

Energy Storage Systems Issues Looking For Integrated Distributed Energy-Resource Planning [†]

Viviane Nascimento *, Patrícia Gimenes, Miguel Udaeta and André Gimenes

Group of Energy, Escola Politécnica, University of São Paulo, São Paulo, SP, Brazil;
patricia.albuquerque@gmail.com (P.G.); udaeta@pea.usp.br (M.U.); gimenes@pea.com.br (A.G.)

* Correspondence: viviane.tavares@usp.br; Tel.: +55-13-99127-1834

† Presented at the First World Energies Forum, 14 September–05 October 2020; Available online:
<https://wef.sciforum.net/>.

Published: 12 September 2020

Abstract: The objective of this work is to develop a framework related to energy storage systems implementation. The work focuses in a Brazilian Scenario, and applies information regarding demographic changes, economic, governmental and energy resources studies, to establish the opportunities and barriers for a battery deployment in the country. This information is classified into organization, technology and standards fronts, enabling to schedule the human resources and deal with possible gaps. Besides, the framework organizes the information to enable a constant review of work fronts and activities, as the implementation scenario changes, and new stakeholders are added. A use case regarding an implementation of a multisource energy system composed by different sources and a battery allows to verify the proposed framework viability. As a result, it is expected that the framework enables medium-size energy consumers to implement a similar infrastructure, reducing risks and gaps, and maximizing the opportunities regarding a battery deployment.

Keywords: energy storage system; framework; technology implementation; Brazil

1. Introduction

Changes regarding population growth, birth rate and aging process, and urban expansion modify the management and planning agenda for vital resources in the coming years [1]. During planning process related to basic and vital resources, these changes establishes how the essential services, consumption and manufacturing tendencies, and workforce reallocation should be reorganized to ensure the peoples access to resources [1]. Regarding the Brazilian scenario, the population reached 208 million people in 2018 and it is predominantly urban [2]. The inhabitants are concentrated in a 200 km area of the Brazilian coast, fact accentuated by the industrialization process—started in 1960, which caused the mass migration to urban zones [2].

The urbanization in Brazil exposed the fragility of the infrastructure and the difficulties to attend vital services, highlighting social and economic inequalities. At the same time, this process shifts consumption pattern, enhancing the usage of appliance of household appliances and new technologies, the profile of urban constructions, and the integration of new consumers [3]. Consequently, the demand for energy increases, and modifies the role of the consumer as a potential generator and supplier [3].

Demographic rates and new consumers profile are potential parameters to structure the energy sector and to modify the market. Concurrently, environmental agreements establish a new market profile, offering solutions to develop a new market profile, developing more sustainable communities, fostering efficient management of resources, energy usage optimization, and energy

matrix diversification [4]. International Energy Agency (IEA) sets that all countries should raise their renewable energy proportion and strive for efficient energy consumption, reducing the global energy demand and the primary energy offer [5]. The increase in renewable energy generation is sustained by international agreements, which states that the deployment of renewable sources and energy efficiency may increase the decarbonization of the sector.

Due to the current stage of the storage systems, technological maturity and costs, the employment of storage-based services is fundamental to lead the integration of renewable sources, simultaneously ensuring the balance of the grid [6,7], contributing to further energy planning strategies. IEA states that the storage addition may strengthen economies and ensure the energy supply along with a more renewable agenda [5].

Despite the strong confidence in the new role presented by storage systems depends on some concerns regarding business and legal barriers, and grid stability [7,8]. To overcome the uncertainties and foster storage implementation, it is fundamental to map its input risks and identify further benefits as parameters to future projects. Therefore, a management method that maps the uncertainties and opportunities regarding time requirement and human resources is essential to the success of a storage system implementation project.

The proposed work presents a methodology to cope with energy storage systems implementation based on barriers and benefits stated for both international and Brazilian scenario. The work distinguishes relevant issues and plans their insertion into a timeline, separating the required actions into short, medium, and long-term. The mapped issues consider strategic market orientation, society and populational changes, available technologies, political targets, and climatic agreements as essential terms to a storage deployment project evaluation. The work also maps the stakeholders and their actions as terms to the project deployment.

