

Perception of electricity service quality and its impact on local development. Study in Jalpan de Serra, Querétaro

Percepción de la calidad del servicio eléctrico y su impacto en el desarrollo local. Estudio en Jalpan de Serra, Querétaro

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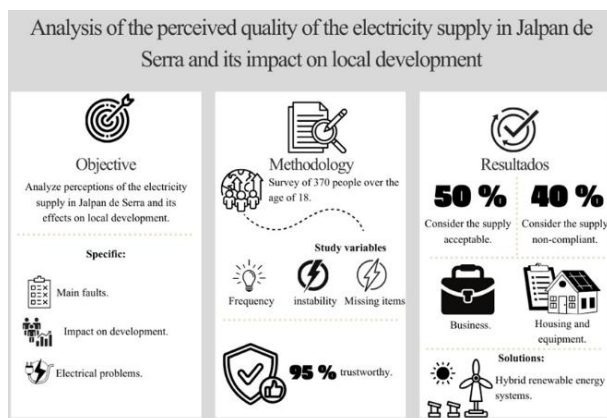


Abstract

The study analyzes the perceived quality of electric service in Jalpan de Serra, Querétaro and its impact on local development. The research examines the main defects of the electric service, its effect on daily activities and the causes of energy problems in the region. A total of 370 surveys were administered to inhabitants over 18 years of age. As a result, 50% of the population considers the electricity supply to be reliable, while 40% expressed dissatisfaction. The main causes of interruptions are maintenance and work on the electrical grid. At the economic level, it was identified that electrical failures generate premature wear of equipment and significant losses in households. Inhabitants identify natural disasters, technical failures and maintenance work as the main causes. The study proposes alternatives such as hybrid solar energy systems, microgrids and renewable energy cooperatives to improve the quality of supply in rural areas.

Resumen

El estudio analiza la calidad percibida del servicio eléctrico en Jalpan de Serra, Querétaro y su impacto en el desarrollo local. La investigación examina los principales defectos del servicio eléctrico, efecto en las actividades cotidianas y causas de los problemas energéticos en la región. Se aplicaron 370 encuestas a habitantes mayores de 18 años. Obteniendo como resultado que el 50% de la población considera confiable el suministro eléctrico, mientras que el 40% manifiesta inconformidad. Las principales causas de interrupciones son los mantenimientos y trabajos en la red eléctrica. A nivel económico, se identificó que las fallas eléctricas generan desgaste prematuro de equipos y pérdidas significativas en los hogares. Los habitantes identifican como principales causas los desastres naturales, fallas técnicas y trabajos de mantenimiento. El estudio propone alternativas como sistemas híbridos de energía solar, micro redes y cooperativas de energías renovables para mejorar la calidad del suministro en zonas rurales.



Quality of electrical service, Local development, Public perception



Calidad del servicio eléctrico, Desarrollo local, Percepción ciudad

Area: Development of strategic leading-edge technologies and open innovation for social transformation

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Introduction

It is important to analyze the impact of the variability in the electric service in the country, since it can provide an overview of the perception that the inhabitants have regarding a service that is assumed to arrive regularly to the localities that have it, such as electric energy. However, the lack of knowledge about the technical operation of the energy system in Mexico, causes the population to measure the impact of the failure only at the level of cost and comfort, leaving aside the possible evaluation in the adoption of new ways of having the service. Together with a government policy that allows a solution to the case, this phenomenon is becoming increasingly complex.

The contribution of this study lies in the options identified to provide a solution to the situation in the medium term, giving an overview of the current perception of the inhabitants and the situation surrounding the solution to the problem.

First of all, the main electricity supply problems identified by the inhabitants of Jalpan de Serra are identified, as well as how these affect the development of their daily activities, to later give way to the perception of the factors that contribute to the proper functioning of this service.

A priori it can be felt in the daily coexistence the high dissatisfaction that the area shows given the constant power outages and the economic impacts that this has on the various sectors of the population.

