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Research article

Smart grid systems infrastructures and distributed solar power generation in urban slums–A case study and energy policy in *Rio de Janeiro*

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Abstract: This article discusses the relationship between urban slums and the management of the urban infrastructure network (electrification). An extensive survey of the scientific literature on the subject points out the main challenges and possible solutions for fixing precarious electrical infrastructure in urban slums through the promotion of public policies and the establishment of new arrangements based on distributed generation technologies and smart grid. A dialogue was also developed involving topics such as sustainable development and electrification of slums; relationship between communities and modernization of electrification; and emerging and sustainable technologies in the context of urban slums. Thus, a design was constructed that triggered a discussion of the relationship between this work and several other works found in the literature. This research indicates the need to strengthen local governance and the participation of urban slums for the technological modernization of the local electrical network, mainly with the implementation of smart grid and photovoltaic generation systems.

Keywords: electrification in urban slums; low-income communities; renewable energy and poverty; smart systems; social inclusion; sustainable development

1. Introduction

The evolution of urban spaces in large and medium-sized cities across the world is the result of historical processes of occupation of the territory by the population and the consequent establishment of typical urban mosaics with unequal socioeconomic conditions. The displacement of rural populations to cities is partly related to the recession in the agricultural sector and mainly to the prospects for city attractions. These relate to employment, better living conditions, basic services including water, sanitation, electricity, education, employment and health. The slums arise as unplanned urbanization takes place.

In Latin America, the consolidation of part of the space of the cities in the form of slums (or formally called precarious settlements or subnormal agglomerations) is a characteristic of the evolution of the big cities in the region, reflecting a historical social inequality in the continent, whose tendency of concentration of the population in urban areas was accelerated by internal migration to countries throughout the 20th and 21st centuries [1–3].

In Brazil, the history of urban spaces, the territorial dynamics of cities and social relations in slums characterize a context of society's reality. This influences national identity and culture, although a whole load of historical prejudice has been formed in the imagination of part of the Brazilian population throughout recent history. This theme is studied in a rich interdisciplinary literature on the subject [4–6], with in-depth biases in the sociological, historical, economic, geographic and urban planning contexts, which they are formalized by several researches found in theses, dissertations, scientific articles and books. This consolidated knowledge provides a broad panorama of scientific views, which explains the dynamics of slums in the construction of urban social identity and the reality of cities. The search for a modern and more sustainable society involves recognizing the need to promote social equity, breaking the imaginary line between the slum and the *non-slum* in the urban environment.

Although the dynamics of occupation of urban space and its socioeconomic aspects are a constant object of updating in the contemporary scene, the understanding of the historical basis and social relations of the slums must compose the foundation for the formulation of public policies, city planning and the urban infrastructure management. A conceptual socioeconomic base characterization is necessary to provide a power technology solution customized to the real needs of local communities and in agreement with the local governance. In this way, robust sustainable solutions are promoted in favor of social equity, with tangible benefits for the urban population. Therefore, limiting ourselves here to the literature review in the context of urban infrastructure (electricity distribution), not refraining from dialoguing, in a non-exhaustive way, with the knowledge associated with the social context of urban slums areas.

The issue of urban infrastructure in slums has been the subject of recurrent reflections throughout Brazilian history (from the end of the 19th century to the present day). The provision of urban public policy actions was centered on urban planning that involved the removal and eradication of slum areas. In the city of *Rio de Janeiro*, the capital city of Brazil until 1960, the resistance and organization of popular forces in slums, associated with the many practical issues limiting the action and agility of public law enforcement, as well as the mobilization policy, reversed in part the practice of removal, as the hegemonic way of providing a definitive urban solution to the "slum problem".

The ineffectiveness of slum removal policies throughout the history of the Brazilian urban environment in the 20th century demonstrated the need to establish differentiated policies for slum

areas [6,7], with a strong presence of government entities during public policies implementation, promoting effective community participation in social collective actions. The absence of the government entities and public law enforcement in the slum regions of Brazilian cities is part of the pathology of exclusion and appropriation of urban environments by the non-governmental criminal groups, involved in organized crime, gangs, militias and drug trafficking. These groups takeover the official law enforcement control in slums and build up an illegitimate and criminal government, known a "parallel state".

