cleantech startup ecosystem impact on the brazilian electricity sector

prepared by

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FGVces
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ABStartups
Brazilian Startups Association

EDP Brasil
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Statkraft
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about the organisations involved

With over 20 years of experience, EDP is one of the largest private companies in the electricity sector operating in the entire value chain. The Company, which has more than 10,000 direct and outsourced employees, operates in Transmission, Commercialization and Energy Services, and has six hydroelectric and one thermoelectric generation units. In Distribution, it serves approximately 3.4 million customers in São Paulo and Espírito Santo. Recently, it acquired a stake in CELESC, in Santa Catarina. In Brazil, it is a reference in areas such as Innovation, Governance and Sustainability, having been on the B3 Corporate Sustainability Index (ISE) for 13 consecutive years.

Statkraft is an international company, a leader in hydroelectric power and the largest generator of renewable energy in Europe. The group produces hydroelectric, wind, solar and gas power and provides district heating. In Brazil, the group controls 18 wind and hydro power generation assets, with a total installed capacity of 450 MW.

Coppe – The Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering (Instituto Alberto Luiz Coimbra de Pós-Graduação e Pesquisa de Engenharia) of the Federal University of Rio de Janeiro - is the largest centre of engineering education and research in Latin America. Supported on three pillars: academic excellence, exclusive dedication on behalf of professors and students and proximity with society, Coppe is a centre producing and radiating knowledge, qualified professionals and teaching methods.

The Centre for Sustainability Studies (FGVces) of the Getulio Vargas Foundation School of Business Administration (FGV EAESP) is an open space for studying, learning, innovation and the production of knowledge. Formed of a multidisciplinary, engaged and committed team with a genuine desire to transform society, the FGVces works to develop strategies, policies and public and business management tools for sustainability at the local, national and international levels. To this end, it has four lines of action: (I) training; (II) research a production of knowledge; (III) coordination and exchange; and (IV) mobilisation and communication.

The Brazilian Startups Association exists to build the ideal environment for startups to transform the country. The association inspires, trains, connects and advocates for startups, because it believes in the role of innovation as the engine for positive transformation of the country.

The objective of Aneel's R&D Program is to properly allocate human and financial resources to projects that demonstrate the originality, applicability, relevance and economic viability of products and services, in the processes and end uses of energy. The aim is to promote a culture of innovation, stimulating research and development in the Brazilian electricity sector, creating new equipment and improving the provision of services that contribute to the security of electricity supply, low tariffs, reducing the environmental impact of the sector and the country's technological dependence.

summary

introduction

The product of a partnership between FGVces, COPPE/UFRJ, ABStartups, EDP and Statkraft, and made possible by the ANEEL R&D Program (project code PD-07267-0010/2018), the unprecedented Startup Ecosystem Impact on the Brazilian Electricity Sector study began in May 2018 with the aim of understanding the Brazilian cleantech segment startup ecosystem and analysing its impact on the Brazilian electricity sector. The results obtained by the study are subsidies for the development of public policy to strengthen the clean technology ecosystem in Brazil. The study also contributes towards bringing large companies and startups closer together, thus allowing them to scale up their innovations.

To this end, the study is structured in different phases and covers the following activities:

• Details the characteristics of Brazilian cleantech startups, including technologies, patents, business segments, entrepreneur profiles, financing models, collaborative networks, etc.;

• Analyses the impact of startups and their technology on the market and the technological development of the Brazilian electricity sector;

• Proposes regulation for cooperation between startups and large companies;

• Empirically tests a new cooperation model between startups and large electricity sector companies;

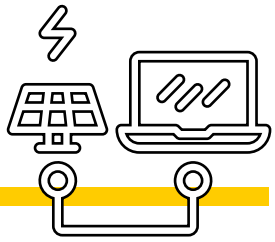
• Structuring of the Clean Technologies Observatory, with the aim of keeping the efforts of this research available to the entire sector in the medium and long term.

The focus of this report is to present, succinctly, the main results and analysis for all stages of the study.

chapter 1

mapping of cleantech startups

what are cleantech companies?



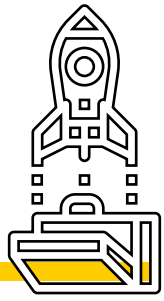
Despite existing definitions being multiple and broad, there are characteristics which a cleantech solution must possess to be identified as such. These are:

• To do more with less

• To pollute less

• To have a profitable business model

what is a startup?



The definitions for startups are also multiple and broad. We can cite the following characteristics that a company must possess in order to be considered a startup:

• Risk/Uncertainty - Dealing with high risk/uncertainty

• Scalability - Is structured to grow quickly

• Time of existence - Has a short time of existence

• Innovation - Innovative (broad sense)

• Technology - Focused on technological innovations

• Size - Small (employees/revenue), but with high growth prospects

• Organizational culture - Has an entrepreneurial organizational culture

More references on the above concepts can be accessed in the full mapping report:

www.gvces.com.br/perfil-das-*startups*-de-*cleantech*/?locale=pt-br

Guided by the concepts of ‘cleantech’ and ‘startup’, this study’s first step was to map the cleantech startups in Brazil through an online questionnaire. The questionnaire sought to understand the profile of the startups, and was divided into five parts:

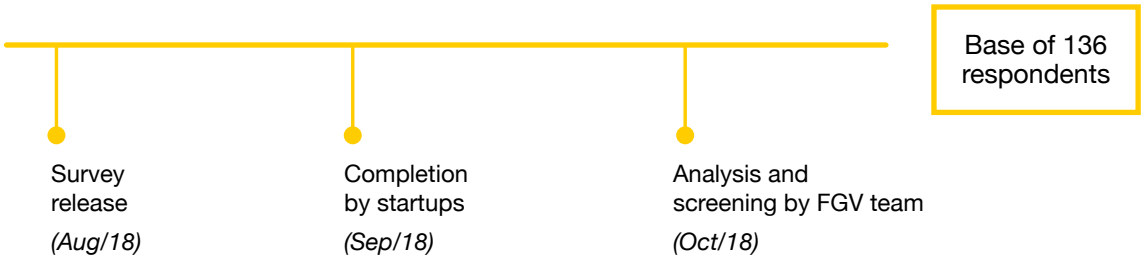
1. Registration Data

2. Profile of Entrepreneurs

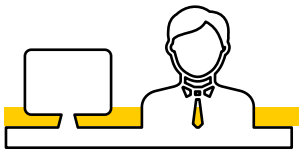
3. Business Profile

4. Innovation

5. Cooperation with Large Companies



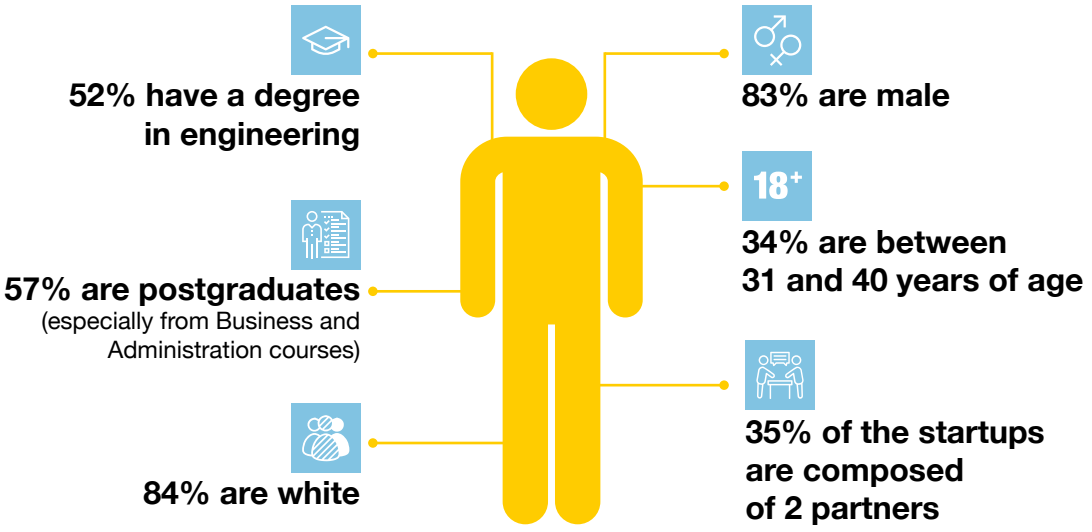
The call for completing the cleantech startup mapping survey remained active for six weeks, between August and September 2018. Of the 189 organisations registered, 53 were ruled out for not meeting one of the following eligibility criteria: to be a startup and to operate in the cleantech segment.



who are the cleantech entrepreneurs?

The profile of cleantech founders does not differ from the public which permeates the startup ecosystem in Brazil: white and predominantly male. The following figure shows the profile highlights of cleantech entrepreneurs.

- **over 50% have previous experience in large companies, academic research and entrepreneurship.**

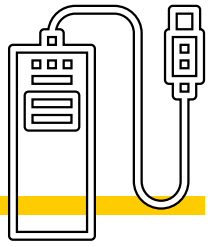


Unlike the characteristic pattern of digital startups, in which founders are in their 20s, a significant portion of cleantech entrepreneurs are between 31 and 40 years old, i.e. they can still be considered young, but with a decade of experience and learning in their professional trajectories.

Additional data on the profile of entrepreneurs can be accessed in the mapping report:

www.gvces.com.br/mapeamento-do-ecossistema-de-startups-de-cleantech-no-brasil-resultado-parcial ?locale=pt-br

entrepreneurial hubs



Almost 80% of startups are from the South and Southeast. The concentration of enterprises in these regions of the country is also observed in other studies on startups in Brazil. The latest edition of the 100 Startups to Watch ranking, released in April 2018, shows that 38% of the startups registered are from the state of São Paulo.

Pernambuco was the best performing state outside of the South-Southeast axis, largely due to the innovation and entrepreneurship ecosystem driven by the Porto Digital technology park. Beyond the disparity between regions, some hubs stand out in the mapping. The anchor of the Campi-

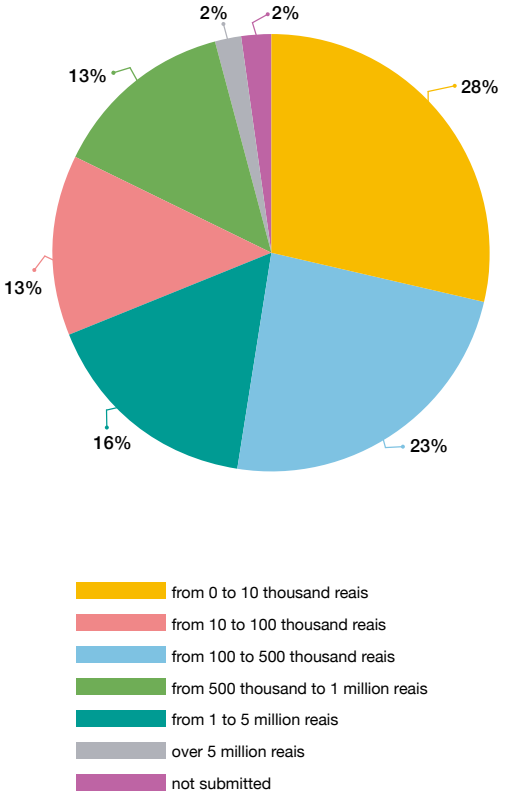
nas ecosystem is its state university, UNICAMP, and its research agency, Inova Unicamp, which identifies opportunities for integration with industry and promotes innovation and entrepreneurial activity.

Itajubá has the Federal University of Itajubá (UNIFEI) and also accommodates demand from large companies which operate in the region, such as Vale, as the south of Minas Gerais is a metal-mechanic and energy centre.

