THE PROCESS OF RURAL ELECTRIFICATION IN DEVELOPING COUNTRIES: SYSTEMIC ANALYSIS BASED ON THE UNDERSTANDING OF POLICIES OF BRAZIL AND CHINA

André Frazão Teixeira[1]
Davi Gabriel Lopes[2]
Juan Arturo Castañeda-Ayarza[3]

[1]Faculdade La Salle Manaus
[2]Faculdade Cantareira
[3]Pontifícia Universidade Católica de Campinas

DOI: https://doi.org/10.47168/rbe.v25i1.418

RESUMO

O presente artigo, utilizando uma abordagem sistêmica, analisou políticas e programas de eletrificação rural na China e no Brasil, dois países que já atingiram o objetivo de fornecer energia elétrica a 99% da população em áreas rurais. A análise foi focada em quatro macro-fatores (governança, financiamento, implementação e monitoramento e disponibilidade tecnológica), os quais influenciam de forma positiva ou negativa a evolução da política de eletrificação rural. O estudo permitiu concluir que foi dada uma clara prioridade aos macro-fatores financiamento (principalmente público) e às tecnologias disponíveis, o que possibilitou os avanços quantitativos na eletrificação rural, mas prejudicou a confiabilidade do sistema e sua relação com os processos locais de geração de renda. No caso da China, observou-se participação em nível local (concessionárias, formas de geração de energia e participação da população), mas com pontos negativos para governança e monitoramento. No caso brasileiro, o gargalo continua sendo a região amazônica, que requer estruturas baseadas no dimensionamento dos macro-fatores de forma individualizada para a região. Finalmente, uma estrutura de tomada de decisão com base em cenários de eletrificação rural nos países em desenvolvimento é sugerida, mostrando que é possível sustentar o processo de eletrificação rural a partir de fortes estruturas de financiamento e tecnologias disponíveis, mas a universalização do atendimento não terá prazo definido se não houver estruturas sólidas de governança e gestão em nível local.

Palvras-chave: Análise Sistêmica, Eletrificação Rural, Países em Desenvolvimento, Desenvolvimento local.

ABSTRACT

The present article, based on a systemic approach, analyzed rural electrification policies and programs in China and Brazil, two countries that have already reached 99% of the population receiving electricity in rural areas. This analysis was focused on four macro-factors (governance, funding, implementation and monitoring and technological available), which together collaborated in a positive or negative way for the evolutionary process of rural electrification policy. The study allowed to conclude that a clear priority was given to macro-factors funding (mainly public) and available technologies, which made possible the advances in rural electrification but undermined the reliability of the system and its relationship with local income generation processes. In the case of China local participation (utilities, energy and population) was observed, but with negative points for governance and monitoring. In the Brazilian case, the bottleneck remains the Amazon region, which requires structures based on the macro factors that are dimensioned for the region. Finally, a decision-making framework was set up based on scenarios for rural electrification in developing countries, showing that it is possible to maintain the rural electrification process from the strong funding structures and available technologies, but the deadline for universalization will have no set term if there are no solid structures of governance and management at the local level.

Keywords: Systemic Analysis, Rural Electrification, Developing Countries; Local Development.

1. CONTEXTUALIZATION

In 2014, according to a study by the International Energy Agency (IEA), there were around 1.1 billion people in the world without uninterrupted and reliable access to electricity. This situation should be a worldwide concern, especially since it is assumed that sustainable development will only occur endemically in all countries if broad access and financing is set up so as to guarantee, inter alia, the electricity service to nations which need it or may need it in the future. This condition was highlighted in the recent Sustainable Development Goals (SDGs) (Sachs, Schmidt-traub, & Durand-delacre, 2016).

In fact, the agenda adopted based on the SDGs suggests that attaining goals related to sustainable socioeconomic development,

social equity, and human rights is a basic prerequisite for permanently combating and eradicating extreme poverty worldwide. Consequently, an exclusive goal for the generation of electric energy from renewable energy sources is often presented in worldwide policies. This situation make it clear that rural electrification and sustainable development are inextricably linked in the same direction, being positively correlated, based on an institutional and global context.

Based on this idea, studies of alternative and clean forms of electric power generation, rural electrification, and distributed generation have become more profound and comprehensive, in recent years. For example, according to a survey conducted by (Schillebeeckx, Parikh, Bansal, & George, 2012), between 1990 and 2011, the number of articles in specialized journals using the keyword rural electrification as the main theme increased by 297% in this period.

This scenario has some external incentives, such as the rising scientific certainty about climate change. This increases the urge for the use of renewable energy sources and practices related to more energy security, such as reducing the weight of fossil fuels in the energy matrix of countries (United Nations, 2015). In spite of that, the main cause for the increase of policies and programs directed at rural electrification and the use of renewable sources in developing countries is economic, as is the case of Brazil and China. Both seek to reduce the distance between rural and urban development levels in order to increase income generation and improve the life quality of rural population and of the people who does not live in large urban centers (MME, 2015b; Shyu, 2012).

In these countries, electricity service provision has reached approximately 99% of their respective populations; however, this has neither resulted in a process of socioeconomic development nor in significant improvements in quality of life. According to IEA (2015a), based on data referring to 2012, concerning the use of renewable and less polluting sources for cooking, in China only about 17% of the rural population has access to non-solid fuels, while in Brazil this number is 66%. These examples suggest that only the availability of electricity to the population will not be sufficient to contribute to the diversification of the end uses of electricity and even less to the popularization of the use of other less polluting forms of energy, at least in the short term.

For these countries, the definition of initial priorities and the connection with broader policies and their own governance aspects were adopted with some success in electrification programs. In addition, because it was a public policy, they had the option of taking into account the efficiency and effectiveness of the process of electrification and universalization to propose and implement changes during its own validity. In other words, electrification programs are evaluated as successful, from their efficiency and effectiveness in view of the

universal service goal. However, when other expected impacts are taken into account, even though they are included as objectives within the programs themselves, the success of this policy becomes doubtful (Teixeira, Castañeda-Ayarza, Lopes, & Sampaio, 2015).

Therefore, an electrification program, when planned in accordance with objectives that consider the universalization of electric service in conjunction with socioeconomic development, should define clear and measurable objectives. Those should meet the initial intentions proposed, which could be:

i - To Make access to electricity universal. This refers to the absolute service, by increasing absolute numbers of residential connections; however, it does not necessarily takes into account the reliability of the electric network and the forecast of increase in demand and supply in the medium and long term;

ii - To Improve quality of life. This refers to improvements in aspects related to quality of life as a result of electrification, such as the use of a larger number of refrigerators, more hours of study, and modern and clean cooking methods; however, it does not necessarily means increases in levels of jobs and wages;

iii - To Integrate a framework conducive to socioeconomic development. This refers to quantitative and qualitative improvements in the quality of life and in aspects such as levels of employment and wages for the beneficiary population.

Electrification policies observe the breadth of possible outcomes as systematically attainable or influenceable effects. However, given the passive stance of public policies with a developmental bias, specially related to populations far from large urban centers or medium housing centers, in practice it is observed in most cases that only the first and/or the second choice of results is actually achieved (Bhattacharyya & Ohiare, 2012).

This limitation is directly related to the process of prioritization of the governmental sphere responsible for the policy, whether these definitions are imposed by conditions external to the process or not. By subordinating the electrification program to an exclusively policy of electrification, the agent responsible for formulating it will prioritize the generation of electric energy as an end goal, regardless of the quality of this supply or possible positive or negative externalities that the policy will have. Furthermore, by linking the process to the use of a single technology, one chooses to exclude the other technological options that may be applicable. This prioritization of one choice over another collaborates either to advance or to delay the progress of the electrification program.

Based on this scenario, the multi-objective policy analysis should consider the process of technical and political understanding, including priorities assumed about the adoption of specific forms of governance, definitions of technological options, and financing choices. Thus, there is a need for a systemic approach, which allows the decision-making process to distance itself from its usual generic character and also makes it replicable to other developing countries or realities.

From the systemic analysis of the Brazilian and Chinese experiences, the final objective of this article is to propose a decision making framework oriented to the policies of electrification, determining key points that make the process can be sustainable from the technological, financial and management structures points of view. It was also determined, from the evolution of the electrification process in both countries, scenarios for processes that ended in the universalization of electric energy service in rural areas.

In this way, this article is subdivided into six topics: a contextualization of the problem presenting the motivations; a topic describing the methodological process used; topics 3 and 4 that present the data and the respective analyzes of the electrification programs of China and Brazil; topic 5 that presents the comparative systemic analysis, showing scenarios for rural electrification from the case studies of China and Brazil; and finally the final considerations.

2. MATERIAL AND METHODS

The methodological process was outlined, firstly, through a comparative assessment (among political, regulatory, financing and technological decisions) between Brazil and Chine. After that, a decision-making framework directed to electrification policies was proposed.

