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COMPETITIVENESS ASSESSMENT WITH THE IMPLEMENTATION OF AN ENERGY CAPACITY MARKET IN BRAZIL

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ABSTRACT

Purpose: This article investigates issues related to the need to implement a capacity market in the Brazilian electricity sector to add security to the system and increase market competitiveness to benefit its energy consumers, as well as attract investments to the supply segments of this industry.

Theoretical Framework: This research focuses on the Market Design Theory and the transition to the capacity market, detailing its principles and relevance in the current context. Through it, we seek to understand the mechanisms that shape the contemporary market.

Design/Methodology/Approach: This research adopts an applied research approach. It is structured as a case study, where Brazil is analyzed in the context of implementing a capacity market. Techniques such as interviews, and documentary research were used to collect data.

Findings: The study delves into the intricacies of establishing a capacity market in a competitive environment. The central findings encompass distinctions between the separation of backing and energy versus the capacity market; the blueprint of the auction and regulation of contracting; shaping the long-term market perspective; and the methodology for deducing the capacity market demand.

Research, Practical & Social Implications: This article contributes to the literature by surveying cases on capacity market development in developed countries. Furthermore, as a practical contribution, it details the benefit of implementing a capacity market in the Brazilian case.

Originality/Value: This research provides innovative solutions for Brazil, drawing from global benchmarks and tailoring them to Brazil's unique challenges and recent legal changes.

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AVALIAÇÃO DA COMPETITIVIDADE COM A IMPLEMENTAÇÃO DE UM MERCADO DE CAPACIDADE DE ENERGIA NO BRASIL

RESUMO

Objetivo: Este artigo investiga questões relacionadas à necessidade de implementar um mercado de capacidade no setor elétrico brasileiro para agregar segurança ao sistema e aumentar a competitividade do mercado em benefício de seus consumidores de energia, bem como atrair investimentos para os segmentos de fornecimento desse setor.

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Estrutura Teórica: Esta pesquisa enfoca a Teoria de Desenho de Mercado e a transição para o mercado de capacidade, detalhando seus princípios e sua relevância no contexto atual. Por meio dela, buscamos entender os mecanismos que moldam o mercado contemporâneo.
Projeto/Metodologia/Abordagem: Esta pesquisa adota uma abordagem de pesquisa aplicada. Está estruturada como um estudo de caso, em que o Brasil é analisado no contexto da implementação de um mercado de capacidade. Técnicas como entrevistas e pesquisa documental foram usadas para coletar dados.
Conclusões: O estudo investiga os meandros do estabelecimento de um mercado de capacidade em um ambiente competitivo. As descobertas centrais abrangem distinções entre a separação de backing e energia versus o mercado de capacidade; o projeto do leilão e a regulamentação da contratação; a formação da perspectiva de mercado de longo prazo; e a metodologia para deduzir a demanda do mercado de capacidade.
Pesquisa, Implicações Práticas e Sociais: Este artigo contribui para a literatura com o levantamento de casos de desenvolvimento de mercados de capacidade em países desenvolvidos. Além disso, como contribuição prática, ele detalha os benefícios da implementação de um mercado de capacidade no caso brasileiro.
Originalidade/Valor: Esta pesquisa oferece soluções inovadoras para o Brasil, com base em referências globais e adaptando-as aos desafios exclusivos do Brasil e às recentes mudanças legais.

Palavras-chave: Mercado Puro, Mercado de Capacidade, Mercado de Energia.

EVALUACIÓN DE LA COMPETITIVIDAD CON LA IMPLEMENTACIÓN DE UN MERCADO DE CAPACIDAD ENERGÉTICA EN BRASIL

RESUMEN
Objetivo: Este artículo investiga cuestiones relacionadas con la necesidad de implementar un mercado de capacidad en el sector eléctrico brasileño para agregar seguridad al sistema y aumentar la competitividad del mercado en beneficio de sus consumidores de energía, así como atraer inversiones a los segmentos de suministro de esta industria.
Marco Teórico: Esta investigación se centra en la Teoría de Diseño de Mercado y la transición al mercado de capacidad, detallando sus principios y relevancia en el contexto actual. A través de ella se busca comprender los mecanismos que conforman el mercado contemporáneo.
Diseño/Metodología/Enfoque: Esta investigación adopta un enfoque de investigación aplicada. Se estructura como un estudio de caso, donde se analiza a Brasil en el contexto de la implementación de un mercado de capacidad. Para la recolección de datos se utilizaron técnicas como entrevistas, entrevistas e investigación documental.
Hallazgos: El estudio profundiza en las complejidades de establecer un mercado de capacidad en un entorno competitivo. Los hallazgos centrales abarcan distinciones entre la separación del respaldo y la energía frente al mercado de capacidad; el plan de la subasta y la regulación de la contratación; la configuración de la perspectiva del mercado a largo plazo; y la metodología para deducir la demanda del mercado de capacidad.
Investigación, Implicaciones Prácticas y Sociales: Este artículo contribuye a la literatura mediante el estudio de casos sobre desarrollo de mercados de capacidad en países desarrollados. Además, como contribución práctica, detalla el beneficio de implementar un mercado de capacidad en el caso brasileño.
Originalidad/Valor: Esta investigación proporciona soluciones innovadoras para Brasil, basadas en puntos de referencia globales y adaptándolas a los desafíos únicos de Brasil y a los recientes cambios legales.

Palabras clave: Mercado Puro, Mercado de Capacidad, Mercado Energético.

INTRODUCTION

A set of different improvements (including generators and circuits, for example) is crucial in expanding an electrical system to meet demand economically and reliably. However, these objectives are conflicting: improving the reliability of the energy supply requires new investments, which implies an increase in costs (Santos et al., 2023). Furthermore, if this improvement is made ecologically sustainably, the consequences would be higher tariffs and prices for the consumer. Finding the balance between affordable prices and tariffs, stimulating competition (Li, Ahmad & Tham, 2023), and achieving a satisfactory standard of service in a sustainable way is a permanent challenge for the electric power industry (Bekheetm Al-Sudany & Najm, 2023; Joskow, 2008). In this sense, the market searches for models that balance the trilemma encompassing reliability, sustainability, and economic accessibility.