Table 1. Electrification challenges in urban slums.

Axes	Challenges
Clandestine connections	The precarious and clandestine power cable connections between utility grid and consumers for power stealing without compensatory tariff payment to the utility company is locally called "*gatos*". They present an important economic loss factor for the power utility company and for the economic balance of the cost of electrification (non-technical losses). Even with the regulation of the social electricity tariff [11], the task of transforming consumers into customers is a complex re-establishment of governance that raises a series of conflicts and operational bottlenecks [12];
Modernization of the grid and improvement of service quality and reliability	Ensuring a better standard of care for both consumers (domestic and commercial) and public lighting. The standard of care in slums presents indicators that must still be the result of investments, in view of the increase in consumption and the need to rebuild precarious electrical connections [9,10,13];
Operability in conflict areas	It is a major challenge for electricity management in slum areas where state governance has degraded (critical risk areas). In areas of armed conflict, the power utility company 's interventions must be the result of a series of conditions that must be properly considered. Network maintenance, implementation of improvements or distribution reordering are open questions in terms of restoring full operating capacity and service availability.

Among the urban planning objectives for slum regions, the territorial reorganization process must include the establishment of the entire electrification infrastructure. This should consider both universal coverage of electricity supply to consumers and an adequate public lighting network. In this sense, the local power utility company Light S/A (in charge of the Metropolitan Region of *Rio de Janeiro*) was officially responsible for reorganizing the electrical network, providing full domestic and commercial services and restructuring public lighting. From a technical point of view, the mission of full electrification would normally be an easy challenge, with feasible targets for universal power access. In general, in the context of coverage of areas for the electrification of *Rio de Janeiro's* slums, universal service indicators are verified. However, in the reality of the field of electricity distribution infrastructure, the indicators of inequality reduction still require a great effort to establish actions for the general reorganization of the network. The works of Pilo [8,9], reinforced by the evaluations of the Inter-American Development Bank (IADB) on the actions of slum *Bairro/Morar Carioca* program [10], indicate that the supply of electricity still requires an important improvement in quality for the promotion of effective reduction of urban inequalities. Electrification and public lighting quality

indicators should still form part of the agenda of major urban challenges for slum areas in *Rio de Janeiro* in the next decade.

The challenges of full electrification and inclusive quality permeate not only technical solutions for network reordering. Table 1 shows three categories of challenges (axes) causing restrictions to the management of the power distribution network.

Considering the socio-operational challenges for the electrification of urban slums, this research addresses two main questions concerning the improvement of electrification indicators:

i. How to broadly integrate the technical and social components (socio-technical perspective) for solutions to complex issues associated with the full electrification of urban slums, both for universal access and quality of care? and
ii. How new contemporary technological solutions can contribute to the sustainability of electricity supply in urban slums, through a conceptual basis of smart grids and distributed generation using photovoltaic solar energy?

The first question about the integration of technical and social components is developed in Section 2 and 3. Section 4 addresses the second question about the conceptual basis for smart grid and photovoltaic solar in slums.

2. Sustainable development and electrification of urban slums

The need to promote urban sustainability through proper management of networked infrastructure (electricity, sanitation, water, digital inclusion, etc.) has been the object of international agendas since the 1990s. Sustainable actions for the urban environment are the object of priorities highlighted in the *Rio de Janeiro* conference document [14], in subsequent conferences [15,16] and other global agenda documents [17].

The UN goals for sustainable development (SDG) in the 2030 agenda present specific points for the search for sustainable cities and healthy urban environments (SDG-6 and SDG-11) and the issue of energy is placed explicitly in its objective SDG-7 (Energy modern, clean and accessible) [18]. Complementarily, the establishment of an equitable and universal electrification network has implications for other indicators (e.g., SDG-10 Reduction of inequalities and SDG-8 Decent work and economic growth). In fact, the reliable availability of electricity is a basis for any action for the socioeconomic insertion of urban populations and has a repercussion on a series of other goals that must have a reliable energy supply.

