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Strategies of electricity distributors in the context of distributed energy resources diffusion

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1. Introduction

As developing countries became more industrialized, electricity demands rose in parallel, with much of this power derived largely from fossil fuels. Therefore, greenhouse gas (GHG) emissions increased, leading to global warming. This phenomenon is confirmed by the Intergovernmental Panel on Climate Change (IPCC, 2014), which stresses that alterations to the planetary climate system are strongly influenced by anthropogenic emissions. This situation is prompting a quest for alternative energy sources that are both safe and secure. Clean energy is the solution to building a more sustainable future, in terms of energy use.

Society is also living through the prelude to a new energy era. Three trends are breaking away from the power sector paradigm: (i) electrification in major economic sectors such as transportation; (ii) decentralization driven by plummeting battery and photovoltaic panel prices; and (iii) power grid digitization of through smart metering, automation, and the internet of things. In this context, some consumers have also become generators (known as prosumers) who expect lower electricity bills with less dependence on energy concessionaires.

The diffusion of distributed energy resources (DER) has been the driver of the decentralization of the power system through replacing conventional power generation options such as hydro, thermo, and nuclear power plants with new distributed generation technologies, demand management, and energy storage. By altering energy flows, this transformation is stepping up the complexity of operating these systems to a significant extent, indicating that the dissemination of these technologies embodies ample disruptive potential for the power sector. Furthermore, DER diffusion is making a decisive contribution to the implementation of new business models and electricity distribution services.

However, as DER are usually connected to the distribution grids, their diffusion represents a technical and economic challenge for distributors (SWECO, 2015). From this standpoint, electricity distributors should be the most severely affected agents. Changes in their business vision and the current regulatory process must be implemented to ensure the survival of electricity distributors. DER diffusion and the new technologies may affect the power sector in either a positive or negative manner, especially the business environment of the electricity distribution sector. This study thus presents a tool to quantify the distributors' perception of the need to change their business model to act efficiently in a DER diffusion environment based on the combination of three methodologies: SWOT, multicriteria, and risk analysis.

This paper is divided into five sections, in addition to this Introduction. Section 2 presents a literature review that assesses the relevance and pertinence of using SWOT, multicriteria, and risk analysis in studies such as those mentioned in this paper. Section 3 presents the methodology used in this paper. The authors present an innovative approach combining three traditional forms of analysis (SWOT, multicriteria, risk). Section 4 identifies the strengths, weaknesses, threats, and opportunities faced by electricity distributors in a DER diffusion context on the basis of different aspects related to their business environments, for example, technological, operational, and regulatory aspects. For each aspect, the authors also considered the answers from a survey that was conducted to sample different views of the Brazilian power sector, in terms of DER diffusion on the domestic market. Section 5 presents a discussion of the challenges for distributors and regulators in adapting the business model and the regulatory framework,

Abbreviations: ABRADEE, Brazilian Association of Electricity Distributors; AHP, Analytic Hierarchical Process; ANEEL, National Electric Energy Agency; CHP, Combined Heat and Power; DER, Distributed Energy Resources; DG, Distributed Generation; DR, Demand Response; DS, Distributed Energy Storage; EM, Electric Mobility; EPE, Energy Research Company; GHG, Greenhouse Gases; ICE, Internal Combustion Engines; IPCC, Intergovernmental Panel on Climate Change; NIS, National Interconnected System; R&D, Research & Development; SHP, Small Hydropower Plants; SWOT, Strengths, Weaknesses, Opportunities, and Threats

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respectively, to create a new environment with DER diffusion. Section 5 also presents two new business models for distributors and the traditional model. Section 6 presents a multicriteria analysis and a risk analysis for different business models to distribution companies. Finally, Section 7 concludes.

2. Literature review

Several studies have pinpointed opportunities for DER adoption, including (Li et al., 2019), who proposed a methodology for quantifying DER values in terms of impacts on the grid. Going further, (Ros et al., 2018) examine economic options for offsetting these impacts, based on costs avoided by utilities. By contrast, (Burger and Luke, 2017) analyze the political and regulatory implications of DER diffusion for different business models. This paper considers all these aspects to analyze the impacts of DER diffusion on distribution utilities through SWOT analyses, aligned with the approach proposed by (Lei et al., 2019), which compares the development of distributed photovoltaic solar power generation in Africa and China.

An acronym for the strengths, weaknesses, opportunities, and threats, the SWOT methodology was developed by Albert Humphrey, a researcher from the United States, while participating in a research project at Stanford University between 1960 and 1970 (Barros, 2014); however, some authors argue that it is not possible to identify its origin (Santos et al., 2014). It has been widely used in strategic planning processes. Some authors posit that the SWOT matrix is not an analysis but a tool for conducting the analysis (Çelik et al., 2012). Nevertheless, the SWOT matrix design may be applied to any type of organization to help define strategies and make decisions. According to (Mintzberg et al., 2003), the SWOT matrix is associated with the strategy formulation as a conceptualization process and is concerned more with how strategies should be applied than with how they are formulated.

Some authors support the use of SWOT matrixes with quantitative methods because strategic planning is usually a complex process involving different criteria and several interdependencies. Use of the SWOT matrix may thus be insufficient (Chang and Huang, 2006). Therefore, several authors explore the combination of a SWOT matrix with decision-making techniques such as the analytic hierarchical process (AHP) (Görener et al., 2012; Gottfried et al., 2018; Yavuz and Baycan, 2013), which provides an order of priority among different alternatives.

Because the importance ranking for the SWOT factors had not been determined, (Görener et al., 2012) proposed to enhance SWOT analysis with a multicriteria decision-making technique, the AHP, to improve the quantitative side of strategic planning with the combined method. According to (Görener et al., 2012), SWOT analysis does not provide a means of systematically determining the relative importance of the criteria or assessing decision alternatives according to these criteria. To handle this insufficiency, the SWOT framework is converted into a hierarchic structure, and the model is integrated and analyzed using the AHP. The objective of using the AHP within the SWOT framework was to systematically qualify SWOT factors and equate their intensities.

The paper of (Yavuz and Baycan, 2013) offers a systematic approach and analytical means with a combination of SWOT analysis—an AHP that can enhance stakeholders' and decision-makers' understanding of the problem and help in the definition of solution objectives and constraints. According to (Yavuz and Baycan, 2013), making pairwise comparisons forces decision-makers to consider the weights of the SWOT factors and to analyze the situation more precisely and in more depth than the standard SWOT does. By integrating SWOT with AHP, not only the mutual weighting of SWOT factors but also the evaluation of alternative strategic decisions can be integrated with ordinary SWOT analyses. In this manner, the most crucial weakness of SWOT can be avoided.

The scientific contribution of (Gottfried et al., 2018) is to close the academic knowledge gap on private stakeholders' investment preferences in the Chinese biogas sector, through a combined application of SWOT-AHP-TOWS analysis, based on first-hand interview data collected in 525 interviews.

However, in some cases, identifying the risks of each option is also required. Then, multicriteria analysis should also be combined with a risk analysis, as proposed in AMPHY methodology (Bryla and Lonchampt, 2003).

This article covers a gap in the literature by applying AMPHY methodology to indicate a strategy action of the distributors in the context of DER diffusion. First, a SWOT matrix was built to identify positive and negative aspects of DER diffusion for distribution utilities, to present a set of possible, but not prioritized, strategic actions. Next, the results were used in a combination with multicriteria and risk analysis to rank three different business models to distribution companies while considering the challenges of DER diffusion in their markets.