An alternative sometimes adopted is the transition from a "pure" energy market ("energy-only") to a model that also adds a capacity market. According to Joskow (2008), pure energy markets are those whose only factor influencing investments is the expected energy price. There are no complementary markets or bilateral agreements (Bhagwat & de Vries, 2013). Electricity capacity markets are market designs that seek to ensure investors build adequate capacity according to consumers' reliability preferences (Cramton et al., 2013). Implementing a capacity market is a response to the mentioned trilemma because it manages to face these challenges more objectively than the pure energy market (Joskow, 2008).

Brazil does not have an implemented and regulated capacity market. However, other capacity markets developed abroad can be good examples for the Brazilian case. The Nordic countries, for example, adopted the capacity market and currently form one of the most solid electricity markets in the world, with several physical and financial products (Bredesen, 2016).

So, in fact, can implementing the capacity market benefit the Brazilian electrical system? This study wants to show that yes. Therefore, this work aims to discuss the implementation of the capacity market, highlighting opportunities and challenges in consolidating this new design of the Brazilian market. For this, a study of the Brazilian case was carried out, compared to an international evaluation base on the best practices of this mechanism in the European and North American markets.

This article contributes to the literature by taking an overview of capacity market development in developed countries. Furthermore, as a practical contribution, we bring details about the benefit of implementing a capacity market in the Brazilian case.

This study consists of five sections, including this introduction. The following section presents the most relevant concepts and theories for the research. In the third section, we approach the method used to carry out the research. In the fourth section, we present the Brazilian and international scenarios. In the fifth section, we discuss and propose a new design for the Brazilian energy market. Finally, in the fifth section, we present conclusions and suggestions for future studies.

THEORETICAL REFERENTIAL

The theoretical framework of this research focuses on the Market Design Theory and the transition to the capacity market, detailing its principles and relevance in the current context. Through it, we seek to understand the mechanisms that shape the contemporary market.

Market Design Theory

Since the 1990s, sectoral reforms have focused on introducing competition through the unbundling of segments. This transition aimed to improve commercialization, particularly in power generation. There was a conviction that the new markets, by themselves, would guarantee the security of supply through the market designs of the time. However, this confidence has not materialized into universal success, leading many electricity markets to restructure their design. The objective was to face operational and expansion challenges, guaranteeing reliable energy at competitive prices (Viana, 2018).

The restructured electricity markets of the past 25 years illustrate the importance of effective market design. They have evolved to deal with economic and engineering challenges, including changing energy mixes and new demands on infrastructure (Cramton, 2017). Historically, power generation markets were dominated by monopolies, where power value primarily reflected the costs of generating companies. However, the scenario has changed dramatically, diversifying market perspectives.

As a result, electricity, which was previously perceived as a single product, has diversified with the evolution of markets, revealing different components intrinsic to its supply: (i) Power, (ii) Energy, (iii) Capacity, and (iv) Ancillary Services (Viana, 2018).Power, understood as the instantaneous value of energy, is priced in monetary units per hour, standing out for its immediate nature. This is often confused with Energy, which represents the ability to generate power movement over a period and whose price is defined in $/MWh, varying according to source restrictions and being traded as a commodity in competitive markets. At the same time, Capacity refers to the vital infrastructure for producing electricity, perceived as a public good due to its role in increasing the security and availability of supply, with its pricing being annual or, in some contexts, hourly. In addition, the Ancillary Services include actions that guarantee security and quality in supply, including frequency stability, voltage control, and operational flexibility (Viana, 2018).

In this context, we have the Market Design Theory for the adequacy of the energy supply, which presents two main approaches: the "Energy-Only Market" and the "Capacity

Market". In the "Energy-Only Market", investors are remunerated exclusively for the energy they sell, with prices that can vary dramatically according to supply and demand, encouraging them to be available at times of high demand. In the "Capacity Market", investors are paid not only for the energy produced but also for the generation capacity available, ensuring that there is always enough production capacity ready to meet needs, even if this means additional costs for consumers (Cramton, 2017).

Defining the value of capability is now done through specific markets for the capability product or through resource adequacy requirements. Purchasing entities must acquire sufficient capacity to meet planning standards (Falk, 2010). In the last 15 years, investment in generation took place under these three paradigms, with advantages and disadvantages.

The Competition and Transition to the Capacity Market

A competitive electrical system model aims to promote energy generation at the lowest possible cost for the consumer in an optimized and safe manner. The complexity involved in planning and operation must consider a series of items, such as characteristics of available energy generation sources, energy flow limits, consumption profile, and energy security (Viana, 2018).

Market design should always seek to pass the price more transparently to promote system efficiency (Cramton, 2017). The optimum application of resources destined for system expansion requires support for decision-making by the planner in conjunction with the operator.

The problem of planning and operating a complex system, such as the Brazilian case, for example, with a diversified generation park and an interconnected continental transmission network, involves not only the expansion of the installed capacity to guarantee the fulfillment of the totality of the demand, but also the coordination of the operation (Viana, 2018).

It should be noted that, in the Brazilian case, decisions about system operation are coupled in time and space due to the interconnection of basins and reservoirs and their multiplicity of owners and uses. For expansion planning, knowledge of the system's energy capacity is fundamental; for this, the planning of the electrical and energy operation, and its rules, are decisive.

In the current context of already established energy markets, the scope of the Capacity Market can be broad or marginal in contracting. From the point of view of supply, the availability of generation has value for society and increases the security of the electrical and energy supply. Therefore, all generators should be paid for their availability. On the demand side, only strategic new or existing resources should receive, as this would be unnecessary extra income for those supported by traditional energy revenue (Viana, 2018).

When deciding on a broad approach, there is a need to discuss legacy contracts in force, which requires a comprehensive reform aimed at separating revenues by energy and capacity in each contract. A practical solution adopted is a Capacity Market with a marginal contracting approach - only new generation assets, or strategic existing ones, with volume and metrics established by the operator and planner, according to metrics established in a procedure approved by the regulation and the market. In this way, the role of the operator and planner is fundamental in a Capacity Market. The calculations to achieve the established reliability metrics are a technical assignment of these institutions (Viana, 2018).

In this scenario of multiple attributions for generation sources, the IRP - Integrated Resource Planning can be mentioned, which consists of selecting the expansion of the electric energy supply, aiming to satisfy the electric energy needs in the surroundings (temporal and geographic). The IRP processes evaluate planning in an integrated way, where the increase in installed capacity is evaluated together with other topics such as conservation and energy efficiency, self-production, and renewable sources. This planning seeks to guarantee the reliability of energy delivery considering the technical, economic-financial, and socio-environmental aspects (Udaeta, 1997). In this sense, the vision and role of the planner, in synchrony with the operator, in the environment of the new Capacity Market design become essential.