Urban electrification, strengthened by new technologies and concepts (smart grids, distributed generation, intelligent energy management, smart cities, energy communities, etc.) can represent a catalytic mobilization in the process of transformation and modernization, with the search for sustainable solutions innovative. Initiatives in this regard have been reported in recent literature [19–26] considering the energy issue as a sustainability vector, or even involving an integrated approach to water-energy-sanitation infrastructures in the context of the Nexus concept [27,28]. All these transformative aspects can be directly associated with the pursuit of clear objectives for urban sustainability, based on SDGs [29–31]. The fact is that provision of electricity together with sanitation form the basis for policies and programs for urban sustainability. This involves, in a contemporary context of cities and their social inequalities, universal access, the quality of services and the reduction of the environmental impacts of generation-transmission-distribution models.

In order to rethink the urban energy infrastructure of the slum areas of the city of *Rio de Janeiro*, some fundamental premises of the *Favela-Bairrro* Program can be established as a starting point, which are summarized in Table 2.

Table 2. Assumptions of the *Favela-Bairro* program in *Rio de Janeiro*.

No.	*Favela-Bairro* program
1	Integrate slums through intersectoral policies, providing full accessibility and mobility of favela residents to the city;
2	Slum areas must be a priority in urban management by the municipal government, articulating public investments and strengthening policies to face problems in order to find solutions;
3	Combating the existing segregation in the urban environment of the city of *Rio de Janeiro*, increasing the presence of the state and the provision of public services (sanitation, electrification, accessibility, public equipment in health and education, etc.);
4	Valuing the history, values and culture of urban slum communities, thus directing government interventions;
5	Foster participatory community decisions and the protagonism of interlocution with community leaders.

These *Favela-Bairro* program axes of action were defined in the 1990s and were revised in the first decade of the 21st century with *Morar Carioca* program.

Comparatively, the sustainable development goal 11 for sustainable cities and communities [17] establishes the following points, as shown in Table 3.

There is good adherence between the different strategic axes, highlighting the still relevance of the urban reordering proposal for slums, proposed by the programs designed for *Rio de Janeiro* in the previous decade. A review of goals and a review of conceptual frameworks for a possible new version of the *Favela-Bairro* program, based on successful experiences and weaknesses [10] could compose a new framework for urban management in the City of *Rio de Janeiro* to the coming decades.

With regard to energy infrastructure, it is observed that the next step in relation to full universalization must include an infrastructure modernization process, in the sense of providing the quality of care in urban slum areas. From a technical point of view, it is necessary to provide systemic reliability to the sub-networks, providing planning for expanding demand and strengthening energy efficiency actions and inclusion of consumers. Integrated actions to modernize the electrification of urban slums can provide important benefits in terms of sustainability indicators, provided by a safe and citizen supply of electricity.

Finally, it is worth mentioning again that the quality of the energy infrastructure is one of the bases for local development. It provides a level playing field for the urban space and provides a capacity to sustain public education and health equipment, as well as a base for boosting the economy in slum areas by supplying undertakings on different scales. In this sense, modernizing the network in urban slums, guaranteeing universal service, integrating electrification programs with social public policies and dialoguing with communities, seems to be a desirable logical path within the conceptual framework of program goals related to sustainable development.

Table 3. Goal 11 (sustainable cities and communities) of the 2030 agenda of the United Nations (UN).

No.	Sustainable development, goal 11
1	Ensure access for all to safe, adequate and affordable housing and basic services and upgrade slums;
2	Provide access to safe, accessible, sustainable and affordable transport systems for all, improving road safety through the expansion of public transport, with special attention to the needs of people in vulnerable situations, women, children, people with disability and elderly;
3	Increase inclusive and sustainable urbanization, and capacities for participatory, integrated and sustainable human settlement planning and management, in all countries;
4	Strengthen efforts to protect and safeguard the world's cultural and natural heritage;
5	Significantly reduce the number of deaths and people affected by disasters and substantially reduce the direct economic losses caused by them in relation to global gross domestic product, including water-related disasters, with a focus on protecting the poor and people in need. vulnerability situation;
6	Reduce the per capita negative environmental impact of cities, including by paying special attention to air quality, municipal and other waste management;
7	Provide universal access to safe, inclusive, accessible and green public spaces, particularly for women and children, older persons and persons with disabilities;
8	Support positive economic, social and environmental relationships between urban, peri-urban and rural areas, reinforcing national and regional development planning;
9	Substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans for inclusiveness, resource efficiency, climate change mitigation and adaptation, disaster resilience; and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030, holistic disaster risk management at all levels;
10	Support least developed countries, including through technical and financial assistance, to build sustainable and resilient buildings using local materials.