The framework is a visual management tool based on different layers to deal with human resources, time requirements, and legal and market barriers. To describe the proposed methodology, the work is structured as follows. Section 2 presents the methodology applied and the opportunities and barriers for the technology entry and arranges the issues into parameters that show how and why to implement the technology. Section 3 presents a real-life Use Case for a battery implementation and details the current steps for the technology deployment. Section 4 concludes the work and presents the future works for this research.

2. Methodology Development and Opportunities

When implementing new technologies, it is a requirement to ensure the project success that the benefits and obstacles are mapped to set the time and human resources expected to reduce risks [9,10]. Concurrently, such project must cope with environmental, economy and even social impacts as different points of view that may encourage different investigations and guiding lines to fulfill the technology insertion. A common method to cope with different parameters is a roadmap, that enables a project planner to deal with marked subjects as evaluating directions to fulfill a task [9]. During a roadmap evaluation, the subjects are time patterns that can be reevaluated and coordinated along the project.

Kostoff and Schaller [9] states that the toll evaluated is relates to the project type and counts more than 150 different types of roadmaps. The authors review methods for a technology-based roadmap, and describe the stages for a product development, the crew organization, and computational methods to set a project. Although the authors do not present a new method; their work enables a roadmap developer to understand concepts and differentiate the methodologies. Phaal, Farrukh and Probert [10] mention the roadmap as a framework to evaluate a technology-based product. The authors states that the possibilities regarding a new product, and market status, including customers and competitors, must be considered as layers for a technology roadmap. The drive to develop a technology and the market are factors that change the time path.

Rinne [11] alleges that a management method should consider different variables to route a new technology implementation. The work states the previous knowledge regarding technology evaluation helps to establish the opportunities, market movements, and possible gaps. Employing a

management tool that forecasts a technology product evaluation is the focus of Hussain, Tapinos and Knight [12]. The authors present a method based on scenarios prediction and their constant monitoring alongside with a roadmap evaluation to define a strategy to deal with technology transitions. The scenarios help to perceive best practices, take advantage of knowledge and feedbacks to improve the definition of the next scenarios. Petrick and Echols [13] present a sustainability-focused discussion. The work discusses a roadmap definition for a technology development focused on sustainable terms. The authors apply a prediction method along with financial perspectives as an approach for a framework building.

IEA [5] built a roadmap for energy storage systems integration, presenting different points regarding storage implementation and the technology growth around the world. The agency highlights that additional capacity required, for both existing and out the grid capacity, policy condition and market status create prices and infrastructure distortions, resulting in poorly structure markets. Besides, public investments, market niches and learned lessons dissemination, power grid structuring, research, and development research are parameters that may encourage the technology deployment in countries.

The built roadmap states that the development of markets and regulatory environments are also parameters that may boost the technology deployment. Therefore, the market may allow that the energy storage systems is a service provider during stated periods, strengthening the energy sector. To support new market parameters, the definition of a business model and regulatory terms that ensures the concurrency are vital issues. These parameters also state which storage-based services may be provided, an ownership model and infrastructure operational rules.

The business model for an energy storage system focuses on the maximization of generation and efficiency, ensuring the system stability [4]. This model must consider the robustness and redundancy of the infrastructure project, project costs, but also must include its location in the grid, transportation, installation and maintenance, the management complexity, and the surrounding environment systems integration [4].

The analysis of social changes, consumption habits, regulatory parameters and laws sets terms that states the opportunities and gaps for a technology implementation. How the energy sector implements the storage systems establishes the opportunities and threats, that are classified in technology, legal and political processes, concurrency, environment, and resources availability. The **Opportunities** consider the particularities of the external scenario—energy market status and expectations regarding storage implementation—that may contribute the storage implementation. The Opportunities encompass Technology, Taxes and Incentives, New Business Model and Process, Pilot Project, Communication, and Resources and Skills terms.