The theoretical approach of this document consists of identifying the characteristics of the subject under study from the perspective of a user, not in a technical way as the discipline of energy studies does. This allows understanding how the perception of energy service quality can be measured in colloquial terms, on the other hand, consumption and infrastructure data are added to help understand the context of the place where the instrument is applied, as well as in the same order of ideas, rural development and the impact of the quality of supply in these areas are circumscribed.

Regarding the findings of this research and the perception of the quality of service, it is mentioned that the inhabitants show a fifty percent of satisfaction and the rest in satisfied mode, being the main concerns about the interruptions that the service has and the economic impact that these represent.

Finally, it is concluded that the Sierra Gorda needs to implement alternatives for the solution to this situation, which leads its localities to lag behind in development and makes the possibilities of a better quality of life more expensive, together with the need for energy supply given the changes in the climate that make the hot season more and more acute in the area. Some alternatives derived from the documentary analysis on the subject are proposed, in which the modalities of sustainable energy cooperatives are visualized.

Theoretical support

Quality of energy supply

This refers to the capacity of the energy to remain stable continuously, that is to say, that it has the adequate voltage and frequency capacities to avoid damage to the inhabitants' electrical equipment, which ensures the proper functioning of daily activities. Likewise, this quality depends on several factors, such as infrastructure, adequate maintenance and the generation capacity of the power supply. Therefore, it is deduced that the increase in the number of loads in the distribution systems is a cause of the degradation of the quality of electric power.

In this sense and in order to have an improvement in the quality of energy supply, the possibility of conducting an analysis to evaluate the impact of the implementation of alternative energy sources that improve the quality conditions of energy supply is not ruled out, according to [Rodríguez et al . \(2018\)](#).

According to the media, [Expreso de Querétaro \(2025\)](#) e in Jalpan de Serra the quality of the energy supply is deficient, that is to say, it generates blackouts, voltage variations, overloads and damages to the users' equipment, which has been analyzed by the Energy Agency of the State of Querétaro, thus, taking a proposal to the Federal Electricity Commission, the above to propose substantial improvements in this service.

Current situation of energy supply in Jalpan

Jalpan de Serra is a municipality in the Sierra Gorda of Querétaro that is characterized by its mountainous geography, which makes infrastructure difficult. Most of its communities are small and scattered, which hinders the proper distribution of energy. In addition, its economy depends mainly on agriculture, livestock and tourism, so these sectors depend on a reliable energy supply for their development.

In the digital media there are notes that mention the improvement of the power grid, which occurs in a context of deficiencies in the quality of electricity supply. An example is the news item "CFE started electrical modernization in Jalpan de Serra", published in [Código Querétaro, written reality \(2024\)](#).

On the other hand, on the website of the [Municipio de Jalpan de Serra \(2025\)](#), only mentions a management for the improvement of the electric service and an adjustment of the rates given the weather conditions. "Gobierno municipal y CFE revisan acciones clave para mejorar el servicio eléctrico en Jalpan".

Therefore, no action is identified that would lead to an improvement of the current conditions.

On the other hand, the media [Expreso Querétaro \(2025\)](#) mentions the document called "Technical Report", which details the actions to be carried out to improve the electric service in the area. This is how Queretaro seeks to solve the lack of electricity in the Sierra Gorda", which mentions the existence of a feasibility document generated by the Energy Agency of the State of Queretaro and submitted to the CFE, which includes the recalibration and reinforcement of power lines, the replacement of deteriorated poles, the expansion of distribution networks and an increase in the capacity of transformers, and which seeks to provide a solution to the quality of service received in the mountainous area. Access to this document is not documented on the energy agency's website.

Based on the aforementioned information, there is currently no plan in place to improve these conditions. However, it is necessary for the authorities to design a public policy to address these needs.

Energy infrastructure and challenges

The national electricity system is composed of power plants of different technologies, the National Transmission Network (RNT) and the General Distribution Networks (RGD), which deliver the electricity produced in the power plants to Basic Service Users (USB) and Market Users (UM).

At the state level, energy consumption is concentrated in industry and medium voltage businesses, followed by residential users and industrial users, with agricultural users occupying a smaller place, according to data from the [Secretaría de Energía \(2022\)](#).