In order to evaluate holistically the electrification program of Chine and Brazil, including variables related to quality of life and socioeconomic development, the following questions were suggested:

- Is it administratively sustainable? This question was raised and studied in the works of (Abdellah & Markandya, 2012, Aklin, Bayer, Harish, & Urpelainen, 2014, Andrade, Rosa, & Da Silva, 2011, Bazilian, Nakhooda, & Van de Graaf, 2014, Echeverri, Monga, Nakicenovic, & Schreck, 2013; Gómez & Silveira, 2015; Luo & Guo, 2013; Shyu, 2012);

- Is there available technology to be implemented and replicated? (Blum, Sryantoro Wakeling, & Schmidt, 2013; Fuso Nerini, Dargaville, Howells, & Bazilian, 2015; Fuso Nerini, Howells, Bazilian, 2015; Fuso

Nerini, Howells, Bazilian , And Gomez, 2014, Hirmer & Cruickshank, 2014, Holtmeyer, Wang, & Axelbaum, 2013, Lahimer et al., 2013, Mainali & Silveira, 2013, Poudyal & Paatero, 2014, Winkler et al., 2011, Zhaohong & Yanling , 2015);

- Is there available capital for necessary investments or for subsidies for the beneficiary population, given the magnitude of the program? This question was made in the following financing studies (Bazilian et al., 2011; Bhattacharyya, 2013; Delina, 2011; Gupta, 2016; IEA, 2011; Liming, 2009; Mainali & Silveira, 2011; Schillebeeckx et al., 2012; Ximei, Ming, Xu, Lilin, & JunRong, 2015);

- Was the population part of the procedure of formulating, implementing and managing the process and/or had any decision-making power that would collaborate with it? This was a central concern in the works of implementation of (Gómez & Silveira, 2010, 2015; Hirmer & Cruickshank, 2014; Parikh, Chaturvedi, & George, 2012; Poudyal & Paatero, 2014; Rojas-Zerpa & Yusta, 2015; Schillebeeckx et al (2005), Teixeira, Franco, & Litaiff, 2010, Van Els, De Souza Vianna, & Brazil, 2012, and Zerriffi, 2007).

Considering the questions above as the main points to be analyzed in this study, the method of joint evaluation of factors was used in this work (Bhattacharya, Paramati, Ozturk, & Bhattacharya, 2016; Schillebeeckx et al., 2012; Teixeira, 2010). These factors were called macro-factors and they converge toward the broadest goal of an electrification program, to promote the socioeconomic development.

Four macro-factors were defined: funding structures, governance structures, form of implementation and monitoring, and available technologies. Separately, these macro-factors were analyzed in a historical context for China and Brazil, justifying, in a systemic approach, the way adopted for the decision in each macro-factor. Then, the interactions between the four macro factors and the consequences on the final result of the rural electrification policy were analyzed.

Thus, the analysis will indicate four framing options for each macro-factor – governance, funding, technology and form of implementation and monitoring – indicating its importance in the process of rural electrification and socioeconomic development. Framing options and their degree of importance within rural electrification policy are:

1. It has no importance within the electrification policy;
2. It is contemplated, but has no/has little relevance;
3. It is relevant;
4. It is a key point.

Finally, systemic convergence analyzes the importance of the rural electrification process to boost socioeconomic development for the populations contemplated: it analyzes the degree of convergence of macro-factors to facilitate socioeconomic development for the regions included in government policies.

1. The policy is potentially relevant for aiding a process of socioeconomic development;

2. The policy is not relevant for aiding a process of socio-economic development.

Systemic analysis predicts that all factors participate in the process of socioeconomic development. Thus, in order to have minimum conditions, it is necessary that all factors are at least relevant, option 3, indicating, for systemic convergence, option 2, as follows in the table 1:

Table 1 - Systemic Analysis

Macro-factor	Framing options	Sistemic convergence
Governance	1. It has no importance within the electrification policy. 2. It is contemplated, but has no/has little relevance. 3. It is relevant. 4. It is a key point.	1. The policy is potentially relevant for aiding a process of socioeconomic development.
Funding		
Technology		2. The policy is not relevant for aiding a process of socio-economic development.
Form of Implementation and Monitoring		

The size of the forms that represent the macro-factors also served as an indicator of importance and priority of one over the other, providing clues about the decisions and objectives proposed by the government policy studied.

Next step was the preparation of a Figure with the main conclusions and recommendations of each macro-factor for Brazil and China, correlating the results with evolution and stage of rural electrification observed in each country. From the analysis of the interaction between the four macro factors, highlighting positive and negative aspects of the process in detail, it was possible to describe recommendations for rural electrification policies that have this three specific objectives: universalization, rural electrification or socioeconomic development.

The sequential structure of analysis is presented in the flowchart contained in Figure 1.

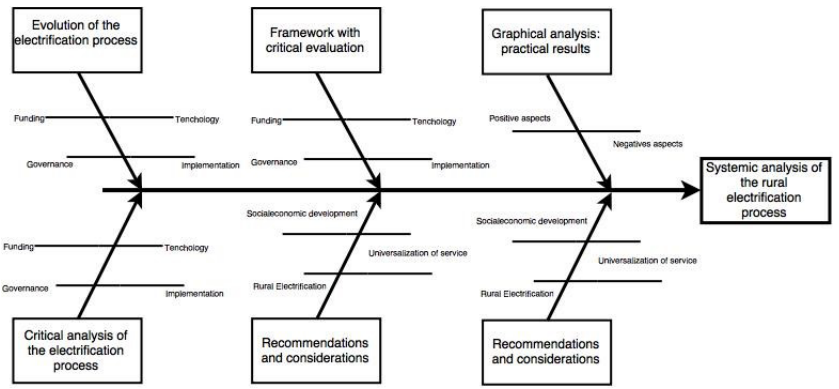

Figure 1 - Methodological structure

3. THE PROCESS OF RURAL ELECTRIFICATION IN CHINA

With a population of 1.3 billion people, much of it still living in small towns, China has unique characteristics regarding the process of rural electrification and its connection with economic development. Considering the size of the population, it is a remarkable achievement the implementation of a policy that universalized the electric service in urban areas and benefited 99% of the inhabitants of rural areas at the end of the first decade of the 2000's.

The policy for rural electrification in China, mainly after the economic reform of 1979 in the rural areas, establishes that the promotion of universal service, together with policies for the modernization of agriculture and the stimulation of the industrialization of cities and towns, is an opportunity to foster national industry and generate income. In addition, it promotes direct and indirect externalities for economic development at local, regional, and national levels (Bhattacharyya & Ohiare, 2012; Yisheng, Minying, & Zhen, 2004).

Out of a lot accumulated experience, the country started from a nonexistent electricity service in the rural areas in the 1950's to 99% of its population served in the 2000's (Bhattacharyya & Ohiare, 2012; Yisheng et al., 2004). Table 2 shows the main characteristics of the rural electrification policy in China from 1998 on.

Table 2 - Summary of the Main Characteristics of Rural Electrification Policy in China since 1998

Rural Electrification Policy in China from 1998 on	
Variable	**Characteristic**
Primary objective	Rural electrification and promotion of socioeconomic development for rural areas.
Main financial agents	Central Government directly. Development agencies, banks, and private initiative indirectly.
Type of policy formulation	Top-down: formulation by central government alone.
Type of policy application	Bottom-up: implementation by the concessionaires and local and provincial governments, with participation of the population involved if considering distributed generation.
Main points	Subsidized tariffs.
	Financing and stimulating the use of renewable sources.
	Financing economic activities.
	Financing the acquisition of autonomous systems of electric power generation.

Since 1998, the so-called Plan to renovate rural grids has been launched pursuing the goal of modernizing the structure of electric energy service in rural areas in locations already served, which would reduce system losses and provide more security and reliability to the system. Up to 32 billion euros was available for the plan, with a five--year completion date. Thus, in 2003, official data presented significant reductions in energy losses, below 10% for high voltage levels and below 12% for low voltage in rural networks (Bhattacharyya & Ohiare, 2012; Zhaohong & Yanling, 2015).

In 1999, the Brigthness Program was implemented, which lasted until 2002. The program initially served to implement pilot projects for the generation of electric power in a distributed way in isolated locations, opening comparative parameters for: forms of financing; possible sources of energy; generation and maintenance costs; and political governance of the process. Following the initial phase, the program was meant to reach up to 50,000 people in northern China and in the provinces of Mongolia, Tibet, and Gansu (Bhattacharyya & Ohiare, 2012; Zhaohong & Yanling, 2015). Through direct financing and subsidies, the central government made a contribution of 5.5 million euros to pilot projects and up to 1.3 billion euros for the remainder of the program's

duration (Bhattacharyya & Ohiare, 2012, Shyu, 2012).

Starting in 2002, with the first phase scheduled to last until 2005, the Township Electrification Program is launched as the largest rural electrification program in the world in terms of investments, financing, and number of electrical connections (Shyu, 2012; Zhang & Kumar, 2011). The problem was to adjust the policy so that towns and cities considered isolated in geographic terms could be contemplated with electrical energy in an uninterrupted and reliable way (Zhang & Kumar, 2011).

To do so, by taking advantage of the know-how acquired in previous programs, the central government in China considered for each case several distributed generation options, which stimulated mainly the use of renewable sources, such as: Small Hydroelectric Power Plants (SHPPs); photovoltaic systems; wind systems; hybrid systems, and small coal-fired thermals already used in some locations. In addition, the program suggested that the use of small networks where feasible. It was also stressed that the whole process should include productive activities and the local population as an interested party, as well as local governments and concessionaires - public or private – when they were present (Liming, 2009; Teixeira, Lopes, & KN Cavaliero, 2010).

