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Distributed generation powered by smart grids

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Received: December 25th, 2023. Received in revised form: June 21th, 2024. Accepted: July 3rd, 2024.

Abstract
Smart grids are conceived as a system to optimally manage the set of means that are part of the electricity grid to achieve adequate performance in the distributed generation system in the supply of quality electricity. The objective of this study was to analyze the importance of smart grids in distributed generation and how the elements that make it up allow the implementation of this technological innovation. The methodology was based on the mixed approach, of experimental design with descriptive scope and documentary support,the experimental method was applied for programming with the use of Homer Pro software. The results were obtained by simulation, carried out for a distributed generation system with a consumption of 197.78 kWh/day, obtaining important data such as the amount of kWof electricity generation supplied in a year, with a value of 98,114 kWh/year.

Keywords: distributed generation; homer pro; monitoring; smart networks; scada, smart grids.

Generación distribuida potenciada con las redes inteligente

Resumen
Las redes inteligentes, están concebidas como un sistema para gestionar de manera óptima el conjunto de medios que forman parte de la red eléctrica para lograr un adecuado desempeño en el sistema de generación distribuida en el suministro con calidad de la electricidad. El presente estudio tuvo como objetivo analizar la importancia que tienen las redes inteligentes en la generación distribuida y cómo los elementos que la conforman permiten la implementación de esta innovación tecnológica. La metodología se fundamentó en el enfoque mixto, de diseño experimental con alcance descriptivo y apoyo documental, se aplicó el método experimental para la programación con el uso del software Homer Pro. Los resultados se obtuvieron por simulación, realizada para un sistema de generación distribuida con un consumo de 197,78 kWh/día, obteniéndose datos de importancia como la cantidad de kW de generación eléctrica suministrada en un año, con un valor de 98.114 kWh/año.

Palabras clave: generación distribuida; homer pro; monitoreo; redes inteligentes; scada; redes inteligentes.

1 Introduction

Since its discovery, electrical energy has been presented as a necessary resource for the development of humanity [1].Over time, societies have evolved and along with them, the demands of users have increased rapidly. From this, the processes of generation, distribution, and commercialization of electrical energy have undergone changes to adapt and guarantee at an adequate level the requirements for reliable, efficient, and quality supply that consumers of this indispensable service currently demand.

Distributed generation of electricity has been gaining ground in various countries around the world, as an alternative to centralized generation; the latter, as a traditional production model that currently provides a large part of electrical fluid on a global scale, through thermal, nuclear, and hydraulic power plants, whose processes entail alarge polluting load of greenhouse gases (GHG) for the environment. atmosphere. This has caused strong global pressure on the supply of electricity with technologies basedon fossil fuels, which do not allow sustainable development,and to develop new technologies for the generation of electricity based on

How to cite: Vélez-Quiroz, A.M., Filgueiras-Sainz de Rozas, M.L., Vilaragut-Llanes, M., Rodríguez-Gámez, M., Mieles-Mieles, G.J., and Pérez-Vega, E., Distributed generation powered by smart grids . DYNA, 91(233), pp. 43-51, July - September, 2024.

cleaner energies. According to the Transform Energy group and the government relations and international affairs technical team of the World Wildlife

Fund (WWF) [2], globally, the energy sector contributes three-quarters of emissions greenhouse gases (GHG).

To this end, according to the report published by the International Energy Agency [3], the electricity sector must cease to be the largest emitting sector in 2020 and begin to be the first sector to reach net zero worldwide by 2040. Sothat, in this way, it contributes to planetary sustainability. In this framework, the energy transition that the sector has been experiencing in several countries around the world for some decades now imposes the responsibility of following the route of what has been called [3] the 5D's (decarbonization, decentralization, digitalization, democratization, and deregulation) that implies challenges in the planning and operation of electrical systems. The adoption of this route brings with it various benefits, among which [4] have been identified: greater proximity between generation and consumption, less need for additional infrastructure, and sales options by prosumers with other prosumers.

Under this approach of centralized energy generation process, it has become evident in various studies developed on this topic that problematic situations involving the generation, transportation, and distribution of electrical energy have been created through its use [6]. The issues thatseem to have the most impact on the above are, firstly, the high cost of generation and maintenance of this type of plant; secondly, the supply of energy through the centralized generation scheme requires transportation over long distances, which is why technical difficulties arise in this transmission stage that implies energy losses in the electrical networks. For this reason, it is essential to strengthen the capacity of the distribution and transmission system, where the appearance of disturbances and instability within the National Interconnected System (SNI) affects the quality of supply.

