UNIVERSIDADE D
COIMBRA

Francisco Miguel dos Santos Simões

CORPORATE POWER PURCHASE AGREEMENTS: PORTUGUESE BUSINESS DRIVERS AND BARRIERS

Master's Dissertation in Energy for Sustainability,
supervised by Professor Patrícia Pereira da Silva and Nuno Carvalho Figueiredo,
submitted to the Faculty of Sciences and Technology of the University of Coimbra

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Abstract

Governments have been diminishing their subsidy programs for investments in renewable energy as the technology matures, forcing producers to find a way in a liberalized energy market to lower the merchant risk their projects face. Companies, on the other hand, are looking for alternate power purchase arrangements in order to decarbonize the industry and have access to renewable energy at fair and predictable prices over time. Setting the interests of renewable electricity producers and companies' side by side, Corporate Power Purchase Agreements (CPPA) can satisfy both parties by defining the direct purchase, by the company, of green electricity from the renewable producer at a contracted price, for a long period of time. This dissertation sought to analyze the market and assess tactics that may be put in place to increase business demand for CPPA in Portugal, with an emphasis on the perspective of the enterprises, using semi-structured interviews and a questionnaire. Through the semi-structured interviews, it was possible to conclude that electricity price, hedging, and access to renewable energy are the main drivers for companies to contract a CPPA in Portugal. In contrast, the reduced literacy of companies regarding these contracts, their low creditworthiness, the existing paradigm of short-term electricity contracting, the regulatory instability, and the difficulty in developing new renewable projects, are the main barriers that affect the growth of demand in this market. Based on the questionnaire answers, it was reasonable to determine that pricing and trust in the renewable energy producer are the variables most important to company decision makers when contracting a CPPA. Regarding the variables related to the sustainability of the energy consumed by the company, these come in second place. Finally, the key recommendations that can be made from this dissertation in order to support the demand side of the CPPA market in Portugal are primarily to enhance company awareness of these contracts and the benefits of long-term power contracts.

Keywords: Corporate Power Purchase Agreements; Renewable energy; Electricity Markets; Risk management, Demand Side.

Resumo

À medida que as tecnologias renováveis ganham maturidade, os decisores de políticas públicas têm vindo a reduzir os subsídios direcionados ao seu investimento, forçando os produtores a encontrar um mecanismo, no seio do mercado liberalizado de energia, para reduzir o risco de mercado enfrentado pelos seus projetos. Por outro lado, as empresas procuram mecanismos alternativos de compra de energia com a necessidade em descarbonizar a indústria e ter acesso às energias renováveis a preços razoáveis e previsíveis ao longo do tempo. Colocando os interesses dos produtores de eletricidade renovável e das empresas lado a lado, os *Corporate Power Purchase Agreements (CPPA)* conseguem satisfazer ambas as partes, definindo a compra direta, pela empresa, de eletricidade verde ao produtor renovável a um preço contratado, por um longo período de tempo. Tendo como foco a perspetiva das empresas, e utilizando uma abordagem científica original, combinando entrevistas semi-estruturadas com um questionário, esta dissertação tem como objetivo analisar o mercado e avaliar estratégias que possam vir a ser implementadas para impulsionar a procura por CPPA em Portugal pelas empresas. Com as entrevistas semi-estrututuradas, foi possível concluir que o preço da eletricidade, o *hedging*, e o acesso a energia renovável são os principais impulsionadores da contratação de CPPA em Portugal, por parte das empresas. Por outro lado, a reduzida literacia das empresas sobre estes contratos, a sua limitada credibilidade de crédito, o paradigma existente de contratualização de curto prazo da eletricidade, a instabilidade regulatória, e a dificuldade no desenvolvimento de novos projetos de renováveis, emergiram como as principais barreiras que prejudicam o crescimento da procura neste mercado. Relativamente aos resultados recolhidos através do questionário, foi possível concluir que o preço e a confiança no produtor de energia renovável são as variáveis mais consideradas pelos decisores empresariais ao contratar um CPPA. No que diz respeito às variáveis relacionadas com a sustentabilidade da energia consumida pelas empresas, estas aparecem em segundo plano. Por fim, as principais conclusões a retirar com este trabalho incidem, principalmente, na necessidade do aumento do conhecimento das empresas sobre estes contratos, assim como também num ampliar da sua sensibilização para as vantagens de contratar eletricidade por longos períodos de tempo.

