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Transition mapping for modern energy service provision under uncertainty: A case study from Brazil

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ABSTRACT

The main objective is to propose a project management method for implementing storage systems. This work applies a literature analysis of previous initiatives for implementing new generation sources and issuing energy storage systems. This analysis allows classifying advantages and barriers of the electricity sector and proposes manageable actions over time. A study of a service station is performed as a case study, and a storage system is deployed for a real customer connected at a medium voltage level in Brazil.

1. Introduction

The climate crisis requires fast-paced action for a low-carbon economy. The energy sector aims to increase renewable energy generation sources, reduce the negative environmental impact, and ensure access to safe and modern infrastructure. The share of renewable energy sources in global electricity generation increased by 29% in 2020, compared to a growth of 27% in 2019, following a growing demand for the resources (Agency, 2021a).

Despite the optimism, the growth of renewable energy generation may not occur at the speed necessary to reduce the impacts of climate change. The new scenario for renewables deployment is driven by energy policies and technology implementation (Agency, 2021b), factors that can amplify inequalities. It is known that access to modern infrastructure and technologies is asymmetric, reinforced in some countries by unequal access to information and strong dependence on fossil fuels (Cantarero, 2020). Although the United Nations (UN) points to renewable energy sources and modern infrastructures as required parameters to reduce poverty in the world (Nations, 2022a), fossil fuel investment and increasing financialization through carbon trading and the power sector are delaying climate policies aimed at the above interests.

With still steep population growth rates and access to natural resources, the countries of the Global South play a prominent role in the

energy transition (Agency, 2021b). Although these are highlighted as advantages and indicate the potential growth of renewable energy sources for these countries, their position concerning technological access and economic development inhibits the natural benefits (Cantarero, 2020). The Global South's definition is broader than countries' geographic location. Commonly referred to as "developing countries," the countries of the Global South are those located on the periphery of capitalism and negatively impacted by globalization. These countries depend on the decisions of nations with greater economic and political power - known as the Global North - and take lower positions on transnational issues (Mahler, 2022). Thus, countries in the Global North are classified as developed and with greater access to economic and social resources.

As they establish strategies to cope with economic disadvantages and modernize the grid infrastructure, Global South countries can rely on Strategic Planning tools to assist in the process and enhance opportunities. Strategic Planning consists of systemic mechanisms that use methodological processes to contextualize and define goals, directing how the actions will be carried out and how to mobilize the available resources. To develop strategic planning, this evaluates different scenarios focusing on identifying opportunity points and barriers for technology implementation. The technology proposed for the analysis is the Battery Energy Storage System (BESS), which is considered the one

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that will meet the demand and reduce the intermittent of renewable energy sources. The work evaluates initiatives to implement new energy sources for countries located in the Global South with a focus on determining strengths for these locations, and issues relevant to the implementation of modern technologies in the electricity sector, especially those that can extend the advantages of renewable sources, are studied to define barriers.

The scenarios are defined using a literature review study, which allowed the evaluation of project initiatives for the implementation of renewable energy sources and energy resource management strategies. Thus, the reviewed literature helps to identify barriers to projects focusing on BESS implementation. The identified issues are subsequently classified into layers and organized into a visually friendly map for those interested in storage technology.

The objective of this work is to map, in a feasible execution time, the goals and actions that aim at a strategic direction for the entry of BESS. To evaluate the proposed method, a management map for a service station located in Brazil is presented.

Brazil, a country classified within the Global South, can also benefit from this planning, directing its future goals and the needs of the national power sector to meet the goals of climate mitigation and economic and social development (Agency, 2021b), (Agency, 2021c). The proposed map is aimed at replacing Diesel Generators with BESS as a short to medium-term solution for consumers employing Time-Of-Use (ToU) programs. Following the incentive strategies for stationary batteries in the country, defined by the regulatory agency, a Research and Development (R&D) project aimed at implementing the BESS was established.

With the focus on developing a manageable map that directs the implementation of BESS, the paper is structured as follows. Section 2 presents the method and shows the tools and parameters for the development of the work. Section 3 presents the literature review on renewable energy sources and BESS deployment, highlighting barriers and opportunities for different countries. Section 4 presents the mapped issues and the proposed map, and Section 5 shows a roadmap built for a real-life case in Brazil. Finally, Section 6 concludes the work and presents future research steps.

2. Method description

One concept used to classify different countries in terms of access to resources and economic dependence on other countries is the Global South and the Global North. The terms describe the phenomenon of the transformation of countries concerning political and economic aspects. Countries that are classified as Global South, to varying degrees, are included in international climate mitigation agreements. Due to the focus on reducing carbon emissions and the dependency on fossil fuels, the initial step was to gather recognized articles that had strategies for implementing renewable energy generation sources. Besides, the articles must present projects for Global South countries.

The research considered published works that presented either the experience of implemented projects or the analysis of the implementation of technologies and renewable energy sources. The gathered works should consider the technical aspects and operation impacts but also point out strategies regarding energy policies, energy resource management, and incentive programs. Another point that limited the studies was that all had to present these aspects from the perspective of the distributed generator.

The second part of the review sought articles that addressed issues relevant to the entry of BESS and its scalability at various locations. This new search did not consider specific countries and aimed to analyze issues concerning technical, regulatory, and market issues. These articles also sought to provide perspectives on access to storage technology as one that enables the reduction of negative impacts on the environment and leads to positive social and economic change.

The work enables the classification of issues as market and industry initiatives on reducing the effects of climate change and initiatives

regarding the implementation and required adaptations in the sector. This information helps in directing actions for the project. Besides, the identification and classification of issues allow learning from previous experiences of the sector itself. As a method to analyze the points raised in the reviewed literature, strategic analysis and activity mapping tools were used for this purpose.

Strategic planning is a systemic process that allows an organization to define the best path to follow to achieve one or more objectives within a context previously analyzed. This type of planning depends on the analysis of different scenarios that allow the definition of goals and actions that allow the feasibility of the desired objective. A tool for assisting in the planning process, SWOT (*Strengths, Weaknesses, Opportunities e Threats*) analysis assesses scenarios and supports decisions.

The advantages of SWOT analysis are the detection of problems still in the phase of defining ideas, the mapping of weak points and internal barriers of the institution, the innovation of internal processes, and the creation of a panorama that contributes to decision-making. The SWOT analysis allows project managers to determine actions and strategies for a given period, reorganizing, and prioritizing those that can make the goal feasible. Another advantage is that this analysis integrates visions from different areas of the institution, strengthening the relationship between those involved in the project and broadening the commitment to the desired goal.

SWOT analysis is adaptable for each project and is a method that evaluates internal and external scenarios to study positive and negative impacts on the institution. The evaluation of internal scenarios enables one to verify the institution's advantages and positioning before its business conduct. These scenarios also allow for evaluating issues that may contribute toward reducing the business' weaknesses. These scenarios are always under the institution's own control and thus manageable by the institution itself. The external scenario analysis helps to map weaknesses and opportunities regarding competitors and changes in the market, economic, political, and social environments. The changes that occur in the external environment cannot be controlled during the project but must be constantly monitored to develop new strategies to reduce risks and increase advantages.