The program's initial goal was to reach at least 1 million people in 1,000 districts in northern and western China, including the provinces of Xinjiang, Qinghai, Gansu, Shaanxi, Sichuan, Hunan, Yunnan, Tibet, and inland regions of Mongolia (Zhaohong & Yanling, 2015). In terms of individual electrical connection, it was stipulated as a goal the delivery of 100 watts per person safely and uninterrupted (Shyu, 2012).

By the end of 2005, another 600 million euros were made available by the central government to the program, making it possible to compute more than 1,000 districts, towns, and communities resulting in more than 1 million people contemplated in the program. Table 3 shows a summary of the amounts available for the 1998 to 2005 plans:

Table 3 - Summary of the amounts available for 1998-2005 plans

Program	Amounts in CNY (RMB)	Amounts in Euros
Brightness Programme (pilot projects)	40,000,000	5,575,200
Total Brightness Programme	9,880,000,000	1,377,074,400
Township Programme	4,700,000,000	655,086,000
Program and 1998 to 2003 renewal of the rural network (CYN/RMB)	230,000,000,000	32,057,400,000

*The Euro quotation of 01/28/2016 was the amount of 0.14 CNY (RMB);

Since 2005, plans have been focusing on reducing economic and social disparities between rural and urban areas, promoting rural electrification. In 2007, these plans resulted in the universalization of services in large and medium-sized cities and a level of service that reached over 99% of the population of geographically isolated villages and communities. All this process has been mostly supported by the central government (Luo & Guo, 2013). Table 4 shows the evolution of electrification in China.

Table 4 - History of the Rural Electrification Rate in China between 1978 and 2015

History of the Rural Electrification Rate in China (%)				
Index	**1978**	**1998**	**2010**	**2015**
Township	86.83	98.20	99.72	100
Village	61.05	98.10	99.76	100
Household	59.4	93.87	99.93	99.99

In recent programs, the massive use of renewable sources for distributed generation has been favored, interconnected or not to the national main network. Programs such as Village Electrification Program, which favored SHPPs, solar systems, and hybrid systems benefitted over 20 thousand villages with isolated electric power generation systems, between 2005 and 2010. According to Zhaohong & Yanling, 2015, this phase also counted on the support of international agencies in conjunction with the central government and local governments.

Based on the main data presented, a summary of the process of rural electrification in China can be assembled since 1998:

- Regarding funding: strong support from the central government, with smaller contributions of local governments, international development agencies, and private banks;

- Regarding the technology used: government incentives to universalize service and rural electrification directly, focusing on the massive use of SHPPs, photovoltaic systems, mini-coal plants and interconnection with the system, with renewable sources taking precedence over distributed generation;

- Regarding governance: policy formulation by central government, large participation of local governments, concessionaires, and cooperatives for electric power generation. In certain projects, participation

of the population, involved in choosing the technology for distributed generation;

- Regarding the form of implementation and monitoring: the greater responsibility is attributed to the concessionaires or governments responsible for the supply of electric power. They are also responsible for the maintenance and operation of the system and for possible increases in the amount of electric energy offered.

Table 5 - Summary of the Characteristics of the Electrification Process in China between 1998 and 2014

Summary of the electrification process in China from 1998 on	
Aspect Analyzed	**Values/References**
Governance	**Formulation:** central government; **Implementation:** concessionaires, cooperatives, and local governments; **Additional responsibilities:** the concessionaires and local governments are responsible for the generation and distribution of electric energy.
Funding	**Agent responsible:** Mostly by the central government directly (subsidies and direct specific financing lines); **Value (until 2005):** 34,095,135,600 (CNY/RMB).
Technology	**Initial priority:** extension of distribution and transmission lines. **Other features:** use of large-scale distributed generation for geographically isolated communities; great diffusion of the use of renewable sources after governmental stimulus.
Form of Implementation	**Main:** through several programs for rural electrification; **Responsible agents:** concessionaires, cooperatives, and local governments; **Other agents involved:** the beneficiary population participates in part of the process related to distributed generation; **Other features:** the electrification policy pertaining to a series of policies with the greater objective of promoting economic development.

3.1 Systemic analysis of the rural electrification process in China

Table 6 - Decision-Making Process - China

Decision-making process			
Macro-Factor	**Structure used**	**Decision-making process**	**Negative aspects**
Governance	Governance is poorly defined.	The structure chosen in the decision-making process provided more rapidity in the process of rural electrification. In addition, it involved the beneficiary population in specific parts of the process.	The governance focused on fast fulfillment of goals and creation of high numbers of electrical connections, result in problems of management, overlap, and lack of definition of skills for a second phase. Therefore, that delayed the fulfillment of the whole program and jeopardized the connection with other policies for rural development.
Funding	Mainly through public funding, including all government spheres.	It clearly defines the importance of public funding for increasing speed, notably where there is no economic attractiveness. In addition, it allowed the attraction (even to a lesser extent) of private capital, international development agencies, and banks.	There is criticism of the excessive level of subsidies, especially for renewable sources, not considering system maintenance needs and improvements in network (or mini-networks) quality.
Technology	Mainly through interconnection with the existing network; however, on the second stage, there is a great emphasis on distributed generation.	From an extensive and targeted government policy, it provided the rapid development of technologies to meet the needs of electrification in rural areas. It is a problem overcome in the Chinese case.	Only the absence of a clearer and more direct link with development in rural areas is highlighted.
Form of Implementation and Monitoring	articipation of all the agents involved and benefited in parts of the process.	It was favorable to the rapid increase in the number of electrical connections, with a strong emphasis on the participation of the beneficiary population in the stage of implementation and in case of distributed generation.	It has flaws related to the participation of all the agents involved, especially if the process is analyzed from a socioeconomic development perspective. Over focused on the implementation of electric energy; however, the monitoring and even the management and operation of the implanted systems was relegated to second place. Revisions are required.

The analysis of the macro-factors in Table 6 concluded that the decision-making processes were structured with a greater focus on the universalization of electric service. This preference has resulted in few clear and replicable interconnections for the promotion of improvements in the quality of life of the population (observed only in some cases) and socioeconomic development. This occurred even considering that the macro-factors had internal structures for these improvements and development to be performed, based on the productive use of electricity in rural areas.

It should also be noted that there are important consequences of the decision-making process, such as the development of industries and productive chains of technologies for the use of renewable sources; however, these are not directly related to a process of socioeconomic and local development for the rural environment.

3.2 The learning about the electrification decision-making process in China

The program for the universalization of electric energy and rural electrification in China has the most success on the decisions based on the learning regarding technological and financing aspects. The energy policy, which encompasses rural electrification, provided sufficient capital and technological alternatives to make the process moved on rapidly and to promote positive developments for the national industry, more specifically regarding renewable energies such as wind, solar, and small and medium-sized hydroelectric.

On the other hand, the process did not bring about significant changes in quality of life improvements and socioeconomic development at the local level, due mainly and coincidentally to the rapid advance of the new electric power connections provided by the rural electrification program. The large number of concessionaires and state-owned companies responsible for the generation and distribution of electric power, which since 1998 gained autonomy to carry out the process at local level, ended up harming the management of the program after the implementation phase. Moreover, this caused problems regarding the efficiency and quality of the network, such as constant power outages.

It should be stressed that this is a governance problem, which can be solved by applying clearer rules about the responsibilities of each agent in each stage of the process and by monitoring it. In fact, the universalization policy should propose a tariff structure that is as horizontal as possible, but that also includes differential tariffs or decreasing subsidies to attract private capital or to make the electric powe

supply efficient even for public and cooperative concessionaires.

It is also necessary to provide conditions for the maintenance of electric energy service in the Chinese countryside from the consumer's perspective. A more solid path is crucial for the generation of income in a sustainable way for the population served regardless of its location. The rural electrification program analyzed here proves that with a suitable financing structure and the use of available technologies, it is possible to provide infrastructure for socioeconomic development. This way, a new structure does not have to be built, but old ones can be modified and adapted to make improvements in quality of life and local development possible.

That is, if for the implementation process this structure was good enough, for management it was not the best choice, requiring at least better inspection and clear definitions of attributions regarding the management, maintenance, and operation of generation systems, especially when done in a distributed way. In 2015, these problems were obstacles to the effective use of electric energy as a vector for socioeconomic development in regions that are still behind.

In conclusion, the structure defined for China's rural electrification policy was more successful due to solid financing structures and technological choices than because of its structures for implementation, monitoring, and governance. The first two ended by leveraging the process while the latter worked as a brake on it, in 2015.

Finally, it is understood that the objective of harnessing electric energy as a vector for the promotion of economic development will only succeed if the process is integrated, offering the same weight for governance, form of implementation, and monitoring at the local level. Table 7 shows the integration of the macro-factors in a systemic analysis aimed at the socioeconomic development of the contemplated population.

Table 7 - Systemic Analysis of the Rural Electrification Process in China

Macro-Factor	Framing options	Sistemic Analisys
Governance	2. It is contemplated, but has no/has little relevance.	1. The policy is potentially relevant for aiding a process of socioeconomic development.
Funding	4. It is a key point.	
Technology	4. It is a key point.	
Form of Implementation and Monitoring	3. It is relevant.	