With data from the [Secretaría de Energía \(2022\)](#), the following table has been prepared, which shows electricity consumption in MWh (megawatt-hour) for Jalpan de Serra, Landa de Matamoros, Pinal de Amoles and Arroyo Seco.

Box 1

Table 1

Consumption in MWh by municipality

Municipality	Residential Consumption in MWh		Commercial Consumption MWh	
Jalpan de Serra	13258.281	38%	3517.093	51%
Landa de Matamoros, Querétaro	8140.1	23%	975.269	14%
Pinal de Amoles	7049.226	20%	925.264	13%
Arroyo Seco	6462.362	19%	1484.25	22%
Total Sierra Gorda	34909.969		6901.876	

Source: Own elaboration with data from [Secretaría de Energía \(2022\)](#)

The grids in Jalpan de Serra come from the national grids which transport energy from more urbanized centers to the municipality that extend from the more urbanized areas by it is necessary to transport energy through medium and low voltage transmission grids, which supply both urban and rural areas of the municipality. In addition, many of the components of the electrical infrastructure, such as poles and transformers, are aging, which causes frequent power failures, these problems not only affect domestic activities, but also the economic development of the region, especially in agricultural and tourism sectors, which depend on a stable electricity supply.

Security in the quality of the energy service

According to the [Dirección General de Comunicación de la UNAM \(2025\)](#), "The lack of access to conventional energy makes some people resort to other sources for lighting or electricity". In these cases, kerosenes, diesel fuels (diesel) and other gas lamps are generally used, so the use of these alternatives has important consequences in terms of cost, safety and environmental damage.

As mentioned above, security of electricity supply includes not only the physical protection of the infrastructure, but also ensuring that energy supplies do not put the population at risk. Power outages can affect inhabitants, especially when they affect street lighting and home security. Thus, the inappropriate use of power generators or other alternative sources, such as light generators, gas lamps, diesel, among others, during power outages can pose additional risks to the population.

Rural areas experience high population growth and accelerated urbanization, which contributes to environmental disruption. In other words, no source of electricity generation is free from producing environmental impacts. In terms of emissions of pollutants into the atmosphere, small amounts of radioactive materials are released, which considerably affect climatological aspects, according to [Campos and Quintanilla \(1997\)](#). This causes storms, rains and floods that can damage power lines and cause unexpected blackouts that can last for days without a response from a company in charge, so the adoption of renewable energy sources can help decrease these risks and maximize quality in the home.

Reliability of energy supply

Rural areas require high power availability with unlimited supply that does not interfere with daily tasks, business or grid connections to enable remote working. Network availability is the goal of telecommunication companies in rural areas to try to provide the same quality of service as in large cities ([enerTIC, 2022](#)). The reliability of the electric service is a concern, as blackouts are frequent and disrupt the daily lives of the inhabitants. In communities near Jalpan de Serra, the reliability of the power supply is often lower than in urban areas due to the lack of investment in it.

The frequency of blackouts is high and the response time of companies to these incidents is late, so these are indicators that allow us to evaluate the reliability of the electricity system.

Energy and rural development

Energy is an important factor for the progress of communities in areas such as health, education and production. In most communities in Jalpan de Serra, access to electricity supply is limited, which affects their development. To this end, the use of renewable energies can be implemented to reach communities where the electricity grid is scarce, especially if we take into account that Querétaro is a state with great potential in renewable energies, such as solar and wind ([Cruz y Vargas, 2021](#)).

It could be said that renewable energies, such as solar and wind, are fundamental to achieve a sustainable electricity supply in the communities of Jalpan de Serra, since they allow reducing the excessive use of electricity and using it more efficiently. The use of these types of energy sources is that they are cleaner and more sustainable, and would also help improve the quality of supply and reduce the environmental impacts associated with commonly used energy sources.

Renewable energies, such as solar and wind, represent a viable option for improving the quality of energy supply in remote rural communities. Due to the growing demand for energy in Mexico, it is possible to analyze and identify alternative energy consumption scenarios, as well as their relationship with the product, prices, possible technological innovation alternatives and their aggregate impact on both the product and prices.