3. The relationship between urban slums and electrification modernization

The city of *Rio de Janeiro* has always been a challenge for urban electrification programs, given its particular relief and coastal geography, its constant territorial expansion due to immigration, its political interests as a center of national decisions and its mosaic of slums. Since the arrival of electricity in Brazil as a transformative technological innovation, planning the urban electricity network has always been a challenge for network management and customer service [32,33]. Among the many changes of the local electricity power utility company, Light S/A, the city has always been influenced in its energy infrastructure by the mutations of the urban space and its elements of technological modernization and expansion. Since the profound urban changes at the beginning of the 20th century, the process of modernizing the electrical grid has always been observed with the permanent challenge of a city with constant population growth, a political center and with industrial

pretensions. Coexistence with slum areas and the precariousness of electricity services have always reflected the absence of social public policies for infrastructure.

The need for universalization of urban energy infrastructure for slums, as a state policy, raises an imminent need to reorganize the electrical network on other technological parameters. The great contemporary challenge lies in the integration between the technical character and the social adaptations of the modernization process, in the context that some authors call sociotechnical perspectives [8,9,12,34,35], aiming to a real confrontation of the equitable electrification of slum areas. Everything goes towards promoting urban sustainability based on consequent state actions through a consistent local program.

Some important reflections corroborate the need for a network modernization process, integrated with the effort to promote socially based action in slums (Table 4).

Table 4. Reflections on the reorganization of the network in slum.

Action	Network reorganization in slum
Improved service quality	The residents' perception of the quality of service is negative, with reports of high indicators of interruptions, precariousness of the network, inefficient public lighting and slow response to maintenance calls [10]. It is observed in this sense that the poor condition is not reported only in the installation of the public network, but also in the access to the residences and their precarious internal installations. It is also noted that individual consumption increased in the last five years, with the purchase of household appliances and, in particular, air-conditioning equipment, which overloads existing installations. The works by [9] point out that an evolution in the conditions of care has been observed in the last decade, but they point out, however, that an improvement in quality is necessary for conditions of equity to be established;
Reduction of non-technical losses (*gatos* of electrical energy)	About 20% of the energy consumed in the metropolitan region of *Rio de Janeiro* is stolen. This indicator grows to 80% for consumption in slums, particularly in the regions of *Baixada Fluminense*. Energy theft is a chronic problem with consequences for formal customers, for the power utility company itself and for the distribution system as a whole [36,37]. This is a serious situation, where a definitive and effective course of action has not yet been established;
Living with critical zones and their restrictions	The condition of territorial control in risk and conflict areas limits full operation by the energy power utility company (Light S.A.). The company presents a mapping of critical zones to regions where access is free. In some slums, clandestine electricity connections are also controlled by parallel power, such as for the supply of other services to the population (gas, cable TV, etc.). Consequently, energy theft indicators in these communities are higher.

It should be noted that in all the factors raised above, they occur in heterogeneous conditions in the different slums of *Rio de Janeiro*, which leads to the elaboration of a set of differentiated solutions, specific to the reality of each community. The third point is the most complex to be faced: it requires the state to take over the full territory of the city of *Rio de Janeiro*, and the strategies and discussions for this permeate the synthesis capacity of this text.

For the first two points, an intervention effort is required through a reorganization of the energy infrastructure of the communities. This is in line with a sociotechnical modernization strategy that adheres to the conceptual axes presented in the previous item of this work. In other words, it involves the elaboration of local plans for each community in which a modern technological base for electricity distribution must be integrated into a participatory process with the community, making clear gains and commitments (see Figure 1). The idea here, therefore, is to use a new technological standard to face the problems of existing electrification, converging interests of the community, the state and the power utility company. This can promote a differentiated condition in search of sustainable solutions for the city of *Rio de Janeiro* [19].

