refers to charging centers, Normative Resolution No. 819/2018, which allows anyone who is approved following the registration criteria to install a charging center and charge for the service provided.

ANEEL (National Electric Energy Agency) opted for a minimum regulation of the topic, with the main objective of avoiding undesirable interference of these activities with the operation of the electricity grid and ensuring that the tariffs of electricity consumers from distributors are not impacted by the provision of said service when carried out by electricity distributors (ANEEL, 2018).

POWER SYSTEM

BRAZILIAN SCENARIO

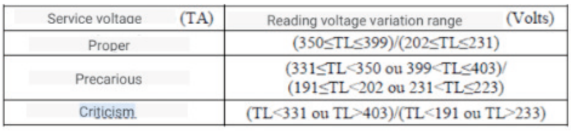
Electric power systems (EPS) have three well-defined subsystems, namely generation, transmission and distribution, which according to Kagan (2017) "have the primary function of providing electrical energy to users, large or small, with the quality appropriate, at the moment it is requested".

In the Brazilian energy matrix, hydroelectric plants predominate in the energy generation scenario, due to the large water potential in the national territory, almost 61% of Brazilian electrical energy production comes from this source. Next are wind energy with almost 16 MW installed, biomass with approximately 15 MW and in seventh place solar photovoltaics, which is constantly growing.

The inclusion of electric vehicles in the power system is the subject of studies and development, as the main objective of researchers is to guarantee greater energy capacity in storage systems, and charging centers carry it out as quickly as possible, generating consequences due to growing demand.

PRODUCT QUALITY

ANEEL created procedures (Module 8 of Prodist, 2022) aimed at regulating distributors, with the purpose of establishing standards for both product quality and service quality. For this article, the indicators studied refer to the quality of the product, that is, the quality of the network will be analyzed in terms of voltage levels in steady state according to table 2, so that 220 V for single-phase and 380 V for three-phase will be equivalent at 1 pu (per unit), therefore values below 0.92 pu will be considered precarious, and values below 0.87 pu, critical.



Service voltage (TA)	Reading voltage variation range (Volts)
Proper	(350≤TL≤399)/(202≤TL≤231)
Precarious	(331≤TL<350 ou 399<TL≤403)/ (191≤TL<202 ou 231<TL≤223)
Criticism	(TL<331 ou TL>403)/(TL<191 ou TL>233)

Table 2. Product quality indicators

3.3 Legislation aimed at distributed generation

According to Normative Resolutions No. 482 (ANEEL, 2012), and No. 687 (ANEEL, 2015), basic parameters were established for distributed generation (DG), from access to the distribution network, compensation system, to limits on levels of supply, it was soon defined that micro generation will have installed power values below 75 kW, with the possibility of being connected to the grid at low voltage, and mini generation will have installed power above 75 kW and less than 5 MW. These resolutions still do not allow the EV storage system to act as a DG for the system, except for the user's own consumer unit.

METHODOLOGY

SAMPLE SPACE

To create charging scenarios, it is first necessary to understand how the autonomy of electric vehicles works within an urban center, or in a capital, which is characterized by dense traffic at peak times, both early in the morning and early in the morning. at night, which will interfere with the data determined by the manufacturers, as they are considered ideal environments, such as favorable wind, mild temperatures and little or no traffic, the latter being the main topic for creating the scope.

According to data from the CET (Traffic Engineering Company) of the state of São Paulo, the capital of that state has an average speed of close to 22 km/h.

Another factor that will be part of the scenario will be the distance covered by a vehicle, so its user travels 12,900 km during the year. Therefore, in a year with 365 days, on average you travel 35 km/day, or around 250 km/week.

A car, with real characteristics, which has a range of 300 km, with an engine powered by a 60 kW storage system, generates a consumption of 20 kWh/100km, that is, 1 kWh will be consumed for every 5 km travelled. According to the data above, 35 km/day is the distance covered, however, the average speed is 22 km/h, so it will be obtained that a vehicle user spends an average of one and a half hours in traffic every day, thus the consumption that would be 7 kWh/35 km per day, will be around 7 kWh/22 km, therefore to complete the 35 km route there would be 10.5 kW of power consumed in one day, due to the time spent in traffic, and at low speeds, therefore greater consumption.

Therefore, from this relationship it is clear that a vehicle that in theory has 300 km of autonomy, would now have around 210 km, a distance covered in 6 days, as it coincides with the total discharge of the battery.