Hence, the dynamics of the development of alternatives to solve the problems and achieve an improvement andefficiency in the electricity supply has focused on different options, of which, in this work, distributed generation (DG) is particularly relevant.

Regarding the Energy Foundation of the Community of Madrid [7], The so-called distributed generation, as an alternative model to the traditional scheme, is understoodas the generation of energy that is closer to the consumer, both physically and virtually. It does not imply using a specific particular technology. DG applications range from base generation, peak generation, and cogeneration, to improving quality supply, backup, andsupport to the transportation and distribution network.

It is interesting to note that scientific and technological evolution has allowed the development of smart grids, a typeof intelligent electrical networks that favor the distributed generation of electricity and constitutes a tool with great potential to support energy transition. The implementation of smart networks that effectively manage the flow of energy in these networks requires the modernization of the current electrical energy transport networks, for their transformation into smart grids or smart electrical grids [6]. The concept of smart grids is synonymous with technological change in the electricity sector [8].

The purpose of converting current electrical networks into smart grids is to satisfy electrical demand with higher quality of supply, using energy from environmentally friendly energy sources and creating a smart electrical network, from generation to consumers. There are several advantages that smart networks offer, among which are: a) it improve the reliability of the system; b) improve system efficiency; c) allow the integration of distributed energy resources; d) the possibility of two-way communication with clients; e) optimization of the use and more efficient operation of assets; f) promote energy demand management and; g) mitigation and adaptation to climate change [9].

It is recognized that Ecuador has also been receptive to the need to make substantial changes in the electrical system; However, much more still needs to be done for the country to catch up with advanced countries, in terms of the advances achieved in modern self-sustainable generation systems and the new technologies used in automated control for the distribution and commercialization of electrical energy on a small and large scale.

Currently, in Ecuador, centralized hydroelectric generation plants provide 92% of the electricity consumed inthe country, thermal plants participate with 7% of electricitygeneration and the participation of electricity generation fromnon-conventional energy sources is barely 1%. Althoughwater is a so-called non-polluting resource [5], the construction of large electrical infrastructures for generating and transporting energy to the final consumergreatly impacts the environment in the different areas where these plants have been built. hydroelectric plants,as well as losses and problems related to the efficiency of the electrical energy supply.

Taking into account all of the above, the objective of this work is to analyze the importance of smart grids in distributed generation and how the elements that comprise itallow the implementation of this technological innovation, with an important group of applications aimed at achieving asupply of electrical energy in a reliable, efficient and qualitymanner to end users, as well as ease of control of the elementsinvolved in generation, transmission, and distribution.

2 Materials and methods

The present research was carried out with a descriptive exploratory study on smart grids, for which an abundant bibliography was compiled, through academic search engines, such as Scopus, IEEE Explore, AMC, Scielo, and Google Academic, to substantiate the theoretical andreferential part of the investigation.

In addition, an experimental type of analysis was carried out, with the use of Homer Pro software, for the simulation of a generation system that allows knowing which operating energy systems use renewable energy sources in their operation, under the principle of decentralized electrical energy generation, in addition to the creation of a model that allows demonstrating and explaining how to use the smart grids with distributed generation.

Therefore, a mixed approach was applied, using quantitative and qualitative methods, since it proceeded with the description of the characteristics and data required for the implementation of distributed generation and the smart grids,as well as the analysis of the values obtained with the Homer Pro software, to obtain the costs per execution of a simulated project with the environmental and economic benefit obtained by implementing these decentralized generation systems.

3 Results and discussion

It is important to highlight that there is still no definitive, clear, and specific definition of distributed generation (DG); therefore, various specialized institutions have given valuable contributions to the afore-mentioned term that should be considered. The Institute of Electrical and Electronics Engineers (IEEE) or Institute of Electrical and Electronics Engineers, defines DG as “electrical generation facilities connected to the electrical system through a common connection point: a subset of distributed sources.” For its part, the International Council of Large Electrical Systems (CIGRÉ) mentions that distributed generation (DG) “It's not usually planned; It is not dispatched centrally either; and its capacity is less than 50 or 100 MW.” At least, it is relevant to point out its main characteristics such as electrical generation, transmission to load centers, and energy distribution, with the advantage of buying or selling electrical energy in the National System. Interconnected (SNI) or in isolation [10].