4. THE PROCESS OF RURAL ELECTRIFICATION IN BRAZIL

Rural electrification as a federal government policy came to prominence only in the 1990's. Previously, small programs and pilot projects under state enterprise responsibility had been observed; however, they had no significant impact in reducing the number of electrically excluded people. At the beginning of the 21st century, according to (IICA, 2011), there were around 10 million inhabitants without electricity. This number increased during the first decade, especially when isolated regions in the North of the country were taken into account. Before, there were no accurate socio-demographic data available about these regions.

From 2003 on, Brazil has started to rely on a policy focused on the universalization of electric energy service in the country, paying considerable attention to rural electrification. In 2015, the program known as the "Light for All Program (LfA)" has reached 99% of rural and urban residences (Teixeira et al., 2015).

Also noteworthy are the large number of electrical connections made from the extension of distribution lines in the first stage of the program and the strong commitment of privatized public service concessionaires. On the other hand, a large gap is observed regarding the scope of the program for the isolated systems in the Amazon region, the last frontier of LfA. This is the main point to be considered in this work, based on macro-factors analysis in tune with the decision-making process for the program.

The beginning of the 1990's saw the emergence of the first programs aimed at the provision of electricity in rural areas as a public policy. In this first moment, the main objective was to acquire technical, economic and political know-how. It was not yet practical to universalize the supply of electric energy for the whole population, be it rural or urban.

With regards to rural electrification, from 1990 on, the following stand out:

- The State and Municipal Energy Development Program (Prodeem) started in 1994, with the main objective of promoting the energy supply to isolated communities, specifically to institutions and community units, such as schools, health posts, associations, etc. The program made use of renewable energy sources available in each locality (SHPP, biomass, solar, and wind energy). According to (Viana, 2007), in practice it was verified the predominance of the installation of photovoltaic panels directed to water pumping and community lighting. After the beginning of the review, evaluation, and

restructuring of the program in 1998, management problems were noted, such as the ownership of solar panels installed in private areas. This showed and corroborated the power of large farmers in rural areas. In addition, another problem was evident as well as: maintenance. There were several unused photovoltaic systems and panels for complete lack of simple maintenance (Teixeira, 2010);

- The Program Light in the Countryside (PLC) started in 1999 and ran until 2002. Its main objective was of promoting the electrification of up to 4 million rural properties, mainly small and medium-sized enterprises, raising the level of service to 50% of the rural population until the end of the program. In essence, problems were observed in the governance process, with the absence of a central figure to manage, prioritize goals, and monitor the program. In addition, it was observed a capital lower than necessary for the full feasibility of the PLC (Teixeira, 2010; Viana, 2007).

4.1 The Program Light for All - LfA

Using the regulatory framework that was part of the Law 10,438/02, about the Universalization Program of electric energy service, and also of decree 223/03, which advanced the deadline for meeting the goal of universalization for the year 2008, LfA was officially created in 2003, by Law 4,873/03, amended by Law 10,762/03 and Decrees 7,250/11 and 8,387/2015 (MME, 2015a).

The main objective of the policy of universalization of electric energy service in Brazil was:

> guarantee access to the public electric energy service to the portion of the population of the Brazilian rural area that does not yet have access to this public service; improve service to the beneficiary population, increase the pace of service, and mitigate the potential tariff impact, through the allocation of subsidized resources and the complement of financed resources (MME, 2015a).

From then on, the government hoped to use electric energy as a vector of socioeconomic development, contributing to poverty reduction and increasing family income. They planned to extend distribution lines where there would be economic viability and the implementation

of decentralized generation systems, through isolated networks and individual systems (Teixeira, Lopes, & Cavaliero, 2010). To do so, the selected viability criteria made it possible to prioritize service projects based on the productive use of electric energy, the potential for fostering the integrated development of localities, and projects that allowed the development of family agriculture and even family-based handicraft activities (MME, 2015a).

According to the program, investments are made by the federal government, state governments and municipal governments, in addition to public and private electric energy concessionaires, when required or allowed. The participation of the three main actors, federal government, state governments and concessionaires were defined as being 80%, 10%, and 10% respectively. Executing agents should be concessionaires and licensees of electricity and, where appropriate, rural electrification cooperatives.

In 2009, the federal government extended the program until 2010 and, based on the Law 60/2009, decided to create what it called "special projects" within the LfA. These "projects" had the clear objective of providing attractiveness to the electrification process in the isolated systems of the northern region of Brazil. In these cases, although the implementation of the program progressed, the electrification of new localities, mainly isolated communities located in the Amazon region, was less than expected, totaling more than 100 thousand households not included in 2009. For the State of Amazonas, until 2008, only 24% of the total had been completed, without considering at this time the update in the number of people to be contemplated (Di Lascio & Barreto, 2009).

The "special projects" were characterized as projects geared to regions where it was not possible to extend transmission lines and that presented low levels of demand, such as isolated communities geographically located in the legal Amazon, allowing the incentive of distributed generation (MME, 2015a).

However, since the deadline for the universalization of electric energy service still remained the year of 2010, the program is renewed once again, including a regulation that allowed a more economically attractive division of costs among the agents involved in the program, especially when related to the "special projects", leading to energy auctions. It was also allowed to use the Fuel Consumption Account (FCA) for the reimbursement of generation costs not covered by original LfA resources (PRESIDÊNCIA DA REPÚBLICA - CASA CIVIL, 2011).

In all, the program completion period has been extended three times, aiming to provide new impetus for the achievement of goals in the regions with a long delay. The last extension, carried out at the end of 2014, foresees the termination of the LfA by the end of 2018. The goals

reached until 2015, the changes, and the expected goal until the end of the program are presented in Table 8.

Table 8 - Goals and Number of Families Reached by theProgram Light for All - 2004 to 2015

LfA service goals			
Goal change	**Goal completion year**	**Service goals/families**	**Increase in comparison with initial goal %**
	2008	2,000,000	
First	2010	1,000,000	50
Second	2014	715,939	35.8
Third	2018	207,000	10.4
	TOTAL Goal LfA	3,922,939	196.1
	Families reached up to July 2015	3,222,933	
	Balance for 2018	700,006	35
	Difference goal 2018/balance 2018	493,006	24.7

The annual data on the number of people benefited and the investment contracted in the program (Figure 2) show the great reach and exponential growth in the number of served families, mainly between the beginning of the program and the year 2010. In the following years, a reduction of service is observed. They were caused by the proximity of the final universalization goal and due to the technical and geographical difficulty in meeting the new demands detected.

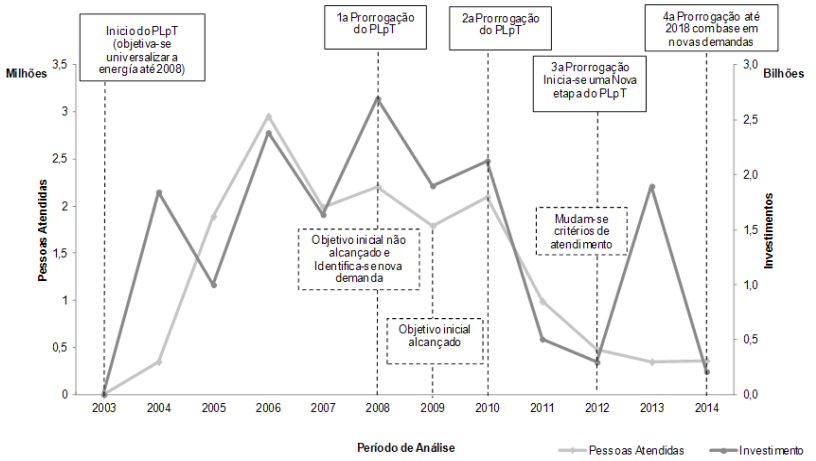

Figure 2 - Number of People Served and Investment Contracted under the LfA Program - 2004 to 2014

About tariff subsidies, no special tariff was provided for the duration of the LfA program. However, Brazilian legislation already includes and constantly revises special rates for low-income families, for rural properties and rural settlements. Moreover, considering a new regulation of 2010, it was possible to charge based on a prepaid electricity supply system, which although not directly included in the LfA legislation is directly related to it (Tavares, 2014).

The summary of the organization and structure of the program for rural electrification in Brazil is presented in Table 9:

Table 9 - Goals and Number of Families Reached by theProgram Light for All - 2004 to 2015

Rural electrification policy in Brazil since 2003	
Variable	**Characteristic**
Main objective	Universalization of electric energy service, including rural electrification and promotion of socioeconomic development for rural areas.
Main funding agent	Central Government directly, state governments directly, municipal governments with voluntary participation, public and private concessionaires directly, and development agencies and banks indirectly.
Type of policy formulation	Top-down: formulation by central government alone.

Table 9 - Goals and Number of Families Reached by theProgram Light for All - 2004 to 2015 (continuation)

Variable	Characteristic
Application type (implementation)	Top-down: implementation by public and private concessionaires, without the participation of the beneficiary population in the decision-making process and in no stage.
Main points	Indirectly subsidized rates.
	Financing and encouragement of the extension of distribution and transmission lines.
	Financing for renewable energy with indirect influence on the process.
	Amendment to contemplate distributed generation applicable to isolated systems.