The SWOT matrix structure shows the strengths and weaknesses factors (internal environment) of the organization's business model, compared with that of its competitors. The opportunity and threat (external environment) factors are beyond the organization's control and have the potential to enhance or undermine its performance.

Multicriteria and risk analysis combine quantitative and qualitative aspects and may be used in many types of organizations and projects, such as renewable energy projects in Africa (Njoh et al., 2019), hydropower projects in China (Penghao et al., 2019), and forest management in Bangladesh (Chen et al., 2019). This justifies the use of these methods for analyzing and defining strategic actions that allow distribution utilities to efficiently manage the challenges of DER diffusion.

3. Methodology

Fig. 1 presents the flowchart of the methodological process adopted in this article.

The SWOT analysis was performed by considering that distribution companies follow a traditional business model and the major challenges related to DER diffusion. The results are the input for the multicriteria and risk analysis. The methodology proposed in this paper is based on (Bryla and Lonchampt, 2003), who describe the application of the AMPHY—*Aide à la Maintenance Pour l'Hydraulique*—to define the maintenance policy of an EDF's power plant.

As per the multicriteria analysis, the AHP was applied. According to (Forman and Selly, 2001), this method allows decision-makers to model a complex problem in a hierarchical structure, showing the relationships of the goals, objectives (criteria), sub-objectives, and alternatives, considering uncertainties and other factors. Fig. 2 presents the structure of the AHP.

The method attempts to identify intangible benefits and analyzes them systematically, quantifying the opinion of decision-makers involved in the evaluation of alternatives. Therefore, it possible to manage objective and subjective issues. For the risk analysis, three variables were considered: impact, probability, and control. The influence of each variable was determined according to a scale of values from 1 to 4 (Table 1).

The themes considered in the survey with stakeholders were the basis for defining the criteria used in the risk analysis (identified as 2nd level). The themes were grouped by considering the external and internal environments of the distributors (Table 2). Next, these criteria were grouped into five categories (identified as 1st level criterion; Table 3).

The values of the scale of the variables (impact, probability, control) of each 2nd level criterion were chosen by considering (i) the results of the SWOT analysis; (ii) the perception of the stakeholders obtained from the research; and (iii) the judgment of the authors (experts in the energy sector) based on their knowledge, experience, and analytical vision. The values of the three variables (impact, probability, control)

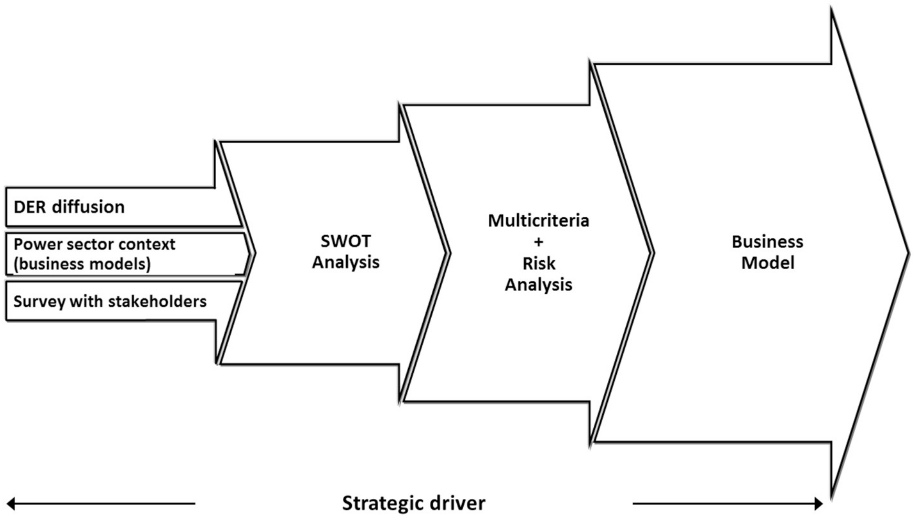

Fig. 1. Flowchart of the methodological process.

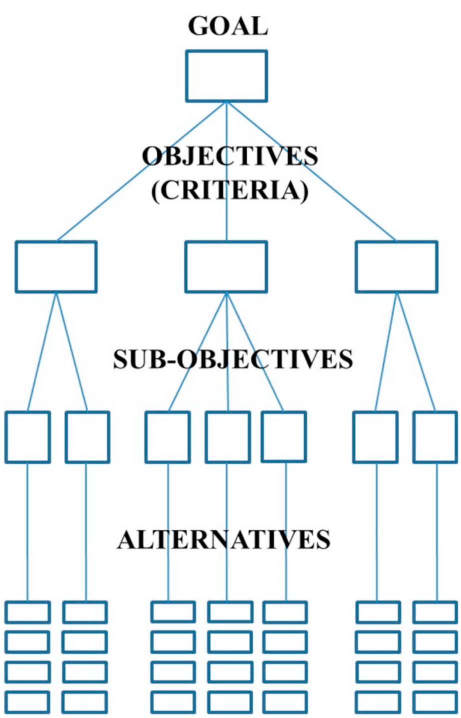

Fig. 2. AHP hierarchical structure.
Source: adapted from (Forman and Selly, 2001)

Table 1
Scale.

	Impact (I)	Probability (P)	Control (C)
1	Low	Low	Controllable
2	Moderate	Moderate	Moderate control
3	Strong	Strong	Low control
4	Extreme	Extreme	Uncontrollable

were multiplied to obtain the weight of each 2nd level criterion, and consequently, their hierarchy in relation to the 1st level criterion to which they are related. Table 4 shows the relationship between the results of the SWOT analysis and the perception of stakeholders.

The multicriteria analysis, associated with the risk analysis, allows for prioritizing the three business models (traditional, protagonist, orchestrator) to determine the hierarchy of the business models for distributors in a scenario of RED diffusion. The combination of traditional SWOT, multicriteria, and risk is an innovative approach that helps distributors have strategic actions (new business models) to face the challenges of DER diffusion. The combination of the three analyses proposed here is a powerful decision-making tool and is primarily for companies in periods of uncertainty regarding the impact of DER diffusion.

SWOT analysis, despite the limitations presented in this article, is a valuable tool to map the external and internal aspects of the distributors that influence the definition of the best strategy to be adopted. The analysis was rigorous, the more representative the choice of the individuals who were invited to respond, interviews were considered with, in addition to the representatives of the leading distributors, other important agents, such as traders, consumers, and organizations in the energy sector.

The combination with the AHP methodology did not follow the traditional approach of hierarchizing the factors of the SWOT matrix. Based on stakeholder responses and the SWOT analysis, the method identifies the 1st and 2nd level criteria necessary for the second analysis using the AHP methodology. We opted to integrate risk analysis into the AHP methodology to improve the decision-maker's power of analysis and thus offer a tool that makes possible capturing their perception and thus measuring intensity, probability, and control of 2nd level criteria.

The approach adopted proved to be robust in indicating the need for distributors to seek more proactive business models, as is discussed in the following sections. The approach also proved suitable for formulating strategies because it can be used by other stakeholders, including the regulatory agency in the analysis of the regulatory changes necessary to ensure that the dissemination of DER is beneficial to all agents in the sector.

4. SWOT analysis for electricity distributors in the DER diffusion context

The following inputs were considered in the SWOT analysis: (i) the types of DER, the associated digital technologies (e.g., smart grids, smart meters, data analytics, big data) and the current and future DER diffusion scenarios; (ii) the power sector, especially the distribution companies (highly regulated and with a conservative profile) and the possible business models for them; and (iii) the survey of stakeholders in the Brazilian electricity sector (Gouvêa, 2019).

DER may be defined as energy generation and/or storage devices located on a consumer's premises or within the electricity distribution

Table 2
Survey themes.