The GD has the purpose of covering the demand that the main electrical substations cannot supply by direct connection to the grid of small generation systems. It is also presented as an efficient alternative to supply isolated communities with renewable energy sources.

3.1 Smart Grid

The smart grid is defined as a smart grid with all the elements that are part of the electricity grid. These networks can census, monitor, and analyze information from all the elements that compose it and do so in real-time, for optimal performance of the electrical networks, control energy flows, including DG, and can detect failures to improve their performance. This makes it possible to link regulatory areas such as protection, control, instrumentation, measurement, quality, and energy management into a single management system, with the main objective of achieving efficient and rational use of energy [12].

Table 1.
Shows some benefits of DG.

	Main benefits
Economical	Reduction of costs in the construction and/or expansion of transmission networks. Increase in energy security. Lower production and transportation costs.
Technical	Reduction of technical losses. Expansion of distributor networks. Positive impacts on the distributor system.
Socio-environmental	Reduction of polluting emitters. Decarbonization and transition to renewableprojects. Promotion for the incorporation of newrenewable technologies. Increase in the electrical frontier. Reliability

Source: Grisales, L., Restrepo, B., & Jaramillo, F., 2017.

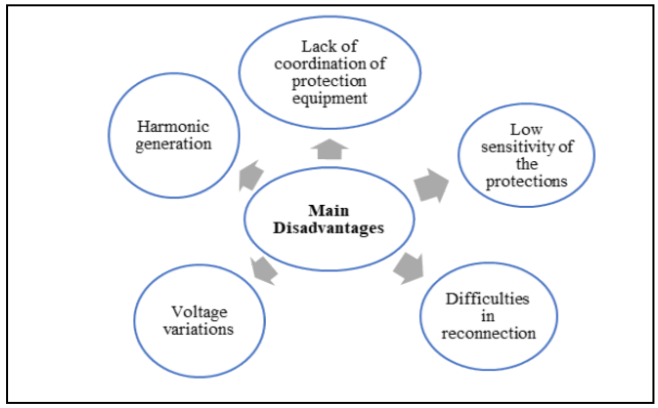

Figure 1. Main disadvantages of distributed generation.
Source: Own elaboration

Likewise, there are some disadvantages linked to DG systems that, although they may be of minor importance, are always relevant (see Fig. 1).

Geographic Information System (GIS)

The quality of the data in the GIS must be reliable, since erroneous data in the procedure that automatically controls the electrical distribution system is not acceptable, because errors can cause prolonged downtime and accidents. Data requirements in smart grid operations imply the need tomeasure how quickly changes are reflected in the GIS; sincethe longer the time, the greater the risk of something failing.The GIS needs to update its database to accurately associate the equipment of the client with the electrical system [15].

Advanced Metering Infrastructure (AMI)

Smart grid designs envision the use of advanced digital meters with two-way communication that can connect and disconnect services remotely, record waveforms, and monitor voltage and current. These should replace previous counters in the same location to avoid changing the design with large dimensions [16].

Outage Management System (OMS)

This phase of the smart grid aims to identify and correct power failures quickly and efficiently. The OMS serves not only as a useful tool for operations departments but also as a customer service tool that allows planning, asset management, and providing engineering and regulatory departments the information collected in the database [15].

Data Acquisition, Supervision and Control System (SCADA)

In this system, an HMI (human-machine interface) resides under software designed and installed on a server dedicated to production control, which cancommunicate with field devices (automatons) and automatically control processes from monitoring screens. The system makes available to the different users all the information generated in the production process. It can also provide them with detailed information about the system such as monitoring, data storage, quality control and production [17].

Distribution Management System (DMS)

The Distribution Management System or Distribution Management System (DMS) constitutes a basic part in the control of the smart grids, whose fundamental objective is the management of these intelligent networks under the premiseof reducing risks and costs by optimizing operations [18]. The implementation of a DMS for the operation of the electrical network will allow a distribution company to improve its level of efficiency in the planning, design and operation of the electrical distribution network, optimizing itsresources (human, financial, assets, others) [19]. The DMS functions as a means for the transition to the smarts grids andprovides the starting basis for modeling operational anddirect field activities safely and efficiently [20].