METHODOLOGY

The methodology seeks to present the theoretical basis and questions related to the objective of this article, that is, the survey of the points necessary for the improvement of the Brazilian electricity market. This chapter presents the methodological procedures, methods, and research techniques used to achieve the objective of this article. For the elaboration of this article, Applied Research is proposed as a purpose.

The work is classified as applied research, as it proposes a way of implementing a capacity market in Brazil, addressing the diagnostic phases of the current design, identifying problems related to lack of competitiveness, and adequate recipes for maintaining reliability, among others. The work will propose actions related to implementing improvements in the capacity market, such as the treatment of legacy contracts and the wide application of payment to users for systemic security, among others.

In addition, this research can be understood as a case study. A case study is a study of an empirical nature that investigates a particular phenomenon, usually contemporary, within a real-life context, when the boundaries between the phenomenon and the context in which it is inserted are not clearly defined. It is an in-depth analysis of one or more objects (cases) to allow broad and detailed knowledge (Gil, 1991).

The case analyzed in this paper is Brazil, concerning implementing a capacity market. Data collection techniques are a set of rules or processes used by science. It corresponds to the practical part of data collection(Lakatos & Marconi, 2003). Interviews, bibliographic research, and documentary research were used.

Eighteen interviews were conducted in different institutions, addressing people with different positions, as shown in Table 1.

Table 1 – List of stakeholders interviewed

Instituições	**Cargos**
ABRAGET - Associação Brasileira Geradoras Termelétricas	Presidente
Delta Energia	Sócio Presidente
MME - Ministério de Minas e Energia do Brasil	Secretário de Energia
ABRACEEL - Associação Brasileira dos Comercializadores de Energia	Presidente
AES Brasil Energia S.A.	Diretor
Thymos Energia	Sócio Diretor
Delta Geração	Presidente
Copel - Companhia Paranaense de Energia	Presidente
Itaipú Binacional	Presidente
APINE - Associação Brasileira dos Produtores Independentes de Energia Elétrica	Presidente
Aneel - Agência Nacional de Energia Elétrica	Diretor
NOS - Operador Nacional do Sistema Elétrico	Presidente
Enel Brasil	Presidente
ABEEOLICA - Associação Brasileira de Energia Eólica	Presidente
GM Energias	Diretor
Bolonhesi Energia	Diretor

Source: Prepared by the authors (2023)

RESULTS AND DISCUSSION

In this chapter, we aim to shed light on Brazil's situation within the capacity market in the energy sector. We will conduct a detailed analysis of national peculiarities, exploring challenges, advancements, and prospects. Moreover, to provide a comprehensive and contextualized understanding, we will present an overview of the capacity market in foreign developed countries. This will allow for a comparison that highlights both the opportunities and lessons to be learned from these nations.

Brazilian Situation

In Brazil, the competition was implemented with a structure called "parallel markets", where the two energy markets coexist, the free market and the captive market. This process began to exist since Law 9.074/95, which defined the creation of the free energy consumer (Goldemberg et al., 2008).

The model of the current Brazilian electricity sector, established by Law 10,848/04 and Decree 5,163/14, is divided into two energy contracting environments: the Regulated Contracting Environment (RCE) and the Free Contracting Environment (FCE). The main difference between RCE and FCE is the way energy is acquired. In RCE, acquisition is done mainly through public auctions, while in FCE, it is done through free negotiation. The purchase and sale of energy can be direct or done through traders.

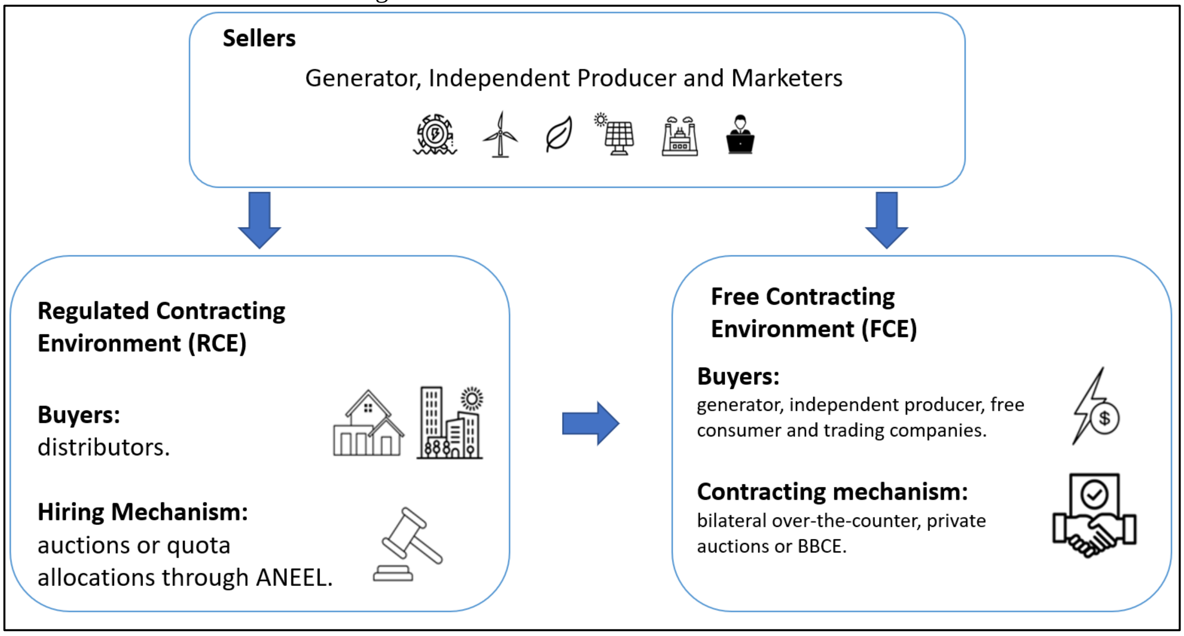
All National Interconnected System (NIS) energy is accounted for in the Electric Energy Trading Chamber (EETC, in portugues “Câmara de Comercialização de Energia Elétrica - CCEE”), although most of this energy is traded through bilateral contracts. In this way, energy contracts correspond to financial agreements and do not imply physical obligations. Considering the deduction of sales and purchases covered by bilateral contracts, net market requirements are financially settled at the EETC clearinghouse and subject to the short-term price (SPD - Settlement Price of Differences, in portugues PLD – Preço de Liquidação de Diferenças) (CCEE, 2022).