Works related to how the power sector, regardless of country, deals with technology entry issues and renewable energy deployment projects are examined as internal scenarios. The analyzed papers and the list of specific points for the BESS deployment are studied as external scenarios. The analysis of the two scenarios produces a matrix that structures the complete panorama and helps to visualize the listed points.

The matrix is based on four quadrants and divides the issues into Strengths and Weaknesses, referring to the internal scenario, and Opportunities and Threats for the external scenario. Analyzing this matrix allows an understanding of the institution and the determining of actions aimed at conducting the business. The actions should be easily manageable and should guide the project team. Thus, the tool chosen to build the map should direct the project and allow the rescheduling of the proposed actions over time.

Roadmap is a project management tool that creates routes for the process, mapping all processes as a function of time. A roadmap is a customizable tool organized into independent but related layers, which are defined according to the objective of the project. The central layer connects all the predicted layers. The top layers describe the procedural changes necessary to make it feasible from the perspective of the operation of the energy sector itself and the lower layer points out the operational processes for the BESS feasibility and refers to the required degree of specialization, standardization, and rules.

The central layer is Technology, and it encompasses actions regarding the development and implementation of BESS, mapping actions related to available technology, costs, and the supply chain. The expectations regarding future development and innovation, research, and real-life implementation are mapped on the Technology layer.

Market and Business are the top layers describing how the project can be implemented. These layers cover actions concerning business

continuity, tariffs, investments, and subsidies. As requirements to cope with technology and changes in the sector, the Business layer must cope with strategies and encouragements, BESS affordability, social and economic development, and reducing negative environmental impacts. Actions related to subsidies and tariff schemes are added to the Market layers. The bottom layers are called Resources and Skills and Regulation. They contain actions focused on labor force training and Human Resources management, standardization, regulation, and operational standards.

3. Distributed energy resources implementation

This section presents the scenarios for projects regarding renewable energy sources for Global South countries and issues for BESS implementation in different locals.

3.1. Integrating renewable energy sources

The international community signed the Paris Agreement in 2015, as an attempt to replace the Kyoto Protocol. The agreement establishes long-term goals to mitigate the effects of climate change. Almost two hundred countries signed the agreement at the time and committed to limiting global warming to no more than 2° above preindustrial levels. The fulfillment of the agreement is not mandatory: the countries established the Intended Nationally Determined Contributions (INDCs) - named NDCs after the agreement signature (Nations, 2015).

The ratification of the Paris Agreement includes goals for the preservation of the environment and the renovation of the energy matrix for countries in the Global South, tied to investments and financial support of countries in the Global North (Nations, 2015), perpetuating the dependency relationship between these countries, including challenging access to technology, the use of fossil fuels in countries, and capital flow (Cantarero, 2020).

The Brazilian government committed in its NDC to reduce greenhouse gas emissions by 37% in 2025, with a subsequent indicative reduction contribution of 43% in 2030, relative to the estimated levels of emissions in 2005 (C). The main Brazilian objective is related to the conservation of biomes, such as the Amazon region and the Cerrado. In recent years, there has been a marked increase in deforested areas for the two mentioned areas: the growth rate of deforestation has increased by 18% in 2022 (de, 2022a),(de, 2022b). These data point to the importance of including and promoting environmental conservation within the government agenda and the mismatch between the current government.

The process of accentuated deforestation has as one of its effects the change in average rainfall for the country, which affects energy production. Hydroelectric power is the country's largest generation source, responsible for approximately 58% of all installed capacity (de EnergiaElétrica, 2022). Investments in power plants and distributed generation increase because of the sector's financialization process.

The entry of distributed generators into the local energy sector is encouraged through current Normative Resolutions and energy efficiency programs. Normative Resolutions are related to distributed sources connected to the grid, general rules for supply, and small distributed consumer limits: 506 (de EnergiaElétrica, 2012), 414 (de EnergiaElétrica, 2010) and 482 (de EnergiaElétrica, 2012). The resolutions set conditions for distributed generators to implement the infrastructure, conditions for economic compensation in the event of energy dispatched to the grid, and conditions for access to the grid. The increase in the deployment of renewable energy sources is reinforced by federal programs on universalization of energy efficiency and access to energy, for example, PROINFA (*Programa de Incentivo às Fontes Alternativas de Energia Elétrica*) and PROCEL (*Programa Nacional de Conservação de Energia Elétrica*).

The Brazilian government approved the Distributed Generation regulatory framework in 2022, changing the rules for financial

compensation for generators starting in 2023 (BrazilLei n ° 14. 300, 2022). As a result, the expectations of financial return for distributed micro and mini generators may be reduced, slowing the industry. Financialization, where production is driven by financial return, is a typical process in the Brazilian electrical sector. Consequently, financialization enhances the inequalities regarding access to low-carbon systems and the effects of climate change (Sovacool et al., 2019), (Knuth, 2018).

The transition is guided by capital flow goals, promoting marketing logic and trade arrangements instead of development and universal access to modern energy services (Knuth, 2018), (Sovacool et al., 2019). The current scenario establishes actors and stakeholders that may lobby during policy-making processes, benefiting from the unfair process and power distribution (Sovacool et al., 2019). Despite the policy-driven process for energy transition, which may encourage strategic planning for the resources following the public agenda, the power distribution reduces the effects of climate policies (Sovacool et al., 2019), (Thomas et al., 2019).

Most countries are in an advanced state of liberalization due to recent institutional reforms, regulation, and privatization processes (da Silva Leite and de Castro, 2014), (Agency, 2021d), (Cantarero, 2020), (Werner, 2019a),(Werner, 2019b). The reforms encourage the participation of private sector agents and public service concessions and planning according to market strategies (Werner, 2019a),(Werner, 2019b), increasing the financial aspects of the energy transition. Actors and stakeholders lobby in different arenas, encouraging a transition focused on market perspectives.

The entry of technologies complies with investments and business plans established by the actors, which inhibits social participation and drives subsidies, intense investments in fossil fuels, bureaucracy, and lobbying (Ozcan, 2018), (Cantarero, 2020), (Werner, 2019a). Because of this, despite easy access to natural resources, most of these countries still depend on fossil fuels and coal to meet demand (Agency, 2021d), (Katal and Fazelpour, 2018), (Diezmartínez, 2021), (Sarkodie and Adams, 2018). The use of fossil fuels is reinforced by a known supply chain and the strong presence of oil exploration industries in these countries (Cantarero, 2020).