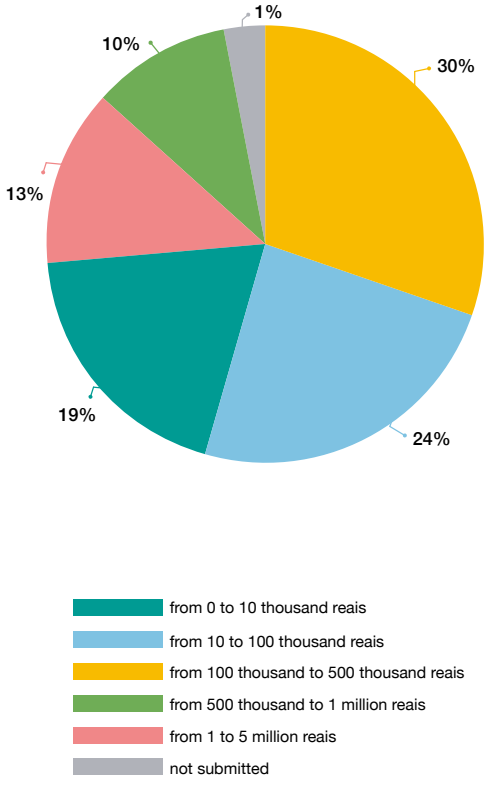
The low share of natural science subjects in the training of cleantech entrepreneurs, added to the low number of enterprises in the North region of the country, highlight a gap which exists between the university and the market for the development of applied science, and shows potential Brazil can develop in the field of bioeconomy.

More information on innovation ecosystems in Brazil can be found in *Chapter 2*.

gross annual revenue *(in R$)*



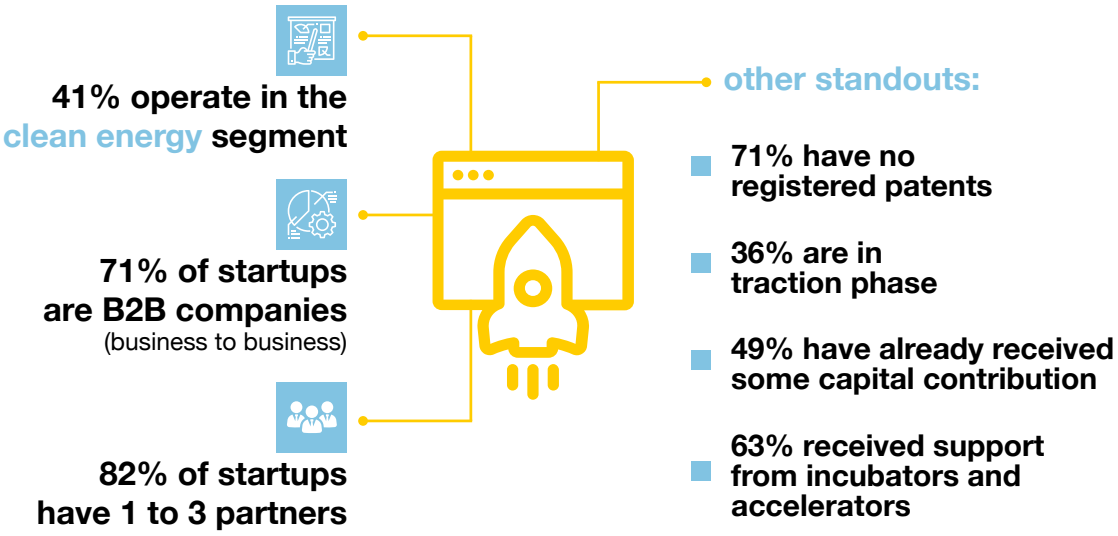
annual expenses *(in R$)*



Although the majority of the companies earn more than 100,000 reais annually, many still seem not to make a profit or to have even reached breakeven point.

When calculating the operating margin of the total base of startups analysed, 39% are still in the negative. There are several startups in development phase, operating with cash on hand through angel investor funding, but which haven't yet reached breakeven point. There are also startups registering low expenses when compared to revenue because they do not account for monthly withdrawals by partners, only operational costs. This is because cleantech ventures generally require high investment.

Some companies declared to be MVP, traction or scale stages recorded zero revenue.



Among those which received capital contribution, the most frequent modality was angel investing. The availability of resources follows the same geographical distribution pattern as cleantech startups: 39% of the companies that received investment are based in São Paulo; 13% are from Minas Gerais; 12% are from Rio de Janeiro; 10% are in Santa Catarina.

The cross-referencing of capital input data with market segments reveals that 21% of companies that received resources are energy efficient and 18% use clean energy.

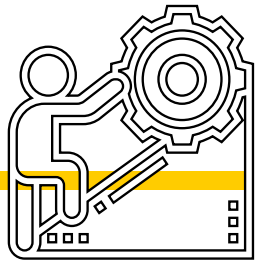
The joint analysis of information on the year of foundation, revenue and degree of maturity of the enterprises reveals an important feature of cleantech startups: extended cycles of research and development. This aspect makes the operation and growth of these ventures more difficult in a risk-averse or fast-return investor market.

technology types

Although 41% of startups operate in the clean energy segment, many businesses are related to waste management.

Most innovations are incremental, concentrated in products and services (44%) and are, in general, solutions already structured in marketable versions rather than in early stages of technology development.

other challenges



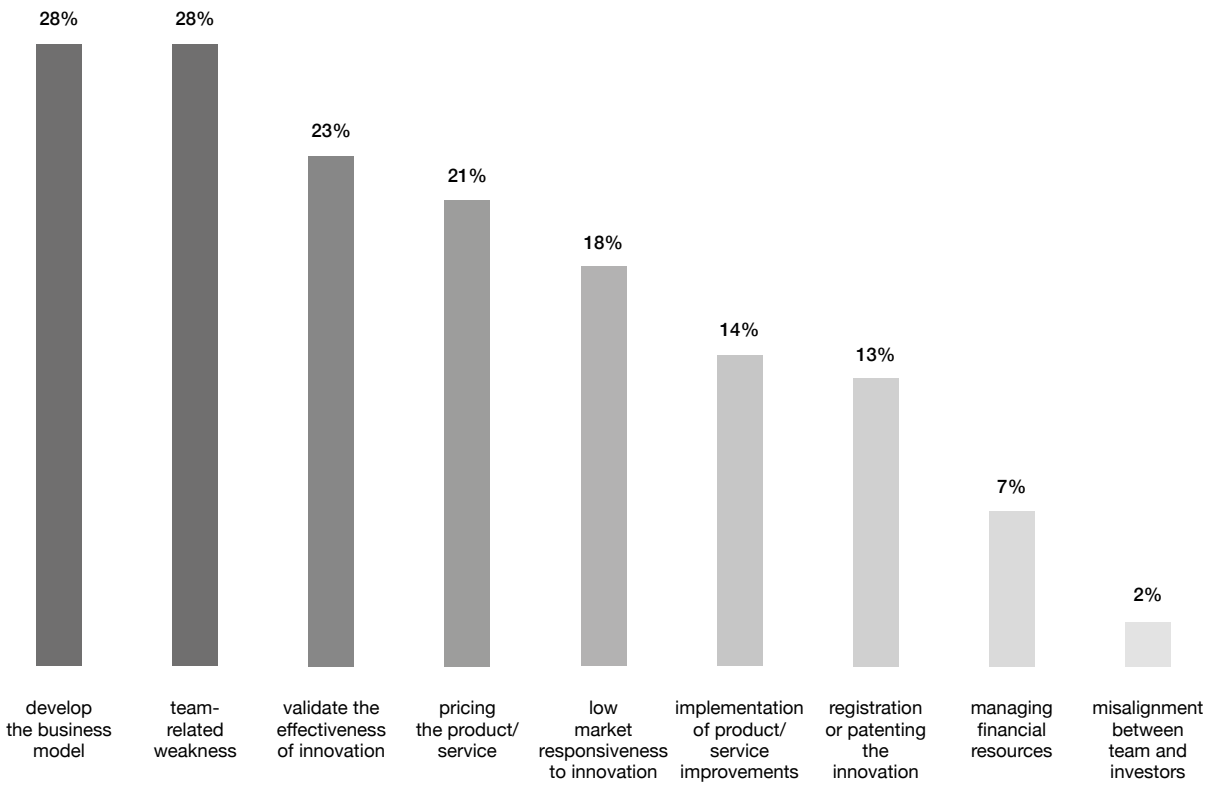
main challenges faced by startups

base: 136 respondent startups

63% expand the business

62% access financial services

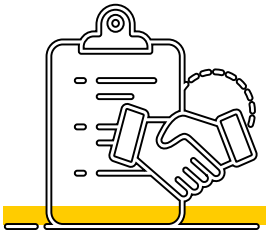
46% communicate value proposition



The difficulty in expanding the business may be associated to the low degree of disruptive or radical innovation of marketable technology and solutions. In turn, the difficulty in obtaining financing reveals a risk-averse investor market, as previously mentioned. Finally, the difficulty in communicating a value proposition can be explained by more technical than business management profile of founders.

Similar to cleantech companies, the main challenges faced by socio-environmental impact businesses in the Pipe Social study are: search for financial resources (48%) and business/solution communication (18%).

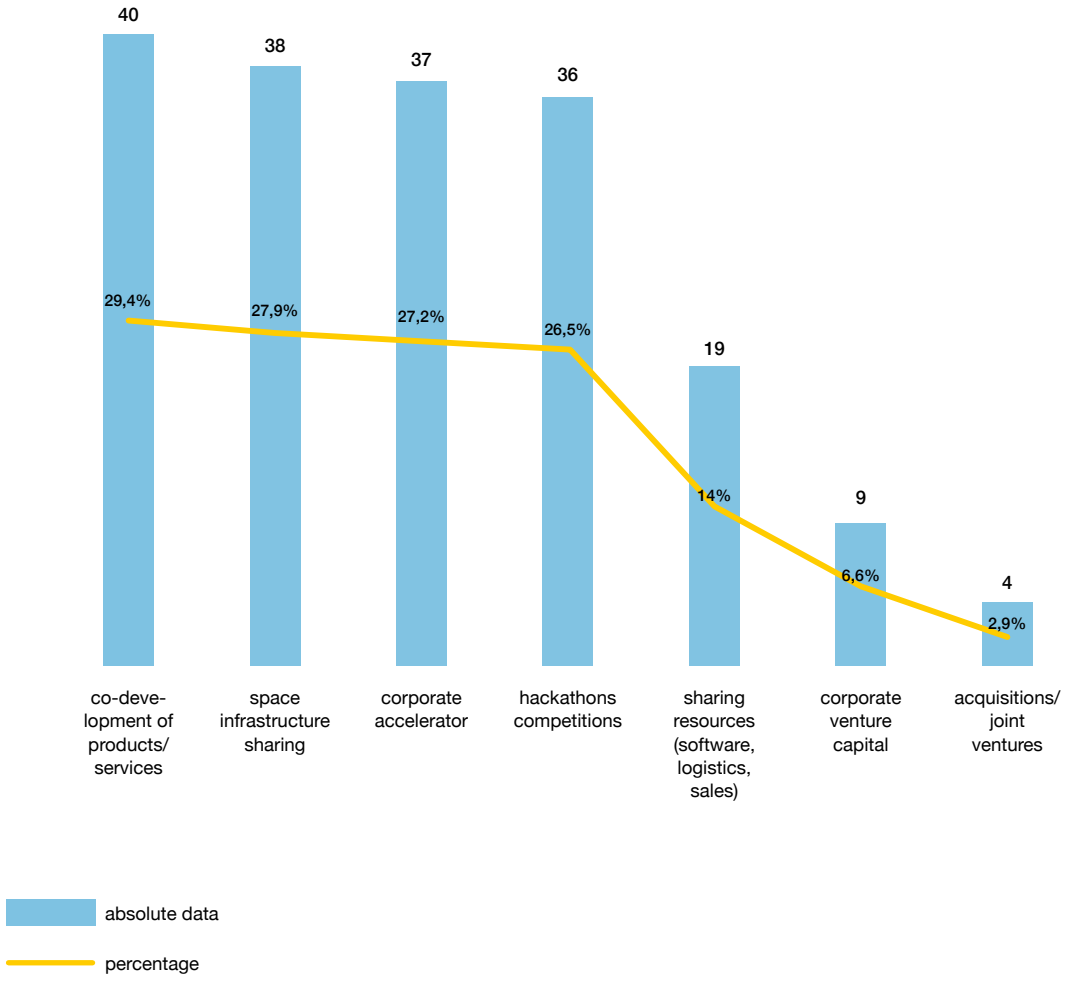
The research conducted for the 100 Startups to Watch ranking indicated four challenges to startup growth: access to capital; customer acquisition (especially in businesses which sell to final consumers and the government); team building; infrastructure (for physical space as well as cloud storage investments).



cooperation between startups and large companies

Cooperation between startups and large companies in the Brazilian energy sector is still in its early stages, but is already a reality.