Environment	Criterion (2nd level)	Description
External	Policy & Regulation	Tariffs, incentive policy; regulatory limits
	Economical/Social	Job opportunities and higher income
	Culture/Environment	Consumer prone to DER diffusion, renewable sources, and energy efficiency
	New technologies	DER, smart grids, energy storage, electric mobility
Internal	Training	Workforce prepared for DER diffusion
	Operation	Workforce prepared to operate and maintain the new technologies
	Quality	Rules and procedures
	Competitiveness/New business	New competitors
	Responsibilities	Shareholders, consumers, society, and regulators
	Economic and financial sustainability	Investment required
	Investments & Assets	Grid infrastructure
	Information security	Workforce and infrastructure prepared to manage this matter

Table 3
Multicriteria and risk analyses relationship.

Multicriteria analysis	Risk analysis
1st level	2nd level
Regulation	Policy & regulation
	Responsibilities
	New technologies[1]
Social-Environmental	New technologies[1]
	Economical/Social
	Culture/environment
Operational	Operation
	Training
Business	New technologies[1]
	Competitiveness/new business
	Quality
	Information security
Investment	Economic and financial sustainability
	Investments & assets

(1) the 2nd level criterion "new technologies" influences three 1st level criteria.

system. These devices respond to local demands, either partially or totally, and may inject power into the grid under certain conditions. The DER examined in this article are

- Distributed Generation (DG): generation of electricity close to the end consumer to fulfill its consumption needs; consumers might or might not sell energy surplus to local electricity concessionaires (MIT, 2016). Microgeneration technologies are, for example, wind turbines, small hydropower plants (SHP), heat pumps, photovoltaic solar panels, microturbines, internal combustion engines, and combined heat and power. For the purposes of this article, the authors focused on renewable sources, especially solar, because of the huge increase in the number of photovoltaic solar panels in Brazil in recent years. This situation is discussed in the next section;
- Distributed Energy Storage (DS): systems that transform electricity into a physical form of storage. Nowadays, it is possible to classify such systems as mechanical, electrochemical, chemical, electrical, and thermal storage (Gallo et al., 2016; Kyriakopoulos and Arabatzis, 2016). Storage systems may be charged at times when surplus renewable electricity is generated, storing energy for use during periods when renewable resources are in short supply (Zakeri and Syri, 2015). The development of large-scale storage mechanisms has the potential to streamline the integration of variable renewable energies, with no significant increase in greenhouse gas emissions, such as those emitted by thermopower plants when brought on-stream (Luo et al., 2015);
- Electric Mobility (EM): a double benefit is provided to the environment. In addition to helping reduce pollutant gas emissions (particularly in countries where power generation is fueled by renewable energy sources), EM may ease the integration of intermittent energy sources with electricity systems. Indeed, plug-in vehicle batteries may be used as energy storage units to provide ancillary services to the grid, integrating renewable energy in

Table 4
SWOT x survey relationship.

SWOT (Strengths)	Criterion (2nd level)
1. Better informed of consumer behavior than its competitors	Competitiveness/new business; Economical/Social; Culture/environment
2. Experience in grid planning, operations, and maintenance	Competitiveness/new business; operation
SWOT (Opportunities)	Criterion (2nd level)
1. Increasing electricity demands	Economic and financial sustainability; Competitiveness/new business
2. Grid expansion investments postponed	Economic and financial sustainability; Investments & assets
3. Lower technical losses	Operation; quality
4. Potentially higher profitability for investments	Economic and financial sustainability; Investments & assets
5. Better image through actions focused on a low-carbon economy	Culture/environment; responsibilities
SWOT (Weaknesses)	Criterion (2nd level)
1. Difficulty in cash flow management	Economic and financial sustainability
2. Difficulty in ensuring electricity supply services	Responsibilities /operation
3. Lack of DER equipment standardization	Quality; responsibilities
4. Obligation to accept reimbursement for damages to the grid	Responsibilities
5. Lack of accumulated knowledge about DER technologies	Training; operation; new technologies; information security
6. Lack of experience in DER management connected to the grid	Training; operation; new technologies; information security
SWOT (Threats)	Criterion (2nd level)
1. Shrinking market for distributors	Policy & regulation; Economic and financial sustainability; Competitiveness/new business
2. Regulatory stumbling blocks for working with DER	Policy & regulation; Information security
3. Higher tariffs for other consumers	Policy & regulation; Economic and financial sustainability; Competitiveness/new business
4. Lack of acknowledgement of investments in grid modernization (smart grid)	Policy & regulation; Investments & assets; New technologies; Information security

Table 5
Survey respondents.

Stakeholder	N°
Distribution companies	14
Traders	6
Associations	10
Organizations in the energy sector	7
Universities/research centers	10
Financing entities	3
Consulting companies	5
Consumers[1]	8

(1) Organizations representing consumers segments (industrial, commercial, residential)

response to power supply fluctuations and varying electricity demands (Borba, 2012; Habib et al., 2015; Zhao et al., 2016). According to (Henze and Thomas, 2017), EM will account for most new car sales worldwide by 2040 and for 33% of all light vehicles on roads; notably, an estimate indicates that sales will remain low until 2025. However, the turning point is likely to occur between 2025 and 2030, when electric vehicles, compared with combustion models, will become more competitive, even without their current subsidies;

- Demand Response (DR): these mechanisms help fulfill electricity demands with quality and reliability, allowing consumers to become actively involved in the market and participate in wholesale and retail signal integration (Catalão et al., 2017). One of the intentions of DR (IEC, 2012) is to flatten consumer load curves, shifting some of these loads to off-peak periods to endow grid operations with greater flexibility and efficiency. Another intention of DR is to contribute dynamically to the balance between system supplies and demands. In this case, if the power distribution concessionaire observes a sharp upsurge in demand or a sudden drop in generation, it sends an electronic signal telling the DR program participants to quickly decrease their consumption (Aalami et al., 2010; Siano, 2014).

The distribution segment, and the power sector in general, is undergoing major transformations because of the dissemination of digital technologies (smart grids) and DER diffusion; their application focuses on the installation of smart meters, namely, two-way communication networks, together with sensors and monitoring and control devices. This allows the automation of distribution network operations, with intensive use of data analytics and big data for processing massive volumes of information that flows in the distribution system.

This understanding requires distributors to invest heavily in innovative technologies and staff qualified to operate networks. DER diffusion leads to technical disturbances in the system, such as voltage variations. Thus, distributors must inevitably prepare to operate and monitor DER, which will increase the complexity of their distribution networks.

In developing countries such as Brazil, particularities must be considered. The power sector is usually a market with increasing electricity consumption rates, consequently requiring regular investments by distributors in grid upgrades and replacement equipment. With the expansion of DER, there is a threat of market shrinkage from consumers withdrawing from the regulated environment. This shrinkage directly interferes with the remuneration of these companies and eventually leads to higher tariffs for consumers. Furthermore, the distribution system still presents challenges related to improvements in electricity supply quality levels, universal access in rural areas, and reductions in non-technical loss levels.

The elements necessary for a SWOT analysis were obtained from bibliographic data and a survey (Gouvêa, 2019). The data was based on documents discussing recent power sector transformations worldwide.