Palavras Chave: *Corporate Power Purchase Agreements*; Energia renovável; Mercados de energia; Gestão de risco, Lado da Procura.

List of Abbreviations and Acronyms

ACER	Agency for the Cooperation of Energy Regulators
APREN	Associação Portuguesa de Energias Renováveis
CapEx	Capital Expenditure
CfD	Contract for Difference
CPPA	Corporate Power Purchase Agreement
CSR	Corporate Social Responsability
FiP	Feed-in Premium
FiT	Feed-in Tariff
Gos	Guarantees of Origin
LCOE	Levelized Cost of Energy
LNEG	Laboratório Nacional de Energia e Geologia
MIBEL	Iberian Electricity Market
MoE	Merit Order Effect
NPV	Net Present Value
PNEC	National Energy and Climate Plan
PPA	Power Purchase Agreement
RED	Renewable Energy Directive
SME	Small and medium-sized enterprises
WSBCD	World Business Council for Sustainable Development
VFA	Volume Firm Agreement

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1

Introduction

1.1. Contex

In order to encourage investment in renewable energy, support schemes were implemented by European Member States aiming to address the low maturity of these technologies, which made them not cost-competitive with the conventional generation technologies (European Commission, 2013). The main objective of these support schemes was to fix the market failure that made investment in renewable energy unattractive. However, as the maturity of renewable energy generation technologies increases, these support schemes should be gradually withdrawn, avoiding additional distortions in the free energy market (European Commission, 2013; Figueiredo & Silva, 2019).

The implementation of these support schemes, with a special focus on feed-in tariffs (FiT) and premiums (FiP) - the main mechanisms used by European Member States (Batlle, 2011), allowed an increase in the renewable energy generation share. Nevertheless, renewable energy sources, such as solar and wind, have currently a high level of maturity and do not require support schemes to be cost competitive with the conventional generation technologies (Ritchie & Roser, 2021). This high level of maturity has allowed European Member States to remove support schemes for these technologies in order to avoid distortions in the market (Figueiredo & Silva, 2019), but the increase of renewable electricity generation in the wholesale electricity market has some impacts.

The wholesale electricity market operates on a merit order basis, i.e. the power plants with the lowest marginal costs enter first and the price of energy for the period is set by the power plant with the highest marginal cost that is producing at the time (ACER, 2021a). Considering that renewable electricity generation technologies present marginal costs close to zero (López Prol et al., 2020), the increase of its penetration in the energy mix reduces the prices in the wholesale market, causing the so called “Merit Order Effect” (MoE) (Alves & Pinto, 2022; Figueiredo & Silva, 2019).

The "Cannibalization Effect" is another concept related to the MoE. The "Cannibalization Effect" is defined as the wholesale market price falling to levels where renewable energy technologies are no longer commercially feasible (López Prol et al., 2020).

The reduction of the wholesale electricity market price through the MoE, and the “Cannibalization Effect”, causes a "Missing Money Problem" (Figueiredo & Silva, 2019). This issue indicates a lack of incentives provided by the wholesale energy market for investments in conventional and renewable power generating, putting future electricity output at risk (Figueiredo & Da Silva, 2018).

As the current wholesale electricity market structure, based on marginal cost, does not give the right incentives to investors, a possible solution for policymakers is to promote business models such as Power Purchase Agreements (PPA) (ACER, 2022; Hildmann et al., 2015)

PPAs are bilateral contracts between an electricity generator and an electricity buyer that could be a retailer or a company. Corporate Power Purchase Agreements (CPPA) are PPAs between a renewable electricity generator and a company (Hedges et al., 2016). The goal of this contract is to be a win-win contract for both parties where the buyer has access to renewable electricity, the generator has a guaranteed revenue, making their project profitable, and both are not dependent on the price volatility of the wholesale market, working as a hedging tool (Hedges et al., 2016).

In addition to PPAs being able to reduce the impact of the "Merit Order Effect", these contracts, in particular CPPAs, provide a way to attract private investment to renewable energy projects, reducing the need for support schemes by the European Member States (European Commission, 2022b; RE-Source, 2021b).