Although 79.4% of startups have already cooperated in some form with large companies, most of these relationships are an instrumental commitment between the parties, such as hackathons, space/infrastructure sharing and co-development of specific products or services, as the following figure shows:



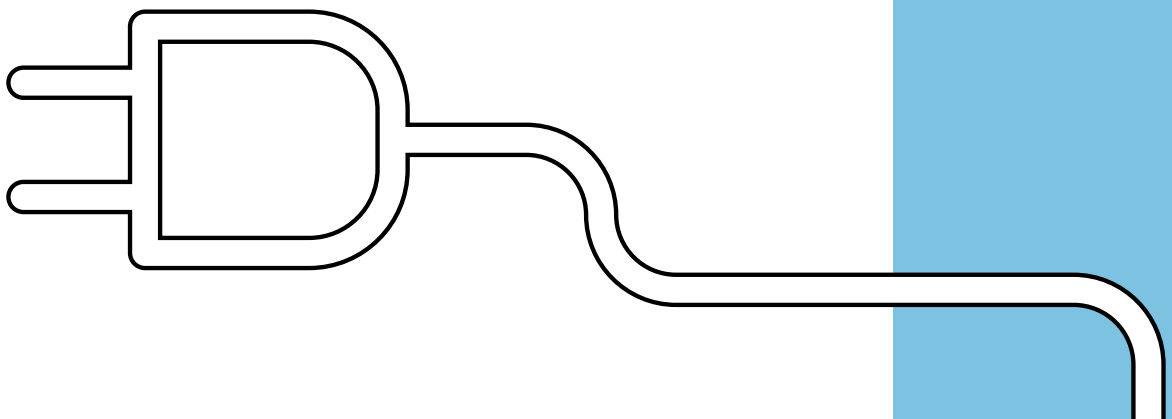
Corporate venture capital and acquisitions/joint ventures, which require deeper negotiating and strategy, are the interactions with the lowest incidence.

Brazilian cleantech startups consider credibility and access to new markets as the most important reasons for cooperating with large companies.

Among the barriers to cooperation, startups pointed out that slow decision-making and finding the right focal point within large companies are the main bottlenecks.

chapter 2

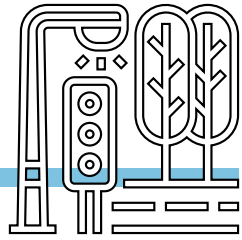
analysis of Brazil's cleantech startup entrepreneurial ecosystem



Among the stages of the study, there is the preparation of a scientific article which analyzes the different dimensions of the Brazilian cleantech ecosystem, highlighting aspects which can be improved to strengthen startups and thus contribute to promote sustainability in the Brazilian electricity sector. This chapter sums up the main contributions of the article, based on semi-structured interviews with specialists and analysis conducted through a bibliographic review.

The methodology used applies a framework developed by Daniel Isenberg. The model proposed by the author is composed of six key dimensions which involve: a propitious culture, which enables policies and leadership; availability of adequate financing; quality human capital; demanding markets, and institutional and infrastructure support. The following are the highlights from each of the dimensions analysed.

public policy dimension

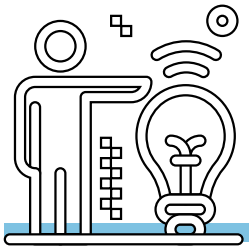


In terms of specific public policies for fostering innovation in the electricity sector, there are few structured efforts. According to experts interviewed, Brazil lacks a single long-term strategy for the transition of the sector which can guide the formulation of coordinated and complementary policies to promote innovation.

Interviews also show that, with the Brazilian electricity sector being highly regulated and dominated by a few large companies, energy distributors, in a general sense, do not have incentives to promote disruptive innovation and interaction with startups.

In this aspect, the article gathers analysis on the main existing policy aiming to foster innovation in the sector: the ANEEL R&D Program. Among opportunities for improvement identified, the following stand out: (I) changes in scope, seeking to incorporate organisational innovation and service innovation, and (II) the creation of a set of indicators which can assess the contribution of projects to society (e.g. jobs, improvements in productive processes).

Analysis of this dimension points to the need for understanding what challenges the Brazilian electricity sector faces and engaging actors to create a long-term strategic plan. Thus, as a result, it would be possible to improve the ANEEL R&D Program and direct incentives to the development of new technologies which can overcome these challenges, avoiding isolated and non-continuous actions.



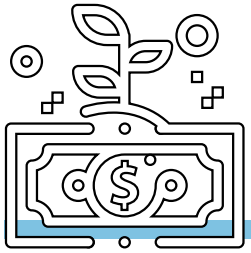
market dimension

Currently, the electricity sector is going through an important paradigm breaking moment. Within the main transformations, the article highlights digitalisation, the decentralised generation of energy and the ascension of alternative renewable energies in response to growing concerns about the environmental impact caused by fossil sources. These and other trends create a fertile ground for innovation, which ensures that new consumer demands are met.

The sector's large companies - especially distributors - can play an important role in driving these changes, provided they are open to incorporating new technologies and processes, offering new services and, fundamentally, reviewing their business models (PwC, 2017).

The article investigated the challenges of corporate venturing (CV), that is, of the interaction between cleantech startups and large companies, in order to provide important benefits for both parties and significantly contribute to the transition of the Brazilian electricity sector.

The main recommendations for the market dimension include transparency in relationships between parties, ensuring the alignment of expectations; the involvement of qualified teams in driving these initiatives, and the possibility that companies contribute to the strengthening of the ecosystem with initiatives specifically designed for this purpose.



financial dimension

According to the 2017 Global Cleantech Innovation Index, in recent years investment in clean technology for the energy sector has gained considerable momentum. Among the main focuses of investment are renewable energy, energy efficiency and the transport segment.

However, the article points out that access to financial resources still stands as one of the most significant challenges for cleantech startups. Among the reasons is the perceived low liquidity of

investments - especially if solutions involve the development of new materials and equipment - and the need for large investments to scale capital-intensive solutions.

Despite a history of highly risk-averse Brazilian investors, the country has been experiencing movements such as the venture capital boom, which could mean a good time for cleantech startups.

This being a subject of great relevance for enhancing the contribution of cleantech startups to the transition of the electricity sector, analysis points to the following recommendations: (I) allocation of resources for cleantech startups based on blended finance strategies, a mixed financing modality which combines resources from philanthropic funds - or development funds - with resources from private investors and (II) the creation of Equity Investment Funds (EIFs) as a modality of execution for the ANEEL R&D Program[1], drawing from successful experiences in the Brazilian capital market and the Informatics Law.

human capital dimension

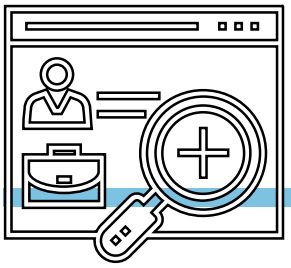
The first academic revolution, which began in the mid-19th century, added research as a mission to universities which hitherto had focused solely on teaching. The second academic revolution incorporated contribution to economic development. It is within this context that the thesis of the Triple Helix is born, in which a university assumes less of a secondary role of providing education and research, and a more primary role of generating new industries, together with business and government.

The 2018 Research in Brazil report shows that, despite Brazil being ranked 13th in the list of countries with the highest production of globally indexed articles, only 1% of them have co-authors from industry. This data reveals that, despite efforts to integrate university, industry and government, the predominant model in Brazilian academia is still focused on preparing students for the conventional job market and producing scientific knowledge independently of industry-focused applications.

However, while MIT (Massachusetts Institute of Technology) and Stanford are pioneers of the entrepreneurial paradigm, there are already universities in this country which stand out for their capitalisation of knowledge and technology transfer. Inova Unicamp, the research agency of the Unicamp state university, has over 500 active daughter companies, of which 50 operate in the

[1] This proposal was sent to ANEEL as one of the products of the Startup Ecosystem Impact on the Brazilian Electricity Sector study.

energy sector. COPPE - The Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering of the Federal University of Rio de Janeiro (UFRJ) has a resource base of varied origin, such as from private companies, multilateral institutions and government agencies, as well as maintaining structured policies and programs to support incubated companies in the energy sector.



support agents dimension

The mapping of Brazilian cleantech startups revealed that a technical background does not cover all the specific needs of startup management, such as assessing the best strategies for marketing a product, formulating value propositions in the language of the market, elaborating institutional presentations for different ends or connecting with large companies and other startups. Support agents therefore play a key role in consolidating entrepreneurial and innovation ecosystems.

Israel and Florianópolis are examples of ecosystems given an initial impulse by public investment and, as they grew, attracted more companies and external investment. However, as shown by the latest edition of the Global Startup Ecosystem Report, in the 150 ecosystems of technology startups analysed, the wealth and opportunities generated tended to be geographically concentrated: around 70% of the financial return of marketed technologies is generated and captured by the ten cities with the largest ecosystems. In Brazil, the economy generated by startups is concentrated in the South-Southeast axis.

One way for support organisations to reduce this regional asymmetry is to intensify connectivity actions. Actions which promote global connections, such as international missions for more mature ecosystems, or talks by successful startups, are relevant. However, there is room for strengthening local support and connection initiatives, such as those led by the Santa Rita do Sapucaí ecosystem. Programs for perfecting and adapting already existing technology in light of the productive resources of each region, the organisation of hackathons focused on the challenges of municipal administration, business rounds with companies installed in the region and mentorships led by local entrepreneurs are a few examples.

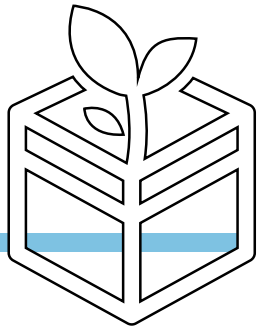
entrepreneurial culture dimension

Although necessity-driven entrepreneurship is a striking feature of this phenomenon in Brazil, Brazilian cleantech entrepreneurs are motivated mainly by the sense of opportunity, given their profile is predominantly male, caucasian, aged 30-40 and with a high degree of schooling. In addition, despite the predominance of technical training among founders, the majority create or replicate business models for already existing and consolidated technologies in the market. These characteristics point to important aspects of entrepreneurial culture to be worked on.