- *Technology* establishes the openness of the energy sector to sustainable initiatives regarding new technologies and initiatives adoption, investments in resilient and intelligent infrastructure. Also, the sector focus in efficiency, reducing environmental impact, affordable and robust energy supply, and demand-side management structure.
- *Taxes and Incentives* shows capacity and technology improvements in energy storage systems lead to costs decreasing. Energy Storage Systems deployment may increase the access of consumers and independent generators to the structure, expanding the concurrency and reducing costs and taxes discounts and subsidies provided to independent generators encourage storage infrastructure acquisition.
- *New Business Models and Process* emphasize that energy storage systems may optimize the energy supply, enabling the distributed generation growth, and encouraging competitiveness. The insertion of storage systems enables to create a commercial model that encompasses new strategic planning, market share, processes building, and performance models. Besides, utility companies may reclassify the clients' profile and their requirements into new products portfolio, establishing niches and rules. The entrance of new manufacturers and independent generators may also encourage the competitiveness.
- *Pilot Project* states how technical information regarding the reliability and quality of storage deployment contribute to the infrastructure implementation.

- Reporting the strong points of the new business model to its consumers is stated as a *Communication* point. This parameter is vital so that the consumers may understand the new model advantages and competitive edges.
- *Resources and Skills* show concerns about the lack of experience and knowledge regarding technology. Learning stages and knowledge management may improve sales skills, rules, benefits, and security terms.

The analysis of external factors also enables to establish the **Threats** that may delay or disable a energy storage system implementation. The lack of representation of suppliers and manufacturer in Brazil is a parameter presented in the **Technology and Incentives** issue. The sector depends on imports or policies to bolster technology. The performance and massive scale production are concerns along with the lack of information regarding the load behavior and its threats to the distribution companies' business. The regulation must deal with market concerns, concurrently dealing with operation problems that may occur during project implementation.

Market concerns to the effects in revenue and costs for distribution companies. The development of a new business model that encompasses this new consumption behavior depends on regulatory terms. *Regulation* may reduce or even disturb sector expansion. The commissions must define interests and stakeholders, but also standardize the operation, processes, and trading. The required time to approve or define these parameters is vital for the success of the storage implementation. *Resources and Skills* points out that the absence of professional crew or professionals that cope with the technology may delay its implementation.

The **Weakness** and **Strengths** identify the qualities and innovation capacity, pointing out how the sector may improve to overcome its limitations. These parameters establish the readiness to renew and the willingness to invest in research and development. The status of the internal energy market and technology-related parameters sets factors that may encourage or inhibit the technology deployment. This information is specified as **Strengths** and **Weakness** that point out the possible qualities, how the energy sector may differentiate itself, innovate or change its own restrictions.

The **Strengths** set parameters of the distribution sector that encourage its development, particularly regarding regulatory terms and project proposals that bolster the distributed generation in Brazil. The assignment of Normative Resolution 482/2012, which stated conditions for micro or mini generators operate in the local energy sector, and the amount of research and development projects, including projects related to storage implementation, are issues that may encourage technology implementation in the country.

Besides, integrated works between Universities, companies and ANEEL encourage an innovative scenario regarding the search for solutions regarding connectivity, operation, and standards. The time differentiation of tariffs for commercial and industrial consumers may encourage the implementation of generation and storage resources that decreases costs and allow new energy-based services offer.

The **Weakness** encompasses factors that may disturb the batteries implementation in Brazil. The *Management* establishes how the absence of parameters regarding the management of these systems may delay the technology implementation. Besides, the parameter establishes that a new business model demands a paradigm change that relies on how the technology is managed, structuring communication and management terms between consumers and distribution companies. Besides, there is not a model for purchasing the technology currently, which causes delays in such moments. *Tariffs* establishes that it is important to differentiate consumers through fees. This differentiation decreases inequalities among consumers regarding access to the technology and consumption levels. The tariffs must be adequate for each group of stakeholders involved in the storage deployment process.

The stated opportunities and gaps establish tasks for a technology implementation. The project deals with the tasks according to time and resources organization. To successfully implement the project and to provide information for the crew, the issues are organized into layers.