The importance of this type of contract to accelerate the energy transition was already presented in the revision of the Renewable Energy Directive II (Rademaekers et al., 2021) and increased with the last events caused by the Russian invasion of Ukraine through the REPowerEU Plan (European Commission, 2022a). Furthermore, the energy crisis and the resulting volatility in electricity prices have shown the need to promote hedging instruments in the electricity wholesale market to increase its stability (European Commission, 2023; Glachant, 2023).

1.1. Goals

This dissertation intends to provide a thorough analysis of the CPPA market from the demand side, namely from the perspective of the firms. The major objective of this empirical study is to provide new evidence on strategies that can support the expansion of the CPPA market's demand side.

Two questions were initially created to steer the research direction:

- What are the factors driving and impeding the growth of demand side CPPA market in Portugal?
- What are the factors that Portuguese corporate decision-makers consider most important when deciding whether to enter a PPA?

To understand the functioning and negotiating process of a PPA, as well as to identify the hurdles and drivers inherent in the growth of a CPPA market, a complete literature research is first performed, concentrating on the firms' perspective.

After the literature research, semi-structured interviews with pertinent Portuguese players in the CPPA ecosystem were conducted to explore the findings and their application in the Portuguese context.

Then, in order to establish its method of contracting electricity and determine the factors that matter most when signing a CPPA, a questionnaire was sent to businesses in electro-intensive industries.

1.2. Dissertation Structure

The dissertation is composed of five chapters and four annexes. This chapter provides a contextualization of the problem under study and also presents the objectives that this dissertation aims to achieve.

In chapter 2, the literature review is presented with the purpose of characterize the CPPAs, identify the risks associated with this type of contract, as well as to identify the drivers and barriers that are associated with the development of a CPPA.

In chapter 3, the methodologies used to answer the two research questions presented in the first chapter are presented and justified. Specifically, two methodologies were used, semi-structured interviews and a questionnaire.

In chapter 4, the data collected is presented and discussed taking into account the current Portuguese and CPPA markets reality, including statistical analysis.

In chapter 5, answers to the research questions are presented as well as policy recommendations to stimulate growth of the Portuguese CPPA market.

Finally, ANNEX A presents a schematic summary of the literature review, ANNEX B presents the available renewable electricity contract models for companies, ANNEX C presents the key topics discussed throughout the semi-structured interviews and ANNEX D presents the questionnaire shared with electro-intensive companies.

2

Literature Review

The purpose of this chapter is to examine the extant literature on the PPA negotiating process from the perspective of companies, as well as the barriers and drivers compelling the growth of the CPPA market. An empirical literature review was conducted in line with Reis et al. (2021), Reindl & Palm (2021), and Emodi et al. (2022).

As a first step, in order to answer the research questions beforementioned, a search for scientific articles in three databases, Scopus, IEEE Xplore, and Google Scholar, was conducted as in A. L. Reis et al. (2023)

To carry out this search, keywords such as "Power Purchase Agreements", "Companies" were used in the search engine of the different databases. Furthermore, the keyword "Corporate Power Purchase Agreements" was also included in the search process with the aim of directing the search engine as much as possible toward the objective of the dissertation.

The result of this search were seventy-nine scientific articles from the SCOPUS database, eighty-six from the IEEE Xplore database, and one hundred and seventy-nine from the Google Scholar database, **Fig. 1**.

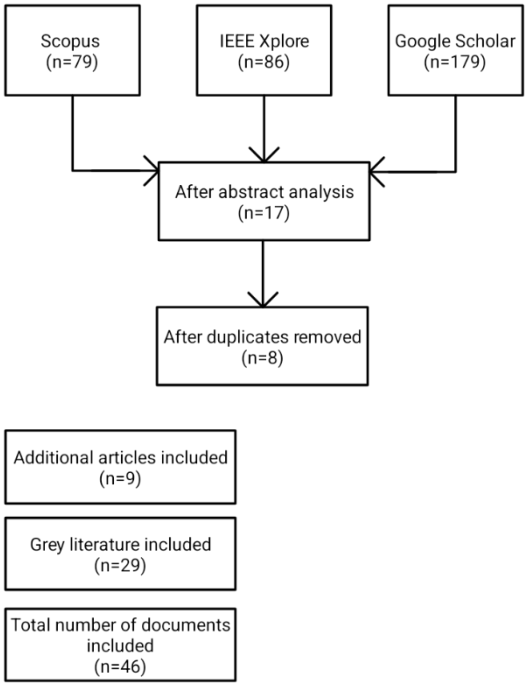

Fig. 1. *Flow diagram of literature review (own elaboration).*

After gathering these scientific publications, a content analysis of each abstract was carried out to determine whether articles included material that was pertinent to the research's topic (ANNEX A). At the conclusion of this analysis, eight scientific articles were chosen.