The value of these payments depends on the volumetric exposure of each agent and the price in effect at that time. Only non-contracted energy flows are subject to the SPD. However, all energy flows are considered to define the optimal generation schedule and the resulting SPD based on the hydrothermal optimization of the system.

In summary, the Brazilian competitive market is a "difference accounting market" managed by the EETC, in which bilateral contracts are financial relations of protection against exposure to the SPD, negotiated between the interested parties with their processes in the RCE (public auctions) and FCE.

The current Brazilian energy market is a "Pure Energy Market", in which the energy price in R$/MWh encompasses all of the generators' revenue. A broad view of the relationship between sellers and buyers ("RCE and FCE") is illustrated in Figure 1. This entire commercial flow is registered and monitored at the EETC, which carries out real-time accounting and settlement and settles the difference at the price spot (SPD) between the physical world and registered contracts.

Figure 1 – Commercial Relations on the NIS



Source: Thymos Energia, 2016.

This market design has been gradually adjusted, including some highlights that were necessary to adapt since its creation in 2004, namely:

- Distributors can sell surpluses to the FCE through the Surplus Sale Mechanism (SSM, in portugues Mecanismo de Venda de Excedentes - MVE).
- The migration process reduced the minimum level of consumption. To migrate to the FCE, it is necessary to have a demand of 1 MW. Consumers between 0.5 MW - 1 MW can migrate to the FCE, but they are considered unique and must purchase incentivized energy.
- Free consumers can transfer energy to each other.
- There are different energy auctions for the RCE and different calendarsThere are several types of quotas introduced by Law 12,873/13 (MP579), which ANEEL regulates.

The SPD reflects the marginal operating cost of the system derived from the optimization models, although it only considers the effects of some transmission constraints. The incremental generation costs of thermal power plants (CVU) and the values of the rationing function (deficit cost) are considered. Currently, the SPD is calculated "ex-ante" daily hourly. The SPD calculation environment is transparent and available to all market agents.

Capacity Market in Foreign Developed Countries

The capacity market has been used as an additional tool to the single energy market – "energy only" in many countries, with the aim of increasing system reliability. This chapter addresses the experience of European Markets (with emphasis on Germany, United Kingdom, and Nordic Countries) and North America (with emphasis on the United States) as relevant experiences of this market design.

European Market

By 2030, Europe's electricity system will have a dominant share of renewable energies. There is currently a solid incentive to include renewable sources. At the same time (Newbery, 2008). The European market encourages country members to create capacity markets to avoid the "freeloader" effect, where a country does not adopt a capacity mechanism, but imports energy from countries that adopt it. In European markets, by 2025, adopting some capacity remuneration mechanism is mandatory.

The debate on contracting in the medium and long term (capacity market) and in the short term (ancillary services) exists in the European market. The focus of the debate is to have adequate and competitive "flexibility" already available in operation with a sign of necessary ancillary services, with the market adjusting to the complementary offers of these services.

Table 2 - Characteristics of European Capacity Markets

Country	Market Characteristic
Portugal	Capacity payments (since 2010 partially suspended between May 2011 and December 2014)
Spain	Capacity payments (since 2008)
France	Capacity requirements (certification started April 1, 2015)
Ireland	Capacity payments (since 2007) considering reliability options
United Kingdom	Capacity auction (since 2014 - first delivery 2018/19)
Netherlands	Strategic reserve (since 1 November 2014)
Greece	New capacity mechanism under evaluation by DG COMP (2006-2014 capacity payments)
Italy	Reliability options (first delivery of contracted capacity 2020)
Bulgaria	Auction (since November 2013)
Lithuania	Strategic reserve
Poland	Strategic Reserve (as of 2016)
Germany	Strategic reserve (as of 2014)
Sweden	Strategic reserve (since 2004)
Finland	Strategic reserve (since 2007)

Source: Prepared by the authors.

Germany

As of 2012, most of Germany's nuclear generation has been shut down. A strong incentive for renewable sources offset this reduction. However, due to its variability in energy production, German system operators now have new concerns: congestion on transmission lines and supply failure in the critical period (winter).

Wind and solar together account for 47% of German capacity. A renewed political emphasis on renewable energy means that this percentage is expected to increase significantly in the coming years, with new targets of 98 GW of solar energy, 20 GW of offshore wind, and 73 GW of onshore wind by 2030.

In 2019, the German coal commission provided recommendations to phase out Germany's coal and lignite capacity by 2038, starting in 2022. Those recommendations have now been redacted in a proposed law released last week. This will formalize the path to zero coal.

Until 2011, Germany was one of the last remaining countries of the "energy-only" market design. However, due to concerns about guaranteeing supply in critical periods, Germany decided to implement a parallel mechanism to guarantee supply during times of stress in its electrical system: the Strategic Reserve.

The option for the Strategic Reserve by the German government is because it is more adherent to the bet on the evolution of electrical systems in the coming decades: an increasingly decentralized electrical system through the expansion of prosumers and self-sustainable cities fully served by renewable sources (Bhagwat & de Vries, 2013; Bublitz et al., 2017).

In the Strategic Reserve, the electric system operator hires a small fraction of the specific generation capacity to guarantee the system's supply. Moreover, as a Strategic Reserve, the contracted volume is no longer offered by plant owners in the day-ahead energy market (day-ahead - bids given by owners in daily auctions for spot price formation).

In other words, the plants participating in the Strategic Reserve now follow a different dispatch order, now determined by the operator, and no longer the one resulting from the next day's energy market, in the order of daily merit based on the price and volume bids given by the plant owners.

The contracting of the Strategic Reserve requires exclusivity. Once the plant's owner is contracted under this regime, his generation project will no longer be able to return to the energy market the next day. Furthermore, the reason for such restriction is that for the Strategic Reserve to be effective, the price must be attractive enough to encourage the investor to renounce participation in the spot market and remain fully dedicated to the Strategic Reserve.

Usually, the plants usually contracted in the German Strategic Reserve mechanism have high variable production costs. They are already dispatched infrequently in the order of merit defined in the next day's energy market.