Many developing countries have easy access to natural resources. Consequently, hydropower is presented as the most widely used renewable energy source for these countries (Fashina et al., 2018), (Bishoge et al., 2018), (de EnergiaElétrica, 2022), (Pupo-Roncillo et al., 2019), (Arango-Aramburo et al., 2019), (Aryanpur et al., 2019), (Gómez-Navarro and Ribó-Pérez, 2018). For example, Iran and Colombia rely on hydropower as an alternative to meet demand. The former proposes increasing hydro generation in its strategic planning and investments in technologies to reduce the dependency on fossil fuels and its effects on the health of the population (Aryanpur et al., 2019), (Katal and Fazelpour, 2018). Colombia analyzes how to encourage investments and the entry of new players to expand the supply of energy generated by this source and ensure lower prices for consumers. (Arango-Aramburo et al., 2019), (Perez and Garcia-Rendon, 2021), (Gómez-Navarro and Ribó-Pérez, 2018). Some countries also rely on biomass, natural gas, geothermal and nuclear energy (Ozcan, 2018), (Sarkodie and Adams, 2018), (Oh et al., 2018), (Belaid and Zrelli, 2019), (Jha and Puppala, 2017) are mentioned as alternative energy sources for different countries.

Some countries also include energy integration with neighboring countries as a strategy to reduce infrastructure costs and increase local economic constructive collaboration (Sarkodie and Adams, 2018),(Zhao et al., 2018), (Murshed, 2021). Energy integration would allow greater penetration of other renewable sources, such as solar and wind, increasing investments, expanding the role of players in the decision-making process, and increasing the potential for the generation and use of energy resources (Murshed, 2021), (Zhao et al., 2018), (Sinsel et al., 2020). Solar and wind potential are cited as potential renewable energy generation that some of these countries can exploit. Integration

of these sources in the grid, access to infrastructure and initial investments, local business models and market rules, incentives, and technical skills are quoted as significant barriers (Gómez-Navarro and Ribó-Pérez, 2018), (Arango-Aramburo et al., 2019), (Pupo-Roncillo et al., 2019), (Jahangiri et al., 2019), (Yuping et al., 2021).

The countries deal simultaneously with increasing demand, driven by population growth (Agency, 2021d), (de Geografía e Estadística, 2018), (Eren et al., 2019), (Aized et al., 2018), along with problems related to the inaccessibility to electricity due to reduced network infrastructure or poor reliability, inequalities, low economic growth, unemployment rate, and public debt (Fashina et al., 2018), (Bishoge et al., 2018), (Cantarero, 2020), (Ozcan, 2018). For countries where a large part of the population lives in rural areas, the difficulty of accessing electricity worsens inequalities and social development (Eren et al., 2019), (Jahangiri et al., 2019). Some countries cope with the recent urbanization process, which can cause disorderly growth of these spaces and pressure on the electrical grid infrastructure (de Geografía e Estadística, 2018), (Bishoge et al., 2018).

Attempts at economic growth, especially incentives for industrialization, drive energy planning issues (Eren et al., 2019), (Sarkodie and Adams, 2018), (Oh et al., 2018). The search for accessible generation sources may be driven by a known and strengthened supply chain (Belaïd and Zrelli, 2019), (Agency, 2021d), with known players with a high agency power within local governments (Cantarero, 2020), (Agency, 2021d). These factors guide the maintenance of investments in fossil fuels and coal, maintaining the adverse effects that the use of these sources causes, such as the worsening of public health indices, air quality, and negative environmental impacts. The presented problems are worsened by barriers to project deployment and a heavy dependence on foreign capital (Fashina et al., 2018), (Belaïd and Zrelli, 2019). These countries are highly dependent on external agents for the success of decentralization projects in these countries, given the high cost of the purchase, maintenance, and operation of infrastructure (Fashina et al., 2018), (Authority, 2020). The elevated level of bureaucracy of the institutions responsible for energy planning in countries is also cited (Bishoge et al., 2018).

Some studies describe that the benefits of short or medium-term implementation of renewable sources of energy generation are beyond the economic ones. The increase in renewable energy sources has a positive impact on economic growth and social development, as a direct result of the reduction of carbon emissions, investments to reduce the impacts of climate change, and universal access to electricity (Sarmiento et al., 2019), (Holjevac et al., 2021), (Solaymani, 2021).

The analysis of how innovative technologies are admitted indicates how local institutions drive implementation projects. The projects are mainly promoted by policies and financial advantages. For many of these countries, the role these institutions play is a barrier to the admission of recent technologies, caused by a blurring of roles within the required changes and intense bureaucratization. The entry of the private sector and the lack of a specialized workforce for the use of technologies imply a delay in action on the part of these institutions and, in implies doubt regarding the effectiveness of their roles in the energy transition scenario (Sarkodie and Adams, 2018), (Agency, 2021d), (Cantarero, 2020), (Salahuddin et al., 2018).

Barriers to the entry of new sources of energy generation are related to access difficulties and financial dependence, highlighted by economic affordability, difficulty in accessing technologies, lack of supply chain, and applicability barriers. Credits, tax breaks, and investments are addressed as policies and a business model to establish a strategy for the implementation of renewable energy sources and the encouragement of the private sector and financial partners (Eren et al., 2019), (Zafar et al., 2019). Additionally, fossil fuel disinvestment and technological advances are encouraged to scale up the renewable sector. Technology manufacturing and production are also targets for a transition sector, pointing to a policy-driven scenario (Eren et al., 2019).

As the deployment of renewable energy sources and energy

conservation policies can have direct impacts on economic indicators, it is implied that policies focused on subsidies and other encouragement strategies for new generators are a social cost that leads to the growth of the Gross Domestic Product (GDP) (Belaïd and Zrelli, 2019). Analysis of the deployment of renewable energy sources shows that social and economic development is the result of the overcoming of the financial barrier, the use of the potential of local resources, and broader cooperation policies that may increase productivity and reduce inequality (Belaïd and Zrelli, 2019), (Kennedy et al., 2019).

Different countries use incentive programs to take advantage of local resources and the entry of technologies. Some programs focus on reducing dependence on fossil fuels (Sarkodie and Adams, 2018), (Belaïd and Zrelli, 2019), yet few programs focus on less energy-intensive consumers, which inhibits their entry as prosumers and their participation in the decision-making process (Kennedy et al., 2019). One of the results of this type of program is the incentive to renewable sources, such as biomass, by local industries (Oh et al., 2018). As an unintended effect of these programs, the cost of energy can increase, reducing access for populations with lower purchasing power (Sarkodie and Adams, 2018). Focusing on the segmentation of consumers and the establishment of a model that takes advantage of their profiles may enhance the entry of consumers into the local sector and establish local communities (Kennedy et al., 2019), (Koirala et al., 2016).

Countries also encourage tariff schemes to encourage the growth of renewable sources of energy generation, as is the case in Feed-in-Tariff (FIT), subsidies, and tax reductions (Oh et al., 2018), (Bishoge et al., 2018), (Sharif et al., 2020), (Agency, 2021d). Cost reduction and incentive programs focus on encouraging the participation of the private sector in the energy sector, expanding decentralization of generation, and programs for energy efficiency, infrastructure improvements, and expansion (Fashina et al., 2018), (Authority, 2020).