In addition, other scientific articles, reports, and European directives were added to this list of relevant articles due to the low number of articles collected previously, **Fig. 1**. To

make this addition, references from articles chosen, searches on specific search engines like RE-Source, the World Business Council for Sustainable Development (WSBCD), and the European Commission, and finally reading reports from consulting firms in the energy sector that were readily available were used .

The use of many reports in this literature review is due to the fact that there is still little scientific literature on the topic under study. Much of the expertise on this issue is centred in platforms like the ones listed above, as well as consulting firms that offer advice on the contracting process of CPPA.

We begin this chapter by defining and characterising the CPPA, then the risks inherent in a CPPA are presented, followed by the explanation of the negotiation process for the price of a CPPA, and finally an analysis is presented on the drivers and barriers to the growth of the CPPA market.

2.1. CPPA Definition and Characterization

CPPA are bilateral arrangements under which a renewable energy provider (the developer) sells power to a firm directly (the off-taker) (Badissy et al., 2016; Hedges et al., 2016; Kobus et al., 2021; Miller et al., 2018).

The goal of this contract is to be a win-win contract for both parties: companies have access to green electricity while generators have a guaranteed revenue, and both are not dependent on the volatility price of the wholesale electricity market (Davis-Sramek, 2021; Hedges et al., 2016).

The contract might be made with a renewable project that is still in the planning stages or with one that is already operational but no longer has government assistance (Douglas et al., 2020).

In the case of a project at an early stage of development, obtaining funding is only possible if the project is bankable (Hedges & Kaufman, 2018), meaning that a project is able to generate revenue, in order to support its financial obligations (Baringa Partners, 2013). From the lender's point of view, making a bankable project without government support is only possible through a PPA, where the off-taker is a creditworthy entity, and the contract's duration is longer than, or equal to the duration of the loan (Hedges & Kaufman, 2018).

Lenders can be debt partners - banks, for instance, who are only interested in receiving the full amount of their loan, or equity partners - renewable investment funds. Equity partners not only receive the full amount of the loan but also retain ownership over a certain part of the project, which guarantees them a percentage return during the entire life of the project (Baringa Partners, 2013).

In a CPPAs, the developer and off-taker, define their rights and responsibilities, the structure and duration of the contract (commonly from 10 to 20 years) (Baringa Partners, 2020), the price mechanism (Dominy & Zubair, 2021), the volume and profile of electricity to be supplied (Brindley et al., 2020), the point of delivery, the period of time to delivery, the source of energy, as well as the transmission of guarantees of origin (GOs) to the off-taker, if any (Hedges & Kaufman, 2018).

By contracting a CPPA, depending on the volume and profile of electricity selected in the contract, the company's demand for electricity can be partially or fully satisfied. Regarding the amount and profile of electricity, five structures are offered. (Brindley et al., 2020; Iberdrola, 2022):

i. Pay-as-Produced – the buyer buys all electricity produced on the renewable power plant;

ii. Annual Baseload – the buyer buys the same fixed volume of electricity every hour or day over the year;

iii. Monthly Baseload – the buyer buys a fixed volume of electricity every hour or day during the month. During the year, each month has a different fixed volume of electricity, to account for the seasonal variation of production;

iv. Pay-as-Consumed – the buyer buys all electricity he needs to satisfy his electricity demand and,

v. Pre-defined Profile – the buyer buys electricity according to a pre-defined daily profile. During the year, each month has a different pre-defined daily profile.

2.1.1. Renewable Project Location

The location of a renewable energy plant can be either on-site or off-site of the company's facilities, and when the PPA is off-site, two alternative structures can be used, **Fig. 2**.