In conclusion, in six days the car's battery would go from 100% to 0%, of course the intention must not be to let the storage system reset, therefore the vehicle would be recharged every five days, with a remaining 12.5% of capacity at the time of recharging, so the scenarios will be created taking into account how long and how much demand would be used for full charging, which could be slow, intermediate, fast or ultra-fast recharges.

SYSTEM MODELING IN OPENDSS

The data used was provided by Enel-CE, containing a real system of a feeder made up of 444 bars, from the reduced system impedance at the transformer input, to bars in the outermost capillarity of the system, thus having more than 460 consumers served. both single-phase and three-phase, with residential and commercial characteristics, with the most diverse energy consumption.

To simplify the simulation, a bus reduction was adopted, where the consumers' most capillary bars were grouped into a number of 71 bars, adding their loads, and compacting the sections, all of them served at low voltage, with a three-phase voltage of 380 V. Therefore, the charging centers are also grouped in these bars for the different scenario setups.

Soon there will be 69 divided loads, with varying values of installed power, all scenarios will be added to loads that have 1 kW installed, the single-line diagram is represented in figure 5 (Data from this research, 2022).

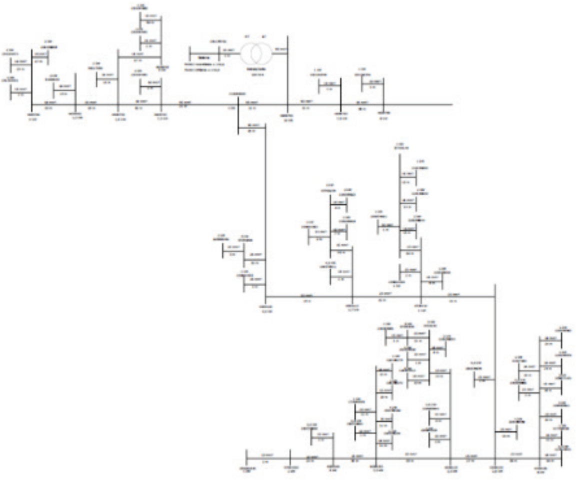


Fig. 5 Simplified single-line diagram of the network under study.

The OpenDSS programming software uses components and data from a distribution system, so the modeling of a system will be based on the same characteristics as a real ENEL-CE system.

In this simulation, the entire electrical system before distribution (generation and transmission), from the SIN, to the ENEL-CE system, will be taken to a single bus, defined in the software by an element called "Circuit", which is the Thévenin Equivalent for the entire system, thus having positive sequence resistance and reactance, or short circuit powers.

The system lines are responsible for transporting energy, their arrangement between an output bar and an input bar is commonly defined as a section, in the program it is modeled as – Pi, for short lines.

The transformer modeling may have several configurations according to the situation for which it is being used. In the case of a feeder, the standard is for it to have a medium voltage input in delta, and a star output at low voltage with neutral. available, so the voltages and connection will be defined for each winding, and for the equipment as a whole its losses.

To build the loads, the system's load curve will first have to be defined, as can be seen in figure 6 (Data from this research, 2022), which will define by time what demand the loads are demanding from the system, then in the early hours of the morning we will have a curve with lower values, while at peak times such as the beginning of the night, these values will be higher due to the entry of more loads.

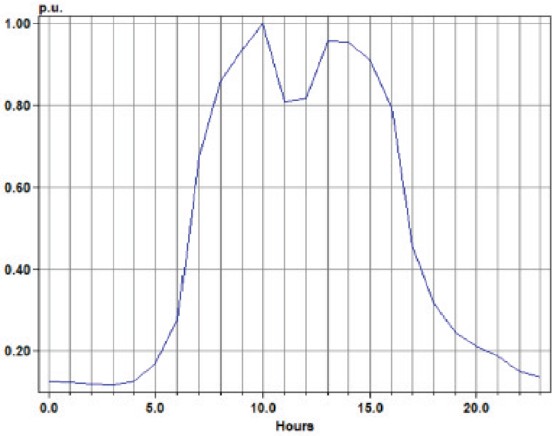


Fig. 6 Load curve of the analyzed system.

CASE STUDY

The data used was provided by ENEL-CE, containing a real system of a feeder composed of 444 bars, from the reduced system impedance at the transformer input, to bars in the outermost capillarity of the system, thus having more than 460 consumers served. both single-phase and three-phase, with residential and commercial characteristics, with the most diverse energy consumption.

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Soon there will be 69 divided loads, with varying values of installed power, in all scenarios loads that have 1 kW installed will be added.