4.1.1 Systemic Analysis of the process of rural electrification in Brazil

Table 10 shows the political structure of the process of rural electrification in Brazil.

Table 10 - Decision-Making Process - Brazil

Decision-making process - Brazil			
Macro-Factor	**Structure used**	**Decision-making process**	**Negative aspects**
Governance	The governance is public and private. In both cases, it is well defined.	The decision-making process for governance counted on the participation of private initiative and government spheres. It was structured in such a way as to provide management, implementation, and monitoring in a well-defined way. To reach levels close to the universalization of electric energy service.	The established governance neglected different realities from that observed in most of the national territory or of the interconnected system. Doing this institutionally until 2009, the governance delayed and underestimated the organization needed to stimulate rural electrification in areas far from urban centers, such as isolated systems in the northern region of the country.

Table 10 - Decision-Making Process - Brazil (continuation)

Macro-Factor	Structure used	Decision-making process	Negative aspects
Funding	The goal of 99% of urban and rural population was reached in the expansion phase of the interconnected network, that is, the process was carried out mainly through the interconnection with the existing network.	The decision-making process for the macro--factor "funding" elected the government as a great guarantor of the process, guaranteeing necessary inputs for its rapid progress. This was mainly done with the purpose that the LfA reached economically unattractive regions, which in fact occurred, as long as these regions belonged to the interconnected system.	The macro-factor "funding" needs to be reformulated to incorporate attractiveness to the isolated systems, since even including direct funding for the implementation phases and operation and maintenance costs, the advancement of the electrification process in the isolated systems was not observed.
Technology	The process was led by contributions from the government spheres, but also conditioned to the participation of private concessionaires.	For much of the Brazilian territory the technological option was the interconnection with the existing system. The decision was based on the fact that the system is already structured, in addition to providing a rapid evolution in the number of families served.	The stimulus to the use of distributed generation for isolated systems exists, but it is not good enough for it to be used. The program should be restructured again, reviewing aspects of funding and governance for isolated systems.
Form of Implementation and Monitoring	With most of the connections being the responsibility of the concessionaires, due to the extension of the interconnected system, there was no decisive participation of all the agents involved in the process, especially the absence of the beneficiary population in cases of distributed generation.	The participation of all agents in the implementation process in the case of the interconnected system is not necessary. This portion of the service representing the majority of the families reached indicates that the form of implementation and monitoring adopted, at least for the first stages, and directed to the interconnected system, was the correct one.	For the isolated systems, the form of implantation must involve all agents, incorporating criteria directed to improvements in quality of life and socioeconomic development.

In Table 10 is should be noted that the decision-making process clearly precluded isolated systems in the early stages of the program. The government tried to work around the problem in the following phases, from 2010 onwards. This scenario has relegated isolated systems to the background. They still need, in 2016, new and differentiated

structures of attraction of private investment or of governance that allows a greater number of connections (Gomez and Silveira, 2010) (Teixeira et al, 2015).

4.1.2 The learning about the electrification decision-making process in Brazil

The systemic analysis of the rural electrification process in Brazil shows that the program has valued the four macro-factors approximately, similarly, presenting a slight preference for financing and technology structures. But this scenario it was reached only when the Brazilian integrated system is analyzed, without the inclusion of distributed generation, the program developed satisfactorily (Table 11).

Table 11 - Structure of Systemic Analysis for the Electrification Process in Brazil: Interconnected System

Macro-Factor	Framing options	Systemic Analysis
Governance	3. It is relevant.	1. The policy is potentially relevant for aiding a process of socioeconomic development.
Funding	4. It is a key point.	
Technology	4. It is a key point.	
Form of Implementation and Monitoring	3. It is relevant.	

In Table 11 and 12 is noted that efforts to structure and maturate the macro-factors “technology” and “funding” were fundamental in achieving the program’s electric service goals. In addition, they were essential, to a large extent, for the universalization of electric energy service; however, they were not enough for the objective of promoting socioeconomic development. This will only be achieved by also strengthening the structures of “governance” and “form of implementation and monitoring”.

In the analysis, when the isolated systems were included, even after the adaptation of the program, a better adjustment towards the socioeconomic development was not obtained. This is because the proposed structures were not enough. Table 12shows that the electrification was initiated but did not evolve satisfactorily.

Table 12 - Structure of Systemic Analysis for the Electrification Process in Brazil: Isolated Systems

Macro-Factor	Framing options	Systemic Analysis
Governance	2. It is contemplated, but has no/has little relevance.	2. The policy is not relevant for aiding a process of socio-economic development.
Funding	3. It is relevant.	
Technology	4. It is a key point.	
Form of Implementation and Monitoring	2. It is contemplated, but has no/has little relevance.	

5. STRUCTURE FOR THE CREATION OF RURAL ELECTRIFICATION PROGRAMS INTEGRATED WITH THE GOAL OF SUSTAINABLE DEVELOPMENT IN DEVELOPING COUNTRIES

Based on the systemic analysis carried out for the cases of Brazil and China, there is a series of needs and problems inherent to the process of rural electrification considering four macro-factors: governance, funding, technology, and form of implementation and monitoring.

The evolution of electrification programs in Brazil and China made it possible to observe the importance of the political structure used to universalize the electric service, especially in rural areas. However, given the challenge of promoting socioeconomic development, priority should be given to the integration of electrification policies and the promotion of income generation. This should be done, to a certain extent, by providing a shorter time frame for socioeconomic development to be completed, like in certain regions of Brazil and China.

The scenarios presented in the early 2000's and even earlier, including qualitative and quantitative factors for the definition of rural electrification policies, were optimistic about the success of creating an economic development process. However, contrary to what was proposed, the electrification process indicates segregated and consecutive public policies for electric energy to emerge effectively as a vector for socioeconomic development.

That is why an electrification program should consider in its structure the four macro-factors: governance, funding, technology,

and form of implantation and monitoring. These should be aligned and hierarchized according to the characteristics of the place or region where it will be implemented.

5.1 Funding and technology structures: priority scenarios for universal service and rural electrification

"Funding" and "technology" structures are the key macro-factors to begin the process of universalization of rural electrification or to gain momentum, as evidenced in the learning process and in the successful evolution of policies and programs in Brazil and China.

The structure set up by both countries favors direct public financing, but private capital participation is not negligible. Based on that, it can be concluded that the greater the government support, either by providing solid structures for private funding or directly supporting, the greater the scope and the speed with which the process will evolve.

Regarding the "technology" macro-factor, a large range of available alternatives increases the amplitude and the speed of the program advance in terms of number of electrical connections. Given available options, including forms of funding, practical applicability is a matter of choice.

The distance between rural electrification policy and other policies, as shown in the cases studied, underlies its structure and conditions its success to the efficiency of the macro-factors "funding" and "technology". That is, the difficulties of managing the systems as soon as they were implemented in Brazil and China have prevented or delayed the evolution of the electrification process, sometimes forcing the prioritization of the number of connections to the detriment of quality of service. This was just made to reach the goals regarding the number of new services.

In addition, it is understood that prioritizing the number of connections over quality negatively influences other expected effects, such as increasing income generation and improving quality of life. This will eventually happen, even though the management of an electrification program towards the trade-off - making new connections or promoting improvements in the quality of life - will opt for the first alternative, especially when the beginning of the program depends on this decision.

Also, based on the line of priorities mentioned before, it can be seen that in other countries, where rural electrification and even electricity supply are not a social reality, there are no political structures that would be able to lead to:

- External funding from private capital.

- Well-defined governance structures, with clear goals and objectives, since there are no previous programs and policies, and there is no previous know-how about government and concessionaire structures to manage the electrification process in rural areas, especially at local and specific levels. That is, there is no clear definition of private financing structures also at a domestic level.

- Political and social maturation to promote the participation of the beneficiary population in the process, both in terms of the supply of raw material for electric power generation and for the use of local potential for income generation.

- The definition and selection of technologies for the universalization of rural electrification and electric service. They are incomplete or limited, although available in specific projects and financing. That is, there are not enough alternatives for each situation, especially with regards to distributed generation.

In those cases, it is preferable to start the process from a qualitative increase of electrical connections, even if it just serves for a short learning process. That is, the formulation of realistic policies and programs should be preferred rather than projects with unattainable objectives. In other words, energy programs can be constructed considering three medium-term scenarios, based on the know-how developed in Brazil and China, within a period of 10 to 20 years.

Scenario 1 with realistic funding structures, even if they are mostly or exclusively public, but which provide security for the beginning and development of the process. Furthermore, the definition of technological structures for primarily economic processes, by providing adequate alternatives to the current reality, even if these technologies are not initially available in the domestic market. Considering this configuration, the probable outcome is an increase in the absolute number of connections, neglecting problems of system reliability in the medium term, as well as uncertainties regarding the governance, including the tariff structure (Figure 3).