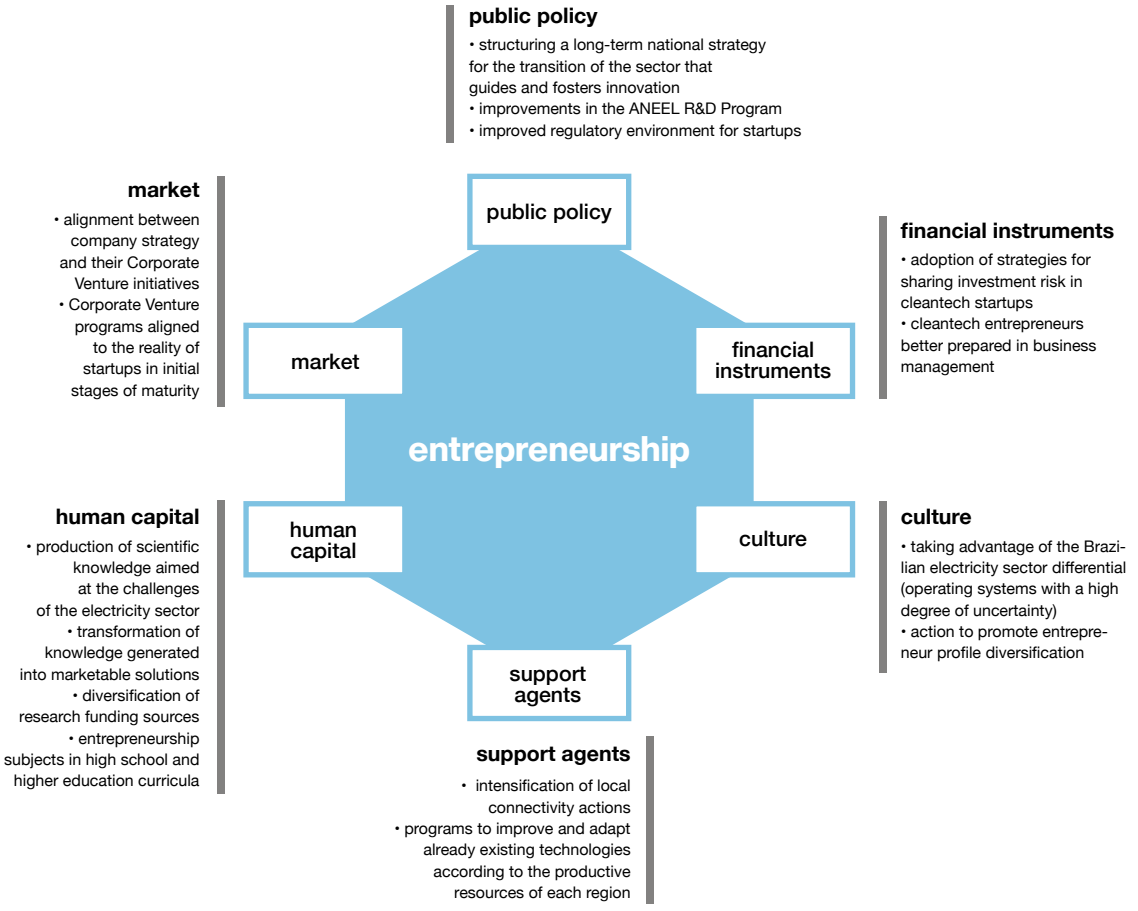
One of these aspects lies in the strengthening of, between current and future Brazilian entrepreneurs, the capacity to identify new applications for existing, yet unexplored, technologies and inventions. Another important point to be strengthened concerns the regard for the natural vocation of each region. Just as Israel is a leader in irrigation solutions in the face of water shortages, Brazil has the potential to develop in the field of bioeconomy, based on the socio-biodiversity of its various biomes.

A further aspect of entrepreneurial culture which deserves attention is the profile diversification of cleantech entrepreneurs. This is less about the need to foster entrepreneurial culture among women and other minorities, and more about the need to include enterprises led by these groups in acceleration and investment processes. In addition, professors and didactic material should be better prepared to promote an egalitarian education which does not reinforce cultural stereotypes, such as the association between technology and masculinity.

final considerations on the ecosystem



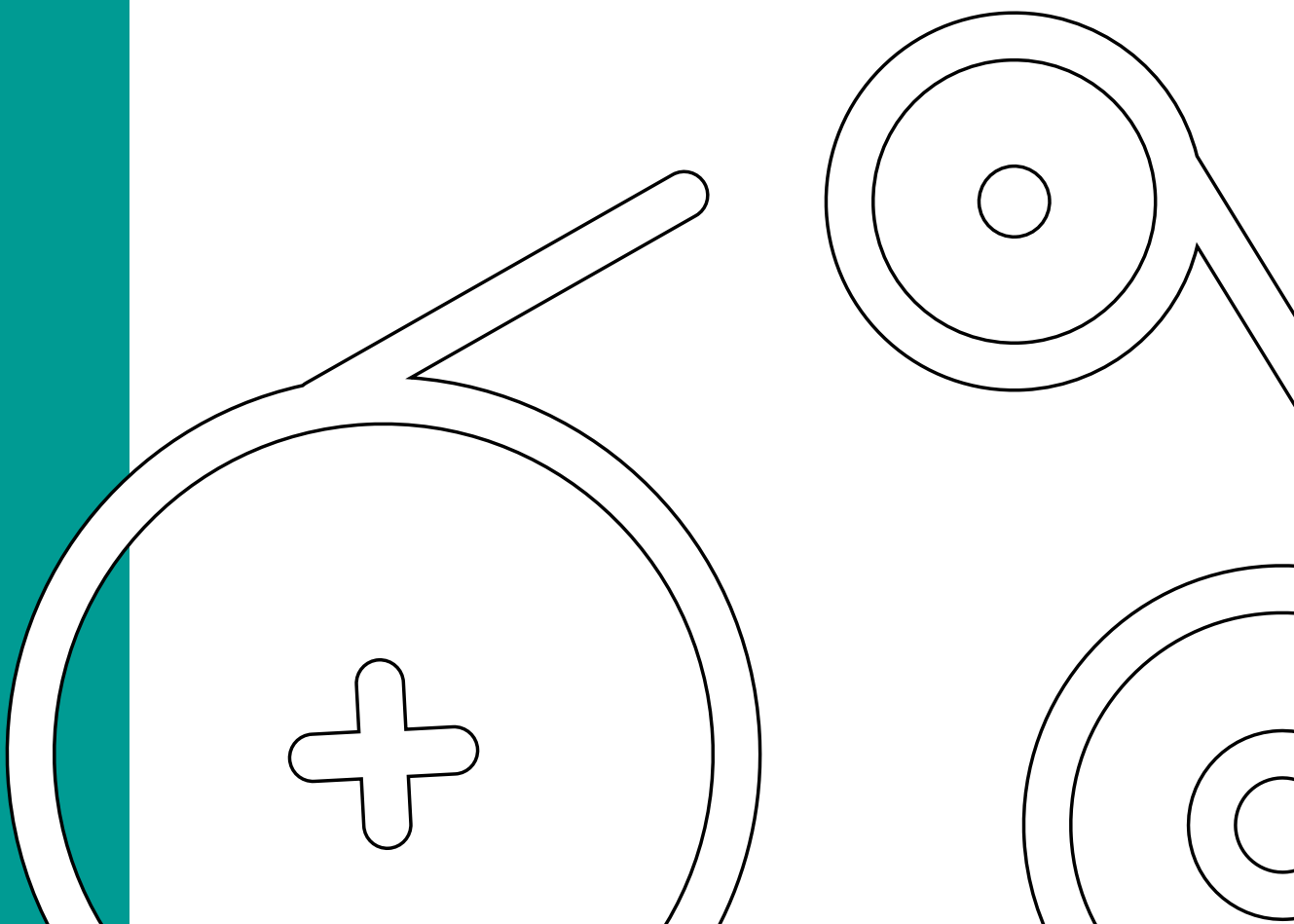
In light of the information and considerations of each of the dimensions of Isenberg's framework, the figure below presents a synthesis of the main recommendations detailed in the session. Results for strengthening the Brazilian cleantech startup ecosystem which contribute to the transition of the electricity sector.



The findings of this study can form the basis for a possible summarised diagnosis of the Brazilian cleantech startup ecosystem. On the one hand, the scarcity of specific entrepreneurial culture initiatives, support agents and human capital focused on cleantech, especially segments related to the electricity sector, show a certain incipience and fragility of the ecosystem in these dimensions. On the other hand, the features revealed in the market, public policy and financial instrument dimensions point to an ecosystem in formation and with the potential to become stronger through a national long-term strategy for the transition of the energy sector which fosters innovation and establishes a favorable regulatory environment for startups.

chapter 3

analysis of technologies



Fast changes in the business environment, and the risks posed by the adoption of new technological solutions, are critical factors in the current sectors involved with the development and use of technologies. Analysis of current technological trends, therefore, is critical to business success. As such, for a company to have a competitive advantage and increase its market share, it must know at what life cycle stage the technology is located, enabling the execution of a strategic plan for the business.

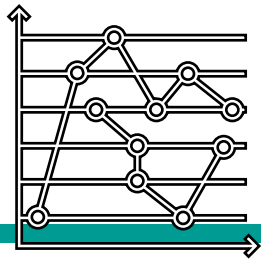
Following this line, the study also contained a scientific paper which applied a methodology to verify the level of development of technologies - previously identified in a survey - in the Brazilian cleantech startup market. The purpose of this analytical effort is to determine which possible developed and/or applied technologies by startups have the potential to provoke or leverage changes in the Brazilian electricity sector.

The use of cleaner technologies has been recognised as an important economic growth multiplier in the 21st century, which in addition to their inherent environmental gains, are also recognised for increasing the competitiveness of nations. These technologies avoid emissions entirely, reducing pollution and waste treatment costs.

Cleantech companies have in common the fact that they are generally small, high tech companies with a significant scalable potential and which normally develop innovation projects. This profile characterises companies known as startups. As such, cleantech startups are involved with risks derived from fast changes in the business environment, and the consequent need for new technological solutions.

The survival of these companies depends on the constant analysis of technological trends, based, among other things, on the knowledge of the maturity stage of technologies, so as to enable the execution of a strategic plan for the business and the conception of an activity system and interface system governing their market actions. Venture capital investors also represent a source of funds for these companies, as they tend to finance startups in the early stages which involve high risk.

the hype cycle curve



There are a lot of uncertainties associated with tech development which can significantly delay, or perhaps even prevent, a technology from entering the market. The use of metrics has therefore increasingly attracted investor interest to measure the maturity and readiness of systems and technologies. However, it is not always clear if the objective of the metrics and methods is to measure the maturity or readiness of these technologies. The literature, in general, does not make a distinction between these two terms, and rarely specifies if a method was designed for a system or a technology. Furthermore, in most cases, the applicability of tools and methods in relation to a technology is vague.

Some authors have made a comprehensive assessment of these methods. The method known as TRL (Technology Readiness Level) was a pioneer developed for this purpose, but was considered an insufficient metric (static methodology), and a number of other qualitative, quantitative and automatic methods have also been proposed.

The Hype Cycle curve methodology, introduced in 1995 by the consulting firm Gartner, enhances the analysis and forecasting of technologies during the initial period of their development, offering a view of its maturity relative to the technologies in a given area. The model shows the path taken by a technology over time (dynamic methodology), in terms of expectations or visibility of its value. It characterises the typical progression of an emerging technology: from over-enthusiasm to a period of disillusionment and, finally, an eventual understanding of the relevance and role of the technology in a market or domain. The methodology provides models which help companies decide when they should adopt a new technology, rather than just performance indicators to separate hype from reality.

The hype cycle is a repeating behaviour pattern occurring with every innovation that captures people's imaginations in some form: either a management trend, a new business process or a new technology. When an innovation emerges, it starts out 'raw' and gradually matures over time.