SETTING UP THE SCENARIOS

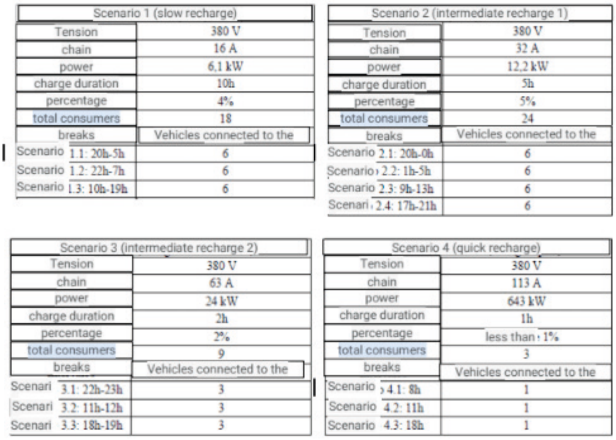
Following IEC 61851, which has the function of standardizing the recharging modes that stations must make power available, in addition to the current waveform, it can be alternating or continuous, which is part of the constructive aspect of electric vehicles, the transmission of energy to the battery can be indirectly in alternating current through the inverter, or directly in DC to the batteries. However, due to limitations of the OpenDSS software, all transmissions will be in alternating current.

Below is table 3 (Data from this research, 2022), with the values of the scenarios, EVs connected to the system will be distributed to a maximum of 5% of the 460 consumers, in some of the scenarios this percentage will be reduced depending on the power value, therefore also the current value.

Scenario 1 will be characterized by simulating slow charging at three different times, lasting 10 hours, 6 cars distributed randomly in the system are connected simultaneously.

Scenarios 2 and 3 simulate intermediate recharges ranging from 5h to 2h in duration, with current varying from 32 A to 63 A, carried out at seven different times taking into consideration, the system's load curve.

Finally, the simulation of scenario 4 was carried out, which is based on rapid recharging, with a current exceeding 100 A, so only one vehicle was used in each interval, which was enough, as will be seen in topic 5, to generate significant consequences. in network quality.



Scenario 1 (slow recharge)	
Tension	380 V
chain	16 A
power	6,1 kW
charge duration	10h
percentage	4%
total consumers	18
breaks	Vehicles connected to the
Scenario 1.1: 20h-5h	6
Scenario 1.2: 22h-7h	6
Scenario 1.3: 10h-19h	6

Scenario 2 (intermediate recharge 1)	
Tension	380 V
chain	32 A
power	12,2 kW
charge duration	5h
percentage	5%
total consumers	24
breaks	Vehicles connected to the
Scenario 2.1: 20h-0h	6
Scenario 2.2: 1h-5h	6
Scenario 2.3: 9h-13h	6
Scenari 2.4: 17h-21h	6

Scenario 3 (intermediate recharge 2)	
Tension	380 V
chain	63 A
power	24 kW
charge duration	2h
percentage	2%
total consumers	9
breaks	Vehicles connected to the
Scenari 3.1: 22h-23h	3
Scenari 3.2: 11h-12h	3
Scenari 3.3: 18h-19h	3

Scenario 4 (quick recharge)	
Tension	380 V
chain	113 A
power	643 kW
charge duration	1h
percentage	less than 1%
total consumers	3
breaks	Vehicles connected to the
Scenario 4.1: 8h	1
Scenario 4.2: 11h	1
Scenario 4.3: 18h	1

Table 3. Construction of scenarios ranging from slow charging (Scenario 1), to intermediate charging (Scenario 2), and finally fast charging (Scenarios 3 and 4)

RESULTS

CASE STUDY

Initially, the scenarios involving the insertion of chargers will be analyzed, and soon after, distributed energy generations will be added, with the function of assisting the low voltage distribution network.

SIMULATION WITH VEHICLES CHARGING AT DIFFERENT TIMES

As can be seen in table 3 and in subtopic 3.3, the 220/380 V voltage levels have limits to be adequately met, outside of these, especially limits below, there may be precarious levels (0.92 pu), or critical (0.87 pu), therefore the analyzes aim to obtain quality indicators.

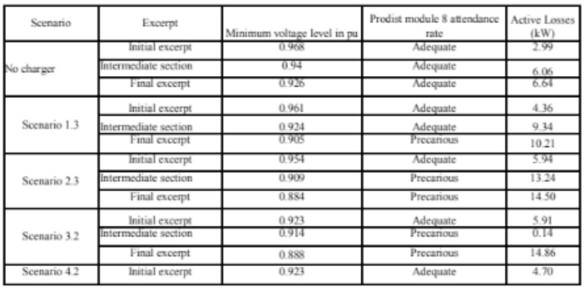
At the end of these simulations, it was possible to verify that most of the scenarios did not present consequences regarding deficits in voltage levels, or in energy demand, times that were more present at night and early in the morning, which was possible only due to two factors, a very small number of residential consumers, and the typical curve that presents itself as commercial.