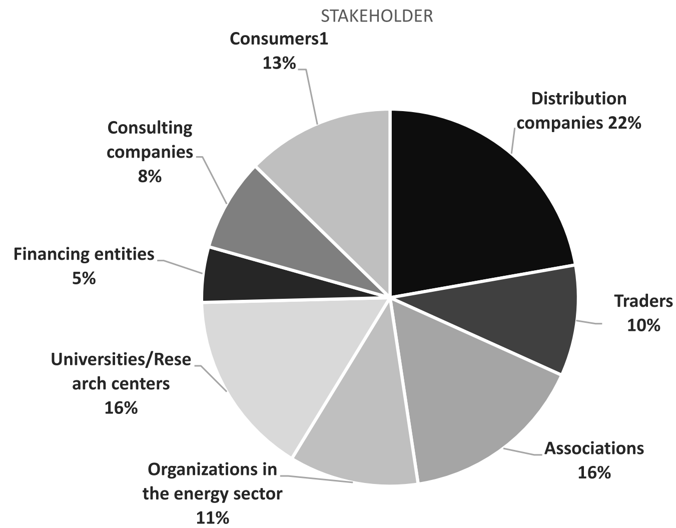

Fig. 3. Stakeholder breakdown.

The survey was conducted to sample different visions of the Brazilian power sector, in terms of DER expansion on the domestic market. A questionnaire was created for the survey and comprised 58 questions related to transformations resulting from DER diffusion. *SurveyMonkey* software was used.

The questions were separated by topics: policy and regulation; economic, social, operational, environmental, and cultural aspects; training; competitiveness; economic and financial sustainability; new businesses; investments and assets; responsibility; quality; impacts of the introduction of new technologies on network expansion; and security aspects related to hacking and cyber-attacks. Sixty-three stakeholders, comprising members of the power sector (distribution companies), universities/research centers, financing entities, associations, organizations in the energy sector, and consulting companies; traders; and consumers, completed the survey. The response rate was 79%. Table 5 and Fig. 3 show the breakdown of entities by type of stakeholder.

In 2018, Brazil had 53 distributors, many of which were linked to the same business group. The 14 companies selected represent approximately 78% of the market, both in terms of GWh and in terms of consumers (Abradee, 2019).

A SWOT matrix was then constructed, based on the received information (Fig. 4).

4.1. Strengths analysis

4.1.1. Greater familiarity with consumer behavior than competitors

Electricity distributors usually function as regulated monopolies, whose know-how in the distribution segment underpins their grid-operating competencies: (i) regular direct access to consumer information and (ii) familiarity with their habits. This expertise endows distributors with comparative advantages over their competitors: (i) better electricity management in their concession areas through familiarity with demand curves and (ii) maintenance of the quality and efficiency of their services, which are rated as essential for society (Aneel, 2018a; Astarloa et al., 2017; MIT, 2016).

According to the survey, the challenge for the distribution companies is how to benefit from this strength once they consider that DER diffusion increases the relationship with consumers/prosumers. Whether they are prepared for this remains unclear. No consensus has been reached among them on how the DER diffusion affects the different layers of the population. Most distribution companies posit that the entry of new agents harms their business.

	POSITIVE	NEGATIVE
INTERNAL	S 1. *Better informed of consumer behavior than its competitors* 2. *Experience in grid planning, operations, and maintenance*	W 1. *Difficulty in cash flow management* 2. *Difficulty in ensuring electricity supply services* 3. *Lack of DER equipment standardization* 4. *Obligation to accept reimbursement for damages to the grid* 5. *Lack of accumulated knowledge about DER technologies* 6. *Lack of experience in DER management connected to the grid*
EXTERNAL	O 1. *Increasing electricity demands* 2. *Grid expansion investments postponed* 3. *Lower technical losses* 4. *Potentially higher profitability for investments* 5. *Better image through actions focused on a low-carbon economy*	T 1. *Shrinking market for distributors* 2. *Regulatory limitations for working with DER* 3. *Higher tariffs for other consumers* 4. *Lack of acknowledgment of investments in grid modernization (Smart Grid)*

Fig. 4. SWOT Matrix in DER Diffusion Scenario.

4.1.2. Experience in grid planning, operations, and maintenance

Having handled grid planning, operations, and maintenance for decades, distributors have acquired and polished their electricity distribution system management skills, which constitute an intangible asset that distinguishes them from newcomers (Aneel, 2018a; Astarloa et al., 2017; Cigre, 2018; MIT, 2016).

The survey shows that the distributors' perception of them is that the DER diffusion affects the technical/operational and planning areas of their organizations. In both cases (4.1.1 and 4.1.2), there is a great challenge to create partnerships with new entrants, because the distribution companies view the entry of new agents negatively.

4.2. Weakness analysis

4.2.1. Difficulties in cash flow management

DER diffusion implies market shrinkage for distributors, with lower electricity consumption and contract revision, increasing the risks of over- or under-contracting energy. With cash flow management difficulties and no possibility of engaging in activities unrelated to electricity distribution, the value creation potential of these utilities may be less appealing to shareholders and investors, as well as to financing and rating agencies (Aneel, 2018b, 2018a; Mariotto et al., 2017).

The survey confirms that traditional distribution companies are pessimistic about DER diffusion. They believe that DER forces them to make investments in new technologies and that regulatory changes are necessary to assure the economic and financial sustainability of their organizations. For most of these companies, it will be necessary to increase the relationship with their shareholders. In assessments of the inside of the organization, they believe that DER diffusion impacts the financial and commercial areas.

4.2.2. Difficulties in guaranteeing electricity supply services

The gradual inclusion of DER implies greater system complexity, requiring heavier investments in grid modernization to fulfill the requirements of supplying good quality electricity to consumers and prosumers, which may affect the business models of these utilities. Moreover, there remains a risk of these investments not being acknowledged as prudent by the regulator. Thus, new criteria and procedures are necessary for the maintenance and reconstitution of the grid in this new context (IEA, 2014; Irena, 2017; Jenkins and Pérez-Arriaga, 2014).

The survey shows that the distribution companies believe that DER diffusion could harm the remuneration of the investments already made by them. They consider that regulatory changes are necessary for quality management of energy supply.

4.2.3. Absence of standardization for DER equipment connected to the grid

The proliferation of DER equipment may hamper the integration of these technologies with the grid, in parallel to greater turbulence throughout the system. The agents involved are aware of the importance of technical cooperation and partnerships with newcomers and the suppliers of goods and services. This is critical to align expertise with needs for equipment certified as acceptable for DER connections to the grid. However, standardization depends on public policies and regulatory actions that are in some cases moving in the opposite direction, discouraging investments in technological innovations and new energy assets (CGEE, 2017; Cossent, 2013).

According to the survey, the distribution companies believe that DER diffusion affects the criteria of the quality and continuity of the services, harming the current quality indicators of electric energy distribution. This perception may be related to the absence of standardization of DER equipment connected to the grid. This concern is linked to the next weakness.

4.2.4. Obligation to accept reimbursement for damages to the grid

The current regulation fails to address reimbursements for incidents resulting from the inclusion of tightly clustered DER in the grid. Without sensors installed in consumer units, agents liable for damages to distribution utilities and/or consumers connected to the electricity network can neither be identified nor penalized. Unless the regulation changes, distributors may have to accept these losses (Jenkins and Pérez-Arriaga, 2017; Medina et al., 2010).

As in Subsection 4.2.3, the perception of distribution companies is that worsening in the quality indicators of the electricity distribution may impose on them obligations that would not be their responsibility. This problem may be because of a lack of standardization of equipment or a lack of regulation in the implementation of DER. This aspect reinforces distribution companies' concern for the need for changes in regulation.