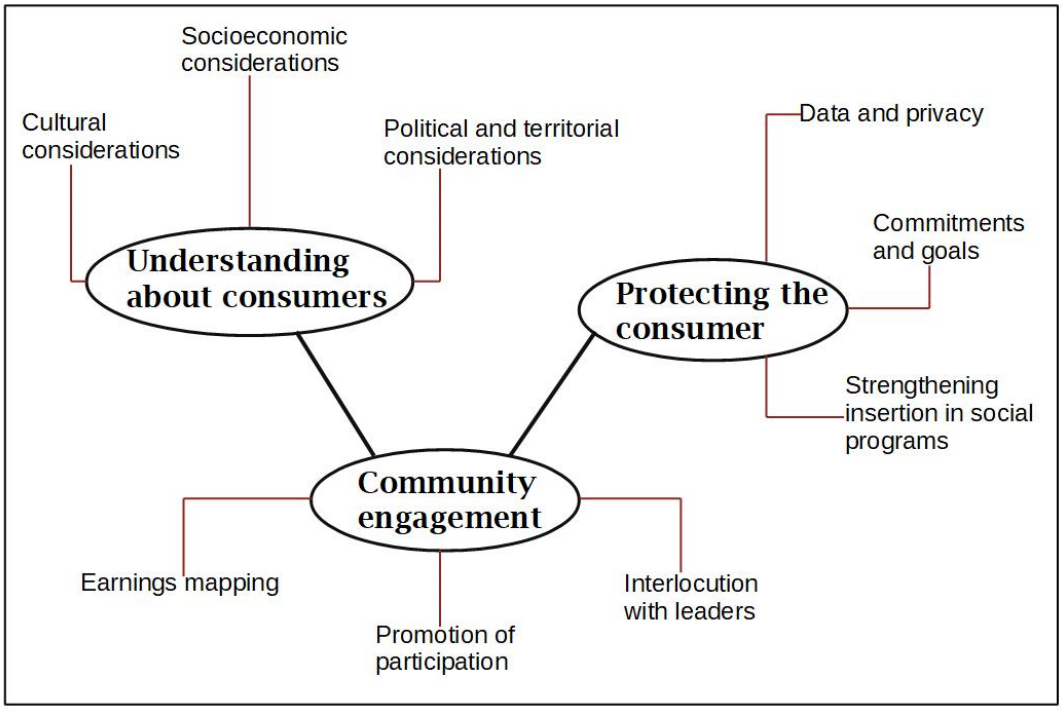

Figure 1. Previous approach to smart grid in urban slums.

It is interesting to observe that the issue of non-technical electricity losses would not necessarily be resolved in a technical modernization action, however, data for different cities in Latin America demonstrate that the improvement in the quality of supply engages a self-regulation effect of consumers [38]. Only commercial strategies for transforming "Consumers into Customers" are not as effective [12] compared to an endogenous process of valuing energy provision through a real gain in service quality. It is about a recovery of part of the citizenship, through a commitment to regularize the rights and duties of the population towards the public concession.

In this sense, a participatory network modernization strategy can be summarized by the following lines of action:

i. Reorganization of the network with re-registration of consumers (formal and non-formal), as well as technical dimensioning of demand with a view to implementing energy efficiency programs and estimates of increased consumption;
ii. Insertion of consumers in the social electricity tariff program, at its different levels;

iii. Establishment of a concessionary-community-government line of dialogue through community leaders, encouraging participatory decision-making processes;
iv. Modernization of installations with adequacy of access points (smart metering), cabling and intelligent substations, as well as synergy with energy efficiency programs;
v. Feasibility assessment of the installation of distributed generation units in a power utility company -community partnership, through the implementation of photovoltaic systems on roofs and/or in public or power utility company areas.

This plan is not new. The local energy power utility company is fully aware of the network modernization needs to promote better quality, and has consolidated its own programs in the different planning lines and in its sustainability agenda. The synergy of Light S.A with the city of *Rio de Janeiro* is full although often conflicting, however, the basis of institutional engagement and awareness of the social problem of the favelas allows an important advance on the modernization and sustainable service of energy.