Moreover, considering that the plant, when contracted in the Strategic Reserve mode, will no longer be accepted in the energy market the next day, the owners consider in their bids in the Strategic Reserve Auction all annual costs in order to cover fixed costs and the opportunity costs they would have in the next day's energy market.

In this way, plants with higher variable costs and a good profile for end-to-end service that cannot cover their fixed costs in the day-ahead energy market migrate to the Strategic Reserve contracting modality. In other words, the Strategic Reserve provides an alternative for these plants to continue operating, specifically in times of scarcity and need for peak service. A classic example of the "missing money" effect, in which the market moved to keep assets available.

In the Strategic Reserve mechanism, the system operator takes over the dispatch of the plants and thus also earns the financial income from this operation. As the dispatch of the plants contracted under the Strategic Reserve regime occurs in extreme situations where a balance between demand and supply is not found in the energy market, the operator "sells" the energy to the market for a price well above the marginal cost of generation in the moments of scarcity.

At that time, the system operator earns a high "profit" as it only pays the participating mills for the plant's production costs. Furthermore, the "profit" earned by the system operator is used to reduce the costs of contracting the Strategic Reserve, which takes place through auctions.

In Germany, the Strategic Reserve was initially implemented in the southern region (2011) and expanded to other regions in 2014. Since then, nine auctions have been held to contract the Strategic Reserve (Bundesnetzagentur, 2019). When well designed, the Strategic Reserve attracts "the right sources" for the needs of the electrical system and will only be used in specific situations (Bublitz et al., 2017).

In the German case, most plants contracted in the Strategic Reserve are thermoelectric plants with charging times of less than 10 hours. The amount to be contracted considers simulations that consider extreme winters that lead to simultaneous load peaks at different points in the system, considering scenarios of reduction or absence of energy imports in neighboring countries.

Nordic Countries

The Nordic energy market is seen as one of the most successful energy markets in the world. The Nord Pool started in the 1990s from the decision of the Norwegian parliament to deregulate the electricity market. In parallel, Sweden also initiated a series of reforms in the infrastructure sectors, including the formal unbundling of state-owned companies and privatizations in the electricity sector (Nord Pool Group, 2018). The market was reformulated in 2000 when it became a Nordic energy market, where it continued to grow, adding other countries and becoming a service provider for other markets in Europe and potentially other parts of the world.

Additionally, unlike most markets where the privatization of energy companies is sought for greater efficiency, the Nordic countries largest energy companies, both in generation and distribution, are state-owned, either wholly or as majority owners. The important thing is that these companies need to be organized like any competitive company, with a professional management and board structure that allows them to operate on equal terms with private companies.

One of the critical elements of energy market reform in Norway and the other Nordic countries was the market opening, which took just two years to complete, primarily because the country's decentralized structure facilitated the process. For an efficient market, there must be an increase in liquidity. One of the main measures to promote liquidity in the Nordic energy market was that available transmission capacity between the different market areas was given to the market (Bredesen, 2016). The Nordic countries currently form one of the strongest electricity markets in the world, with various physical and financial products.

The physical transactions are established by the operator ("Nord Pool"), which is a regional company formed by the TSOs of the member countries, operating in a loose pool system with several price areas ("Bidding Areas").

There are two energy exchanges, Nasdaq Commodities and EEX, where it is possible to enter into financial contracts for future delivery and hedge services against price differences between areas. Capacity markets in the Nordic countries operate in Sweden and Finland. Norway, for having an eminently exporting character with hydraulic and renewable offers, did not adopt this new design because it has an available capacity consistently above the local demand.

North America

The California electricity crisis of 2000 and 2001 shocked all US markets. Troublesome regulation combined with market manipulation by companies such as ENRON has led to significant and prolonged blackouts and power outages, hitting consumers and industry alike.

Several grid operators have responded by implementing capacity mechanisms, while others have reformed the energy-only market.

The USA now coexists with different designs of markets between the American States. The most crucial network operator with a capacity mechanism is PJM Interconnection, which serves 13 states and Washington, DC. California has had a capacity system in place since 2007.

Traditional wholesale electricity markets exist primarily in the Southeast, Southwest, and Northwest, where utilities are responsible for system operations and management and, typically, for supplying power to retail customers (FERC – Federal Energy Regulatory Commission, 2016). Public service concessionaires in these markets are often vertically integrated, a theme opposite to the design of most world markets that have evolved toward market opening. Wholesale physical energy trading typically occurs through bilateral transactions, although the industry has historically traded electricity through bilateral transactions and power pool agreements.

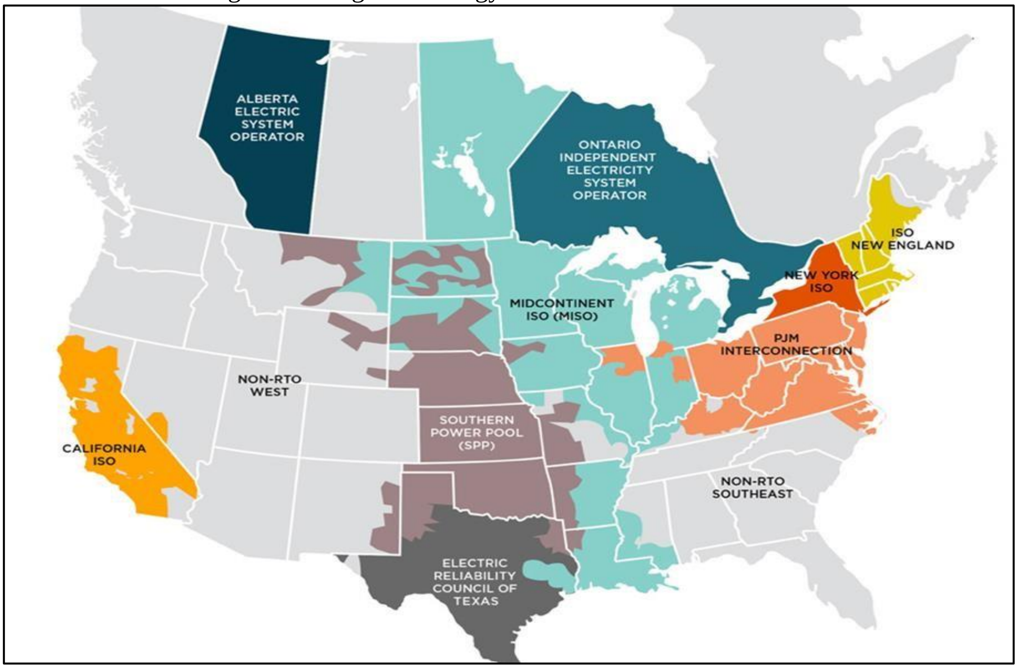
Along with facilitating open access to transmission, ISOs operate the transmission system independently and foster competition for electricity generation among wholesale market participants. Several transmission owners have formed ISOs, some of the existing power pools.