4.2.5. Absence of accumulated knowledge of DER Technologies

Distribution utilities are not necessarily equipped with the skills necessary to keep pace with the technical and commercial progression of maturing DER technologies. Furthermore, they must acquire a vast range of technical expertise related to digital technologies, such as (i) management of incidents caused by the broad-ranging inclusion of these resources in the grid and (ii) responses against invading hackers, to guarantee data security for their clients and rapid responses to these incidents (CGEE, 2017; Mariotto et al., 2017; Muller, 2017; Taranto et al., 2017).

In this aspect, the survey shows the dubious position of the distribution companies. Although they recognize the need for training the existing workforce, they seem to demonstrate a false sense of security. They consider themselves prepared against the intrusion of hackers and threats to the privacy of consumers and the systems themselves.

4.2.6. Absence of experience in managing DER connected to the grid

Transmission system operators have traditionally been responsible for system stability, and this makes sense because large-scale generation facilities (powerplants, major consumers) are all connected to grids. Transmission system operators control generator flexibility to ensure well-balanced supplies and render ancillary services, for example, frequency control, reactive energy supplies, and black starts.

In the case of ancillary services, they will have to be supplied as well through the distribution network, once renewable energy tops 50% of the installed capacity. In a system where DER are connected to the grid, it seems reasonable to assign at least shared responsibility for system stability to the distribution network operators, jointly with their transmission system counterparts. (Catalão et al., 2017; Ekanayake et al., 2012; Kagan et al., 2013; Six et al., 2018).

In this aspect, the distribution companies seem to be aware of the need to prepare for DER diffusion. The survey shows that they recognize that DER affects several of their organizations (financing, commercial, technical/operational, planning) and that they are preparing the existing workforce to manage this new scenario.

4.3. Opportunity analysis

4.3.1. Boosting electricity demands

Based on the business model currently used by distributors in some countries, including Brazil, the only DER that might directly involve traditional regulated utilities is public supplies for electric vehicles. This market is rated as a captive market assigned to the concessionaires, namely, small-scale electricity sales, a monopoly held by these companies (Accenture, 2016; Astarloa et al., 2017; Henze and Thomas, 2017; IEA, 2011).

According to the survey, the challenge for distribution companies is to start viewing EM as a real opportunity. Brazil took a long time to pay attention to this segment. Currently, many are investing in R&D, motivated by a public call made by the regulatory agency, for electrification projects for their fleet or third parties, infrastructure for a public charge, and new business models.

4.3.2. Postponing Investments in Electricity Network Expansion

DER diffusion is an opportunity for distributors because this may allow the postponement of investments in expanding the distribution network. For example, distributors may decide to adopt an electricity storage system through installing batteries in substations, instead of investing in new network expansion equipment, considering that such solutions are feasible in technical and economic terms (Cigre, 2018; EPE, 2016).

In this aspect, the distribution companies seem to have contradictory views, as well. Although they consider that DER diffusion does not delay investments in transmission or distribution lines, they envision the possibility of using storage systems in their operations, which could delay investment in transmission or distribution lines. The challenge for them is to have procedures and a workforce to manage these new technologies.

4.3.3. Reduction in technical losses

Decentralizing the electricity system helps reduce technical losses during transmission, because of the possibility of generating power together with the load. Favorable solutions thus include incentives for non-clustered small-scale DG and adopting local and distributed battery systems, together with demand management (Accenture, 2016; Taranto et al., 2017).

Distribution companies' challenge is to change the pessimistic view of DER diffusion and invest in new businesses and take advantage of the advantages of decentralization for the operation of the system.

4.3.4. Potential gains in investment profitability

Because of the importance of distributors in the electricity network segment, regulation must ensure minimum profitability for underpinning the investments necessary to modernize and operate the network in a DER diffusion context. The regulator must address the challenge of allowing the acknowledgment of these investments in the distributor tariffs review process while also ensuring sufficient appeal for the agents to introduce DER technologies (Aneel, 2018c; Jenkins and Pérez-Arriaga, 2017; Jenkins and Pérez-Arriaga, 2014).

According to the perception of distribution companies in the survey, the challenge is for the regulator to make changes in regulations that guarantee the recognition of investments already made and those necessary for new technologies.

4.3.5. Image enhancement through low-carbon economy actions

The use of renewable energy sources (wind, water, sun, and biomass) or qualified co-generation options helps lower GHG emissions through less frequent use of thermopower plants and offers greater flexibility when contracting electricity. Demand management programs, based on consumer behaviors, may also help lower GHG emissions. These programs may be direct, through controlling and monitoring electricity consumption, or indirect, through tariff mechanisms (Astarloa et al., 2017; Baboli et al., 2011).

The distribution companies' challenge is to take this opportunity. Brazil has a clean power sector, which differentiates it from other countries where the implementation of DER, mainly with renewable sources, has the advantage of reducing the use of fossil fuels and GHG emissions, as well as energy efficiency and demand-side management actions. However, according to the survey, there is no consensus among the distribution companies on the importance of energy efficiency and demand-side management programs. However, in Brazil, distribution companies are not managing to capitalize on the great interest of consumers in solar generation with photovoltaic panels.

4.4. Threat analysis

4.4.1. Shrinking distributor market

Equipment subsidies, tax breaks, local content incentives for goods and services, and the absence of specific quality parameters and standards for new items of equipment connected to the grid all foster DER diffusion. By contrast, they undermine the current business model followed by distributors, shrinking their markets and attracting newcomers such as merchants, prosumers, integrators, and aggregators. Brazil, and some other countries, has not raised any effective barriers against newcomers entering this market. Moreover, DER diffusion will also usher in changes in consumer behaviors, altering how they consume, store, and produce electricity, decreasing their dependence on the distributors (Baboli et al., 2011; Irena, 2018; Maurer, 2009; Medina et al., 2010; Verhaegen and Dierckxsens, 2016).

The net metering scheme in Brazil allows significant expansion of DER. Despite the positive result of this policy in terms of DER deployment, it implies a cross-subsidy between the owner of photovoltaic panels (usually the most affluent) and the other consumers.

4.4.2. Regulatory limitations for operating with DER

Regulatory obstacles associated with public utility service concessions within a natural monopoly setting include constraints on concessionaires working with some of the new services and businesses being created by DER. For example, distributors are forbidden to operate competitively on the non-regulated market, as is the case in Brazil. Moreover, the current model is based on a one-way electricity flow structure with volume-based low-voltage tariffs, without the slightest hint of any incentives for installing DER in the network (Aneel, 2018a; BV, 2018; FERC, 2018; OFGEM, 2016).

There is consensus among the distribution companies that the main barrier to their performance in the dissemination of DER is the regulatory barrier. They support changes in regulations that would guarantee the sustainability of their business model.

4.4.3. Higher tariffs for other consumers

The remuneration of distributors in Brazil is connected to tariff components that are proportional to electricity consumption levels. As the consumption of grid-supplied electricity shrinks through rising DG, and distributor remuneration drops. The reduction in electricity consumption forces distributors to cover their costs by increasing tariffs for consumers not supplied through DG. In turn, these higher tariffs encourage consumers to migrate to DG, leading to a vicious cycle called a “death spiral” (Aneel, 2018b; Bajay et al., 2018; Jenkins and Pérez-Arriaga, 2017; Penghao et al., 2019).

As in the previous aspect, the challenge for the distribution companies is to be able to defend with the regulator the need for changes in regulation and to explain to society the reasons that justify them. There is a consensus among them that DER diffusion will favor the classes with greater purchasing power, which has already been occurring in Brazil (and in other countries) with the growth of the installation of photovoltaic panels; additionally, it will negatively impact low-income consumers.