4. Emerging and sustainable technologies in the context of urban slums

The current context on technologies for electricity distribution in cities is directed towards two perspectives: smart grid and the trend towards distributed generation with the insertion of renewable sources.

4.1. Smart grid in slums

In this new distribution scenario, the way to rethink the technical concepts of electricity supply is to integrate it with cybernetic components associated with intelligent digital systems, with information technologies. Therefore, an important technological reorganization must be engendered, with gains for society. The evolution of distribution systems, in an additional step to automation in the form of smart grids, provides better operating conditions, planning and cost reduction [39,40].

Despite the fact that the technical conviction of companies is already consolidated by the need to invest in technological options for smart distribution networks, the real social gains for consumers still present controversial aspects [41–45]. The problem that arises here however is slightly different. Most of the articles associated with the evaluation of smart grid are based on the assumption that the modernization of the system takes place in an operating network with a reasonable efficiency standard, thus implementing a new technological leap in a new operating concept—which certainly provides gains directly to the operator, whose benefits will not be fully passed on to the consumer. Added to this is the fact that the collection of information on family consumption habits, based on the consumer measurement system (smart metering), leads to a technological insertion in the private environment, with relevant ethical consequences.

Here, the problem is actually positioned from the perspective of an appropriation of the technological modernization process based on the precariousness of the current system, already in need of technological intervention. Therefore, the modernization process using a more advanced technological concept can provide mutual gains between slum consumers, power utility company and government. This situation should guide the negotiation of a differentiated sociotechnical solution based on smart grids, thus using the technological leap towards a gain in local sustainability [19,20,46].

Gains in network stability and facility security outweigh the issues underlying the concept of smart grids.

In this sense, the collective gain of a process can be made possible from the perspective of a sociotechnical intervention if:

- The installation of new systems is the result of a clear exchange of gains for slum communities, clearly qualifying the best reliability conditions for a smart grid, both for operation and for future planning. The synergy of the network's technological contribution proposal with energy efficiency programs and the insertion or improvement of the internet standard can be an element of social negotiation with consumers;
- The network modernization must represent a reorganization agreed with the community, in synchrony with the actions of social access to electrification, involving municipal, state and national government programs;
- The quality of electrification of public equipment must represent a fundamental social gain, strengthening the conditions of health, education and public safety indicators, with a superior supply of energy;
- Eventually, the modernization processes of the electrical network must be integrated into the agendas of multisectoral programs for slum areas, in particular with the infrastructure programs for sanitation networks and digital inclusion.

Table 5. Matrix of benefits of modernizing facilities by smart grids in urban slums.

Action	Consumers	Power utility company	Municipal government
Registration and reordering of consumers	Social tariff eligibility Regulation of the situation Access to services	Regulation of the situation Revenue increase Consumption planning	Data for planning Construction of indicators
Access to electricity Smart meter Support domestic and commercial installations	Power quality improvement Safety	Systemic improvement Reliable consumption data Fault detection Increased governance	Data construction of indicators Safety
Local network modernization (cabling and installations)	Power quality improvement Safety	Systemic improvement Fault detection Cost reduction	Improvement of urban sustainability indicators (energy quality)
Improved public lighting	Improvement of urban indicators Reduction of security risks	Consolidation of service indicators	Improvement of urban sustainability indicators
Smart systems	Digital inclusion	Systemic improvement	Improvement of urban sustainability indicators
Energy efficiency	Reduction of consumption by families and businesses	Consumption reduction Consolidation of service indicators	Improvement of urban sustainability indicators

In this way, the main elements of modernization of an electrical network in a slum area can provide a differentiated vision of a common public good, improving the deficiencies pointed out in the

quality of energy supply to communities. This encourages co-responsibility in relation to the infrastructure provided by a concession that is, above all, public. Recent literature indicates that the implementation of advanced technological systems based on smart grid can, if well negotiated with society, provide real gains in sustainability. Table 5 presents an overview of benefits that can be provided by the program to modernize the service system in favelas using smart grid technologies.