DMS is a combination of many technologies focused onthe electrical distribution sector. They are packages implemented on multiple platforms that include diverse hardware and software components, which, in addition to the constant evolution of technology, generate a wide spectrumof variables that must be integrated into a single system [19]. DMSs are programmed with an emphasis on reliability, efficiency, security, and interoperability [20].

DMS has numerous advantages, including a) actionable information and real-time control; b) more efficient ability to meet regulatory requirements; c) more efficient customer service through fault management and better voltage; d) open systems platform; e) security; f) scalability and g) simplified workstations. Due to its usefulness, it is the strategic systemthat facilitates the management of an intelligent network and its advantages [21].

Distribution Automation (DA)

This system is responsible for monitoring, controlling, and establishing communication functions located in the feeder; within it are the areas of communication and protection. The elements of this system have the purpose of interrupting the flow of current when it detects faults in the line; For which, it monitors the current and voltage that circulates in the network to automatically restore electrical service to customers. This system is required to be capable, flexible, and fast to reconfigure the feeder network; Thus, the distribution components will have the capacity to accept transfers, in addition, it is also required that the protection system can isolate the fault in the reconnected topology [15].

Smart grids currently entail a series of advantages and disadvantages, as described in Table 2 [22]. To manage additional services to users, the stage known as Advanced Metering Infrastructure (AMI), which is based on the association of communication networks, can provide clients with a group of benefits such as monitoring energy use, to economize based on the price of the energy used, giving riseto distribution companies also having access to the load, to manage demand remotely [15].

Hybrid systems

Many authors have shown that the network connectivity with the hybrid system has been more efficient and reliable than the standalone system. Today, solar and wind energy constitute a better option to generate electricity by synchronizing each other, both systems independently can provide results, but with difficulties according to the demand to be covered, because the resources are clean but intermittent due to their duty cycle. To achieve optimization and productivity of this hybrid system, the selected location must be in accordance with the minimum requirements necessary to use generation elements [23].

Table 2.
Advantages and Disadvantages of the Smart Grids.

Advantages	Disadvantages
Existence of interconnected electrical net Works throughout the planet.	High costs in its implementation at thestate level
Reduction of power outages	Obsolete electrical networks
Grid frequency stabilization	Little standardization of the products that make up this technology.
Automation of some processes in the electrical system	Complex urban infrastructures.
	Lack of incentives on the part of governments to promote the use of this type of technology.
	Lack of international standards.

Source: Duque, M., & Romero, G. 2016.

One of the tools or software that allows simulations or feasibility studies to be carried out is the Homer Pro "Hybrid Optimization Model for Renewable Electrical Energies". Midwest Research Institute holds the copyright to this software. It was developed by the National Renewable Energy Laboratory (NREL) of the United States [24]. This program is mainly used to design power plants incorporating non-conventional energy sources such as solar or wind or a combination of both since it includes configurations that allow studies to be carried out to implement the type of energy to be used and thus optimally establish the operating cost concerning current prices [25].

Related Studies

In this section, some international and national studies were considered whose central subject dealt with elements, tools, and new technologies that make up DG and smart grids.

In the first instance, at the international level, a study is presented aimed at determining the incidence of the implementation of a smart grid in the distribution system in a province of Peru. The methodology was adaptive, correlational using software smart grids which collect real-time data on the normal state and failures of the electrical system. The results show that the response time was improved, since it was reduced from 148.50 minutes to 86.92minutes, with a total of 61 minutes and 58 seconds, reachinga considerable time difference. Likewise, reliability increased from 98.62% without the use of smart grids to 99.92% when implementing smart grids in the distribution system. It concluded that response time and reliability were improved through the implementation of a smart grid in the distribution system [26].

The research is closely linked to thepresent study, on the topic of integration of smart grids in thedistribution system to achieve the optimization of theelectrical system and improve the response time, reliability and quality of its supply. Likewise, software is used to obtain real-time data on the operation of the generation of theelectric fluid.

In another contribution, a study from the University of Zaragoza, Spain, whose objectivewas to analyze and evaluate the impact on the electrical system already established in the Cape Verde archipelago using new smart grid technologies. Protection against energy theft and control of effective payment of electricity consumption were analyzed; determining that an update of the electrical system is required to quickly respond to energydemand. In addition, the financing problems that may appearwere analyzed if it is not sized correctly; proposing the inclusion of an AMI to solve the electrical losses that occur in the archipelago due to conventional measurements [27].