Policies focused on renewable energy sources may use the effects of energy consumption and technology-intensive implementation to achieve development goals. The absence of policies focused on energy sector innovation, including access to the market, R&D, and technology development, are barriers (Sarkodie and Adams, 2018). The association between the interested parties may encourage a business model that drives technology advances and R&D encouragement, which encourages a new industry sector and business sector establishment. As opportunities, the new business may establish a new supply chain and increase trade openness. The status of the energy transition in the sector points out the importance of public interest in the deployment of renewable sources and the reduction of environmental impacts (Zafar et al., 2019).

Strategic direction identifies how policies and investments, technology development, market status, and formation of skilled capacity are developed. Due to the financialization stage and the liberalization of the energy sector, governments are expected to engage private investors in the technology input process; the inclusion of investors adds new stakeholders to the sector, along with policymakers and the industry sector's actors (Oh et al., 2018). Policies focused on natural gas and oil tariffs are examples of subsidies for innovative programs, as well as agencies and new regulatory acts establishing frameworks and aspects regarding technology and market directives (Oh et al., 2018).

The lack of technology transfer may also inhibit local energy-related goals. The technology gap is a challenge related to the costs, maintenance, and operation of the infrastructure, and the development of institutions and frameworks for energy production (Bishoge et al., 2018). Institutional limits enhance risks, investments, deployment of decentralized systems, and the entry of new generators. Additionally, the local energy sector may not be able to cope with new models and technical requirements resulting from decentralization (Bishoge et al., 2018).

Labor force qualification and high unemployment levels are significant barriers to technology implementation (Authority, 2020), (Oh et al., 2018), and the strengthening of R&D is an opportunity to reduce the technological gap, encouraging local production of technology and the qualification of workers (Fashina et al., 2018), (Oh et al., 2018),

(Bishoge et al., 2018), (Jahangiri et al., 2019), especially in rural areas. The workforce may also expand the dissemination of reliable and specialized information on energy use and generation, leading to new projects and boosting confidence in the local energy sector (Bishoge et al., 2018).

3.2. Evaluating scenarios for BESS deployment

The technological maturity of BESS establishes the balance between costs and services provisioning, enabling its larger-scale deployment. This implementation sets a new perspective for the growth of renewable sources of energy generation, although this new stage depends on new market and operational definitions. The transition is oriented toward an economic perspective, and the system deployment is driven by policies, market deregulation, the positioning of non-renewable energy sources - such as Diesel Generators - and increasing the competitiveness and profitability of decentralized systems (Blazquez et al.). This scenario is strengthened by tariffs or credit systems - FIT, feed-in premiums, production tax credits, investment tax credits, green certificates, and renewable portfolio standards - that benefit price variation and power generation growth (Blazquez et al.). Even though the system has a growing market share, via cost reduction, its access still does not reach all consumer profiles.

The economic viability of a BESS, from the perspective of the initial investment and maintenance costs over the entire life cycle, is uncertain (Nascimento et al., 2020a). Feasibility studies point to how governments can direct policies to encourage the use of technology. For short-term priority, it required that financial incentives and market strategies be encouraged, favoring the entry of technologies and the availability of new services (Nascimento et al., 2020a), (Diezmartínez, 2021).

Incentives and financial support regarding recent technologies deployment should also include strategic use of intermittent sources and allows access to communities that have difficulty accessing electricity-based services, as is the case in rural communities (Pupo-Roncallo et al., 2019), (Diouf and Avis, 2019), (Aghahosseini et al., 2018), (Mandelli et al., 2016). From a community perspective, issues such as technical feasibility, reliability, efficient use of space, social participation and inclusion, and inequalities reduction are under evaluation (Thomas et al., 2019), (Tronchin et al., 2018). Despite the newness of the subject, social participation may contribute to the scalability of technology and its access to urban spaces (Thomas et al., 2019). Thus, social acceptance may guide opportunities and marketing strategies, focused on a low-carbon society (Diouf and Avis, 2019), (Thomas et al., 2019), (Nascimento et al., 2020b).

Despite the belief that the transition relies on consumer preferences (Blazquez et al.), a transition driven by economic parameters benefits the most powerful actors. Thus, works related to the entry of BESS into the sector cite aspects of competitiveness rather than ease of access and participation in the electricity sector. Business models, regulations, and energy market parameters must be addressed to allow small-scale generators to participate in decision-making and ensure infrastructure access.

Despite referred strategies that may increase inequalities and inhibit the entry of non-wholesale generators, policies and business models may be addressed to meet the demand and enhance access to modern energy services. If the distributed generation grows, generators and prosumers will assume a more dynamic role in shaping the electricity sector in comparison to the current model. Besides recent technologies that can facilitate the communication, monitoring, and operation of the grid at the distribution level, systems that may ensure energy supply and demand are required.

The challenges regarding Distributed Generators input can be listed as control and monitoring of the capacity, power production, and generators and consumers connected to the grid; evolution of roles and relationships, which requires management of different capacity generators, transmission and communication codes establishment; support to

all human resources connected; which encompasses training and qualification to cope with problems and processes inherent to business exchange (Bell and Gill, 2018). These challenges should be addressed in such a way that all information is published to the generator, reducing risks, and increasing the scalability of the solution (Bell and Gill, 2018). Policies and regulations must be developed to ensure the support and risk minimization of Distributed Generators.

The regulation establishes the operation and commercial frameworks for the sector's actors, including financial returns and infrastructure management. Advances have been made toward regulatory definitions, with several countries presenting proposals and discussing the theme. Despite these advances, the regulation still presents significant barriers regarding BESS implementation. Questions related to subsidies and financial aid programs, grid management and load control, charges and financial return, classification and allocation of the BESS, classification of services provisioning, lack of methodologies regarding business and management, and risks related to affordability are regulatory barriers that must be addressed for storage implementation (Anuta et al., 2014).

These questions are addressed by contracts describing issues regarding services provisioning, operation time stamps, and acceptable failures (Bell and Gill, 2018). In addition, these contracts mitigate the risks of predatory competition through the lowest-cost solutions (Bell and Gill, 2018). These issues do not boost technology and modern services provisioning, and they can inhibit the input of small-scale generators, which may have difficulty accessing subsidies and financial support for business continuity. In addition, the regulatory framework should address scheduling - acceptance time for decisions made regarding the operation and changes following the physical infrastructure availability and services transactions, in response to market and participants' demands (Bell and Gill, 2018).

The framework may also consider spatial variation, such as cost, price zones, and contract periods. Due to the time variation and intermittence bounded to renewable energy sources and the time particularities of BESS operation, contracts may be manageable and negotiable in the different schedules (Bell and Gill, 2018). These aspects directly impact the type of energy-based services provided and expectations regarding the system implementation, payback, and profitability.