4.2. Distributed power generation in slums

Distributed generation in slums is a current topic, where solar or wind generation systems, associated or not with storage systems, are intelligently connected to the grid, thus allowing the insertion of the renewable matrix directly into consumption [47–49]. In Brazil, this discussion is quite relevant both for the availability of renewable energy for isolated communities, as well as part of the urban problem of providing equitable electrification [12,50–52]. Specifically for urban slum areas, recently some experiences have been accumulated in the implementation of small photovoltaic solar energy systems on roofs [53–58] (also, the real-world distributed PV solar projects in slums by NGO Revusolar—https://revolusolar.org.br; or the Pilar Solar project—https://www.solarpilar.com.br/). These reported experiences demonstrate a techno-economic feasibility of successfully deploying distributed generation using photovoltaic solar energy systems in slum areas. It should be remembered that the cost reduction of photovoltaic systems associated with the good availability of incident solar energy in the city of *Rio de Janeiro* provide a viable and robust potential for its use on roofs and ground installations. Energy costs are balanced against the local tariff.

The successful installation and operation of a solar system in urban slums must involve some conditions:

- Technical feasibility of installation on roofs, considering the availability of area and structural support for this [24]. Alternatively, the installation can be positioned in ground arrangements close to the consumer;
- Technical feasibility of access to the network and availability of incident solar energy. Access may be subject to rearrangement in the consumer's partnership with the power utility company;
- Need for technology adoption by the community or by a consumer [58], thus strengthening the technical governance of the technology in partnership and/or with technical support from the power utility company.

Finally, it should be noted that the implementation of distributed photovoltaic solar energy systems in urban slums provides a complementary basis for the project to modernize the network and recover consumers, transforming part of them into partners of the power utility company through the co-management of photovoltaic systems. The Brazilian experiences for distributed generation using photovoltaic solar energy, as well as the few pilot projects for installing photovoltaic installations in urban slums, corroborate the following considerations:

- The feasibility of energy and economic potential of photovoltaic installations on roofs is a reality in the country, in particular if the reference costs are based on tariff balance, that is, in the long term the installation costs present the return on investment. The discussions punctuated by [59] strengthen the feasibility of photovoltaic systems from the point of view of the microgenerator, highlighting, however, the risks for the distributor over a long-term view.
- The installation of community systems presents the same constraints as the old government programs for the massive installation of photovoltaic energy (e.g., PRODEEM in the 90s).

Installation management and community governance of systems must be duly negotiated so that, in the long term, the energy and economic return on investment is made possible, with adequate community governance. In this sense, the concept of a partnership for the management of generating units involving users, community energy cooperatives and the distributor seems to be an attractive model for projects in slums [53]. The difficulty of establishing the energy governance arrangement cannot be put in the background.

The idea of establishing an energy partnership in urban slums can be referenced in the concept of energy community applied in European Union countries [60]. In this conception, the participation of citizens and communities as partners in energy projects is promoted, thus transforming the energy system as well as new opportunities for citizens, who must become actively involved in energy issues. The cooperative model, expanded by strengthening the partnership with the distributor, may represent a model to be built in the context of the reality of different favela communities in the city of *Rio de Janeiro*.

5. Conclusions

The literature survey presented highlighted the general context of the modernization process required for electrical service infrastructure in urban slums. It is evident that the modernization project is part of the concepts of urban integration programs in the space of urban slums (taking the *Favela-Bairro/Morar Carioca* program as a reference) as well as the sustainable development agendas for cities proposed by the UN (ODS- 7 and ODS-11). It also emphasizes the need to design an agenda of actions and pilot projects that should provide socio-technical solutions, based on a participatory construction of reliable energy supply models for communities. In this sense, although the universal service indicators of electrification for the city of *Rio de Janeiro* are full, it is observed that there are still important gaps for improving service, in particular providing quality and reliability.

In view of, the current reality and a vision of the future, providing energy in urban slums makes room for the design of a broader technological model, involving the implementation of smart grids and partnerships of distributed photovoltaic solar energy systems.

Finally, from this study, it is clear that future initiatives must involve socio-technical solutions that permeate coherent government plans and action strategies of the power utility company. Successful experiences in governance based on community participation, can provide a basis for action to be discussed by different local actors (citizens and institutions), promoting not only an adequate supply of energy in urban slum areas but also opening opportunities for partnerships and local opportunities.

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Conflict of interest

The authors declare no conflict of interest.

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