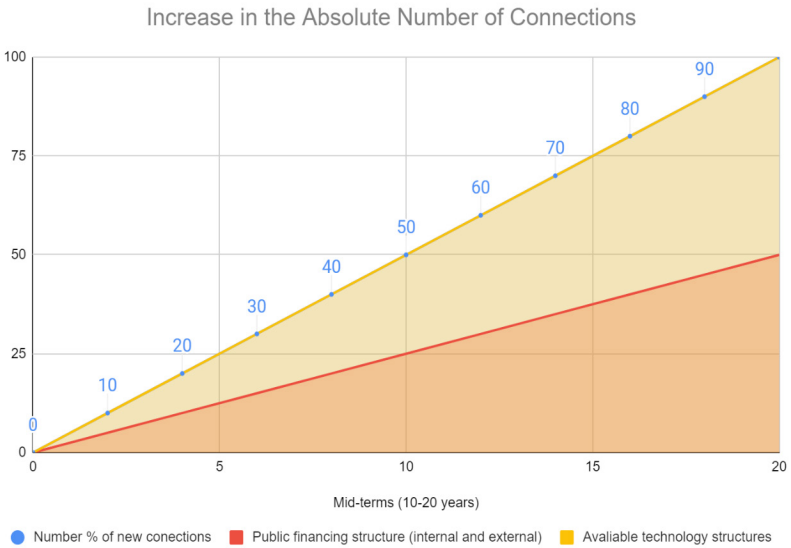

Figure 3 - Increase in the Absolute Number of Connections in the Electrification Process (Funding + Technology)

- Possible issues: system reliability and governance issues.

Unbalanced “funding” and “technology” structures may lead to regulatory uncertainties in financing, insufficient amounts of capital, and lack of commitment from government spheres. From the technological perspective, it can also result in lack of definition of incentive structures and no selection of the appropriate technologies. In this case, even the absolute increase in the number of connections may not happen, since such uncertainties result in discontinuation of investments (even public ones) and shutdowns of programs in progress.

In general, such scenarios are those currently observed in several countries that have not yet developed an internal and mature policy of universal service and rural electrification.

In Scenario 2, it is concluded that by providing few funding structures (or unreliable structures), even considering the structures of technology selection well developed, the number of new services will not be satisfactory. This is mainly because, in terms of distributed generation, the process will be stagnant if there is not strong involvement of government spheres acting as funding agencies (Figure 4).

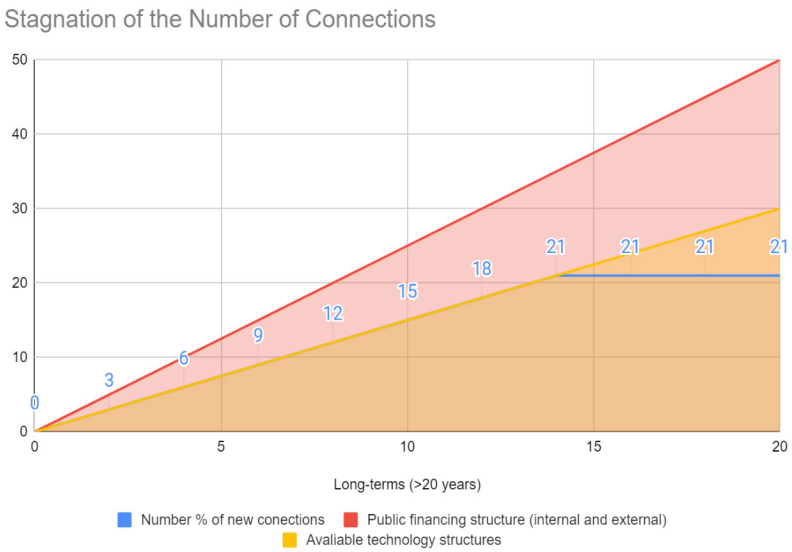

Figure 4 - Stagnation of the Absolute Number of Connections - Larger Weight for Technology

- Possible issues: Without large-scale financing structures, although with available technologies, there will be a long term for the universalization of electric energy service.

Likewise, Scenario 3 shows a stagnation because of weak and unavailable structures of technology selection. Therefore, it presents a small number of new connections even if there are consolidated (internal or external) financing structures, since the absence of suitable technologies for each situation makes it impossible to provide distributed generation in rural regions (Figure 5).

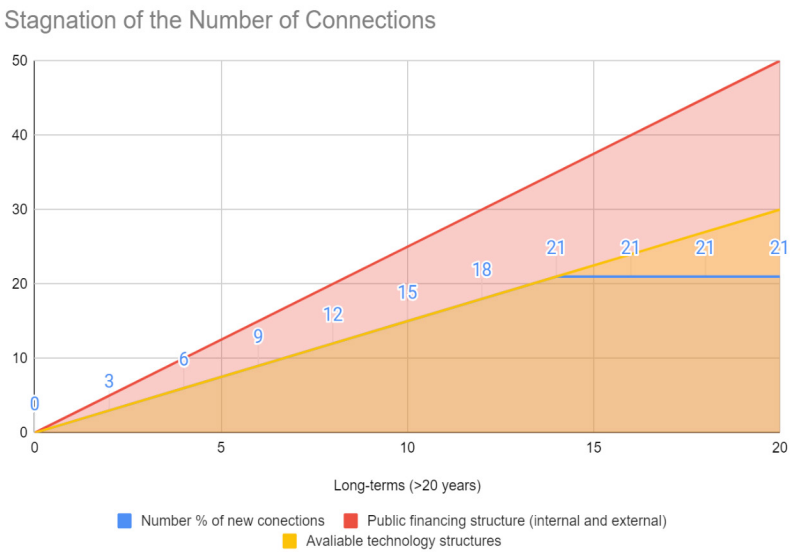

Figure 5 - Stagnation of the Number of Connections - Larger Weight for Funding

- Possible issues: Without available technologies, but with funding structures, there is an indefinite deadline for completing the process.

5.2 Governance, implementation and monitoring structures: scenarios for expanding the objectives of rural electrification

The adoption of structures that allow for the participation of the beneficiary population, government, and private enterprises, in addition to economic planning through a clear and well-defined policy directly encourages the symbiosis between the energy policy focused on rural electrification and other policies to promote socioeconomic development.

The electrification process in Brazil and China have presented cases in which the macro-factors were unbalanced, resulting in electrification, but not in socioeconomic development.

Thus, if on the one hand the use of reliable financing structures and the expansion of the range of technologies available for the electrification process lead to a large number of people served in the short and medium term, on the other hand, the use of electric energy as a vector to the beginning and development of a process of income generation at the local level was not observed. This occurred even assuming that the horizons of implantation of the electrification process and observable changes in terms of socioeconomic development are different, and that more time is needed to observe substantial changes in socioeconomic development.

The problem of the practical application of the rural electrification program occurs because providing the same level of importance to implementation and monitoring structures does not depend exclusively on the formulation of the program. Even if the program is modified and adapted to contemplate new realities, such as isolated localities (Brazil) and forms of distributed generation (China), the changes will not be enough if there is no linkage of the electric policy with other policies for income generation and local development.

This is the main reason why this macro-factor does not directly influence the progress of the electrification process. It is not directly linked to this process, because it has in its roots aspects that, if on the one hand are also goals of the process of electrification, on the other, do not depend on it to happen.

Consequently, the macro-factor “form of implementation and monitoring” should have the same weight and importance since the beginning of the process, as long as this process clearly includes interconnections with other public policies and objectives besides electrification, that is, if rural electrification is included in a larger policy for local and regional development. Otherwise, as observed in the case studies, this macro-factor can be left to a second stage. Therefore, as observed in the previous topic, this would lead to a rural electrification program with an increase in the absolute number of connections, without positive results regarding the creation of income locally.

As for the last macro-factor, “governance”, in an analogous way, its integration will indicate the sustainability of the process, as well as provide bases for the monitoring to be carried out, including structures of a PIR in its essence. In the cases of Brazil and China, it was noticed that well-defined governance structures guarantee these aspects to the rural electrification program. Specifically, in the case of Brazil, it was also noticed an increase of the number of connections in a sustainable way.

In the absence of long-term governance-related agenda, as well as a lack of clear definitions of responsibilities after the implementation of electricity generation, the process is bound to cope with structural problems. For example: lack of system reliability, which results in

constant power shutdowns. In addition, poor governance policies also lead to undefined tariffs, which cause distrust to final consumers, alienating potential investors, such as private capital. This scenario, in addition to delaying the progress of the rural electrification program, leads to a lack of definition that impairs the beginning or maturation of a process of income generation and socioeconomic development, since the structures necessary for it to start become unreliable and have no guarantees in terms of governance that will be achieved.

These governance structures should be associated with improvements in the quality of life. By considering the sustainability of the rural electrification process after the implementation of electric energy, it would be ensured that residential electricity would be sufficient for the use of refrigerators for food preservation, the use of radios and televisions for entertainment, more study hours at night, and even the use of washing machines and machines able to heat or cool the house. It is noteworthy that these elements, while indicating clear improvements in quality of life, do not necessarily indicate a socioeconomic development in a sustainable manner, such as an increase in the income levels.

Like the macro-factor “form of implementation and monitoring”, the absence of clear and defined governance structures will not make the rural electrification process unfeasible, especially when the process is finalized at the moment of the electric power supply. However, by associating the process with a higher level of efficiency, with attracting private capital, and with a process of socioeconomic development, this macro factor should have the same weight as the others. Its importance should be well-defined and carefully applied since the beginning of the rural electrification program formulation, whether linked to an energy policy or to broader local development policies.