The market operation deals with real-time energy-based services provisioning, which alters the positioning of contractual parts. This aspect implies redefining the wholesale market and a reserve capacity definition to fulfill contract requirements and price maintenance (Bell and Gill, 2018). The energy policies address these requirements by establishing mechanisms that balance payment and set price compensation regimes, ensuring the business continuity for utilities and Distributed Generators (Bell and Gill, 2018). The regulations set limitations regarding the infrastructure but do not limit the operation and management parameters (Bell and Gill, 2018), (Anuta et al., 2014).

The policy-driven actions establish tariffs scheme and price encouragement strategies to cope with renewable technologies input (Horváth and Szabó, 2018). Based on long-term strategies, governments set subsidies and incentives, or disinvestment, by technologies input and planning approach; this approach sets the potential participation of the private sector and issues regarding payback, initial investments, and their roles in the recent technologies implementation (Horváth and Szabó, 2018). However, the participation of the private sector commonly reduces the population's participation due to government programs focused on the profitability of this sector (Horváth and Szabó, 2018), (Cantarero, 2020).

Financial encouragement may focus on innovative business models that reduce or eliminate residential or community-owned infrastructure costs, setting strategic market rules focusing on these groups. Due to the technological stage, the business models and gains are associated with social and environmental values, establishing an opportunity for a model focused on social awareness and acceptance of technologies and development problems. These business models are associated with

technological barriers.

The excessive costs related to initial investments, maintenance, operation, and management costs including the values for participation in market transactions and grid connections - are significant barriers for most citizens and countries. Technology development, associated with research and development issues and skilled labor training, strengthens the supply chain and reduces significant financial barriers (Horváth and Szabó, 2018). The cost evaluation and technology barrier are also related to the lack of information and awareness issues for renewable energy sources deployment: the associated risks and reliability problems affect the demand and discourage potential generators (Horváth and Szabó, 2018).

The business model sets propositions that structure the strategy and mediate the customer and supply chain formation, translating technical information for differentiating products and services. The model may establish a value process for renewable energy source deployment aligned to social awareness, satisfying customer needs, and meeting the demand requirements. Thus, this model deals with organization and technology courses, reducing risks and boosting innovation (Hamwi and Lizarralde, 2017).

Customer-owned infrastructure may lead to solutions focused on solutions solving and risks mitigation, establishing a scenario for partnership and community participation (Hamwi and Lizarralde, 2017). These models are expected to encourage social participation through democratic decision-making and acceptance of renewable resources (Hamwi and Lizarralde, 2017).

Works mention models focused on infrastructure owned by the customer, which includes third part service-oriented ownership and services provisioning, customer-owned infrastructure, and community-centered (Hamwi and Lizarralde, 2017). The models focus on the new consumer's active role and establishing social values for services provisioning, energy security, and local support (Hamwi and Lizarralde, 2017), (Von Wirth et al., 2018). The new models innovate through collaborative participation and ownership, reducing risks and increasing demand management for a decentralized generation (Hamwi and Lizarralde, 2017), (Von Wirth et al., 2018).

Thus, the models consider the actors' roles and perspectives regarding infrastructure management, decision-making, and relevance (Von Wirth et al., 2018). The proximity of the generation infrastructure expands the temporal analysis and individual and community decisions, including new characteristics regarding social acceptance and relevance for technology implementation (Von Wirth et al., 2018).

The new market structure, more technology-prone, enables universal energy provisioning and participation access and provides new value for infrastructure ownership. Market flexibility acts following price and demand signals provided by all actors and improves participation in the wholesale market and investments that sustain cost recovery and business maintenance (González and Rendon, 2022). Besides, the required structure also implies a new classification of grid configuration and services recognition. Despite the current discussions regarding the BESS role in the grid, the storage must be classified as new infrastructure in the energy sector, and the provisioning of the services should be classified and differentiated from the existing ones. The new classification allows the analysis of efficiency and applicability from different perspectives, which enables the incorporation of new actors into the sector.

The shaping market also needs to deal with the technology's viability, including feasibility and reliability issues. Despite the commercialized status of the BESS, the next stage of the technology must improve technical issues that decrease the feasibility of the BESS. Research and development and Pilot Projects are required to achieve the technology capabilities next stage (Zame et al., 2018).

Governments and funding agencies commonly support technology development as a strategy for local development, establishing a schedule and progressive scale for larger project implementation (Zame et al., 2018). As a result of research and development and government strategy for technologies implementation, the deployment of pilot projects is a

milestone for a development and scale schedule. Besides, pilot projects enable the evaluation of the BESS regarding technical and operational aspects that allow the definition of economic parameters and standardization, which includes services description, BESS placement, and grid configuration (Zame et al., 2018).

The deployment of BESS in these countries is an opportunity to promote market reform and encourage third-party entry into the sector, promoting capacity growth and divestment in fossil fuels. The retail market could establish new prices and scheduling strategies to cope with the variables of the BESS operation, reducing risks and optimizing renewable sources generation (Das et al., 2018). The system's reliability and social prioritization are factors evaluated in these countries to promote universal access to resources and social acceptance.

4. Roadmap for BESS input

The internal and external scenarios presented provide information for conducting the SWOT analysis. The scenarios are evaluated from the perspective of distributed generators and show the main points related to renewable energy sources and the implementation of BESS. The issues are listed in this section. From the Brazilian energy sector perspective, Normative Resolutions and the recent Regulatory Framework aimed at determining rules and standards for access to the grid of the distribution company, classification of distributed generators, and possibilities of acting within the market are mapped as strengths. The definition of differentiated tariffs throughout the day, determining a ToU method for a group of consumers, establishes different prices for electric energy and is a stimulus for creating an hourly standard for energy dispatch and battery charging.

The private sector participation in decision-making sets the market preferences for delimitating rules and roles. From the perspective of the distribution sector, it helps to define technical rules and operational standards from the business continuity point of view. These companies may help the development of new business models that include BESS and renewable energy sources, ensuring the grid's reliability. Besides, the new business models must establish new roles and demands for the distribution companies by describing the obligations and rights of the stakeholders. In addition, these companies should assist national development and technology incentive programs, focusing on providing modern electric power services and meeting international environmental objectives.

These companies have close relationships with universities and research centers, encouraging the sector's search for solutions and innovation. This innovation process is supported by the regulatory agency, which stimulates R&D projects, such as the call for projects to evaluate the implementation of BESS in Brazil. The integration of universities, companies, and regulatory agencies creates an environment of stimulus and the creation of innovative ideas.

National agreements should strengthen the private sector entry and expand international agreements to exchange technology and research. As weaknesses, the long processes for innovation, the development of recent technologies, and asymmetrical access to recent technologies are a constant for the Global South countries. The delay in technology development also hinders the maturation of automation, measurement, and safety systems, which extend reliability and can ensure a timely return on the initial investment of the distributed generator. The difficulty in accessing technologies entails potential problems in project management and enhances the effort in training professionals, the entry of new suppliers, and the immaturity of the supply chain, causing the delay in market routes and a performance model creation.