Therefore, the installation of solar panels and small wind turbines in Jalpan de Serra can increase the stability of supply and reduce interruptions, improving the quality of life of the inhabitants.

It should be noted that these alternatives to improve supply are not economically accessible for most rural localities, as they imply high financing costs.

As mentioned by [Zarate \(2022\)](#), the process of transition to renewable energies has stalled in federal public management, which returns electric power to the category of national investment priority as a method of centralizing resources.

Methodology

General Objective:

To analyze the perceived quality of Jalpan de Serra's electricity supply and its impact on local development.

Specific objectives:

1. To identify the main perceived defects of the electrical supply in Jalpan de Serra.
2. To analyze the impact of electrical problems on the daily activities of the inhabitants.
3. To analyze the causes of electrical problems in Jalpan de Serra.

Justification:

The constant blackouts in the municipality of Jalpan de Serra cause interruptions in daily activities, as well as in the safety and well-being of the population.

The constant blackouts in the municipality of Jalpan de Serra cause interruptions in daily activities, as well as in the safety and well-being of the population. It is important to highlight that the present research contributes to identify how the lack of electricity is faced and the availability of opting for alternative energies that support the current deficiency of electricity supply.

Population and sample

The population under study are the people over 18 years of age in the neighborhoods of Jalpan de Serra, estimated according to the Population and Housing Census of INEGI in 9250 inhabitants, from which 370 people will be selected, with a confidence level of 95%.

Variables

The variables defined below are taken from technical studies in the area of electricity, which allow us to determine the elements that constitute the instrument that measures the perceived quality of electricity supply in a specific region. A conceptual definition of these variables is presented below:

Duration of interruptions

It is the total time during which users are left without power supply during a specific period [Pesantez et al., \(2021\)](#).

Electrical stability

Variability of electrical voltage with respect to the voltage levels recommended by technical standards. Voltage stability is essential for the proper functioning of connected electrical equipment [Mercado Polo et al., \(2017\)](#).

Reliability of supply

Capacity of the electrical system to provide energy reliably, minimizing the number of interruptions and unwanted fluctuations [Levy and Carrasco \(2020\)](#).

Technical and non-technical losses

Technical losses: "Occur naturally as a direct result of the physical characteristics of the networks and consist mainly of energy lost during transport and distribution within the electrical network, in the various components of the electrical system: transmission and distribution lines, transformers, metering systems and other equipment".

Non-technical losses: these are losses (not directly related to the physical characteristics of the networks) associated with the amount of electricity associated with the amount of electricity that was supplied but not billed.

Refers to energy losses during transmission and distribution, which can be technical (Joule effect in transmission lines) or non-technical (energy theft, metering errors) according [Herrera \(2004\)](#).

Economic costs

Economic impact derived from electrical problems, including losses due to damage to household appliances and downtime in productive activities [Arrellano and Chapa \(2017\)](#).

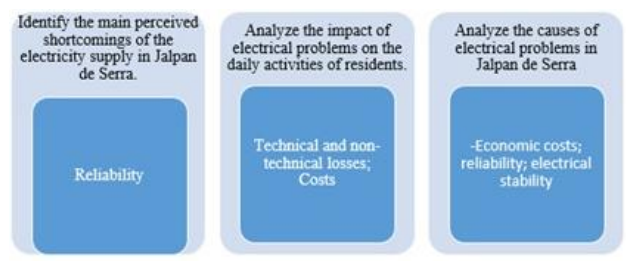
Develop give the meaning of the variables in linear writing and important is the comparison of the used criteria.

Results

The following are the results aligned with the objectives of this research related to the variables that were evaluated through the perception of the inhabitants. The results shall be by section of the article.

Box 2

Figure 1
Relationship between variables and objectives



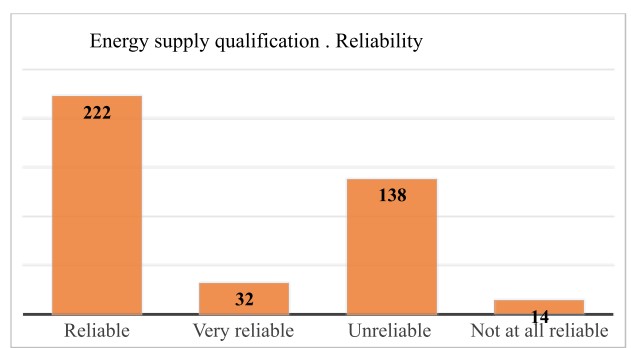
Source: Own Elaboration

Identify the main perceived defects of the electricity supply in Jalpan de Serra.