Finally, from a systemic point of view, it is possible to conclude that the process of rural electrification can be initiated and supported by well-defined financing structures, whether public or private, and by the technological options available for each case, especially regarding the interconnection with an existing network or distributed generation. This should happen if the process is associated only with an increase in the absolute number of connections and terminated at the beginning of the electric power generation.

However, the rural electrification program designed in this way will present structural problems such as lack of definition of tariffs, lack of medium- and long-term planning, and interruptions in the supply of electricity due to low load sizing for the system, etc. This will cause low reliability of the electrification process and will alienate the private capital necessary to socioeconomic development.

Aiming at the sustainability of the program and the possibility of achieving objectives related to the improvement of quality of life and socioeconomic development, the four macro-factors must be integrated

and given equal importance: “funding”, “technology”, “governance”, and “form of implementation and monitoring”. It is expected that since the planning stage the government defines clear responsibilities, a correct load sizing, fair electric energy tariffs, and the plan to expand the networks prioritizing the reliability of the system.

Furthermore, in addition to promoting a program based on the integration of the four macro-factors, the connection of the electrification program with other development policies will also be necessary. Figure 6 summarizes the model considering the four macro-factors analyzed in this study, as well as their influence overall process.

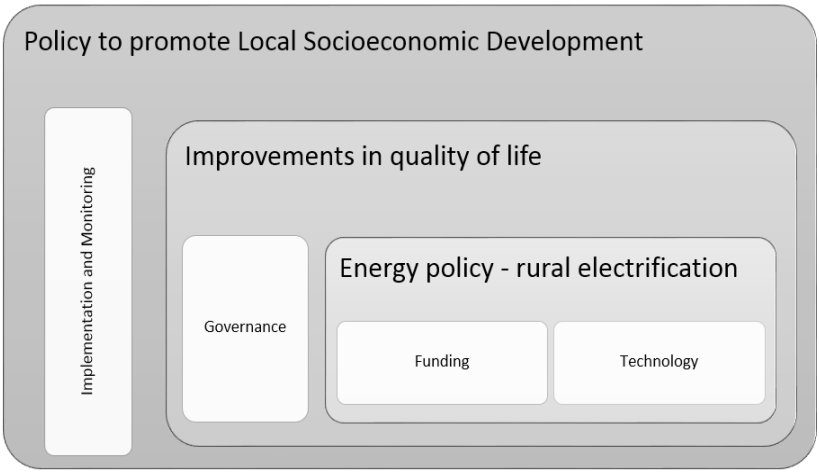

Figure 6 - Implementation Model Based on the Macro-Factors Studied

6. COMMENTS AND FINAL CONSIDERATIONS

The inclusion of a rural electrification program, of a program to provide universalization of electric energy service, and even the association of an energy policy to policies for sustainable socioeconomic development for developing countries are much desired. However, these are tasks of great complexity, since for most countries that need to start rural electrification processes (and even urban electrification), funding and governance structures are not well-developed. They only have isolated projects and specific programs, which are mostly maintained by international aid and financing structures, such as the World Bank and non-governmental organizations.

In these cases, governments consider promoting electrification processes in all possible ways, instead of structuring and implementing an ambitious policy for the promotion of socioeconomic development in rural areas. These results, initially, in the increase in the absolute number of electrical connections, making the electrification program a goal of the electric policy.

However, as noted, the lack of maturation of political organizations, and financial and technological structures lead to this path, leaving no other alternative. Of course, absolute numbers will be considered, but the quality of the service, the financial efficiency of the program, and the management and maintenance of these programs will fail and may potentially make the program unfeasible, as observed previously.

It is also worth noting that, even though rural electrification is generally related to development processes in the future, the absence of adequate structures for the rural electrification program during its creation makes this symbiosis unfeasible. This eventually leads to further delays and more inefficiencies, making the program ineffective to promote a process of income generation and economic development, serving at best for improvements in quality of life for the beneficiary population.

It is concluded that the four structures analyzed have the potential to include the process of rural electrification in a major development policy, if implemented in a balanced way in conjunction with other policies, with clear definitions of financing, technological options, tariff structures, management, and maintenance. Nevertheless, such interconnection must be organized and structured early in the formulation of the energy policy, including the rural electrification process. In addition, rural electrification should also be subordinated to a major policy with clear rules and definitions for promotion of local and/or rural socio-economic development, depending on each case.

REFERENCES

ABDULLAH, S., & MARKANDYA, A. (2012). Rural electrification programmes in Kenya: Policy conclusions from a valuation study. Energy for Sustainable Development, 16(1), 103–110.

AKLIN, M., BAYER, P., HARISH, S. P., & URPELAINEN, J. (2014). Information and energy policy preferences: a survey experiment on public opinion about electricity pricing reform in rural India. Economics of Governance, 15(4), 305–327.

ANDRADE, C. S., ROSA, L. P., & DA SILVA, N. F. (2011). Generation of electric energy in isolated rural communities in the Amazon Region a proposal for the autonomy and sustainability of the local populations. Renewable and Sustainable Energy Reviews, 15(1), 493–503.

BAZILIAN, M., NAKHOODA, S., & VAN DE GRAAF, T. (2014). Energy governance and poverty. Energy Research & Social Science, 1, 217–225.

BAZILIAN, M., NUSSBAUMER, P., GUALBERTI, G., HAITES, E., LEVI, M., SIEGEL, J., FENHANN, J. (2011). Informing the Financing of Universal Energy Access: An Assessment of Current Financial Flows. Electricity Journal, 24(7), 57–82.

BHATTACHARYA, M., PARAMATI, S. R., OZTURK, I., & BHATTACHARYA, S. (2016). The effect of renewable energy consumption on economic growth: Evidence from top 38 countries. Applied Energy, 162.

BHATTACHARYYA, S. C. (2013). Financing energy access and off--grid electrification: A review of status, options and challenges. Renewable and Sustainable Energy Reviews, 20, 462–472.

BHATTACHARYYA, S. C., OHIARE, S. (2012). The Chinese electricity access model for rural electrification: Approach, experience and lessons for others. Energy Policy, 49, 676–687.

BLUM, N. U., Sryantoro Wakeling, R., & Schmidt, T. S. (2013). Rural electrification through village grids—Assessing the cost competitiveness of isolated renewable energy technologies in Indonesia. Renewable and Sustainable Energy Reviews, 22, 482–496.

DELINA, L. L. (2011). Clean energy financing at Asian Development Bank. Energy for Sustainable Development, 15(2), 195–199.

DI LASCIO, M. A. ., & BARRETO, E. J. F. (2009). Energia e Desenvolvimento Sustentável para a Amazônia Rural Brasileira: Eletrificação de Comunidades Isoladas. Brasília.

ECHEVERRI, L. G., Monga, P., Nakicenovic, N., & Schreck, B. (2013). Access to Modern Energy Assessment and Outlook for Developing and Emerging Regions.

EIA, E. I. A. (2015). China international energy data and analysis (Vol. 2015). Retrieved from http://www.eia.gov/beta/international/analysis_includes/countries_long/China/china.pdf

FUSO NERINI, F., DARGAVILLE, R., HOWELLS, M., & BAZILIAN, M. (2015). Estimating the cost of energy access: The case of the village of Suro Craic in Timor Leste. Energy, 79, 385–397.

FUSO NERINI, F., HOWELLS, M., BAZILIAN, M., & GOMEZ, M. F. (2014). Rural electrification options in the Brazilian Amazon. Energy for Sustainable Development, 20, 36–48.

GÓMEZ, M. F., & SILVEIRA, S. (2010). Rural electrification of the Brazilian Amazon - achievements and lessons. Energy Policy, 38(10), 6251–6260.

GÓMEZ, M. F., & SILVEIRA, S. (2015). The last mile in the Brazilian Amazon – A potential pathway for universal electricity access. Energy Policy, 82, 23–37.

GUPTA, A. (2016). Handbook of Environmental and Sustainable Finance. Handbook of Environmental and Sustainable Finance. Elsevier.

HIRMER, S., & CRUICKSHANK, H. (2014). The user-value of rural electrification: An analysis and adoption of existing models and theories. Renewable and Sustainable Energy Reviews, 34, 145–154.

HOLTMEYER, M. L., WANG, S., & AXELBAUM, R. L. (2013). Considerations for decision-making on distributed power generation in rural areas. Energy Policy, 63, 708–715.

IEA, I. E. A. (2011). Energy for All: Financing access for the poor (Special early excerpt of the World Energy Outlook 2011). World Energy Outlook 2011. Retrieved from http://www.iea.org/media/weowebsite/energydevelopment/weo2011_energy_for_all-1.pdf

IEA, I. E. A. (2015a). World Energy Outlook: Biomass database (2015).

IEA, I. E. A. (2015b). World Energy Outlook: Electricity database (2015).

IICA. (2011). Universalização do acesso e uso da energia elétrica no meio rural brasileiro: lições do Programa Luz para Todos. (F. Tallarico, Ed.), … Río de Janeiro (Brasil …. Retrieved from http://orton.catie.ac.cr/cgi-bin/wxis.exe/?IsisScript=iicacr.xis&B1=Buscar&formato=2&cantidad=50&expresion=ENERGIA ELECTRICA

LAHIMER, A. A., ALGHOUL, M. A., YOUSIF, F., RAZYKOV, T. M., AMIN, N., & SOPIAN, K. (2013). Research and development aspects on decentralized electrification options for rural household. Renewable and Sustainable Energy Reviews, 24, 314–324.