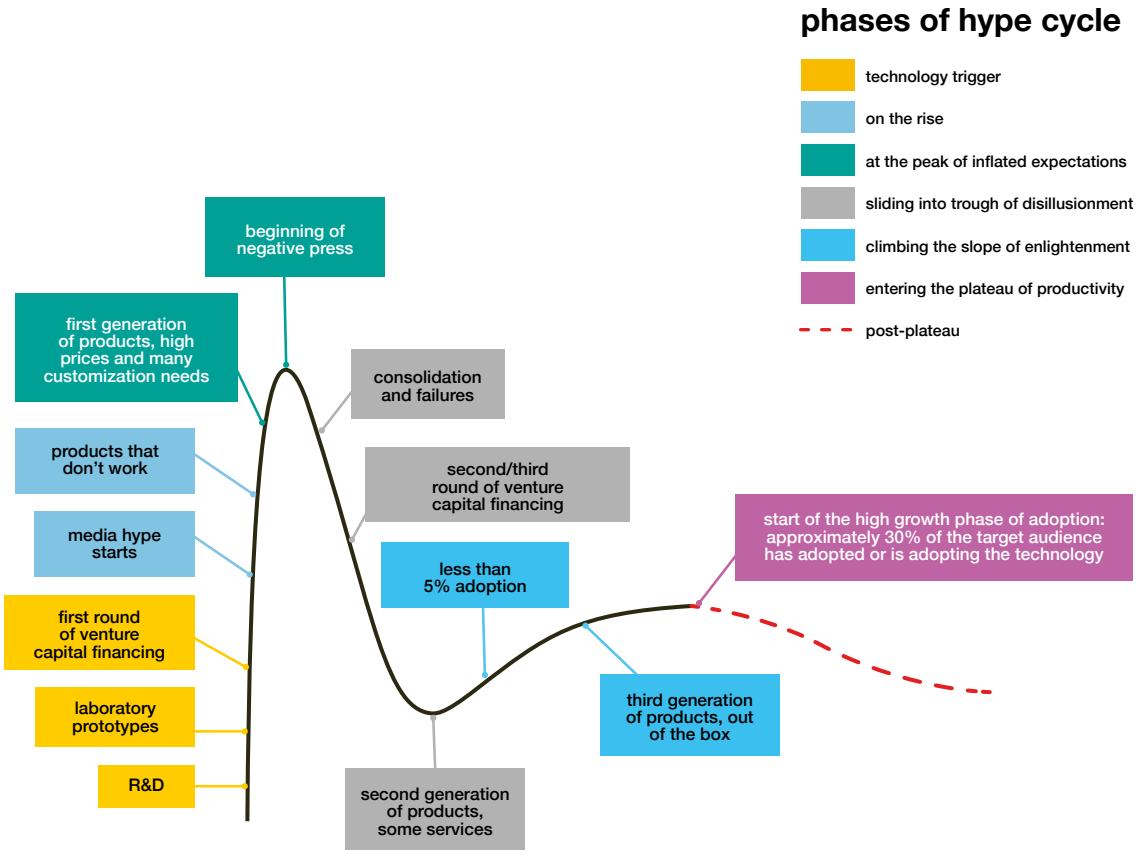
The horizontal axis of the hype cycle represents time, but the vertical axis does not only represent maturity. The premise is that the more visible an innovation - in marketing, conversations, news and media, conferences and elsewhere - the more 'sensationalist' it will be. The vertical axis represents expectations.

Although the dissemination of the model has been relatively limited to academic circles, there is growing interest within the literature on technology and innovation management, especially evident in technology forecasting. In the period in which people are excited about an innovation, expectations increase rapidly, but are easily frustrated. This happens because new technologies rarely deliver on their promises.

Meanwhile, the development of technology happens at a different pace, causing a lack of synchrony between the expectations and development of the technology. These two factors can be described by two different curves: the first is a bell curve, which represents the initial enthusiasm and then disappointment caused by positive and negative enthusiasm; the second is an 'S' curve which represents the performance of an innovation which slowly improves at the beginning, increases continuously and then finally produces diminishing returns.

The hype cycle curve is built on the fusion of two different equations/curves. The first part of the curve or equation is based on human behaviour and describes expectations in the form of a hype level curve. The second part or equation is an 'S' curve of classic technology with the purpose of describing technological maturity.

The hype cycle is also a measurement of knowledge and risk. At the start of the cycle, the companies did not yet know much about the technology studied, which made it difficult to make judgements about its costs and benefits. In this phase the risk is high. At the end of the cycle, when the company has gathered more knowledge about a technology, it becomes easier to know where and when to apply it, greatly reducing the risk involved. The hype cycle curve can be divided into seven phases: *Figure below* shows the characteristics of each phase.



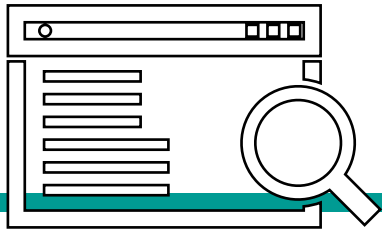
materials and methods

To build the Hype Cycle curve, a set of publications discussing the theoretical and empirical methods of its construction were analysed. In general, studies start from a quantification of the number of articles in journals, patents, books and news in specialised magazines, among others.

As mentioned previously, the Hype Cycle curve can be developed through two different curves: the first is a bell curve (representing initial enthusiasm and then disappointment with the technology) which goes from Innovation Trigger to Trough of Disillusionment, and the second, an S-shaped curve (representing the performance of the innovation), which goes from the Slope of Enlightenment to the Plateau of Productivity.

The articles analysed basically count the number of items found through researching news, articles, books, journals, newspapers, etc. on the technology, with the aim of measuring expectations, setting the first stage of the Hype Cycle curve. On the other hand, for the second stage, patent statistics are used, obtained through research. The methodology employed proposes a combination of S-curves (Sigmoid curves) and a subsequent adjustment of curves with polynomial functions. In order to obtain the Hype Cycle curve, a combination of bell-shaped and S-shaped curves was used.

bibliometric survey



The first stage of the methodology consisted of a bibliometric survey of the Web of Science (WoS) database on electrical energy storage, distributed photovoltaic generation and microelectrical networks technologies. The WoS database was chosen for its scope and use in other bibliometric studies, as it allows access to references and abstracts of various articles in all areas of knowledge.

Articles published in the WoS database were used as data to simulate the Hype Cycle curves of the selected technologies. All articles published by Brazilian institutions based on WoS data - from the first publications for each technology until 2018 - were considered, being divided as follows: storage - 520, distributed photovoltaic generation - 1467 and micro grids - 266.

hype cycle curve construction

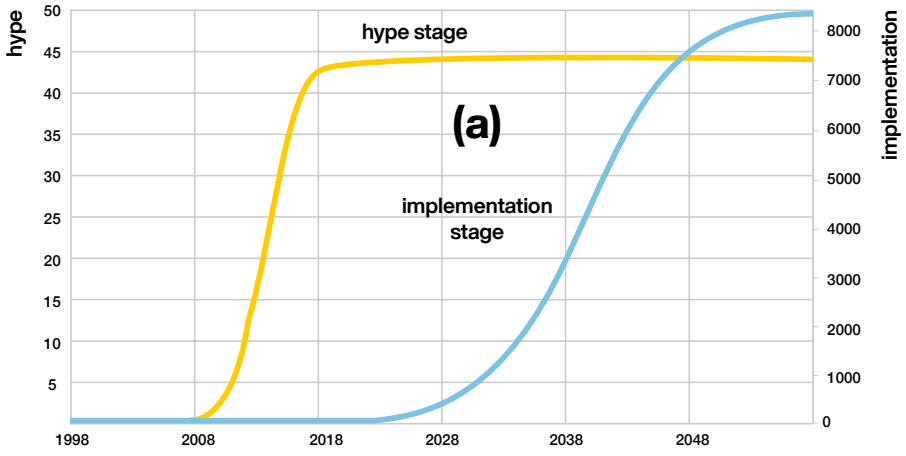
Hype Stage: is the period from the Innovation Trigger up to the Trough of Disillusionment. At this stage, the curve as a bell shape, where time is along the X axis and the instantaneous (non-cumulative) number of articles is along the Y axis.

Implement Stage: from the Slope of Enlightenment to the Plateau of Productivity. At this stage, the curve has an S-shape, where time is along the X axis and the cumulative number of articles is along the Y axis.

An adequate way of building the Hype Stage is to use the number of articles published per year which mention the technology. When building the Implement Stage, an important issue to determine is which articles should form part of this stage. In this sense, as indicated by the methodology, the abstracts and titles of articles were analysed, in order to verify if the technology mentioned is in the implementation stage. Consequently, phrases such as 'the implementation of a prototype' or 'experimental results' or 'implementation of a laboratory', among others, indicate that the technology mentioned is in the implementation stage.

curve fitting and polynomial adjustment

The graphs were obtained using five Sigmoid functions: Logistics, Gompertz, Brody, Von Bertalanffy, and Richards. This study applied each of these functions in each of the two development stages of the Hype Cycle curve. To form a Hype stage curve, the S-curve will be transformed into a bell shaped curve, and through the combination of both curves, after standardization, the Hype Cycle curve is obtained, as can be seen in the *next Figure*. To mathematically formulate the Hype Cycle curve, polynomial adjustments of the dotted line for degrees 7, 8, 9, 10, 11 and 12 were performed.


hype
implementation
hype stage
(a)
implementation stage
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45
40
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30
25
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1998
2008
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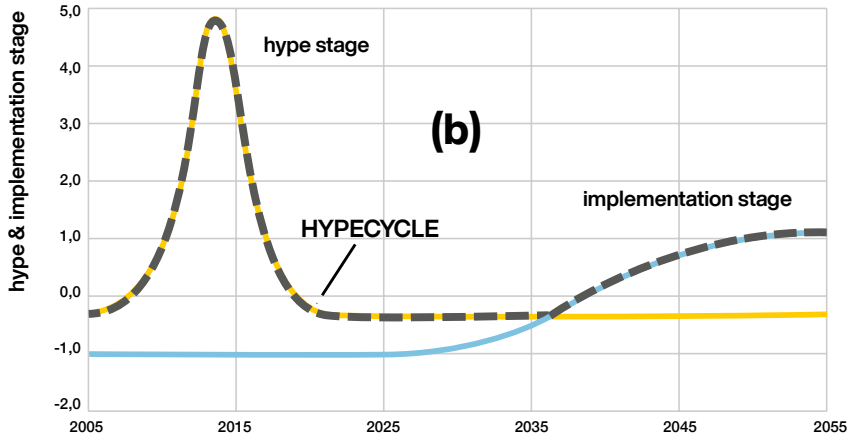
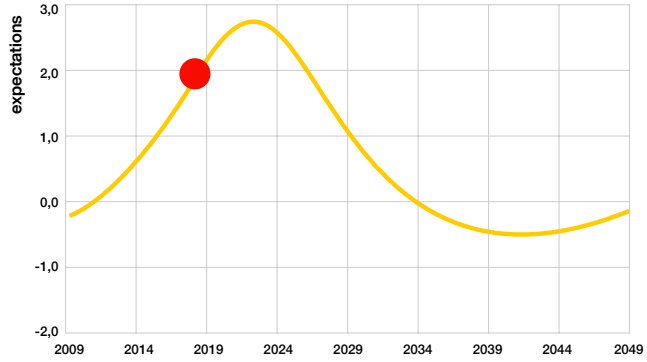
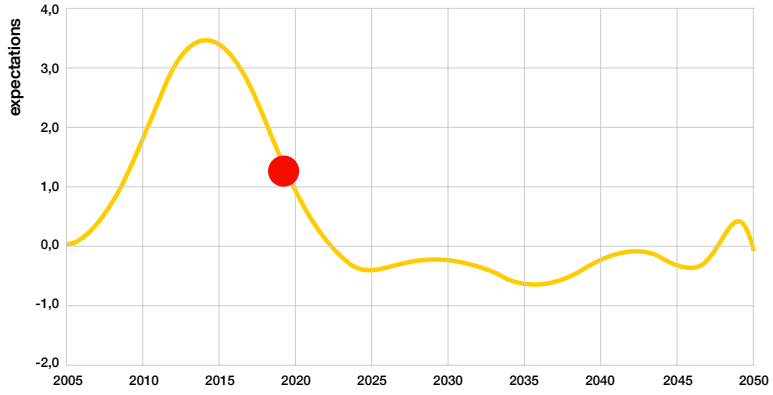

hype & implementation stage
hype stage
(b)
HYPECYCLE
implementation stage
5,0
4,0
3,0
2,0
1,0
0,0
-1,0
-2,0
2005
2015
2025
2035
2045
2055

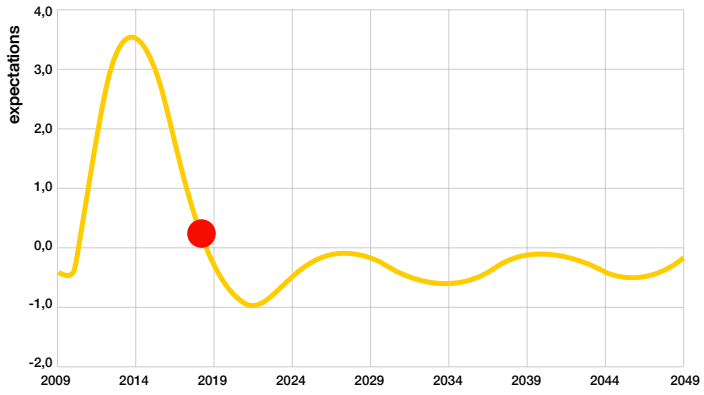
Electric energy storage: After the polynomial adjustment, the Hype Cycle curve for electric energy storage is obtained, as shown in the figure below. The circle indicates the position of energy storage technology in relation to expectation in the year 2018.