On-site CPPA, also known as behind the meter CPPA, the renewable power plant is installed at, or close to the company's facility. Both times, the renewable energy source is connected to the business through a private wire, negating the need to pay for the use of the public grid (Douglas et al., 2020; Hedges et al., 2016). However, this type of project only allows the production of a small amount of energy due to the scarcity of space, and in some cases, due to the poor site conditions for the renewable electricity production (Hedges et al., 2016). Furthermore, the electricity produced behind the meter does not generate GOs (Douglas et al., 2020).

In this particular model, ***Fig. 3***, only the energy it consumes from that project must be paid for by the firm, at the agreed-upon price. The development and maintenance of the project is the developer's responsibility and is financed by a third party, the lender (Hedges et al., 2016). If the company operates on a rented site, it must obtain a permission from the landlord to approve the installation of a renewable power plant on the company's site (Douglas et al., 2020).

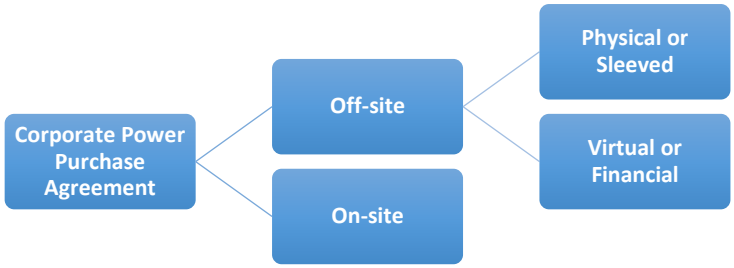

Fig. 2 *CPPA variations diagram (own elaboration).*

The electricity surplus, depending on the country's regulatory framework, can be sold to the electricity supplier (Mendicino et al., 2019). As the electricity sold to the electricity supplier is metered, this electricity receives a GOs (Douglas et al., 2020) .

To guarantee that its total energy demand is covered, the business must also have a contract with a nearby electricity supplier in addition to the on-site CPPA (Douglas et al., 2020).

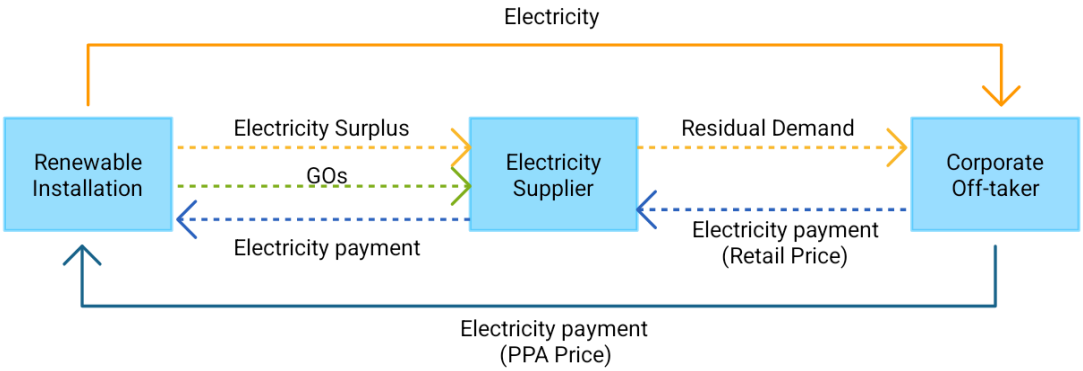

Fig. 3. *CPPA on-site model, adapted from* (Douglas et al., 2020).

On the other hand, off-site CPPA is a contract where the renewable generation project is located in an appropriate location for the production of renewable energy, without space restrictions, allowing the production of large volumes of energy, i.e. outside of the company's facilities (Hedges et al., 2016).

Contrary to on-site CPPA, where renewable project is only developed thanks to CPPA contractualization, off-site CPPA can be established with a renewable project at an early stage of development or with an existing renewable project that no longer receives government support (Douglas et al., 2020).

The physical structure (sleeved) and the financial structure (virtual) are the two basic structures that make up off-site CPPA (Davis-Sramek, 2021).

A sleeved contract, ***Fig. 4*** is characterized as being a tri-party contract between a developer, an off-taker present on the same grid network, and an electricity supplier, the sleeved agent (Davis-Sramek, 2021; Hedges & Kaufman, 2018). The electricity produced by the developer is delivered by the electricity supplier to the buyer, a process characterized as sleeving, through a sleeving fee (Hedges et al., 2016). Then the buyer pays the energy to the developer at the contract price and receives the GOs if these are present in the contract (Baringa Partners, 2020). In addition to this contract, a second contract is signed between the buyer and the electricity supplier where the retailer ensures the delivery of the residual demand at retail price (Hedges et al., 2016).