4.4.4. Non-acknowledgement of smart grid investments and modernization

DER diffusion hampers electricity demand planning and operations by distributors and may cause harmonic distortions in the grid. However, distributors must ensure good quality services for all consumers. To monitor and control the flow of energy more tightly, distributors must invest in digital technologies that upgrade the grid, although these investments are not acknowledged by the regulator, which may well lead to economic and financial imbalance for these utilities. (Astarloa et al., 2017; Ekanayake et al., 2012; MIT, 2016; Muller, 2017).

As observed in the aforementioned aspects, the challenge for the distribution companies is to assure regulatory changes will recognize the investments in network modernization, smart grids, and new technologies necessary for DER diffusion.

5. Discussion

This energy transition tends to result in decentralized, environmentally sustainable electricity supplies, in parallel to changes in how utilities relate to electricity consumers, as their clients become more empowered. Now, consumers are investing mainly in photovoltaic solar panels, as they attempt to control and curtail their electricity costs; this is also helping pump up renewable electricity supply figures to significant levels worldwide. In general, the power sector contributes significantly to GHG emissions, and changes in how electricity is generated and used are the main alternatives for developing a low-carbon economy.

In Brazil, as in other countries, DG is expanding exponentially, especially solar power through photovoltaic panels, with a threefold increase in the accumulated installed capacity between 2015 and 2017, ending the year at approximately 200 MW. At the end of 2019, this capacity topped almost 2.000 MW (Aneel, 2019).

Notably, the official institutions in Brazil did not foresee the great growth of DG. According to the Energy Research Company (EPE (2016)), DG associated with photovoltaic solar power generation should reach an installed capacity of approximately 78 GWp in the 2050 Reference Scenario (Table 6).

This projection reflects the conviction that DG must play a critical role in responding to Brazil's electricity demands during the forthcoming decades. An estimate is that generation capacity will reach almost 12 GW mean by the end of the period, equivalent to 5.7% of the projected total electricity demands for Brazil's National Interconnected System (NIS) in that same year.

However, to ensure that the new policies scenario pursues its path to materialization, governments must be more firmly committed and introduce mechanisms that encourage the adoption of this energy alternative. From this standpoint, installed capacity would reach 118 GWp by 2050, generating just over 18 GW mean, equivalent to 8.7% of the NIS load.

In most cases, distributed energy resources use renewable energy types, connected directly to distribution networks and fostering DER diffusion, requiring that networks prepare for massive DER diffusion, including digitization and the inclusion of smart meters. In this scenario, distribution utilities must gear up for major challenges over the medium and long terms.

The SWOT analysis shows the many threats to distribution utility activities in the DER diffusion scenario, because of regulatory limitations, as well as a plethora of weaknesses deriving from the current business model. To manage this, distributors should play a more active role by adopting the business models proposed by (Cross-Call et al., 2018; Frantzis et al., 2008). As a result, they would

- Serve as facilitators through loans and financing that allow consumers to acquire generation systems. There are no political incentives or credits. Consumers own the electricity that they generate and benefit from surpluses injected into the network through the offset system, curtailing distributor sales. However, distributors have a strength: helping consumers purchase equipment, and rendering operating and maintenance services;
- Contract DER electricity for resale, with regulated distributors signing up for electricity for resale to consumers through bilateral agreements (auctions), shielding electricity prices from any market swings; this avoids any generation-side operating and maintenance

Table 6
Distributed Generation Projections – Photovoltaic.

	Reference				New policies			
	2020	2030	2040	2050	2020	2030	2040	2050
Power (GWp)	0.5	10	50	78	1	20	82	118
Energy (MWyr[a])	78	1523	7466	11,797	153	3001	12,511	18,029
% Total Load (NIS)	0.1	1.3	4.7	5.7	0.2	2.6	7.9	8.7

Source: Adapted from (EPE, 2016).
[a] MWyr: MWh/number of hours during a year.

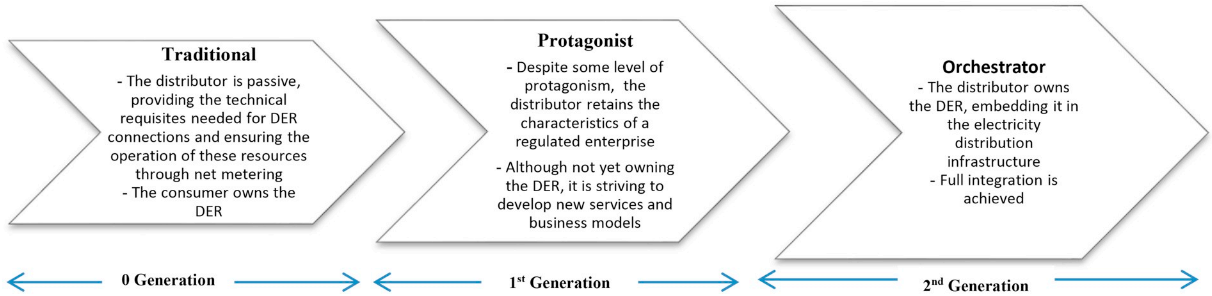

Fig. 5. Business Model Progression.
Source: Adapted from(Frantzis et al., 2008)

risks for these utilities. This electricity may be from virtual power plants consisting of a DG management system that encompasses renewable sources (wind, SHP, photovoltaic solar, and biomass), as well as electricity storage systems;

- Work with hybrid models to manage regulatory constraints while adapting to consumer demands and seeking third-party partnerships or offering new services.

In addition to these business models, and according to (Frantzis et al., 2008), there is yet another option where distributors could act as orchestrators: owning DER assets and including them in the electricity distribution infrastructure. This future model depends on sweeping changes in the regulations. Fig. 5 shows the business model progression.

Strategic actions by distributors must be directed toward dealing with external challenges, and other difficulties affecting internal corporate structures: (i) the need for mechanisms able to handle rising uncertainty about the future costs of distributors and (ii) introducing tolls for sharing gains in efficiency that usher in the adoption of innovations, ensuring systemic benefits while encouraging more a proactive stance for distributors.

Looking ahead to a regulatory framework endowed with flexibility, distributors will be able to play a more proactive role, as shown in the first generation of the model. This role may extend beyond what can be traditionally achieved by this segment. Even regulated, protagonist companies will also be able to offer a distributed services platform with new responsibilities, outstanding among which would be

i. Dynamic capacity control for buffering peak consumption, through adding photovoltaic solar panels, smart inverters, controllable loads, and storage facilities, all designed to lower peak demands on distribution systems and postpone investment.
ii. Dynamic flexibilization of the power generation ramp rate, with the dynamic control of DER providing immediate input supporting peak periods, both system-wide and at the local level.
iii. Voltage control and reactive support using smart inverters, which could upgrade electricity quality, decreasing consumption while reducing network losses.
iv. Reliability and resilience through installing storage facilities throughout the network.
v. Integrated system planning, should it prove necessary, is used to establish a transparent process that allows third parties to make investment decisions on devices offering flexibility or flexibility based on this planning process.

In this context, the regulator must remove barriers to DER while protecting current and future consumers—including the most vulnerable, who may find it difficult to engage in the electricity sector transformations—by applying a more flexible approach in response to different electricity end-users. To this end, the experience of other countries should be considered for improving Brazil's regulatory framework, offering an appropriate price/charge system for more dynamic electricity services, together with recognition of investments in modernization that usher in smart networks (automation, measurement, actuation, communication, and supervision) in distributor assets. Through this approach, distributors may also exchange experiences and establish technical and financial cooperation projects with international institutions working with DER, to become more familiar with the use of distributed resources.