In 5 of the 13 scenarios (1.3, 2.3, 2.4, 3.2

and 4.2) there was a need for a higher power demand than the transformer can provide, also in the same five scenarios there was a minimum service voltage lower than that specified in module 8 of the Prodist, presented in table 4.

Therefore, it can be assumed that as negative consequences, the opening of the transformer protections will occur, causing losses in both the quality of the service and the product, such as voltage variation, increased frequency of interruptions and prolongation of the period without supply.

Table 4 (Data from this research, 2022) summarizes four of these five scenarios, which had loads in different sections presented, and how the presence of these chargers in specific locations on the circuit can be permitted or not permitted, as long as an improvement in the infrastructure of this system, mainly in relation to power demand.



Scenario	Excerpt	Minimum voltage level in pu	Prodist module 8 attendance rate	Active Losses (kW)
No charger	Initial excerpt	0.968	Adequate	2.99
	Intermediate section	0.94	Adequate	6.06
	Final excerpt	0.926	Adequate	6.64
Scenario 1.3	Initial excerpt	0.961	Adequate	4.36
	Intermediate section	0.924	Adequate	9.34
	Final excerpt	0.905	Precarious	10.21
Scenario 2.3	Initial excerpt	0.954	Adequate	5.94
	Intermediate section	0.909	Precarious	13.24
	Final excerpt	0.884	Precarious	14.50
Scenario 3.2	Initial excerpt	0.923	Adequate	5.91
	Intermediate section	0.914	Precarious	0.14
	Final excerpt	0.888	Precarious	14.86
Scenario 4.2	Initial excerpt	0.923	Adequate	4.70

Table 4. Comparison between scenarios

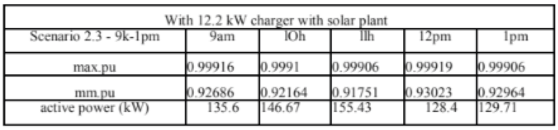
SIMULATION WITH THE HELP OF DISTRIBUTED GENERATIONS

When the electric vehicle is parked at the owner's residence, in the parking lots of shopping centers or universities, it will behave, if connected to the distribution network, as a storage system with the capacity to charge itself, and also to supply energy to the network.

The formation of a scenario with the input of renewable energy sources such as distributed generation allows the car to be supplied during the day by renewable sources, in this case a 70 kVA micro generation was adopted, and at night when there are peak periods of demand, more precisely from 6pm to 9pm, the EV storage system supplies energy to users' properties, if the curve of this system is residential. On the contrary, in a system with a greater commercial nature, with greater demand in the afternoon and early evening, the vehicle storage system would assist in generating energy for this circuit.

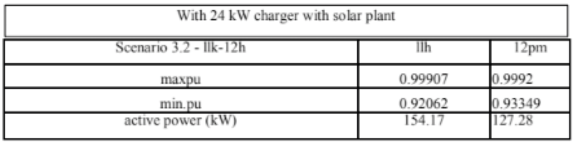
This way, the scenarios will be recreated with the help of a photovoltaic solar plant in the system, or the storage system, or both in the system, respectively, which can be seen in tables 5 to 10 (Data from this research 2022).

SIMULATION WITH CHARGER AND ASSISTANCE OF A 70-KVA PHOTOVOLTAIC SOLAR PLANT



With 12.2 kW charger with solar plant					
Scenario 2.3 - 9k-1pm	9am	lOh	llh	12pm	1pm
max.pu	0.99916	0.9991	0.99906	0.99919	0.99906
mm.pu	0.92686	0.92164	0.91751	0.93023	0.92964
active power (kW)	135.6	146.67	155.43	128.4	129.71

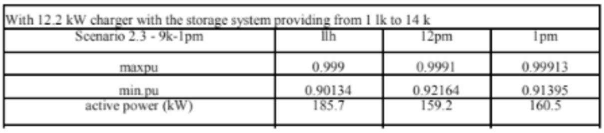
Table 5. Results for scenario 2.3 with the help of the solar plant



With 24 kW charger with solar plant		
Scenario 3.2 - llk-12h	llh	12pm
maxpu	0.99907	0.9992
min.pu	0.92062	0.93349
active power (kW)	154.17	127.28