Associated variable: Reliability of supply

Box 3

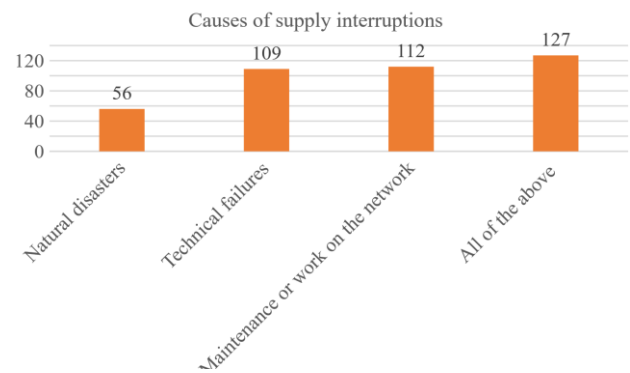
Figure 2
Rating of power supply



Source: Own Elaboration

Box 4

Figure 3
Causes of supply interruption



Source: Own elaboration

The instrument shows that fifty percent of the population considers that the electricity supply is reliable, while forty percent indicate that they are not satisfied with it and point out that the main causes of electricity interruptions are maintenance or work on the network. As a result, users have little confidence in the electric system and those who participate in its management.

The reliability of an electric system is measured using methods that not all the inhabitants of a locality are willing to pay for, since the benefit of the service is assumed by the simple fact of residing in a locality with the services.

Therefore, and given the variability of the service, it can be assumed that the situation in some cases can lead to energy poverty, given the difficult access to a totally reliable supply that does not affect the lives of the inhabitants, according to Ceballos et al. (2022)

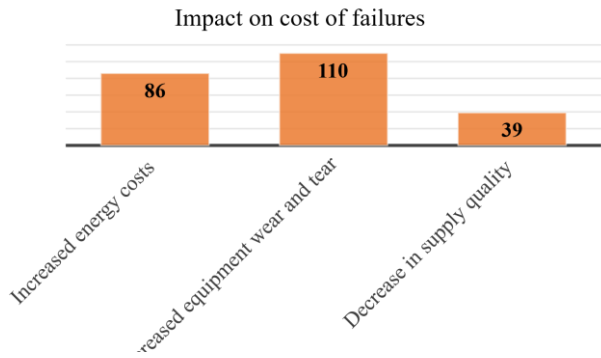
Objective 2. Analyze the impact of electrical problems on the daily activities of the inhabitants.

Associated variable: Technical and non-technical losses; economic costs.

Box 5

Figure 4

Affected by technical and non-technical losses



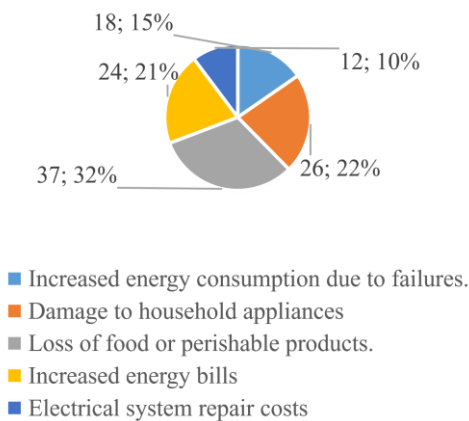
Source: Own Elaboration

Box 6

Figure 5

Economic impact on housing. Costs

Economic impact on housing. Costs



Source: Own Elaboration

The second objective is to analyze the impact of electrical problems in the region. Surveys conducted with the inhabitants show that one of the main problems caused by interruptions in the electricity supply is the premature wear of equipment, which underlines the importance of having a stable electrical system.