The method categorizes the layers into three types that enable to visually arrange the mapped issues. Figure 1 presents how the layers are organized and how they are related. The upper layers are

related to organization activities and establish the reasons to end the predicted actions. They are generally related to market, consumers, environment, industry, motivation, goals, and threats issues. The lower layers present the deployed resources to the upper layers' issues. They are commonly related to skills, partnerships, suppliers, infrastructure, standards. The layers located in the middle states the activities required to connects the upper- and lower-layers actions [14].

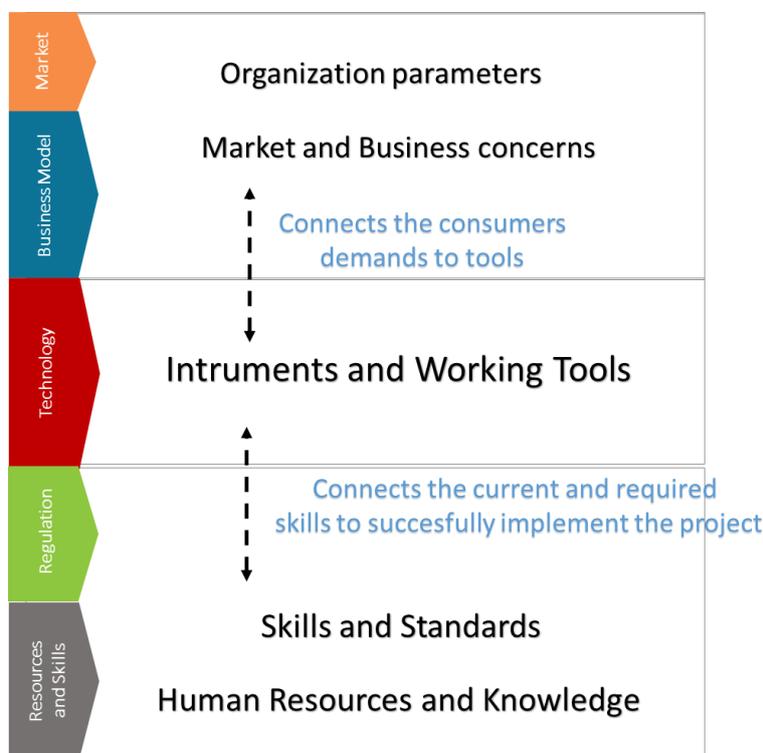


Figure 1. Layers organization for a battery insertion in Brazil.

The *Market* layer presents the actions and requirements for the successful implementation of storage technologies, along with the *Business* layer, which states how to implement the required actions to successfully end the project, and current standards and required changes to enable the entry of a technology in the sector.

How to manage the human resources to attend the demands of the previous layers are stated in the *Resources and Skills* layer. The layer states that knowledge level regarding the technology of different professionals, mapping the paradigms, preconceived ideas, and information barriers must be considered for human resources and crew training. The layer also helps to develop a training platform for employees from the energy sector, maintenance and technical crews, new specialized professionals, presenting improvements opportunities and components, and interested in energy efficiency, such civil engineers and architects that may improve the installments to receive storage equipment.

The *Market* layer proposes a cultural change to encourage storage deployment through communication and encouragement actions. As communication actions, the work states release regarding advantages of energy storage systems, websites, helpdesk, specialized media, committee and conferences, and specialized crew training as possible paths to inform stakeholders. The communication must be focused and straightforward, providing technical explanations. Financial and encouragement plans encourage the segment and may be structured through specialized supply and demand points of view. The supply plan provides the requirement to develop internal production or provide information to promote imports, and the client planning sets requirements to allow the technology purchasing.

The *Business Model* layer shows the required activities to develop a specific model for the storage system and its services, considering economic and financial viability of the storage deployment, and implementation risks - regulation, market, and environmental - regarding the entry or not of the technology. This layer states the stakeholders' profile and possible market niches and communication

strategies; the consumers’ demand and business strategy set possible products portfolio and tariffs strategy. Besides, the communication establishes marketing channels, such as straightforward sales between suppliers and clients or representative sales, stating possible partnerships in the sector.

The *Technology* layer studies the technology potential and designs the infrastructure. The research of potential batteries technology and materials, and how to deploy the infrastructure to achieve the most affordable results. This research provides information regarding the purchase of storage technology and how a pilot unit installation can be set. The gathering of data regarding the functioning of the pilot is also a responsibility of this layer; therefore, spreading the results and academic publications are part of this layer task.