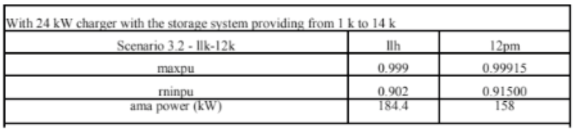
Table 6. Results for scenario 3.2 with the help of the solar plant

SIMULATION WITH CHARGER AND STORAGE SYSTEM ASSISTANCE PROVIDING



With 12.2 kW charger with the storage system providing from 1 lk to 14 k			
Scenario 2.3 - 9k-1pm	llh	12pm	1pm
maxpu	0.999	0.9991	0.99913
min.pu	0.90134	0.92164	0.91395
active power (kW)	185.7	159.2	160.5

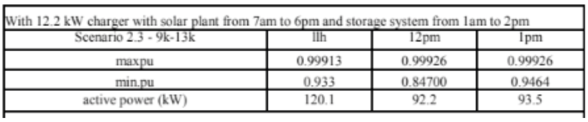
Table 7. Results for scenario 2.3 with the help of the storage system supplying energy to the grid



With 24 kW charger with the storage system providing from 1 k to 14 k		
Scenario 3.2 - Ilk-12k	llh	12pm
maxpu	0.999	0.99915
rninpu	0.902	0.91500
ama power (kW)	184.4	158

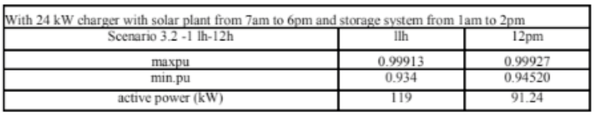
Table 8. Results for scenario 3.2 with the help of the storage system supplying energy to the grid

SIMULATION WITH CHARGER AND ASSISTANCE FROM BOTH DISTRIBUTED GENERATIONS



With 12.2 kW charger with solar plant from 7am to 6pm and storage system from 1am to 2pm			
Scenario 2.3 - 9k-13k	llh	12pm	1pm
maxpu	0.99913	0.99926	0.99926
min.pu	0.933	0.84700	0.9464
active power (kW)	120.1	92.2	93.5

Table 9. Results for scenario 2.3 with the help of both distributed generations



With 24 kW charger with solar plant from 7am to 6pm and storage system from 1am to 2pm		
Scenario 3.2 -1 lh-12h	llh	12pm
maxpu	0.99913	0.99927
min.pu	0.934	0.94520
active power (kW)	119	91.24

Table 10. Results for scenario 3.2 with the help of both distributed generations

These results proved that the input of a photovoltaic plant, or a set of them, adding its power to a value of 70 kVA, and the storage system of an electric vehicle supplying energy will substantially assist the system, ensuring that the levels of service and product quality are met.

CONCLUSIONS

Brazil has a predominantly clean and sustainable electrical energy matrix, with reduced greenhouse gas emissions. However, our passenger and cargo transport system is predominantly road based on MCI vehicles, which are responsible for a large amount of greenhouse gas (GHG) emissions. In this sense, plug-in electric vehicles gain importance because they do not emit pollutants locally, therefore the Brazilian electrical system must be prepared for this challenge.

The insertion of this new consumer into the distribution network was presented in this work through simulations using the OpenDSS software, to analyze charging operations at different times and with different charging levels, 4 charging scenarios were designed. A low voltage distribution feeder with a commercial load curve was chosen for the case study, to facilitate the simulation, the loads and bars were reduced, while maintaining the validity of the feeder data.

The scenarios were set up with a maximum of 5% of consumer units with the presence of EVs, this number, for the current reality seems to be very significant, market analysts believe in an increase in EV sales, whether driven by public stimulus policies to the sector or by popularizing the market. It is observed, based on the feeder under study, that there will be a need for readjustment/modernization of the entire distribution network.

The simulation results showed that at off-peak times, the network quality parameters were acceptable, although with a reduced number of EVs connected to the network. Recharges that were carried out during business hours resulted in precarious levels of product and service quality, defined by module 8 of Prodist. Always based on the feeder under study, the simulation indicates the possibility of more critical locations for EV charging connections, with a possible need for restructuring the network.

In order to mitigate the problems encountered, simulations were carried out by inserting two sources of distributed generation, one that is already a reality (photovoltaic in micro generation) and another that may become so (storage system supplying energy to the grid, V2G), and the results were very promising, as the mitigating solutions helped the network maintain its supply quality indicators.

Of course, to obtain these types of solutions, an advanced infrastructure is necessary, with communication between the network, through a meter, and with the storage system itself, through the BMS, which will read and acquire data, allowing V2G control, this way network management and difference billing will be carried out, however this concept is only possible through a Smart Grid.

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