This research is articulated with the present work because it is focused on reducing costs that are sometimes not economically convenient for the consumer, studying how to achieve an effective and reliable supply, through smart networks.

In the same order, [28] in his investigation proposed the objective of reducing the polluting effects to influence the massive use of renewable energy sources and in turn, sustain energy in the country. In this research, with the qualitative method, the attributes, problems, and benefits involved in the installation of small power plants are explored. Obtaining that distributed generation, using medium voltage photovoltaic systems, allows improvement in the quality of electrical energy; conclude that distributed generation helps maintain voltage at stable levels in theelectrical system and users use decentralized generation systems which help their economy and the environment.

This study is also connected with this research, since it is focused on the reduction of polluting effects resulting from centralized and conventional generation, because the area where the study was carried out: the Atacames municipality in theprovince of Esmeraldas is a tourist place, wherein they sought to managethe use of resources in an environment-friendly manner, to attract the attention of tourists and in turn generating savings in the use of electrical energy.

It also conducted a study that consisted of estimating the costs of electricity distribution, considering the status and performance of the current infrastructure system in the generation, transmission, and distribution of energy, to guide technological development through the application of distributed generation, using a comparison between distribution companies versus network systems, designed with optimization criteria [29].

The results obtained in this research demonstrated that the costs are not high to implement DG in the short term, in the Colombian network. It was determined that the implementation of DG would not establish large implementation costs, nor could it affect the quality of the service; considering that the costs will depend on the demand that needs to be covered, the infrastructure that will be installed, and the quality of service that will be provided on a low, medium andlarge scale.

The research was based on analyzing the energygenerated by a photovoltaic system in the city of Manizales-Colombia, implementing a system for monitoring and characterizing the energy performance of the proposed system [30].

The methodology assumed was experimental and quantitative, the information collected was related to climatic factors at a given time. The results are obtained from the analysis of external factors that affect the efficiency of solar panels, and climatic variations such as radiation, rainfall, and ambient temperature. Likewise, some points were taken into account that affect and benefit the installation of photovoltaic systems in the city of Manizales, because being a territory with a lot of cloud cover affects solar gain; despite this, it has the advantage of being located in the Andean Mountain range where the winds clear the clouds. Another aspect analyzed focused on the use of centralized inverters and microinverters, finding that the capacity to generate more power lies in the use of microinverters in this case

In this sense, the research is linked to this work in aspects such as the technical part and location of the photovoltaic systems, in the most suitable place for better capture of solar radiation

Conditions in Ecuador for the development of distributed generation and smart grids

Ecuador has established a normative-legal body for the use of DG, which is endorsed, in the first instance in the Constitution of the Republic, and then by a set of laws that emerge from it, such as the Organic Law of Public Service Electrical Networks [13]. In this law, it is established that, to move towards modernization of electricity networks, regulatory aspects must be considered for energy transportation and distribution networks, communications networks, distributed generation, energy storage, smart meters, distributed control, active demand management, new products, and services; also take into account the opportunity to do so [13].

It also has a series of regulations identified as ARCERNNR: 001/2021 and 002/2021, which establish provisions for the process of qualification, connection, installation, and operation of distributed generation systems based on renewable energy sources for the self-supply of regulated consumers, and determines the technical and commercial conditions that must be met concerning the development and operation of distributed generation plants, owned by companies that are duly authorized by the respective government ministry, to carry out generation activities [14].

In the national context, research [11] was developed whose objective was to understand and report on the effectiveness and importance of distributed generation and the different types of renewable sources. As a result, the use of renewable sources aimed at distributed generation in Ecuador was successfully verified, which can be used for future research, making known, in conclusion, the types of sources available in our Ecuadorian territory.

The scientific article is linked to the present work, in the interest of knowing the renewable resources that can be usedin the country, to implement generation technologies with renewable sources in various places in the Ecuadorian territory, in harmony with the environment.

On the other hand, the study presented by the authors [31] focuses on exposing the possible scenarios that arise when implementing wind as an energy resource in Ecuador.

The methodology used is described as exploratory, which allowed collecting information from different sources; determining that Ecuador meets all the requirements to plan activities for the massive use of renewable resources; however, the high costs and lack of vision have limited the country to an environmentally friendly energy change, concluding that Ecuador, geographically, cangenerate green energy through the use of wind, and take fulladvantage of the potential that this natural resource has.