The *Regulation* layer maps the barriers of the current regulatory documents, specifying the rules for implementing and managing a storage system, the stakeholders and their interests, and services possibilities. This layer also sets stakeholders’ responsibilities and the energy-related services trades, measurement, detailing this front specifies the maintenance, security, environmental rules.

3. Use Case

The use case presents the implementation plan for a medium voltage client, located in Campinas, a city near São Paulo. There are a gas station and a restaurant in the location, both working 24 h a day. The tariff of this consumer varies from the peak and off-peak periods, complemented by a single tariff for its contracted demand. The energy demand and consumption peak occur around lunch time, out of the peak period.

The pilot adds a Lithium battery as an alternative energy source during the peak period. The battery must supply the client during the peak period (three hours) or power loss conditions. The unit counts with multiple energy sources: besides the battery, the customer has photovoltaic panels and a diesel generator set. The client is connected to the grid so that the unit can purchase energy from the distribution company. The current project does not consider the dispatch of energy to the grid.

Figures 2–6 present how the issues regarding Opportunities and Threats were organized through time and layer requirements. The activities are organized into current (short-term), medium-term and long-term, and the colors blue and grey states the status of each activity.



Figure 2. Market Layer for the Brazilian Use Case.

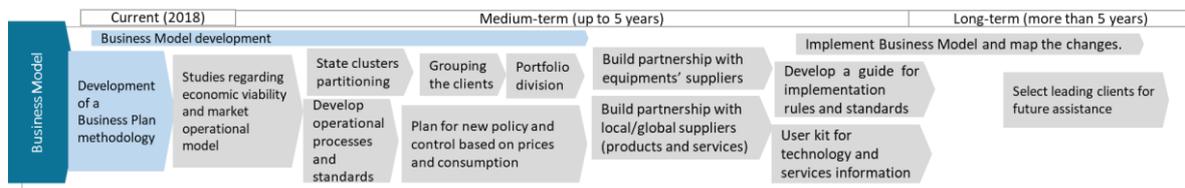


Figure 3. Business Model Layer for the Brazilian Use Roadmap.

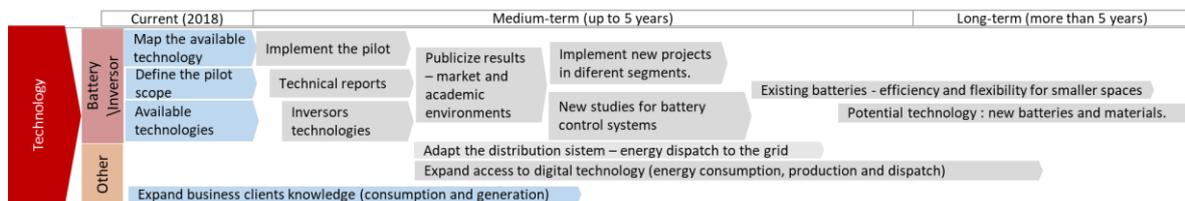


Figure 4. Technology Layer for the Brazilian Use Case Roadmap.

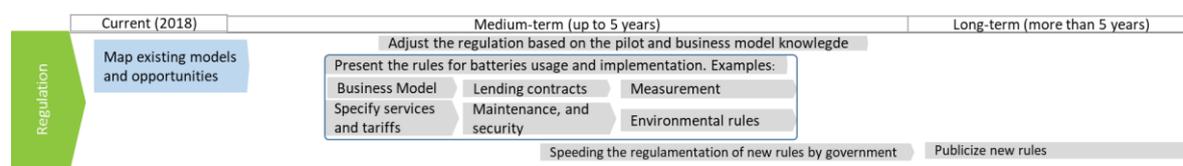


Figure 5. Regulation Layer for the Brazilian Use Case Roadmap.