The significant barrier to technology access is reinforced by the delay in determining new tariff schemes, adaptable to the variation of demand and energy supply, and creating differentiated business models and services focused on decarbonizing the sector and improving social and health parameters. The elevated levels of bureaucratization and difficulty in establishing the roles of the public sector hinder the

transparency of information and the reduction of inequalities in access to the grid and information relevant to the electricity sector. These relationships must also be satisfactory for the distributed generator, who needs a new form of communication and a relationship with the sector at this stage of technology implementation.

Some companies in the sector still assess the growth of distributed generators as a threat to their business model. This distrust is related to the market structure for the electrical energy negotiation and should be addressed through rules and standardization. Thus, the advance in regulatory issues, both for the definition of rules and technical standards and for the implementation of the required regulation, is a weakness for the deployment of BESS. The time to define these rules can delay the implementation of larger projects or even the system’s scalability.

The existence of international environmental agreements and energy efficiency initiatives encourages the development of technology that may expand access to modern generation sources and the universalization of access to electricity. The opportunities and threats for a BESS deployment are evaluated from the perspective of a technology that may enhance renewable energy sources’ growth. The development and strengthening of the BESS as a structure that allows a scenario of reduction of carbon emissions contribute to the modernization of the existing infrastructure, increasing the efficiency and robustness of the network.

Implementing BESS creates the opportunity to establish more inclusive business models from a social perspective and to determine routes and market segments that allow the new carbon emissions reduction scenario. New processes and performance models may be established in the medium term, as well as the definition of market niches for performance. For these new business models to be successful, there is the opportunity to establish subsidy programs and review the current pricing and financial compensation schemes for generators.

These programs should focus on the viability of the technology. The creation of new consumption routes and new communication forms should be created to ensure access to information and definitions of market rules. This communication aims to ensure that consumers of different consumption profiles can understand the progress of the electricity sector and define the goals and expectations regarding the deployment and operation of BESS.

The high cost and reliability of the BESS are listed as threats. Although the development of the system will lead to improvements in the operation and consequently make the technology more viable, the misinformation regarding the operational and reliability of BESS on the grid, including the effect that this operation may have on other consumers, is still pending and depends on the research and implementation of large-scale projects.

The initial investment to purchase the infrastructure is a threat that public policies and viability strategies should address. The R&D status for most Global South countries is a significant threat to the BESS implementation, which may delay technological exchange and development of local technology. The economic position of these countries also makes the import process harder due to high tariffs and the difficulty of negotiation in the international market. The points listed can be compounded for decisions that require larger-scale systems and can contribute to innovative projects and short-term substitution for fossil fuel use. These aspects are aggravated by economic barriers, difficulty accessing technologies, and little incentive to R&D, despite the easy access to natural resources. The previous aspects contribute to the scarcity of trained professionals.

According to the SWOT analysis, the issues are classified as barriers and opportunities for the electricity sector. The next step is establishing actions that allow the project to overcome the barriers and take advantage of opportunities to meet the specified goal. These actions are

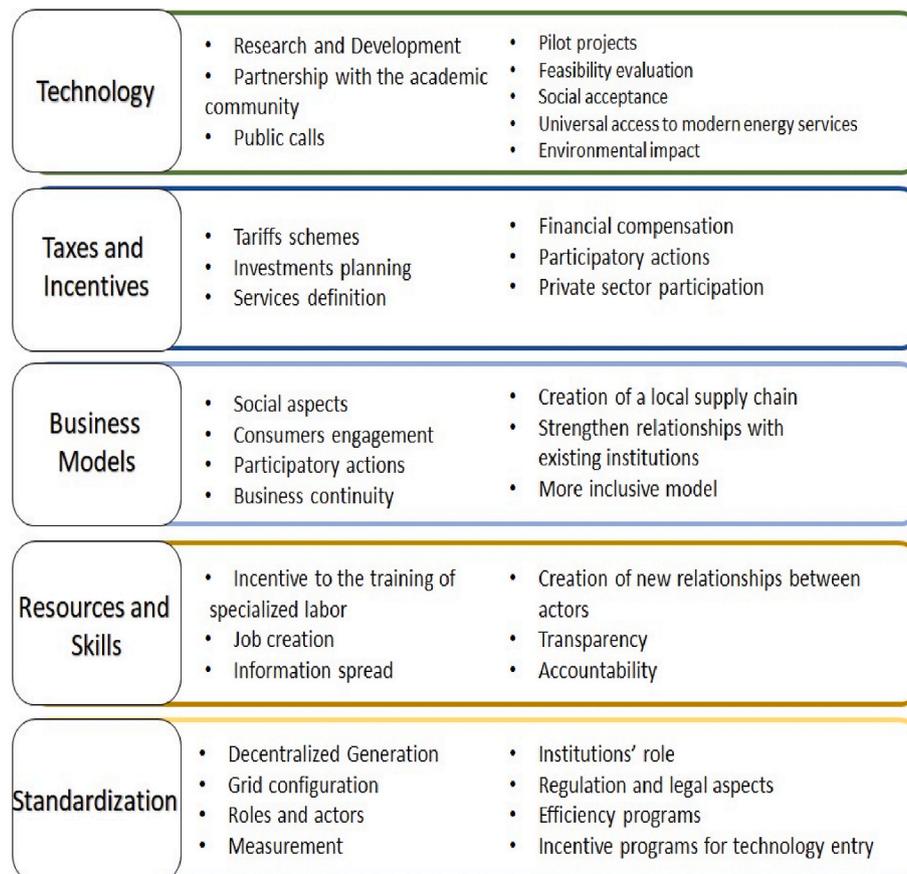


Fig. 1. Mapped actions identified after the scenario analysis.

allocated in layers according to their execution characteristics, as described in the Method. Fig. 1 presents the foreseen actions.

For this stage, the planned actions are not scheduled. The planned actions must change according to the project scope and the location, but the proposed layers do not vary. Furthermore, the actions direct the project, and new actions may be added or proposed as the technology develops. The proposed actions are distributed in layers, as explained below.

The Technology layer presents actions related to the impacts of the BESS input, research and development, and the design and development of new materials. These actions address the sector's openness to technologies and innovative actions and investment programs to encourage the implementation of the system. The actions that describe the motivation to implement a BESS are classified into business layers. Taxes and Incentives gather actions regarding costs and encouragements for BESS deployment, which may lead to access of new stakeholders to the system and the expansion of the concurrency. These actions are related to tax discounts and subsidies, based on governmental support, to cleaner and improved generation sources.

Costs and entry of technology imply how energy-based services are provided, leading to the evaluation of the business and new processes. Subsidies and viability-oriented plans must-have factors to increase technology from the specialized point of view of supply and demand. Incentives and federal programs should support this plan focused on developing internal production or improving the supply chain responsible for importing technology. Market actions and business are included in this layer.

The Business Model focuses on the development of inclusion and a participatory model for technology deployment. The actions describe economic and financial viability from a social perspective, establishing process-building and performance models while meeting the expectations of newly Distributed Generators and consumers. Actions are related to the expansion of distributed generation and the establishment of new and inclusive commercial models.