In Order No. 2000, the Commission encouraged utility companies to join regional transmission organizations (RTOs), which, like an ISO, would operate transmission systems and develop innovative procedures to manage transmission equitably. Each IS and RTOs have ancillary power and services markets where buyers and sellers could bid on or offer generation. ISOs and RTOs use bid-based markets to determine economic dispatch.

Although the main sections of the country operate under more traditional market structures, two-thirds of the nation's electricity load is served in the RTO regions (FERC – Federal Energy Regulatory Commission, 2016). Figure 2 illustrates the division of markets by region and companies in this country.

Capacity markets have succeeded in delivering long-term stability of energy supply. There are problems, such as high price volatility, but investments in new capacities still occur. There are substantial criticisms that capacity markets result in windfall profits for owners of existing power plants and cost the consumer too much. Recently, a substantial PJM update was introduced. The performance and reliability of capacity providers need to improve. Penalties for non-delivery have been increased, and in early 2014, freezing weather led to an increase in power station outages and a tight supply situation on PJM's grid.

Figure 2 – Regional Energy Markets in the United States



Source: FERC (2019)

More generally, some major US markets have adopted capability markets to ensure reliability in a competitive environment.

DISCUSSION OF NEW BRAZILIAN DESIGN

Given the technical and regulatory complexity of the Brazilian Electric System (BES, in portuguese Sistema Elétrico Brasileiro - SEB), in particular the market design, it is natural that the introduction of a new market raises discussions and relevant issues that must be faced with a view to allocative efficiency, which includes costs that are possible to be paid in a context of promoting competition wherever possible.

Differences between Ballast and Energy Separation and the Capacity Market

The discussion on the adoption of a capacity market preceded the discussion at BES on the separation of ballast and energy, given that the RE-BES Project already foresaw the adoption of a capacity charge aimed at eventually meeting peak problems, something that ended up being abandoned, given that until the end of the 1990s, as well as the rationing faced by the country in 2001-2002, the problem was essentially of an energy nature.

The discussion “separation of ballast and energy” arose throughout the second half of the 2001-2010 decade, when the term ballast was consolidated in the electricity sector after the sectoral reform promoted with the approval of Law nº 10.848/2004 and with the consolidation expansion of generation through energy auctions in RCE.

The joint contracting of ballast and energy materializes when it is determined that consumers and sellers (generators or traders) present 100% coverage. For consumers (distributors in the RCE or free and unique consumers in the FCE), 100% consumption coverage is required through energy purchase agreements.

In the case of generators, they must cover their sales using the Physical Guarantee (GF) of plants they own or through purchase contracts with other generators or traders. Traders can cover their sales through purchase agreements with other traders or generators.

Despite the market architecture allowing agents to buy and sell contracts with a financial logic, there is practically a link between consumption and the physical ballast of a plant, which links the contracting of ballast and energy.

The separation of ballast and energy and the capacity market has the same conceptual and theoretical source. That is, the contracting of electricity should be seen as a commodity and resolved between BES agents, either through auctions purely of energy in the RCE or bilateral negotiations in the FCE, and what is contracted as services for the general benefit of the system should be borne by all consumers.

Another similarity in the conceptual basis is that the energy market should be prioritized considering the spot price to induce investments and allocative efficiency. Extras should only be paid for projects that are not feasible through the market.

However, at the current stage of the BES discussion, there are specific differences in our market that differentiate the separation of ballast and energy from the capacity market, in particular, the treatment of legacy contracts, the maintenance of GF for commercialization purposes, and an eventual concept of income universal for reliability for all plants. Such a discussion is often not fully explicit but indirectly permeates the conceptual discussions between analysts of sectoral entities and other BES stakeholders.

The separation of ballast and energy at the current stage leads to an immense discussion of the separation of the ballast component and those of the legacy contracts of the RCE and apportioning these costs to all consumers, including the FCE.

From the point of view of allocative justice, it is reasonable to propose that all consumers should bear the reliability component of the system represented by the ballast. It is, however, a solution that is not pragmatic. This is based on the fact that the consumer who migrated from the RCE to the FCE chose precisely to escape the considered high costs of the RCE, so judicialization tends to be likely even with a transition window.

Additionally, a new high charge arising from the sharing of legacy contract costs should be an even greater stimulus for companies to look for self-production formats to avoid such a charge, which is logical and efficient in a private view, but leads BES to a global inefficiency of overcapacity.

To avoid a judicial discussion of the FCE on the allocation of these costs, it is proposed here in this article, in a transitional phase, to address the problem of "Legacy Contracts" only in synchrony with the expansion of the opening of the free market. The current design of the capacity market with Law 14.120/21 is based on the previous framework of reserve energy. It assumes that the new contract, whether from a new or existing plant, is paid by all consumers of the RCE and FCE, which reduces possible allocative injustice of the old model of energy auctions in the RCE with the cost of thermal reliability being borne mainly by regulated consumers.

In the same way that the reserve energy in the original Brazilian design did not change the past GF ratios of generators, the current mechanism did not re-discuss the cost allocation of legacy contracts. From the point of allocative justice, it would not be ideal, but possible from a pragmatic point of view to avoid judicialization that would have much more severe effects on the BES.

The role of GF in commercial aspects is another relevant discussion that differentiates the separation of ballast and energy from the capacity market since, in the ballast concept, the figure of GF is essentially considered for energy planning purposes and should lose its role and relevance in commercial matters and regulatory.

In the current BES capacity market, GF's loss of relevance is also observed for thermal plants, given the arrangement that allows the total sale of energy, even above GF, in bilateral contracts.

However, the current capacity market was created from improvements in the existing legal framework rather than in the context of complete sectoral reform, so the GF calculation continues to be carried out and reflected throughout regulation and commercialization. From the point of view of conceptual consistency, when consolidating the capacity market, one could adopt the principle that GF is only calculated for energy planning purposes and that it would no longer be a commercial element, including penalties for insufficient ballast for consumption and sales.