Distributors may sign up with regulatory and certification agencies to adopt standards and complete certification procedures for integrating DER equipment into their networks. These procedures should focus on safety, security reliability, exchangeability, and interface standardization. In parallel, the regulator should establish a synergy with federal, state, and municipal governments. The regulator should also present financial models of the technical and economic impacts of DER diffusion, encompassing distributors, consumers, governments (taxes), and social aspects (more jobs and higher incomes), as well as environmental aspects (lower GHG emissions). They should also promote actions in wide-reaching media channels and social networks, showing end-users the economic impacts of DER diffusion, especially DG, under the current regulations.

Furthermore, electricity consumption over the next few years will probably be very different from what it is today. However, changes cannot be precisely predicted because of the particularities of each region. Nevertheless, it is expected that consumers will be able to manage their electricity more actively, choosing when to consume and feeding surplus electricity back into the network and/or storage on-site. The relationship between traditional electricity suppliers and consumers must also be modified by third-party intermediation, with service packages offering complementary products for the use of DER. This means that the regulator will need to ensure that regulations respond to new consumer needs by facilitating innovation and mitigating risks. It should promote actions explaining the impacts of adopting of hourly, seasonal tariffs for low-voltage consumers, striving to offset investments in meter modernization.

Based on the three business models, the SWOT analysis, and the survey with the stakeholders, the next step was to choose the best business model for the distributors to face DER diffusion, using the proposed methodology.

6. Multicriteria and risk analyses of business models

The distributors' challenges are enormous, as the SWOT analysis demonstrated and the survey revealed. These factors indicate the need to adapt the business model of these companies, and the natural path seems to be to migrate from a traditional business model to an orchestrating business model. However, the distributors are conservative players who unaccustomed to cooperating with other agents and in the time scale that DER diffusion requires.

Fig. 6 shows the diagram with the flow and the decision tree for prioritizing business models.

As mentioned in the methodology (Section 3), the 1st and 2nd level

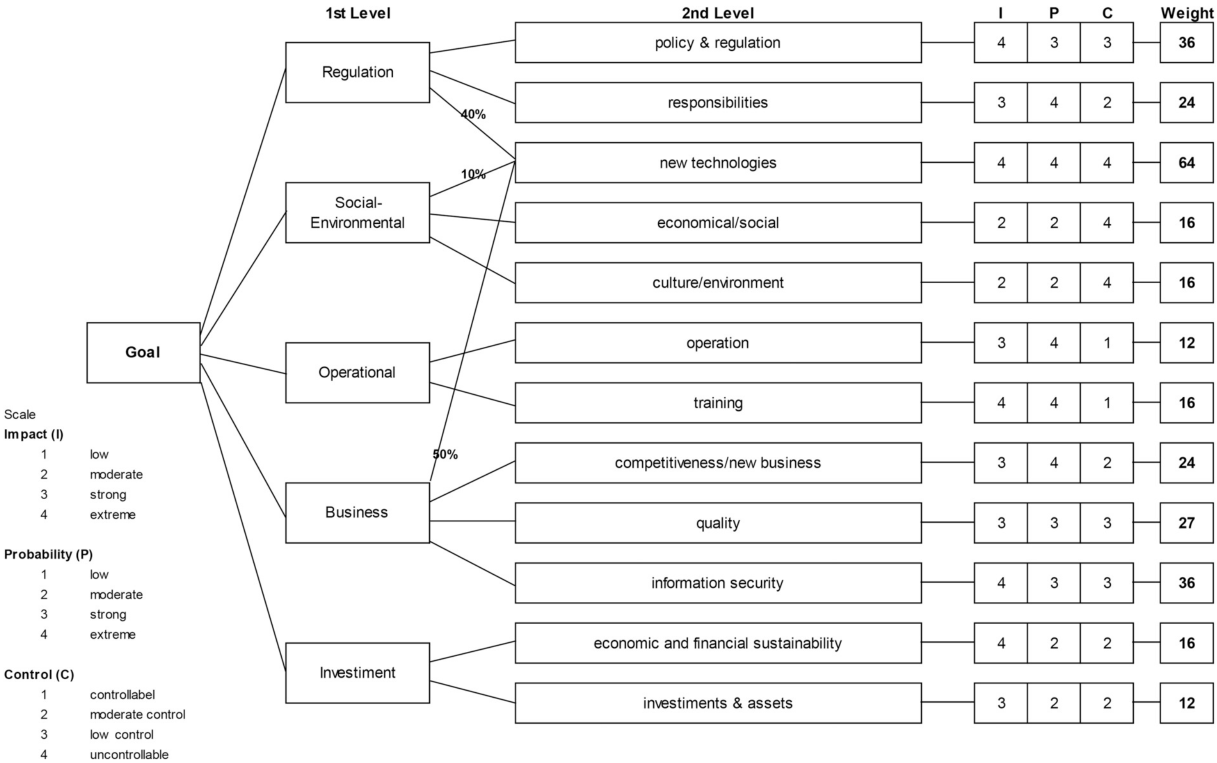

Fig. 6. Flow and decision tree.

criteria for comparing the models were from the survey with stakeholders. Each 2nd level criterion is related to a 1st level criterion. In the case of the "new technologies" criterion, it is related to more than a 1st level criterion. The AHP method was used to define the order of importance of the 1st level criteria. In the definition of the 2nd level criteria, risk analysis was used. To define the order of importance of the business models, the combination of the AHP method with the risk analysis was used.

The pairwise comparison of the AHP method and the determination of the weights (impact, probability, control) of the risk analysis were made by the authors based on the survey, as explained in the methodology.

Table 7 shows the pairwise comparison matrix for the 1st level criteria.

After setting up the comparison matrix, the consistency of comparisons (less than 0.10) was evaluated, and the corresponding eigenvector was calculated. The hierarchy of the 1st level criteria was defined according to the criteria in Table 8.

The next step was the pairwise comparison of the three business models (traditional, protagonist, orchestrator) for each of the 2nd level criteria, using the AHP method. The hierarchy of the 2nd level criteria was defined based on the risk analysis, considering the Impact (I), the Probability of occurrence (P), and the degree of Control of each of the criteria (C).

The results of the multicriteria and risk analyses are presented for the 1st level Regulation criterion and the 2nd level criteria linked to it:

Table 7
Comparison matrix of 1st level criteria.

	R	S	O	B	I
Regulation (R)	1	5	7	5	5
Social-Environmental (S)	0.20	1	1	0.50	0.50
Operational (O)	0.14	1	1	0.33	0.33
Business (B)	0.20	2	3	1	0.50
Investment (I)	0.20	2	3	2	1

Table 8
Hierarchy of 1st level criteria.

Criteria 1st level	Hierarchy	Eigenvector
Regulation	1°	0.26
Investment	2°	0.23
Business	3°	0.20
Social-Environmental	4°	0.16
Operational	5°	0.15

policy & regulation, responsibilities, and new technologies. The process was repeated for the other 1st and 2nd level criteria (Fig. 2).

Fig. 7 presents the weight (importance) of each 2nd level criterion calculated from the I, P, and C scores defined by the authors.

The risk assessment was conducted according to the value scales indicated in Table 3.

1) Criteria "Policy & regulation".
   I: grade 4 (extreme), considering that this criterion is related to all threats from the SWOT analysis.
   P: grade 3 (strong), considering that regulatory changes are already underway for the diffusion of DER.

C: note 3 (low), considering that the distributors have some negotiating power with the regulator.