Resources and Skills encompass actions related to human resources management, job creation, and training of skilled labor. These issues also are related to knowledge management and information spread, as reliability and management data and technical results can be disseminated to all actors and the creation of communication channels - web-sites, helpdesk, specialized media, technical committees, and conferences. Standardization encompasses the actions regarding regulatory terms and standards for BESS management, which is still under discussion and development in several countries, operation, restrictions, and conditions for access to the primary grid, and quality parameters for services providing and contracting services that this system can provide.

5. Acting for a BESS implementation

The case study aims to show the proposed tool's applicability to a consumer in Brazil. The goal is to show the roadmap built for a Distributed Generator and an interested party in a BESS implementation. The approach is to encourage the BESS deployment as a replacement for Diesel Generators, a non-renewable and less efficient energy source. Commercial and industrial consumers commonly use solutions based on Diesel generators as an alternative to cope with costs or increase supply reliability. The employment of Diesel generators grew during the rise of energy tariffs or water scarcity: around twenty thousand Diesel generators were deployed in 2015 in São Paulo state (de, 2015). This fact contributes to the country's high deployment of non-renewable energy sources, 4.9% of Diesel and fuel oil (de PesquisaEnergética, 2020).

The case report evaluates the implementation of a BESS as an alternative for a consumer connected to a medium-voltage grid. The consumer is a service station located in Jundiaí, a city near São Paulo, and the station includes a gas station, an electric vehicle charging station, and a restaurant the location, both working 24 h a day. Jundiaí is in a concession area of CPFL (*Companhia Paulista de Força e Luz*) Paulista,

formed by 234 cities. The chosen consumer is classified as an A4 sub-group - tension required from 2.3 kV until 25 kV - and benefits from a ToU-based tariff scheme. The tariff for this consumer is divided into the peak - a 3-h interval that starts at 6 p.m. and ends at 9 p.m. daily, besides weekends and holidays - and off-peak periods, complemented by a single tariff for its contracted demand.

The goal for this consumer is to reduce its costs during peak periods: currently, the local is supplied by a Diesel Generator during such periods, and the grid supplies it in off-peak periods. The service station does not use other sources of energy generation. A BESS based on Lithium technology is the most affordable alternative energy source; the system must meet the demand for the entire peak period and, occasionally, during power shortages. The grid supplies during off-peak periods, and the battery is charged for off-peak periods.

Based on the consumer's profile and goals and addressed by the proposed actions, the expected tasks were classified into Technology, Market, Business Model, Resources and Skills, and Regulation layers. The current market and regulatory status and a Public Call for projects focused on BESS implementation are the baselines for the proposed roadmap. Besides, the actions are sorted by period: the Public Call was set in 2018 as a strategy of the regulatory agency to encourage projects, and the project was scheduled for three years.

The initial action is the Paris Agreement, and the short-term actions are immediate to the agreement. The medium-term actions are measured and executed within five years of the public call, and long-term actions are scheduled for more than five years. The roadmap foresees the follow-up of the system and points related to BESS after the implementation since several issues mapped are expected to evolve in the coming years. The upper layers set organization activities, describing the motivation of stakeholders to implement the project. The lower layers present the resources required to fulfill the upper layers' issues, and they are related to skills, partnerships, suppliers, infrastructure, and standards. The other layers, located between the other ones, connect the activities of the upper and lower layers.

The Market actions refer to the environmental agreement established and the terms that refer to decreasing carbon emissions. For the medium and long term, a plan for a new supply chain and the development of the domestic industry are proposed. The expected long-term actions concern communication activities, increasing the information and data regarding such a system's management, reliability, and affordability.

The Business Model concerns actions related to BESS deployment and the establishment of new energy-based services. The actions at this stage require cultural and operational changes and demand an innovative and inclusive model focused on meeting social needs. Given the learning capacity required at this deployment stage, the roadmap states that the project may provide information to help build these new models.

The actions are focused on developing a Business Model that establishes the economic and financial viability of the project, aiming the analysis of the project affordability based on initial costs, mapping the operation rules and management processes, setting performance parameters relevant to regulation studies, establishing a marketing channel focusing on consumer's contact and entry, design of a Sale and Services chain, developing customers' clusters and consumer's niche segment, segment the Product Portfolio, which enables the product and services specifications and the analysis of a differentiated pricing policy. The development of partnerships for a new supply chain and new guides with standards and implementation rules for customers, and guides regarding services and technology affordability for potential consumers are described as actions in the Business Model layer as well.

Technology presents actions for a solution that deals with environmental goals and encourages renewable energy sources employment. The actions concern access and viability to technology and modern energy-based systems, Pilot Project deployment, data collection, and analysis. The actions also refer to access to the grid, management, operation, and R&D.

The actual implementation of a system is one of the main goals of this project, and the actions referring to the Pilot Project are described in the layers of enabling technology in the country. The Project Design comprises all the mapping of the types of technology, scope design, site selection, technologies evaluation, and purchase process. The deployment of the Pilot Project is expected to provide information related to learning and technical skills vital to the Communication, Resources, and Skills layers. The results regarding the project must be disclosed, and knowledge sharing is a predicted action. The information should be disseminated to academia and interested parties in general, and it should be focused on technological advances and consider business models, product segments, customer segments, pricing, and regulation.

The Regulation layer encompasses actions that allow standards definition and the energy sector business continuity. The actions concern Pilot Projects implementation, evaluation of terms that ensure the fulfillment of stakeholders' requirements, and the reliability of the energy services supply. The actions also refer to method improvement, citizens' acceptance and participation in the decision-making process, rules and quality of service issues, and programs focused on encouraging new actors' entry. The long-term actions concern publicizing rules and legal terms to stakeholders and society, which increases transparency in technology deployment processes.

The actions of this layer should contribute to overcoming possible regulatory and legal barriers that may hinder the grid connection and BESS management. These actions also refer to the current state of regulatory benchmarks. The actions for these layers are expected to be reallocated during the project, either by new rules or by necessary definitions and internal discussions in the regulatory agencies and stakeholders. The related actions do not depend on the project manager.

The Resources and Skills actions drive specialized professionals' formation through courses and specialization programs. These actions are required to overcome the cultural and employment gaps. The layer contains initiatives regarding professionals for both the private sector and academia and encompasses activities related to R&D, the

development of training platforms, and education materials for different professionals' profiles.

The implementation of the project is set in three periods: short-term (starting with the Public Call for BESS projects), medium-term), and long-term. Fig. 2 shows the five layers and the mapped actions for a BESS implementation in Brazil.

6. Conclusion and future works

The pressure to reduce carbon emissions and mitigate climate change drives short-term solutions for countries. Environmental agreements can drive the energy transition, but the difference in access to technologies and support mechanisms is challenging for Global South countries. Barriers for countries in the Global South can delay significant changes in the energy matrix that, in addition to reducing the impacts of climate change, can also bring social gains.