Finally, universal income through reliability for all plants differentiates the separation of ballast and energy from the capacity market. The separation of ballast and energy in the context of the BES would allow all plants to claim a universal income for the reliability provided to the system, regardless of whether the plant would become viable via market prices or not.

Another way to mitigate such a request would be to understand that all plants, regardless of providing a service that is scarce and necessary to BES, could participate in a ballast auction through the current GF metric or a variation of this approach since the fact that generating energy would bring an implicit value of leaving other plants that are dispatchable ready to provide reliable services, especially hydroelectric ones.

This discussion is closely related to the concept of production ballast; that is, a plant would be eligible to claim a ballast revenue because it increases the global reliability of the system when generating energy.

The capacity market, both in the international view and in the current Brazilian stage, foresees that only values should be paid for projects necessary for the system. There needs to be more than the energy market price to make such projects viable. That is, it must be a marginal market and not the center of the market. The solution addressed by Law 14.120/21 already solves the bases of a marginal capacity market with the new contracting of existing or new plants, which are necessary for the NIS.

However, despite the differences listed in the BES discussion on the separation of ballast and energy and the capacity market, it should be reiterated that the conceptual nature of both is similar, noting that the energy negotiation is bilateral and that a charge funds the contract should only be for necessary services that are not provided via the energy market and are something familiar that benefits all consumers.

Although the solution addressed by Law 14.120/21 resolves the bases of a marginal capacity market, the "Sectorial Modernization Project" insists that this is a transitory solution until a solution is reached for the "separation of ballast and energy."

Auction Design and Hiring Regulation - Expansion

The expansion of the Brazilian matrix in the last 15-20 years was heavily based on new energy auctions as inducers of the technological mix and finance ability. This trend is mainly changing due to the growth of FCE, retail DG, and some lessons learned, such as over-contracting by distributors. This mechanism will still be present in the national regulation for contracting in the RCE, albeit with some changes. The thermal plants will no longer be the direct object of the energy balance of buyers in the RCE but will be focused on systemic security.

In the FCE, the practices remain the same with the arbitration of each agent in the contracting of new energy with the products Bilateral Contracting, Private Auctions, and Autoproduction. Contracting risks are managed by each agent in this environment: consumers, generators, or suppliers.

The terminology "new energy" adopted here is a reference to current regulations that separate energy products into "new" and "existing" energy for the RCE. In the FCE, however, this distinction does not exist, and the origin of the purchase is a decision of each agent. The focus we want to give here in this item is whether the boundary conditions of the matrix expansion are preserved. Notwithstanding the classification of "new" and "existing" for the RCE, the FCE will also participate in the expansion, as the "existing" energy environment will only have liquidity if the expansion takes place. Therefore, expanding the "energy" product will not be a problem, given that there will be a competitive buyer market in both environments, even with different characteristics in terms of duration, indexation, counterparties, guarantees, and financing.

At first, the thermal plants will be more focused on safety. The trend is that with the current capacity market with the Capacity Reserve Auctions, the future thermal park will be primarily contracted in this new contracting route, very focused on the security of the capacity made available to the ONS, with energy as a consequence of production associated with the use of the source. Note that the change in direction is evident, given that it is essential to understand that this contract now favors the system and all consumers in the RCE and FCE.

The combination of capacity and energy in future Capacity Reserve Auctions will be a dimension to be addressed based on the volume of associated energy (base thermal, rapid start-up, ultra-rapid), with the destination of this energy being the main topic to be addressed. They will always be tailor-made solutions according to the granting authority's demand for security.

Considering the technical characteristics of the BES plants and their respective costs, it is understood that some adaptations of the concept used internationally for the capacity market are necessary, especially concerning products and the indexation of the fuel component in Fixed Revenue.

The adoption of three products is suggested, aiming at portfolio diversity and greater flexibility in system operation by the National System Operator (ONS): Ultra-fast Capacity Reserve, Fast Capacity Reservation, and Structural Capacity Reservation.

- Ultra-fast Capacity Reserve: When activated, it must deliver power in up to 1 hour, indicated to overcome improbable equipment failures. Consequently, this flexibility is reflected in higher prices.
- Quick Capacity Reserve: When activated, it must deliver power in up to 5 hours, being indicated to supply power when the power margin reaches critical levels (<3%, for example), with a tendency towards moderate costs.
- Structural Capacity Reserve: When activated, it must deliver power in up to 10 hours, and, depending on the machine's technology, there is a reflection in the minimum time for maintenance of the dispatch (time on) and eventual reconnection. It would be indicated to supply power when the power margin reaches low levels (<5%, for example) and has lower costs.

Portfolio diversity will always be relevant in the case of BES, both due to the issue of having different technologies and costs, as well as the relevance of hydroelectric power in the generation mix, which, due to the variation in inflows, naturally reflects in volatility in the water level in the reservoirs, hydropower generation level and consequently results in SPD volatility.

Concerning the component of inflexibility in Fixed Revenue, it is suggested that the current indexation by fuel in the international market be maintained, at least during a transition period, known in the sector's jargon as "factor i."

Such a suggestion is based on the low predictability of dispatch by capacity over a long-term horizon, especially in a scenario of changes in the energy matrix. Suppose this risk is not mitigated with the transfer of the costs of this difference between the plant's CVU and the SPD, as done in the current regulation. In that case, it should reflect an unnecessary overpricing of the fixed revenue, increasing consumer costs.

It is also observed that the capacity market was conceived conceptually in markets that mostly have "hard currency" and a fuel market with liquidity, elements not present in the BES since the exchange rate component and the difficulties in the fuel market are relevant in the sectoral discussion.

The national capacity market is not exclusive to the thermal park; however, at the moment, it is the technology that fits the demand for security, with competitiveness and fuel available nationally and internationally, based mainly on natural gas, the energy of the transition.

New storage technologies and demand-side management will also become available as soon as they become competitive, controllable, and technologically mature. The solution with reversible hydroelectric plants, which is still little used in Brazil, is one of the leading research routes to provide capacity and storage services. Energy stock control is not a priority for reversible plants, but electrical balance management is one of the goals.