LIMING, H. (2009). Financing rural renewable energy: A comparison between China and India. Renewable and Sustainable Energy Reviews, 13(5), 1096–1103.

LIU, H., ESSER, L. J., & WHITING, K. (2013). Realising Rio principles through sustainable energy solutions: Application of small hydropower (SHP) in China and other developing countries. International Journal of Technology Management & Sustainable Development, 12(3), 281–300.

LUO, G., & GUO, Y. (2013). Rural electrification in China: A policy and institutional analysis. Renewable and Sustainable Energy Reviews, 23, 320–329.

MAINALI, B., & SILVEIRA, S. (2011). Financing off-grid rural electrification: Country case Nepal. Energy, 36(4), 2194–2201.

MAINALI, B., & SILVEIRA, S. (2013). Alternative pathways for providing access to electricity in developing countries. Renewable Energy, 57, 299–310.

MME, M. das M. e E. (2015a). Programa Luz para Todos: legislação. Brasilía. Retrieved from http://luzparatodos.mme.gov.br/luzparatodos/Asp/legislacao.asp

MME, M. das M. e E. (2015b). Resultados Luz para Todos 2015. Governo Do Brasil.

PARIKH, P., CHATURVEDI, S., & GEORGE, G. (2012). Empowering change: The effects of energy provision on individual aspirations in slum communities. Energy Policy, 50, 477–485.

PORTAL BRASIL. (2015). Programa Luz para Todos é prorrogado até 2018. Retrieved September 18, 2015, from http://www.brasil.gov.br/infraestrutura/2015/01/programa-luz-para-todos-e-prorrogado-ate-2018.

POUDYAL, a., & PAATERO, J. V. (2014). Rural Energy Modeling and Planning: A Review on Tools and Methodology. Bulletin of Science, Technology & Society, 33(5–6), 191–197.

PRESIDÊNCIA DA REPÚBLICA CASA CIVIL. (2011). Decreto n. 7.520. Retrieved August 30, 2015, from https://www.planalto.gov.br/ccivil_03/_Ato2011-2014/2011/Decreto/D7520.htm

ROJAS-ZERPA, J. C., & YUSTA, J. M. (2015). Application of multicriteria decision methods for electric supply planning in rural and remote areas. Renewable and Sustainable Energy Reviews, 52, 557–571.

SACHS, J. D., SCHMIDT-TRAUB, G., & DURAND-DELACRE, D. (2016). Preliminary Sustainable Development Goal (SDG) Index and Dashboard.

SCHILLEBEECKX, S. J. D., PARIKH, P., BANSAL, R., & GEORGE, G. (2012). An integrated framework for rural electrification: Adopting a user-centric approach to business model development. Energy Policy, 48, 687–697.

SHYU, C. W. (2012). Rural electrification program with renewable energy sources: An analysis of China's Township Electrification Program. Energy Policy, 51, 842–853.

TAVARES, M. (2014). Saem as regras da Aneel para consumidor comprar energia pré-paga. Retrieved May 25, 2016, from http://oglobo.globo.com/economia/saem-as-regras-da-aneel-para-consumidor-comprar-energia-pre-paga-12470297

TEIXEIRA, A. F. (2010). Elementos do Desenvolvimento Endógeno e do Planejamento Integrado de Recursos para a Eletrificação de Comunidades Isoladas : estudo de caso em Pico do Amor / MT Elementos do Desenvolvimento Endógeno e do Planejamento Integrado de Recursos para a Eletrific. Universidade Estadual de Campinas (UNICAMP).

TEIXEIRA, A. F., CASTAÑEDA-AYARZA, J. A., LOPES, D. G., & SAMPAIO, G. P. (2015). A Evolução e o Aprendizado da Política de Universalização de Energia Eletrica no Brasil para o Período de 2004 a 2015 (Vol. 2015).

TEIXEIRA, A. F., FRANCO, S., & LITAIFF, A. (2010). Artigo Elementos de um modelo de desenvolvimento endógeno aplicáveis ao aproveitamento de potencialidades locais para as comunidades isoladas da Região Amazônica1, (February), 62–66.

TEIXEIRA, A. F., LOPES, D. G., & CAVALIERO, C. K. N. (2010). Uma Análise Crítica do Programa Luz Para Todos para a Eletrificação de Comunidades Isoladas na Região Amazônica. Anais Do VII Congresso Brasileiro de Planejamento Energético.

TEIXEIRA, A. F., LOPES, D. G., & K N CAVALIERO, C. (2010). Programas de eletrificação para comunidades isoladas : uma análise a partir de casos específicos de Brasil , China , Índia e Tanzânia. In 8. Encontro de Energia no Meio Rural e Geração Distribuída (p. n/d). Campinas/ SP.

UNITED NATIONS. (2015). The Millennium Development Goals Report. United Nations. Retrieved from https://visit.un.org/millenniumgoals/2008highlevel/pdf/MDG_Report_2008_Addendum.pdf

VAN ELS, R. H., DE SOUZA VIANNA, J. N., & BRASIL, A. C. P. (2012). The Brazilian experience of rural electrification in the Amazon with decentralized generation - The need to change the paradigm from electrification to development. Renewable and Sustainable Energy Reviews, 16(3), 1450–1461.

VIANA, F. G. (2007). Luz no Campo e Luz para Todos:duas experiências em busca da plena universalização dos serviços de energia elétrica no Brasil. PCH Notícias & SHP News, 34(9), 12–18. Retrieved from http://cerpch.unifei.edu.br/wp-content/uploads/revistas/revista-34.pdf#page=12

WINKLER, H., SIM??ES, A. F., ROVERE, E. L. la, ALAM, M., RAHMAN, A., & MWAKASONDA, S. (2011). Access and Affordability of Electricity in Developing Countries. World Development, 39(6), 1037–1050.

XIMEI, L., MING, Z., XU, H., LILIN, P., & JUNRONG, D. (2015). Small hydropower financing in China: External environment analyses, financing modes and problems with solutions. Renewable and Sustainable Energy Reviews, 48, 813–824.

YISHENG, Z., MINYING, Y., & ZHEN, S. (2004). Rural Energy Policy in China. Energy, 1–20. Retrieved from http://iis-db.stanford.edu/evnts/3920/ZHENG_paper.pdf

ZERRIFFI, H. (2007). Making Small Work : Business Models for Electrifying the World. Retrieved from http://pesd.fsi.stanford.edu/sites/default/files/WP63,_Zerriffi,_Making_Small_Work_20070926.pdf

ZHANG, X., & KUMAR, A. (2011). Evaluating renewable energy-based rural electrification program in western China: Emerging problems and possible scenarios. Renewable and Sustainable Energy Reviews, 15(1), 773–779.

ZHAOHONG, B., & YANLING, L. (2015). An Overview of Rural Electrification in China: History, technology, and emerging trends. IEEE Electrification Magazine, 3(1), 36–47.

Informações para Autores

Propostas de publicações em consonância com o disposto na missão da Revista Brasileira de Energia (RBE) poderão ser enviadas ao Comitê Editoral para análise, através de link específico existente no site da Sociedade Brasileira de Planejamento Energético (www.sbpe.org.br).

A formatação final para publicação ficará por conta do departamento de diagramação da RBE, porquanto os artigos deverão ser enviados em formatação simples, conforme o disposto a seguir:

• Os trabalhos devem ser editados e enviados em arquivo Word.

• Papel A4, margens 20 mm, fonte Times New Roman tamanho 12, espaçamento simples.

• Figuras com resolução mínima de 300 dpi.

• O nome do autor ou autores, não devem ser abreviados, e as respectivas informações de instituição, endereço, cidade, cep, estado, telefone e e-mail devem ser apresentadas.

• Todos os itens devem ser numerados sequencialmente, exceto Resumo e Abstract. Não usar numeração automática do processador de texto. Serão aceitos no máximo 3 subníveis de numeração, a partir dos quais poderão ser usadas letras como único subnível adicional.

• Títulos de figuras e tabelas, abaixo e acima das mesmas, respectivamente, sem descrição de fonte, a qual deverá ser feita ao longo do texto, muito menos a existência do termo “autoria própria”.

• Referências a trabalhos deverão ser citadas no texto com nome do autor (ou autores) e ano de publicação, entre parêntesis [Ex.: (Autor 1, 1928); (Autor 1 e Autor 2, 1928)]. Na existência de mais de dois autores, escreve-se o nome do primeiro autor seguido da expressão et al. [Ex.: (Autor 1 et al, 1928)].

Referências Bibliográficas:

• Somente deverão ser citados autores ou trabalhos que estejam incluídos na lista de referências bibliográficas, assim como todos os trabalhos listados nas referências bibliográficas deverão ter sido citados no texto.

• Referências a autor(es) deverão ser citadas no texto com nome do autor (ou autores) sucedida do ano de publicação entre parêntesis [Ex.: Autor 1 (1928); Autor 1 e Autor2 (1928)].

• Na existência de mais de dois autores, escreve-se o nome do primeiro autor seguido da expressão et al. [Ex.:Autor 1 et al (1928)].