Photovoltaic Distributed Generation: After the polynomial adjustment, the Hype Cycle curve for photovoltaic distributed generation is obtained, as shown in figure below. The circle indicates the position of photovoltaic distributed generation in relation to expectation in the year 2018.



Electric Micro Grids: After the polynomial adjustment, the Hype Cycle curve for electric micro grids is obtained, as shown in figure below. The circle indicates the position of electric micro grids in relation to expectation in the year 2018.



conclusions

It can be observed that, for both technologies of photovoltaic distributed generation as well as micro grids, market expectations are falling mainly due to the lack of incentives for their use. Despite technical issues being analysed, these technologies still have regulatory barriers and high costs that prevent their further dissemination. However, in the short and medium term, these same technologies could obtain a high degree of competitive advantage if they had the necessary conditions to develop, as they are close to the Slope of Enlightenment stage.

The greater development of distributed generation could contribute to the evolution of electric energy storage technologies, as they are appropriate for diminishing their intermittence. This evolution of technologies could leverage a greater development of micro grids, which are major components of these.

It should be emphasised that, in accelerating the process of adopting these technologies, the government should implement more systematic policies for supporting innovation, especially aiming to engage companies, in order to reach a higher level of development and income gene-

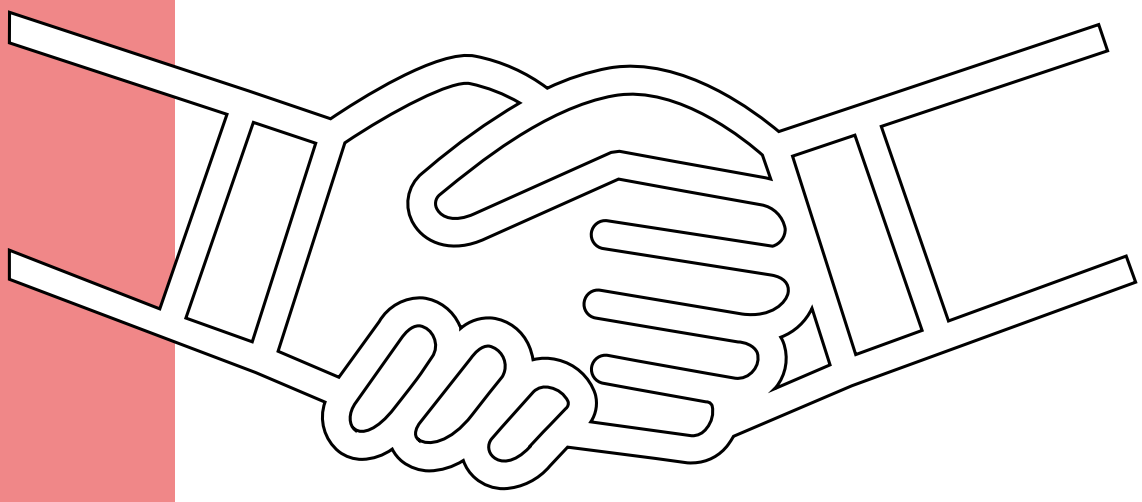
ration, placing innovation as a fundamental factor for the quality leap of the Brazilian industry.

This study proposes to consolidate an analytical approach, exemplified through the analysis (title and abstract) of publications from a single base - WoS - to represent the life cycle of the technologies explained. As such, the extension of analysis, not only for all the content of the work as well as for the publications from other bases - SCOPUS for example - has the potential to broaden the statistical analysis and consolidate the method proposed.

Finally, this study presents a form of measuring the Hype Cycle curve, as well as important results regarding what type of technologies can be observed, showing which sources can be monitored for this purpose. The results also leave open the possibility for a great deal of research to show the life cycle of other technologies.

chapter 4

proposed regulation for cooperation between startups and large companies in the electricity sector



This stage consists of the elaboration and presentation of suggestions for alteration of the ANEEL R&D Program Manual, with the purpose of fostering cooperation between startups and large companies in the sector. One of the main inferences of the study was that the creation and development of startups focused on the energy sector could, in a certain sense, change the very configuration of the electricity sector. In a more holistic view, it is possible to see that the boundaries which define the electricity sector must be widely modified in the next decades.

The advent of electric vehicles will enable new reciprocations with the automotive, oil, gas and biofuels sectors. The expansion of solar energy and batteries will enable different types of interaction with the electronics and chemical industries. In addition, smart grids and smart blockchain contracts will elevate the sector to high convergence with segments linked to information technology. Together with new technologies, new business models could substantially change certain current sector paradigms, not only in Brazil but the entire world.

Changes will certainly undergo reflection and intense debate from a regulatory point of view, which can act as either a brake or catalyst for innovation. The role of ANEEL - and also the ANP - will be critical in defining the country as a pioneer in the global energy transition, or a follower of innovations developed in other countries.

In parallel, throughout this study some of these issues were widely debated, such as the review of Normative Resolution 482/12, which entered public consultation to discuss new general conditions of access to distributed micro and mini generation in distribution systems and compensation of electric energy. As these issues were already being addressed institutionally, it was decided, for this study, to focus suggestions on another phenomenon which has grown substantially in the world and various sectors: corporate venture capital (CVC).

CVC has expanded its investment volume worldwide: it has grown on average by 38% per year in the last 6 years, and reached its historical record in 2018 with close to US$53.2 billion invested (CB Insights, 2019). In the energy sector, CVC funds have been widely used as an open innovation tool capable of leveraging and managing radical innovation for traditional energy companies. Inspired by this movement to engage startups and large companies, Law No. 13.674, of the 11th June 2018 was passed for the information technology sector, which allows for resources from the Information Technology Law to be used for investments in startups via Equity Investment Funds (EIFs) regulated by the CVM.

Market and tech reports and articles indicate that the CVC route could be promising for the energy sector, in the same way the new law for the IT sector was. This was explored as a regulatory suggestion for the development of innovation via cooperation between startups and large companies: the IS modality (Investment in Startups) for ANEEL R&D projects. It is worth mentioning that this is just one of many ways to operationalize this type of cooperation, but the research team understood that it is a promising route that combines the rigour in applying resources with the flexibility required to foster startups in the sector. The document with the suggestions was delivered to ANEEL and considered in the Public Consultation 17/2019 on new instruments to encourage innovation in the electricity sector. It will also be available for consultation at the Clean Technologies Observatory.
The following are some of the general considerations on the proposal.

general considerations on the proposal

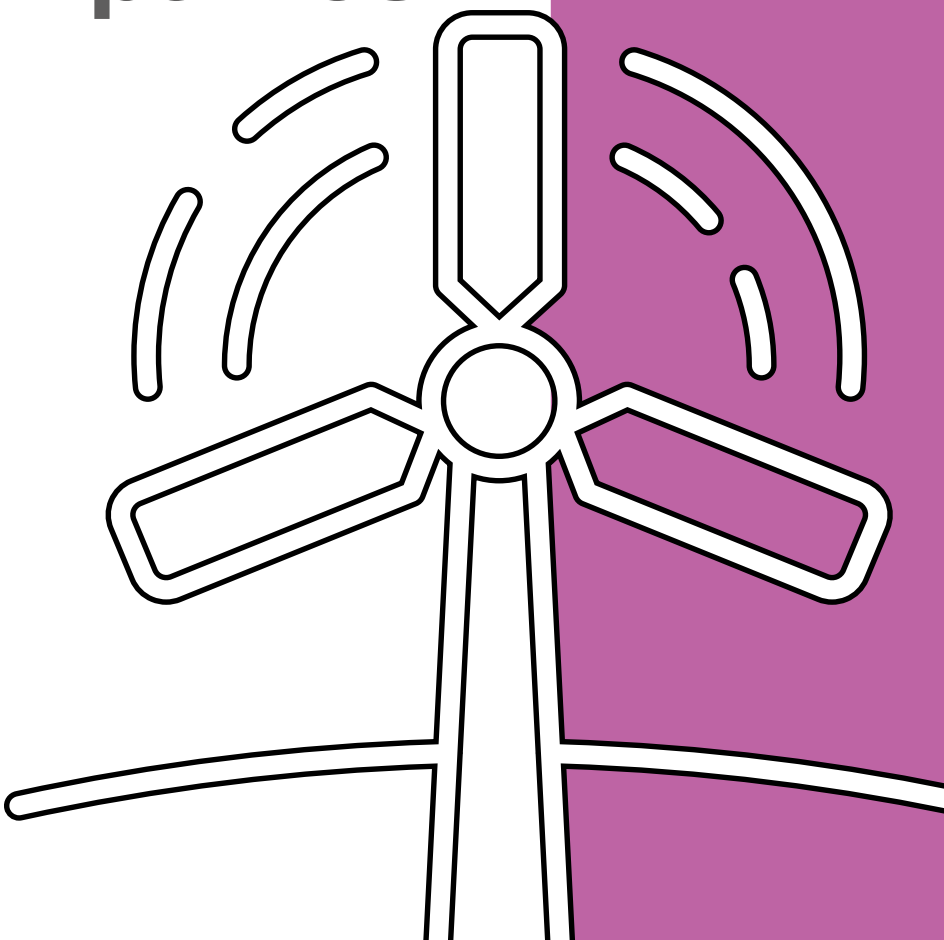
• The current environment for fostering innovation in the electricity sector through investments in startups is favourable both in terms of legal permission, objectives and concepts (Module 1 of PROP&D) as well as will and context (ANEEL and sector companies wish that the R,D&I of the Program generate more positive impact on the market and society);

• The general view of this contribution is based on suggestions for specific alterations in the ANEEL R&D Program Manual (PROP&D) considering the creation of a new type of ANEEL R&D project: Investment in Startups - IS, based on modern open innovation models and cooperation between large companies and startups (corporate venturing) which has significantly grown in Brazil and the world. This approach was chosen considering the need to maximize impact and positive externalities with minimum possible alteration of already established ANEEL R&D program norms. The initial mapping of the study, with 136 sector startups, highlighted the difficulty in accessing investments as one of the main limitations to growth;

• Operationally, the proposal seeks to build on successful, tried and tested experiences such as Equity Investment Funds (EIFs) regulated by CVM through ICVM 578/2016 (whose formulation is based on more than 20 years of operation of ICVM 209/94 and ICVM 391/03), and also modelling for the use of resources from the Information Technology Law (Laws 8.248/91 and 13.674/18; and MCTIC Ordinance 5.894/18). EIFs are currently the most used investment vehicles in Brazil for investing in startups and were fundamental to the expansion of venture capital in other segments.

chapter 5

empirical cooperation test for startups and large companies



One of the stages covered by the study is comprised of the validation of the thesis of engagement between startups and large companies, with the application of an empirical cooperation test. The following methodology was used for the test, based on the startups mapped in the study's first stage:

1. Definition of relevant challenges for EDP (pilot)
2. Curation of startups for cooperation
3. Preparing startups for the challenges
4. Presentation of startup pitches to an appraisal board

EDP participated in this test as a pilot company. The challenges presented by the company were:

1. the future of mobility is electric!