These electrical failures are not identified as an isolated event in localities with higher demand, but are national situations that have been occurring since the growth of electricity demand, which in turn is affected by the demand due to economic growth and the development of new industrial parks in specific poles, (Instituto Mexicano de la Competitividad, 2024).

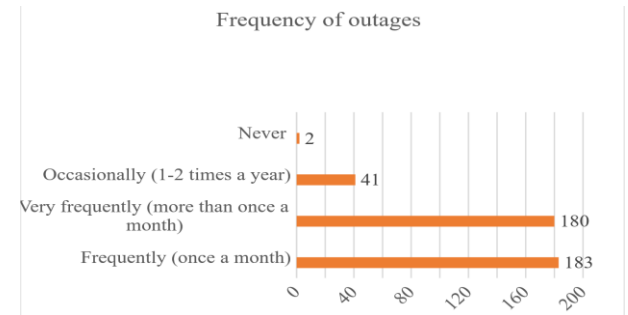
Objective 3. Analyze the causes of electrical problems in the communities of Jalpan de Serra.

Associated variable: Economic costs, Reliability of supply, electrical stability

Box 7

Figure 6

Electrical Stability

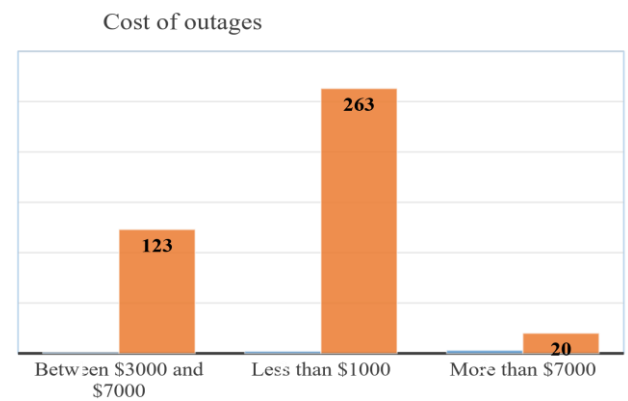


Source: Own Elaboration

Box 8

Figure 7

Cost of blackouts in the last year

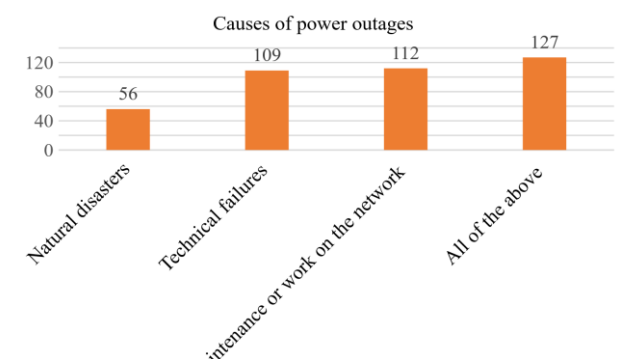


Source: Own elaboration

Box 9

Figure 8

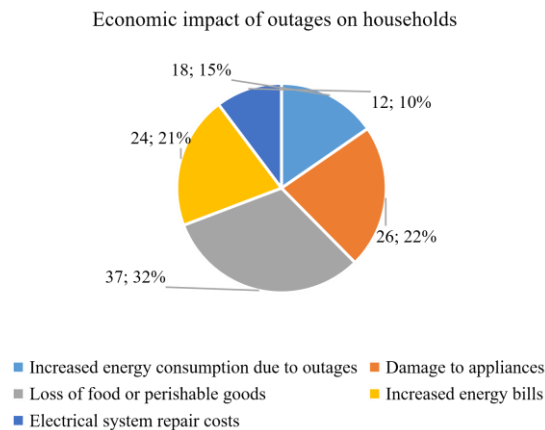
Causes of power outages



Source: Own Elaboration

Box 10**Figure 9**

Types of costs involved in power outages

*Source: Own Elaboration*

In order to analyze the causes of electricity problems in the region, respondents were asked to indicate the possible causes of the interruptions. Respondents indicated that these could be due to natural disasters, technical failures, maintenance or work on the grid, which in turn generate significant consequences in households, such as damage to household appliances and loss of food and products that spoil faster due to lack of electricity.