The previous investigation presents similarities with this study, in that it presents an approach related to the use of wind energy, as an alternative source for the generation of electricity aimed at improving energy distribution, reducing fossil fuel consumption, and achieving the implementation of the use of hybrid generation technologiesin the national energy system.

Finally, in the investigative work developed by the authors [32], the objective was to install a photovoltaic system to reduce costs on the electricity bill, giving importance to the use of renewable energy sources. The sizing and justification of the elements of a photovoltaic solar installation dedicated to supplying a free house is carried out,providing daily help to a total of 6 people. To obtain these resources, the PVSyst program has been used, which offers great help to make an appropriate simulation of the installation, making useful and precise data easier to achievethe future installation. The reason why the analysis has beenchosen with this type of installation is the area in which the home will be located, a coastal location where most of the days of the year are sunny days, where temperatures are considered high. In conclusion, the estimated sizing is capable of achieving optimal functioning of the devices used in the analysis and producing electrical performance withoutpower outages.

The study is associated with the present research work, since both are oriented towards the implementation of an alternative electrical generation system with the objective of reducing the costs of electrical energy delivered by the network, thanks to the introduction of systems called clean generation, giving the opportunity to renewable resources asa better alternative for generation and savings.

Experimental analysis through the simulation of a DG network with the Homer Pro software

The Homer pro software allows you to handle real data in this study because it groups factors that allow you to estimate the appropriate costs and resources to use simulations that allow you to implement a project of this type.

The simulation is carried out for the Salima parish of the Atacames municipality in the province of Esmeraldas. Based on the results, it is possible to propose the implementation of a system to improve the electricity supply through the application of DG, which will allow the use of generated electricity in a sustainable manner and at a lower cost, and even inject the surplus energy generated and not consumed by the end-user into the national electricity system.

To carry out the simulation, it was necessary to manage the installation and temporary license, for academic purposes of the mentioned software. In this first stage of the program, the software interface is presented. Fig. 2 shows how this interface is presented, in which the project was developed, executing the steps mentioned in the following paragraphs, in this way, the feasibility of the study is configured, sized, analyzed, and determined.

As a first step, the coordinates were inserted, to geographically locate the place where the study was conducted, in this case, it was located at 0° 55' 54.04" N - 79°46' 19.02" W, this place is located in Atacames-Esmeraldas specifically in the Chávele campus, once the information was incorporated, the program allows the visualization on the map of the location of the chosen place, then the descriptionofthe activities carried out was established to detail the corresponding loads.

The second phase begins once the steps described above have been carried out, thus, the data of the calculated load was incorporated, which corresponded to the value of 197.78kWh/d, distributed among the consumption elements such asappliances and systems lighting, at this same point the software allows for determining the level of the project, in this case, a residential system was selected.

Figure 2. Homer Pro Program Interface
Source: Source: Own elaboration whith Home Pro

After defining the load, the components or generation system that covered the indicated demand were selected. This software allowed simulations to be carried out with elementsof distributed generation with renewable energy sources suchas wind turbines, photovoltaic systems, and hydraulic turbines; Likewise, support systems with energy generation from non-renewable sources also allow the use of elements such as voltage inverters and storage batteries, which are components that enhance generation using alternative energy sources.

Programming requires the use of data such as DNI or irradiation index in the year of the selected place; This data is consulted on the NASA website, (https://power.larc.nasa.gov/) as well as the wind speed available at the location to be implemented. These allowfordetermining the feasibility of using the type of equipment according to the energy values provided by the resources to be used.

It is important to note that the study, to be conceptualizedas a DG system, was located in the public supply network, which was connected to the system, in this case, CNEL EP Atacames, because this generation system is projected from the types of smart grids. The program allows knowing the sales values of kW/h in the electrical system of Ecuador, as well asknowing the consumption that is generated in the case of consumers (prosumers). Once these parameters were determined, the structure of the system could be observed with the different components referred to above.

After carrying out the analysis with the program, the values can be processed in Excel for better visualization andin this way to determine the estimated investment costs for the projection of the system, as well as the investment recovery times, the energy sales and purchase values.