Another point to be noted is the positioning of hydroelectric plants – large, medium, and small. Brazil still has excellent potential to be explored. However, the difficulties with socio-environmental costs, transport logistics, and inventory potential have made the expansion of this source much less attractive. Competition with renewables made the option for hydroelectric plants less likely.

Despite this expansion difficulty, the existing park is a significant asset base for the national energy sector. In terms of security in the short and medium term, it is an unbeatable park with attributes in sync with the needs of the NIS operation. Hydroelectric dams are great for support generation, but there is extensive use of their potential in energy production with minimal storage already. The current "modus operandi" aims to maximize energy generation at the expense of broader uses.

It is necessary to find a suitable revenue mix for the existing hydroelectric plants in which, in addition to the revenue for the "energy" product, other revenues, such as payment for capacity and ancillary services, are obtained. Regarding expansion, the motorization of some hydroelectric plants is a good solution for the national capacity market. However, it needs to be more structural for the segment.

Long-Term Market Design

A relevant concern of BES analysts and specialists is that the capacity market becomes, in the long term, a mechanism for contracting inefficient projects and technologies and that, in the end, the global cost allocated to consumers will be higher than the current one. Thus, a discussion anchored in a long-term market design view is relevant.

The future market design tends to emphasize consumer empowerment, a more dynamic energy price that is more representative of physical reality at the wholesale and retail levels, and product slicing. The energy consumer will have a voice in the energy transition.

It is essential to understand the design of the capacity market in this context; that is, the mechanism should not be used to reduce the consumer's power of choice and adoption of new technologies.

It would also not be recommended that the design of the capacity market emit distorted signals for the operation of the system with repercussions on the SPD or even that the capacity market be used as a solution to replace the necessary slicing of services, something evident in the case of a market ancillary services.

The temptation to use the capacity market as the holy grail that would address all costs that cannot be recovered through the energy market is observed in the BES discussion. The classic concept of the international literature is "missing money" for situations of system reliability; that is, what is not within this concept should be avoided so that it does not incur, in the end, an inefficient system that hires unnecessary services and technologies at the consumer.

To this end, it is essential that "capacity procedures" be designed, similar to what exists today in network procedures, so that the criteria, tools, and data to calculate compliance indicators of the new general supply guarantee criteria, which the CNPE approved at the end of 2019 (Resolution No. 29, of December 12, 2019).

Demand Calculation Procedure in the Capacity Market

One of the main criticisms of the capacity market, as implemented in Brazil, is that the hiring demand is an attribute of central government entities, which can create more pessimistic future scenarios than those expected by the market and thus burden all consumers with costs beyond what is necessary.

Therefore, a “Procedure for Calculating the Capacity Market Demand” must be approved in the regulation and debated with all agents in a public hearing. This is a process already adopted in approving the “Network Procedures” of the ONS and the “Commercialization Procedures” of the CEEE. The experience is that, despite the approval of these procedures, they are constantly subject to periodic reviews, with notable advances concerning new technologies and business practices.

Planning a resilient electrical system is increasingly challenging, given the growing complexity of uncertainties, scenarios, disruptive situations, and climate change. Because of this, the responsibilities of the Granting Authority and the system planner increase in their commitment to understanding the physical reality of the NIS. The new general supply guarantee criteria were approved by the CNPE at the end of 2019 (Resolution No. 29, of December 12, 2019), positively revised the energy supply criterion, and included the general supply guarantee criterion to assess the suitability of the power supply.

In the case of Energy supply, the concepts CVaR (ENS - energy not supplied) and CVaR (CMO) are applied, and in the Power supply, the concepts CVaR (PNS - power not supplied) and LOLP (probability of loss of load) were applied. The criteria will be applied simultaneously in evaluating the investment decision in the planning studies to expand the electricity supply.

These criteria are probabilistic, and the analyzes must incorporate all the most critical NIS uncertainties. Meeting the power supply guarantee criteria is the methodology for the granting authority (MME) to define the need for capacity in the system.

This was already a need identified by agents with the massive entry of intermittent renewables in retail and wholesale, in addition to other run-of-river hydroelectric sources without storage capacity and biomass projects, which are very dependent on associated crops and plantations. In short, the NIS became increasingly dependent on sources with significant variability in the primary energy resource, subordinated to nature and potential climatic events.

CONCLUSION

This article sought to assess issues related to the need to implement a capacity market in the Brazilian electricity sector in order to add security to the system and increase the market's competitiveness to the benefit of its energy consumers, as well as attract investments to the segments of the offer of this industry.

In its structuring, we initially proposed introducing the aspect of needs and problems related to competitive structures in the electricity sector. The dissertation also offered a qualification of the main economic structures and the main types of regulation applied in restructuring the electricity sector worldwide and in Brazil.

The main point of the debate discussed in this paper was the transition from a "pure" energy market ("energy only") to a capacity market. The work contextualizes the real needs of the Brazilian electricity sector, evaluates the best international practices of market models, and evaluates the effectiveness of implementing a capacity market in Brazil.

We have the contribution of renowned players in the sector, including generators, traders, consumers, energy distributors, regulatory agents, system operators, and consultants. Notably, it was pointed out that Brazil needs major structural reforms, and adopting a capacity market would be an essential step to expand the free market, guaranteeing the system's security, according to the current Brazilian electricity matrix.

Topics such as the possibility of an energy market based on price supply were widely discussed, a topic that still requires many studies related to the market power of agents, treatment of legacy contracts, needs to reformulate the currently existing bases for the implementation of a capacity market, need to review energy contracting with very long-term contracts.

As a result, we present relevant contributions that should be considered to consolidate the capacity market in a competitive environment, with a view to its continuity in the medium and long term. These contributions are in line with a BES context that increasingly demands a flexible market design and architecture to accommodate new technologies and business models: (i) differences between ballast and energy separation and the capacity market; (ii) auction design and contract regulation; (iii) long-term market design; and (iv) capacity market demand calculation procedure.

Some issues and possible solutions for a capacity market in Brazil are discussed, in line with the new regulation recently offered to the Brazilian market with Law 14.120/21.

The analyses and propositions addressed demonstrate the complexity of competitiveness in the electricity sector. As topics for future research, the following can be listed: (i) pricing model for attributes of ancillary sources/services; (ii) assessment of the risks and benefits of price-by-offer modeling, including market power analysis and how to develop mitigation mechanisms; and (iii) improvement of models and products to respond to demand.

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