According to research based on electricity supply costs:

"The average selling price of electricity in Mexico is not enough to cover the cost of the service, as it includes the payment of a high leverage. By law, this charge could be used to finance the expansion of the service, but the authorities have preferred to use it to cover other federal government expenses", according to [Rodríguez and Sheinbaum \(2002\)](#).

In turn, it mentions that many users pay a price much higher than the real cost of electricity. If we relate this to our research, this could be due to the large number of failures in the system, which cause the user to be affected by having to pay for a service that does not correspond to him.

Conclusions

Power outages and voltage fluctuations generate dissatisfaction among service users, and challenges related to electricity distribution and transmission continue.

The laws and concessions promoted and halted throughout history by successive federal governments have slowed down the process of adopting alternative energies that would enable the development of some localities and access to a decent standard of living. Added to this is climate change, which entails greater energy demand to cope with its impacts, [Ceballos et al \(2022\)](#).

Although there has recently been a major rollout of fiber optics and new stations that favor digitization, energy has been a highly controllable issue that has been relegated to improving sections of infrastructure that temporarily solve the supply problem.

Currently, the federal government is spearheading a proposal that revisits previous plans and continues with the intention of preserving the country's legacy, as pointed out by [Goldwyn and Hernández \(2025\)](#) in their article "Mexico's new electricity law could boost the country's energy sector. But big questions remain"

On the other hand, it is worth noting some alternatives that can be envisaged in the current scenario of political management and national priorities: a hybrid solar energy and battery system would make it possible to supply the energy needed to meet the demand in these rural areas and offer the quality of life that is needed. The hybrid system is an economical solution for a reliable electricity supply ([Díaz et al, 2022](#)).

Another alternative is a microgrid, which is feasible for remote areas and can complement a hybrid system such as the one mentioned above.

These independent electrical grids allow for energy generation and distribution that increases reliability, quality, and electrical stability, enabling resilience to adverse external factors. According to the "Energy without Borders" project, which analyzes the feasibility of these systems with wind, hydro, and biomass energy alternatives, according to [Alaminos et al \(2013\)](#), these grids can be a solution for remote areas.

Policy management models that solve the energy supply problem are scarce; success stories come from industry, which has sought to solve its problems, such as Grupo Bimbo, which announced that 92% of its global electricity already comes from renewable sources such as solar and wind, and that by 2025 it will consolidate its position as a company that uses 100% renewable electricity in countries such as Mexico, Ecuador, Brazil, South Korea, Guatemala, and China, among others (Grupo Bimbo, 2023).

There are alternatives on the table, such as renewable energy cooperatives, an option shared by the *Deutsche Gesellschaft für Internationale Zusammenarbeit* (2020) in its publication *Guide to Sustainable Energy Cooperatives in Mexico*. These function as a tool to promote participation and democratization of energy generation, and are a management and operational option to solve the problem in the medium and long term, especially in the context of the small and medium-scale photovoltaic market. In this sense, they can support the resolution of the energy problem and place the local government of the Sierra Gorda as the coordinator of actions.

Some examples of these cooperatives in Mexico, according to the text *Instituto Nacional de la Economía Social* (2020), are:

- Onergia: a cooperative that promotes community solar projects, especially in rural and indigenous areas. They work with collective ownership models and local training.
- CEEOAX (Oaxaca Energy and Ecology Cooperative): focused on sustainable solutions for Oaxacan communities, combining renewable energy with ecological practices.
- Báaxal: a cooperative that promotes clean energy projects in the south of the country, with a focus on energy justice.
- Cooperativa Mixta “La Esperanza”: linked to sustainable brick producers, integrating electricity generation with production processes

Declarations

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Author contribution

Morado-Huerta, Ma. Guadalupe: Responsible for the research project, research design and data analysis.

Márquez Hernández, Olga: Method drafting.

López Hernández, Edgardo: Theoretical support

Ibarra-Pérez, Juan: Review of publication requirements

Availability of data and materials

The information needed to carry out this work can be found in the research database stored in the institutional drive account.

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