In the coming years the fleet of electric cars will see large growth in Brazil. EDP is strategically positioning itself in this market. We have a corridor which connects the Rio - São Paulo metropolises and we want to continue growing. That's why we're looking for solutions for the integration of electric vehicle recharging systems and infrastructure.

2. making processes more efficient and innovative

EDP has transversal areas which support its businesses, such as HR, Legal, Finance, Compliance, etc. These areas are not specifically the core business, but are essential to the company's success. We seek to constantly improve efficiency in these areas.

3. the client - our raison d'être!

EDP has over 3 million energy distribution customers. We are now operating in the B2C market by offering various services to the end customer. Our client is our raison d'être, which is why we always want to improve the user experience and differentiate it, from the opening of a purchase order to the after-sales relationship.

4. it's the cleantechs' turn: when innovation meets sustainability

We are constantly seeking solutions to improve the use of natural resources in our various activities (distribution, energy trading and solutions, generation and transmission). We also seek to understand how we can generate a more positive socio-environmental impact in the communities where we operate.

The next step was to curate the startups for cooperation. Of a universe of 205 companies (136 from the mapping base and 69 from ABStartups), 5 were chosen:

1. Justto
Platform for the resolution of legal cases based on machine learning algorithms.

2. SintecSyS
Fire detection and monitoring system for remote areas.

3. Dispor Energia
Platform and signature solutions for solar generators.

4. ElectroWave
Monitoring and identification of risk of electrical damage.

5. Volt
Electric mobility as a delivery service solution.

For the third step, startups and entrepreneurs were prepared by the ABStartups and research teams for their pitch presentation at Arena Cleantech during the 2019 Annual Startup and Entrepreneurship Conference (CASE), the largest startup event in Latin America.

Finally, the 5 startups presented their pitches at CASE in two sessions before a board formed of the following members:

1. Hudson Mendonça
LabrInTOS/COPPE/UFRJ Researcher

2. Rafael Marciano
EDP Brasil Strategy and Innovation Manager

3. Renato Paquet
ABStartups Cleantech Committee CEO

4. Rosario Cannata
EDP Ventures Investment Manager

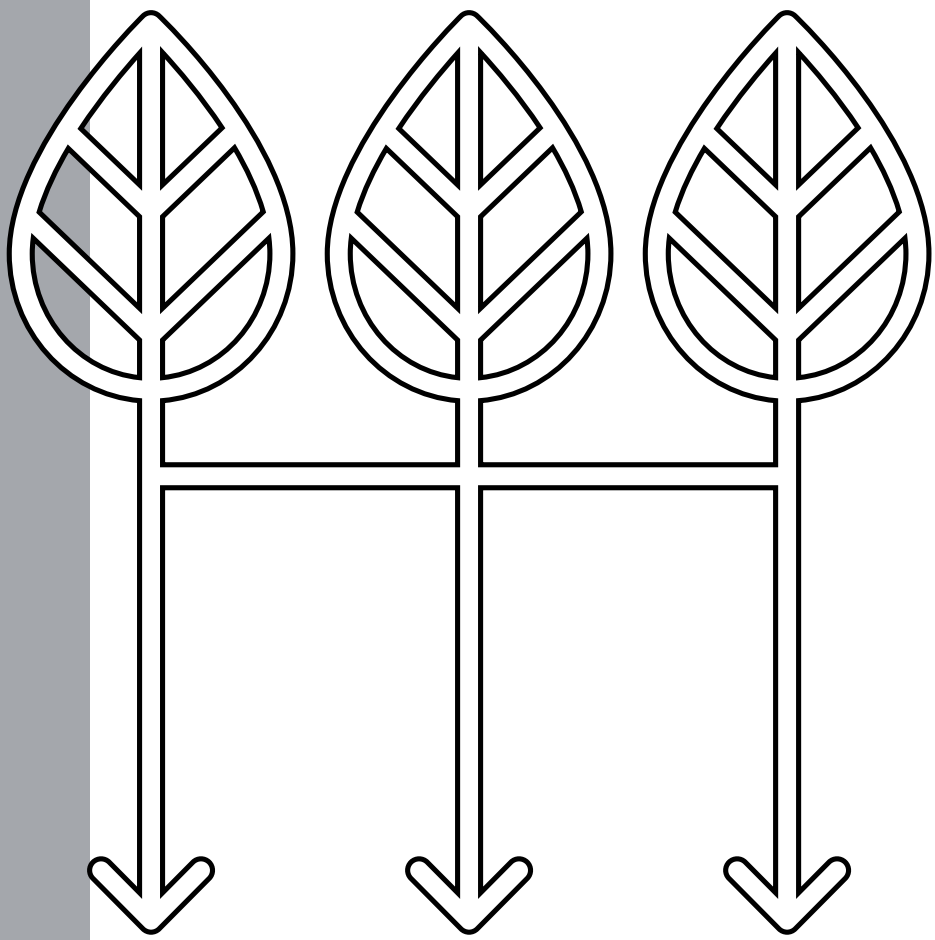
5. Gustavo Pinheiro
ICS Portfolio Coordinator

6. Nuno Pinto
B2C Products Manager at EDP Brasil

The presentations were made and questions clarified. The contact between startups and the applicant company (EDP) was initiated for future commercial or investment cooperation.

chapter 6

the clean technologies observatory

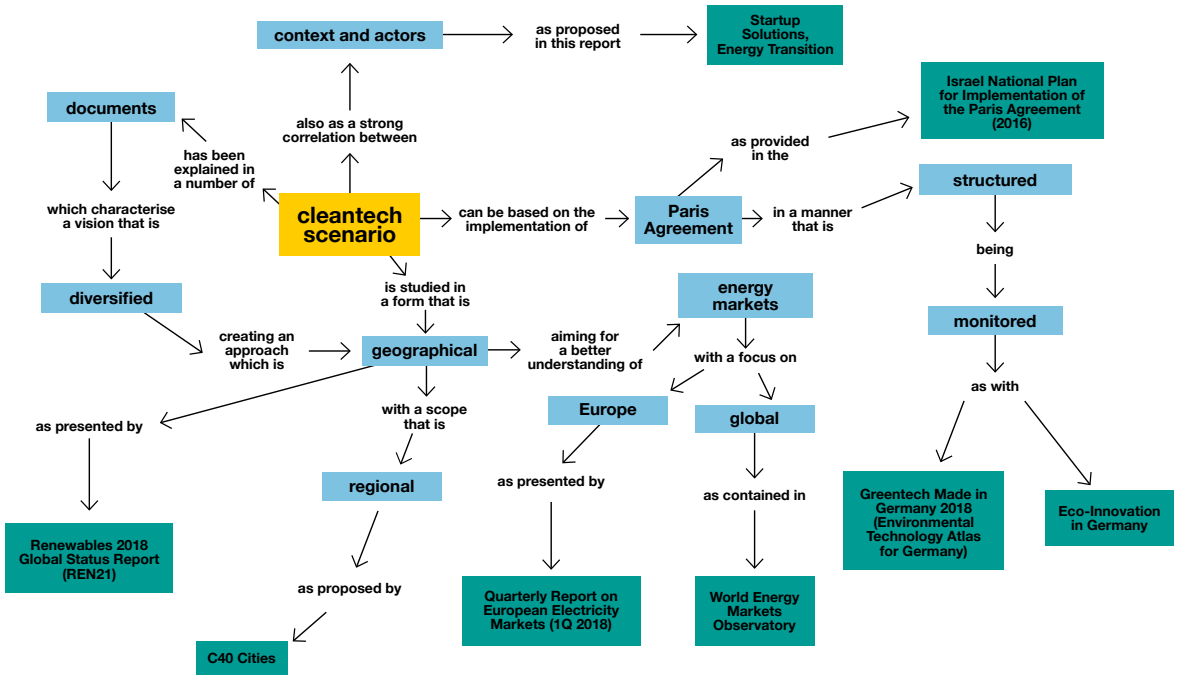


The premise of the Observatory is to inform, collectively build knowledge and give those who participate the opportunity to analyse and shape scenarios.

The multiplicity of data and information contained in an Observatory also allows companies and professionals to create strategies, tactical plans and operational models based on sectoral trends and transformations.

For the Clean Technologies Observatory, a set of basic information sources was sought that could substantiate the scenario presented in the scope of cleantech linked to the sector, both in Brazil and abroad.

A conceptual map was created to show how information is interlinked (figure below). This map represents the way different documents - which enhance the formatting of the cleantech scenario in the Observatory - are presented.



Scope of document/scenario mode of interconnection focused on Energy Transition and Cleantechs - Energy

Relevant publications are part of this map and will be available in the Observatory, credited and linked to their primary sources, allowing the researcher or entrepreneur to access complementary information of interest.

Infographics also have a place in the Observatory, and show the evolution of the energy transition we are witnessing, as well as comparisons between regions and periods. This data allows us to visualise the geography of change and its effective consequences and impact regarding the actions and public policy of the sector.

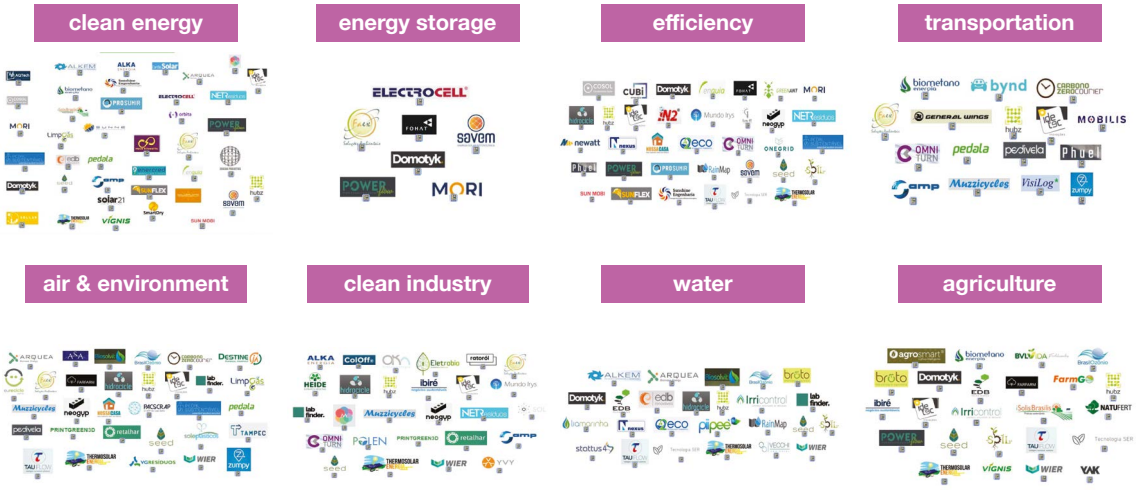
The incorporation of publications such as articles from national and international magazines contributes to the robustness of the Observatory. As the energy transition is consolidated, various researchers and business managers use business-academia interconnections to align, detail and even counteract the scenario being established.

Videos are also present at the Observatory. Be they presentations of the technologies of energy cleantech startups, or showing the evolution dynamics of their share in the energy matrix of various countries, videos are a part of what has been designated Environment 21 (Ambiente 21): a contemporary context characterised by the acceleration of changes in technology, the market and values. Videos were also produced on subjects about the implementation of hardtech startups with the presence of specialists in different sectors. For example:

Industry 4.0... What is it?; Challenges of Industrial Hardtechs; Intellectual Property for Startups; The Importance of the Academia-Business Relationship; The Pitch Deck and What It's For.