The results provided by the simulation in the Homer Pro determine the best options for arrangements to include in the

Architecture: Dispatch	Cost: COE ($)	NPC ($)	Operating cost ($/yr)	Initial capital ($)
LF	$0,108	$169.537	$12.671	$24.236
LF	$0,112	$176.685	$12.618	$31.999
LF	$0,243	$385.072	$27.095	$74.367
LF	$0,248	$392.222	$27.059	$81.934
LF	$0,890	$736.746	$64.249	$0,00
LF	$0,899	$744.434	$64.212	$8.113

Figure 3. Architecture options in relation to investment costs. Where: COE→ Cost of Energy NPC→ Net Present Cost
Source: Own

System			
Ren Frac (%)	Total Fuel (L/yr)	Excess Elec (%)	Excess Elec (kWh/yr)
69,4	0	0,251	351

Figure 4. System Resulting Values. Where: Ren Frac→ Renewable Fraction (Renewable Fraction)
Source: Own

Cost			
COE ($)	NPC ($)	Operating cost ($/yr)	Initial capital ($)
$0,108	$169.537	$12.671	$24.236

Figure 5. Operation cost table.
Source: Own

distributed energy generation project, considering the elements and costs required for it, as shown in Figure 3, where it can be observed the parameters and equipmentconsidered in the study or design of the network. The simulated distributed generation system consists of a 59-kW photovoltaic array, the 30-kW converter and a 10 kW wind turbine connected to the CNEL EP network.

The software displays the results, shown in Fig. 4, in which you can observe data such as the fraction of energy delivered to the load that originated from renewable energy sources, thetotal fuel which for this simulation is 0% as well as the % ofsurplus energy generated and the value of this respectively

Another value that the software provides is the amount ofenergy purchased and sold to the grid, these values are 41,968 kWh and 54,046 kWh respectively

Fig. 5 shows the table of the operating cost values and the value obtained according to the simulation of the program, such as the life cycle cost of the system in relation to spare parts and maintenance, as well as the operating cost with theannualized value of all costs and income other than the initialcapital costs and the cost of the initial investment programmed for a period of 30 years of the useful life of the system.

The expansion of distributed generation in the energy systemcan bring enormous benefits, but it also requires deep andthorough research of its technologies, because to be able todo it with full functionality, all signals from these sources must be managed through a robust communication system that guarantees their availability at the time of implementation in the network, thus becoming a smart grid. According to the analysis of the results, the smart gridsconstitute an optimal process for its implementation in the development of modern, efficient, effective, and qualityelectrical systems in the energy supply. Although it is true that currently, the investment costs to implement this systemare high, a factor that could influence the decision toimplement this system. [29], The benefits reportedthroughout this study may constitute an incentive for the fulladoption of this system in the coming time

4 Conclusions

The analysis of the importance of smart grids in distributed generation and how the elements that compose them allow the implementation of this technological innovation, with an important group of applications aimed at achieving a reliable, efficient, and quality supply of electricity to end users, as well as the ease of controlling the elements involvedin generation, transmission, and distribution.

on the previous literary review, it was possible to verify that smart grids or smart networks present a set ofadvantages that make it possible to contribute to the control and monitoring of electrical systems for the collection, transportation, and distribution of electrical energy. However, it is necessary to modernize the current electrical networks, introducing a set of elements that allow it to be converted intoan intelligent network (smart grid).

The results obtained in the experimental analysis with a simulation of a DG network using the Homer pro software, based on the proposed objective, of analyzing the importanceof smart grids in distributed generation and how the elementsthat make it up, allow the implementation of this technological innovation. It was found that:

- Simulation tools such as Homer Pro are presented as an important element, as demonstrated in this study, to be able to carry out feasibility studies for the design of a mixed system, which allows the application of smartnetworks in the distributed generation system, because it allows knowing and analyzing how they interact with the supply network thanks to the elements of generation, transformation, energy storage, andmeasurement control.
- The elements of smart grids are essential for their use as bidirectional meters or electricity meters that allow measuring the energy flowing from the network to the user and vice versa and can be installed in homes in industry and/or commerce, in such a way that the user can control the energy used, which leads to take care of their economy and consequently the environment.
- The systems and elements that intervene in a distributed generation system with the support of smart electrical networks allow greater efficiency and effectiveness in terms of generation, transmission, distribution,monitoring, and control. Therefore, they are estimated as necessary for the provision of efficient, safe, and quality electrical energy service in the country.

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