This work proposes a management tool that directs the implementation of BESS for a consumer that can benefit from ToU programs. To this end, the proposed work analyzes experiences regarding deploying renewable energy sources for various countries and topics pertinent to deploying BESS. From analyzing the issues pertinent to access to technologies, this work develops a strategic planning strategy based on SWOT analysis and mapping of actions.

The analysis method allows the identification of issues for the electricity sector, noting barriers for BESS but also defining possible competitive advantages to the energy sector. As points of attention for the method, there is challenging to obtain published works that address the topic of technology deployment and entry of energy generation sources in countries classified as Global South. Most studies dealt with developed countries with easier access to technologies.

It can also be highlighted as a point of attention to the direction necessary for SWOT analysis. The analysis is based on the debate of current ideas and the collaboration of various actors in the electricity sector. The literature review aimed to identify realities and questions to

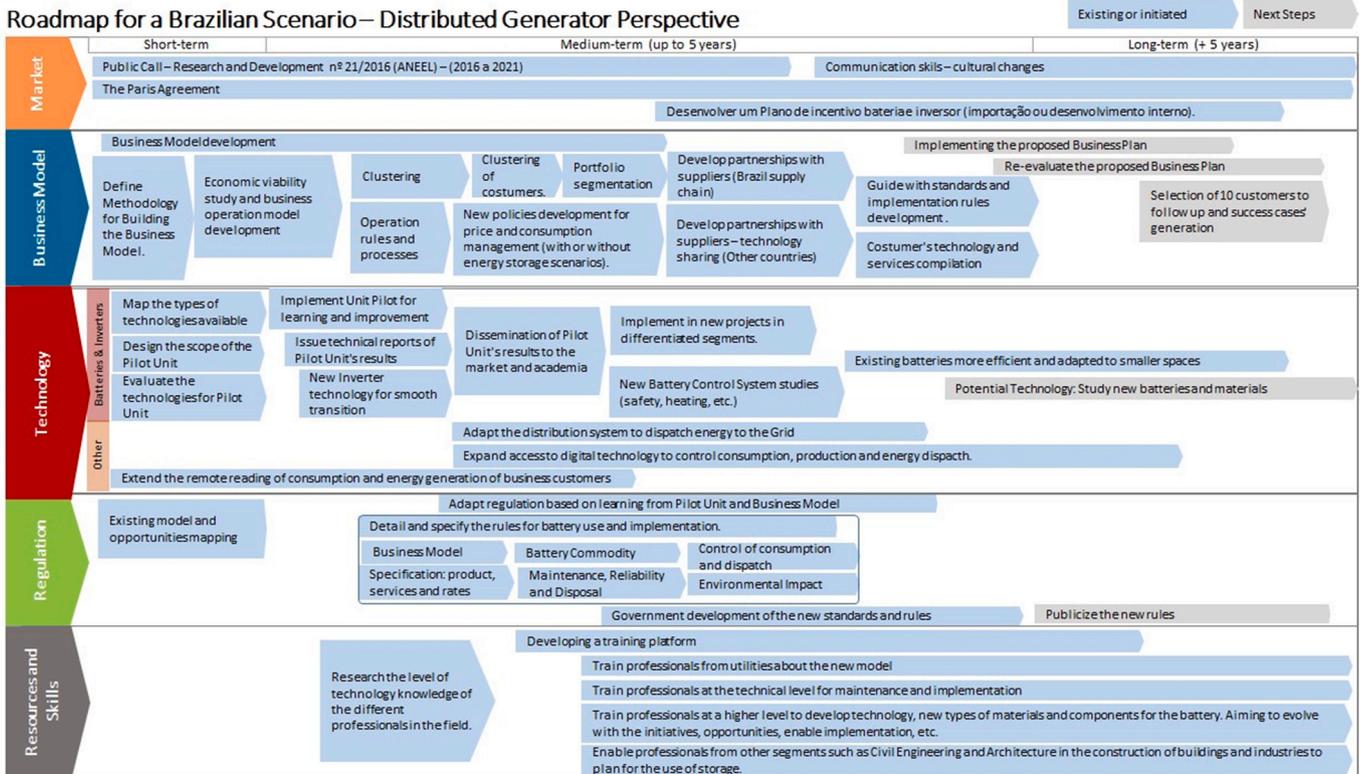


Fig. 2. Roadmap for BESS implementation in a real-life pilot project.

the research, from the study of different works and with different views about the deployment of technologies and increasing access to renewable energy sources. Thus, the definition of objectives and the positioning of the organization it proposes to analyze is a limitation for similar work.

SWOT analysis and Roadmap, methods known and practiced in several institutions, were used as strategic tools to plan and direct the action for the BESS implementation. This direction is manageable over time and allows the technology stakeholders to change activities as the evaluated scenarios change and new issues are detected. Thus, the proposed analysis methods can readily adapt to new barriers and significant changes but are also adaptable to the number of issues that the topic of energy transition brings.

Energy transition and technological input are complex topics that require analysis of technical aspects and social, economic, political, and cultural issues. Given the variety of themes inherent in implementing recent technologies and changes in the energy matrix, the proposed actions cope with barriers and issues focusing on Global South countries. The proposed tool has the advantage of dealing with different perspectives and presenting an analysis of several scenarios, proposing actions that can be adapted for other countries. The methodology and the description of the foreseen actions allow a project manager focused on BESS implementation to adapt the proposed Roadmap according to the actions and the time needed for the project to be concluded. Still, as an advantage, the tool is user-friendly, and the easy visualization controls the control of the project by all involved.

The mapped actions are classified into Regulation, Business Model, Knowledge and skilled workforce, Technology, Cultural changes, and Communication layers. The issues and the actions foreseen for each theme are connected and show the importance of analyzing various scenarios and mapping actions regarding the entry of technologies to vector the entry of new Distributed Generators.

Categorizing the issues allows for establishing actions for a manageable implementation of BESS over time: A project manager or stakeholders can manage issues according to the priorities or the technology's status in their country. Due to the amount of information required to set the actions, the map is expected to focus efforts on building new business models and policies for technology deployment, especially BESS and technologies for modern energy-services provisioning.

Due to the current technology and BESS deployment stage, issues and barriers are expected to change. With the expectation of scalability of the technology, the proposed tool should be re-analyzed to adapt actions and remove those that have been outgrown. However, we note that the learning and reorganizing process of actions is part of the tools themselves proposed, and, therefore, the countries' initiatives should be periodically reviewed to avoid lag in the process.

The next steps of this work consider the establishment of business models focused on the entry and social participation of consumers and the evaluation of parameters on the social acceptance and environmental impacts of implementing BESS for these countries.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Viviane Tavares Nascimento reports financial support was provided by CPFL Energy. Victor Baiocchi Riboldi reports a relationship with CPFL Energy that includes: employment. Tuo Ji reports a relationship with CPFL Energy that includes: employment.

Data availability

No data was used for the research described in the article.

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