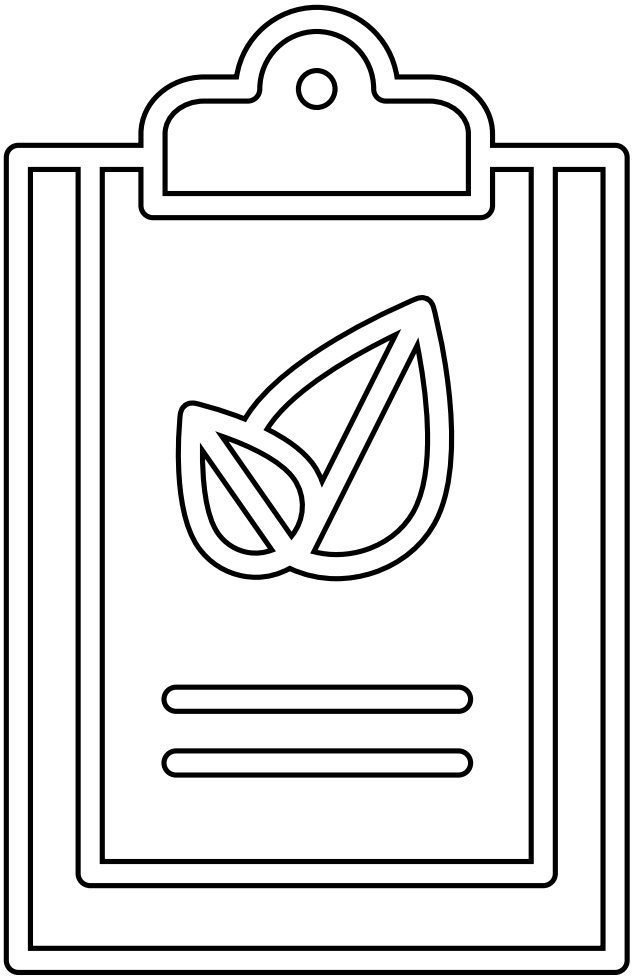
Based on the survey which mapped the cleantech startup ecosystem in Brazil, a permanent register will remain open at the Observatory, allowing us to periodically know the set of startups operating in the energy market. This register will link each startup to a Kachan category of classification – figure below. Each mark will be linked to the company's site to access information about available services and products.

Finally, the Observatory will have a space dedicated to legislation pertaining to the electricity sector, and mainly to the induction of cleantech startups. This area has been improved and an Observatory on the subject must disseminate, analyse and scenarize this impact.
The Observatory will be a dynamic and interactive environment, which allows its structure, presentation, products and services to evolve as the energy transition takes place.



Companies integrating the Brazilian Cleantech Startup Ecosystem - Energy, grouped by Kachan classification

conclusions



When started, in May 2018, this study had among its main motivations the electricity sector's need for transition - in line with the premises of decarbonisation, decentralisation and digitalisation - and the recognition of the impact potential of startups to front the innovation needed for this transition.

In addition to being pertinent, these motivations pointed to the urgency and need for advancing these agendas in Brazil. Proof of this are the alarming scenarios in relation to climate change, to which the electricity sector is of absolute importance due to the matrix of sources adopted. In addition, the intensification of the debate around the review of Normative Resolution 482/12, which is in public consultation, brought the features and implications of distributed generation to a wider audience, not only from the point of view of opportunities for a number of startups, but also the challenges to the business models of large companies and the balance of the sector as a whole.

This pertinence gives the Startup Ecosystem Impact on the Brazilian Electricity Sector study an enormous relevance, as it dialogues with real demands of society and points to paths and solutions in accordance with the regulatory environment and market needs, in line with what is expected by the ANEEL R&D Program, which has enabled this partnership between FGVces, COPPE/UFRJ, ABStartups, EDP and Statkraft.

Among the main results obtained, the following are worth highlighting:

• A detailed profile of the cleantech startups which relate directly or indirectly to the electricity sector and the dimensions which influence the business ecosystem in which they operate, namely: public policy, market, financial, human capital, support agents and entrepreneurial culture. This data contributes decisively to any effort to foster entrepreneurism and innovation oriented to sustainable development.

• The understanding of the life cycle of some key technologies for the Brazilian electricity sector: distributed generation, energy storage and micro grids. This understanding qualifies the analysis of economic agents, reducing risks and maximizing opportunities in investment decision-making;

• The proposal for improvements in the ANEEL R&D Program Manual in relation to the use of Equity Investment Funds (EIFs) as an alternative to reducing legal insecurity and attracting investors, which is essential to leveraging resources for startups in the form of venture capital, corporate venture capital, and other modes of investment;

• The greater visibility of the mapped cleantech startups, not only through the networks of the organizations executing this study but also through CASE 2019, one of the biggest entrepreneur events in Latin America, which this year for the first time featured a specific arena for businesses related to cleantech;

• The creation of a knowledge base on the subject, including key content on the transition of the electricity sector and mapping of cleantech startups, which is a legacy for public and private actors in the form of the Clean Technologies Observatory.

All of these results point to the importance of advancing the relationship between large compa-

nies and startups, enhancing the skills of both in favour of the transition of the Brazilian electricity sector. To this end, some paths can be shown as a continuity to this study, such as:

(I) Expansion of the mapping of startups and different actors related to the entrepreneurial and innovation ecosystem which influence the electricity sector;

(II) Analysis of the life cycle of other key technologies aligned with the premises of decarbonisation, decentralisation and digitalisation of the electricity sector;

(III) Projection of the impact of EIFs in relation to the mobilisation of financial resources for cleantech startups linked to the electricity sector;

(IV) Implementation of a model of governance for the Clean Technologies Observatory which ensures its appropriation as a public good and its continuity as a reference source for the innovation and entrepreneurial ecosystem.

From the point of view of the executing organisations, the results of this study make evident the importance of the ANEEL R&D Program in fostering applied research, and the EDP Group and Statkraft in jointly leading the startup ecosystem in Brazil. To these organisations, our sincere thanks!

list of mapped startups

Agrosmart - Cultivo Inteligente	www.agrosmart.com.br
ALKA ENERGIA	www.alkaenergia.com.br
ALKEM ENERGIA & AMBIENTAL	www.alkem.com.br
Andrômeda Green Energy	
AQBITS	www.aquabit.com.br
AQTech Power Prognostics	www.aqtech.com.br
Arquea Biomass Energy	www.arquea.eco.br
ASACON	www.asacon.com.br
aya tech	www.aya-tech.com.br
Biomatter	
Biometano	www.biometanoenergia.com.br
Biosolvit	www.biosolvit.com
Biovida	www.biovidaba.com.br
Brasil Ozonio	www.brasilozonio.com.br
Broto	
bynd	
Carbono Zero	www.carbonozero.com.br
CARTÃO SOLAR	www.cartaosolar.com.br
Ciclo Reverso	
ColOff®	www.coloff.com.br
COOPSOLAR	
Courrieros	www.courrieros.com.br
CUBi Energia	www.cubi.com.br
Desígnio ecodesign | Oka bioemblagens	www.okabioembalagens.com.br
Destine já	www.des2neja.com.br
DOMOTYK Eco Smart	www.domotyk.com.br
E4 Engenharia Elétrica Eficiência Energética	www.e4.com.br
EDB Polióis	www.polioisvegetais.com.br
EDB Renováveis	www.edbrenovaveis.com
EKONOWATER	www.ekonowater.com
Electrocell	www.electrocell.com.br
Eletrobio	www.eletrobio.com.br
Enercred	www.enercred.com.br
EnerGym	
EnGuia	www.enguia.eco.br
ENTAER	
ERGON PROJETOS	www.ergonprojetos.com.br
Estúdio RatoRói	hIps://readymag.com/ratoroi/1145797/
Eureciclo	www.eureciclo.com.br
FAEX	www.faex.com.br
FARFARM	www.farfarm.co

FarmGO	www.farmgo.com.br
FOHAT CORPORATION	www.fohat.io
Fornari Indústria de Equipamentos para o Agronegócio	www.fornariindustria.com.br
Gelo Solar	
General Wings Bicicletas Elétricas	www.generalwings.com.br
GreenAnt	www.greenant.com.br
Grupo Mori	www.energiasolarmori.com
Grupo NBR Digital Serviços Virtuais	
Heide Extratos Vegetais	www.heide.com.br
Hidrocicle	www.hidrocicle.com.br
hubz	www.hubz.com.br
IBIRÉ	www.ibire.com.br
Idetec Inovações	www.idetec.ind.br
iN2	www.in2.com.br
INOCAS	
Irricontrol – Controle Inteligente De Irrigação	www.irricontrol.com.br
Irys Brasil Ltda	www.mundoirys.com.br
iSolis Brasilis	www.isolis.com.br
IXTRONIC	
LABFINDER	www.labfinder.com.br
LiaMarinha	www.liamarinha.com.br
Limpgas Tecnologia	www.limpgas.com.br
livealoe	www.livealoe.com.br
Low-IT	www.low-it.com.br
Luminase	
Marina Tech	www.marinatecnologia.com.br
MeuReciclador	
Meus Kilowatts	www.meuskilowals.com.br
Mobilis Veículos Elétricos	www.mobilis.me
Molegolar Habitação Resiliente	www.molegolar.com.br
Morada da Floresta	www.moradadafloresta.eco.br
Muzzicycles	www.muzzicycles.com.br
Natufert Fertilizantes	www.natufert.com.br
Neogyp	www.neogyp.com.br
Netresiduos	www.netresiduos.com.br
Newatt	www.newal.com.br
NEXUS	www.nexusbr.com
Nossa Casa	www.instagram.com/clubenossacasa
O SOL	www.osolweb.com.br
O2eco Tecnologia Ambiental	www.o2eco.com.br
Omniturn	www.omniturn.com.br
ONEGRID	www.onegrid.co
Orbita	www.orbita.cc
PACSCRAP	www.pacscrap.com
Pedal Sustentável	www.pedalsustentavel.com.br
Pedala entregas sustentaveis	www.pedala.eco.br
Pedivela	www.pedivela.com
PHUEL	www.phuel.com.br

Piipee Comércio de Produtos de Limpeza	www.piipee.com.br
Plataforma Verde	www.plataformaverde.com.br
Polen - Solução e valoração de Resíduos	www.brpolen.com.br
Power Flow	www.powerflow.net.br
PrintGreen3D	www.printgreen3d.com.br
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RainMap	www.rainmap.com.br
Recicle Jah	www.recyclejah.com.br
Renova Lixo	www.renovalixo.com.br
Residuall	www.residuall.com
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Retalhar	
S.O.ESCO	www.soesco.com.br
Sampdesign / Samp Motors	www.maurisamp.wixsite.com/sampmotors
SAVEM	www.savem.com.br
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Soloplásticos Construções Sustentáveis	www.soloplas2cos.eco.br
Startup com divulgação não autorizada	
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SUNSHINE ENGENHARIA	www.sunshineengenharia.com.br
Sylittex	
Tamoios Tecnologia	www.tamoiostecnologia.com.br
Tampec	www.tampec.com.br
Tau Flow	www.tauflow.com
Tecnologia SER	www.tecnologiaser.com
Thermo Consultoria e Projetos	www.thermosolar.com.br
TOCO	www.biotoco.com.br
Vecchi Ambiental	www.vecchiambiental.com.br
VG Resíduos	www.vgresiduos.com.br
Vignis	www.vignis.com.br
VisiLog	www.visilog.com.br
WIER PLASMA E OZÔNIO	www.wier.com.br
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YAK	www.yaktractors.com
YVY Brasil	www.yvybrasil.com
Zumpy	www.zumpy.com.br

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