2) Criteria "Responsibilities".
   I: grade 3 (strong), considering that this criterion is related to an opportunity and several weaknesses of the SWOT analysis.
   P: grade 4 (extreme), considering that the distributors have established a good relationship with their stakeholders.
   C: note 2 (moderate control), considering that the distributors have established practices and experience in the relationship with stakeholders.
3) Criteria "New technologies".
   I: grade 4 (extreme), considering that this criterion is related to

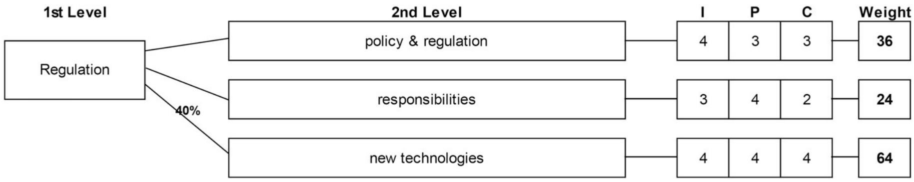

Fig. 7. Flow and decision tree – 1st criterion Regulation.

several weaknesses and threats of the SWOT analysis.
P: grade 4 (extreme), considering that new technologies are being implemented.
C: note 4 (non-controllable), considering that distributors cannot prevent or influence the spread of new technologies.

The criterion New technologies contributes only 40% because it is also related to other criteria of the 1st level (Social-Environmental and Business; Chart 8).

Table 9 represents the hierarchy of the 2nd level criteria linked to the 1st level criterion Regulation.

Next, the three business models (traditional, protagonist, orchestrator) were evaluated in relation to each of the 2nd level criteria (political and regulatory, responsibilities, new technologies). The criteria were compared pairwise, the consistency of comparisons was evaluated, and the corresponding eigenvectors were calculated.

The result was the model comparison matrix in relation to the criteria (Table 10).

The product of the eigenvector of the 2nd level criteria (Table 9) with the comparison matrix (Table 10) resulted in the hierarchy of the business models in relation to the 1st level criteria "Regulation" (Table 11).

As aforementioned, the process was repeated for all other 1st and 2nd level criteria. Notably, at each stage, the consistency of the judgment was verified, as explained before.

The result was the comparison matrix of the three models for all 1st level criteria (Table 12).

The last step of the process was the calculation of the eigenvector product of the 1st level criteria (Table 8) using the business models x criteria comparison matrix (Table 12). Table 13 shows the order of importance for business models. The result indicates that distributors should be prepared to adopt a business model with an orchestrator profile to take advantage of opportunities and manage the challenges of DER diffusion.

The result of the analysis may seem obvious at first: Distributors need to adopt more proactive business models. However, the challenge for distributors, and not just for them, is enormous, in Brazil and any other country. Electricity is an essential asset; the sector is highly regulated and has lived in a stable environment for several decades. The distributors are accustomed to their traditional model, and some of them have great resistance to changes. The challenge is also great for the regulator that needs to manage the energy trilemma—balancing the security of supply, decarbonization, and the cost of energy—and to prepare the sector for DER diffusion.

7. Conclusion

Electricity is an essential service that requires regular investments in networks, ensuring compliance with minimum standards for all connected consumers. Given the pace of these transitions, the growing integration of DER into the grid has a negative impact on the planning and operation of the existing network. It is becoming increasingly difficult to estimate how electricity consumption will develop, because of technological changes. Although consumption patterns have mostly remained the same over the past decade, companies in the electricity sector must be prepared for consumption patterns during the next decade that vary daily, and they must depend on adaptation rates for new technologies and the development of new market mechanisms. Utilities must adapt to an era where new technologies deeply affect their businesses. The age of passive consumers and old-fashioned utilities is over. Thus, principles and guidelines must be established that address this new context.

Table 9
Hierarchy of criteria.

Criteria 2nd level	Hierarchy	Eigenvector
Policy & regulation	1°	0.42
New technologies	2°	0.30
Responsibilities	3°	0.28

Table 10
Comparison matrix.

	Policy & regulation	Responsibilities	New technologies
Traditional	0.07	0,11	0.06
Protagonist	0.32	0,31	0.35
Orchestrator	0.61	0.58	0.59

Table 11
Business models hierarchy in relation to Regulation criterion.

Business Models	Hierarchy	Eigenvector
Orchestrator	1°	0.60
Protagonist	2°	0.32
Traditional	3°	0.08

The main contribution of this article is to present a tool that allows for quantifying the perception of distributors and for the need to change their business model, based on the combination of qualitative and quantitative analysis methodologies (SWOT, multicriteria, and risk).

The result of the study shows that despite the possible resistance of some distributors, they are aware of the need to change their business model.

To reinforce this point, the authors cite the case of photovoltaic energy in Brazil. In recent years, according to ANEEL data, the evolution of distributed photovoltaic solar has contributed significantly to the greater integration of DER in the system. The adhesion to this distributed resource allows consumers to become generators for their use (prosumer), and in the case of surplus, the remaining energy can be injected into the network and converted into credit for future use, according to the compensation system established in Resolution REN n° 482 / 2012 (Aneel, 2012).

However, as aforementioned, the remuneration of distributors is connected to tariff components proportional to electricity consumption levels. As the consumption of grid-supplied electricity shrinks because of the rising photovoltaic energy, distributor remuneration decreases. The reduction in electricity consumption forces distributors to cover their costs by increasing tariffs for consumers not supplied through photovoltaic panels. In turn, these higher tariffs encourage consumers to migrate to DG ("death spiral").

However, neither the regulator nor the distributors (traditional model) can to explain to society the need to review the regulation. Thus, the distributors are being severely criticized for hindering the diffusion of RED and are simultaneously witnessing the exponential

Table 12
Comparison matrix: business models x criteria.

	Regulation	Social-Environmental	Operational	Business	Investments
Traditional	0.08	0.07	0.08	0.06	0.07
Protagonist	0.32	0.34	0.33	0.34	0.34
Orchestrator	0.60	0.59	0.59	0.60	0.59

Table 13
Final hierarchy.

Business models	Hierarchy	Eigenvector
Orchestrator	1°	0.60
Protagonist	2°	0.33
Traditional	3°	0.07

growth of photovoltaic energy in their markets.

The intention of this paper is to contribute to discussions on the implications of DER diffusion in the electricity distribution sector and its many different impacts, including regulatory, economic, political, and operating aspects. The proposed strategy is merely one among other possible solutions that could surmount the challenge of operating in this new business environment.

This challenge is massive: Although the traditional business model of the distributors has worked well over the years, it is not set up to respond to the demands of future consumers. This conventional model has managed to keep pace with its past responsibilities of ensuring accessibility with affordability and reliability, in addition to safety and security. However, modifications are now required in response to rapid changes: (i) demands for better environmental performances, (ii) expansion of DER, (iii) rising needs for greater resilience, (iv) innovative options for upgrading grid performance, (v) advent of big data, and (vi) new client expectations.

Thus, backed by technical, regulatory and commercial resources, electricity distributors will be able to define priority uses for specific loads through incentive and/or price programs, tailored to consumer realities and paving the way for new energy efficiency and electricity sales models that benefit both utilities and consumers. The introduction of new business models and the implementation of innovative technologies will help fine-tune the relationship between concessionaires and their clients while fostering the sustainable use of energy resources.

This study was not exhaustive for the following reasons: the external and internal environments of companies are dynamic, the distribution sector is undergoing major transformations, each company or economic group has its strategy, and strategic planning is not the end but rather the means for companies to ensure they meet stakeholder expectations (including shareholder value generation, rendering good customer services and preserving the environment).

As aforementioned, the proposed actions are just some of many other possible strategies for companies striving to respond to the challenges of operating in a new business environment. Studying these implications and proposing strategic actions for companies in this sector, regulated or not, opens new horizons for improvement.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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