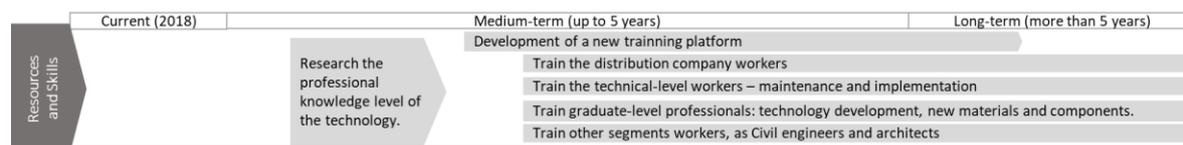


Figure 6. Resources and Skills for the Brazilian Use Case Roadmap.

The goal of this unit is to evaluate the technical and economic aspects of a multiple source location. These aspects test the reliability, operational and technical costs, and the optimized dispatch of the energy. The secondary goal is the technical training of human resources to operate and manage a multiple source infrastructure. The project is structured in two stages: the first one deals with requirements gathering for the infrastructure implementation, including technical requirements and the acquisition of the battery, management, and measurement equipment. The second stage refers to data collection and feasibility studies. The pilot implementation is part of a research and development project with the distribution company CPFL (*Companhia Paulista de Força e Luz*).

There are four work fronts for the project, focused in market and business, technical, regulation, and the environmental impacts of the battery deployment. The work fronts deal with economic, political, and cultural parameters, equipment, architecture and topology, grid status, current laws, and regulation statements for the implementation of the batteries, and the economic feasibility for the consumer and market trends, respectively.

At the beginning of the project, the crew took part in interviews processes. Those sessions focused in understand the learning process and connect each work front goal. This stage mapped the perspective for the battery implementation for the Brazilian scenario, considering the existing barriers for the energy sector. The barriers referenced are the profitability, regulation, current tariff model, scale economy and new suppliers' entrance.

The researchers pointed out as possible opportunities the training and investment in human resources, that must deal with the new operating model for batteries functioning, and the knowledge regarding the technology deployment. All the work fronts present governmental encouragement for new storage technologies acquiring, such as subsidies programs in Germany, Japan, and Australia. They believe that this point may encourage the private sector and companies to invest in the technology, enlarging its development.

The stated issues establish a route for Brazil, presenting design and operational process, standards, and norms to encourage this new segment. Besides, working with new technologies is an option to study the generated distribution behavior and its impacts on the grid. The energy storage systems may foment the Brazilian market, dealing with specificities of consumers and companies. Therefore, the implementation of technologies is still slow in the country, due to the business model, cost-effectiveness, regulation, and feasibility.

The implementation is set in three periods: short-term period, starting in 2018, medium-term, five years (up to 2023), and long-term, more than five years since the start of the project.

4. Conclusions and Future Works

Energy storage systems are used as a reference to bolster renewable energy sources integration, promoting the decarbonization of the energy sector. Therefore, the implementation of the technology still concerns the energy sector, presenting challenges to its deployment. These challenges concerns to business conducting, supply chain, norms and standards, regulation, and reliability. The storage

deployment still needs information and knowledge that is under construction, despite the known advantages of the technology.

The country copes with different opportunities. The absence of suppliers, the specific regulation for the technology, and technical skills bring opportunities for those interested in changes in energy supply in the country. Despite the significant opportunities, a method that enables to map different issues, establish work front, and set time terms for their solving contributes to manage the concerns and take advantage of the opportunities.

The work presents a method to map these issues, but also sets the human resources allocation and manages the work front connections. The Use Case demonstrates the research period for pilot implementation and points out the work fronts learning process at this stage. As the implementation of a real-life pilot is under development, as well as possible changes in market rules and regulation in the country, the framework is going to be continuously revisited. The future work for this research is the evaluation of the stated term according to real-life pilot and technical terms changes during the unit implementation.

Funding: this research received no external funding.

Acknowledgments: This study was financed in part by the Conselho Nacional de Desenvolvimento Científico e Tecnológico - Brazil (CNPq). Acknowledgment to CPFL/State Grid Company for funding the R\&D strategic project ANEEL 00063-3025/2016 \textit{[Sistemas de Armazenamento Integrados a mais de uma fonte energética: Gestão híbrida de Sistemas energéticos Multi-fontes]}, enabling the idealization and development of this work.

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