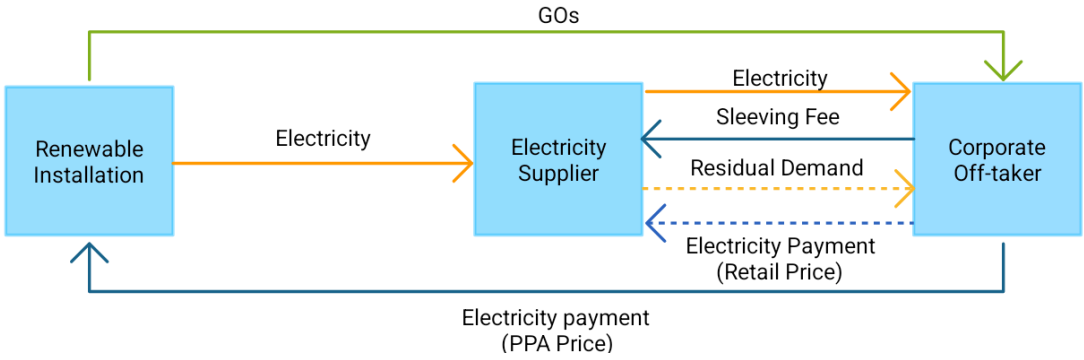

Fig. 4. *CPPA off-site model – sleeved contract, adapted from* (Douglas et al., 2020).

A virtual contract, ***Fig. 5***, is characterized as a contract for difference (CfD), where the developer and the buyer do not need to be part of the same grid network (Baringa Partners, 2020). The developer sells the energy produced on the wholesale market (Hedges et al., 2016), if the sale price is higher than the strike price set in the contract the buyer receives the difference, if the price is lower, the buyer pays the difference (Davis-Sramek, 2021). In order to meet the buyer's energy demand, the buyer has a separate contract with a local electricity supplier (Baringa Partners, 2020). Besides payments between developer and buyer, GOs are also transacted if they are included in the contract (Davis-Sramek, 2021).

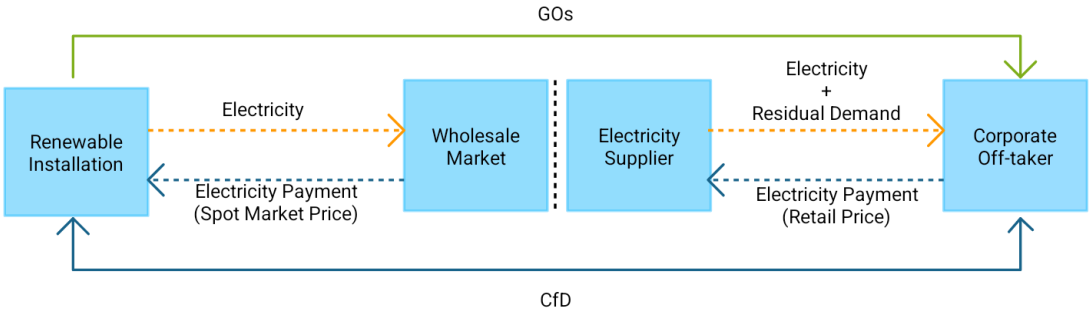

Fig. 5. *CPPA off-site model – virtual contract, adapted from* (Douglas et al., 2020)

Other off-site CPPA variations can also be applied to the virtual and sleeved framework (Douglas et al., 2020):

- Multi-buyer PPA – a contract between a developer and a consortium of companies as an off-taker, typically, companies from different economic activity areas;

- Multi-Seller PPA – a contract between an off-taker and a developer operating as an aggregator who manages a portfolio of renewable projects;

- Multi-Technology PPA – similar to a Multi-seller PPA, but the renewable portfolio is formed by projects with different technologies (Hedges & Duvoor, 2019);

- Cross-Border PPA – a contract between a developer and off-taker that are located in different countries (Peter Swank et al., 2020);

2.1.2. Pricing Structures

A CPPA has two main price structures: the fixed price, and the floating price, according to Hedges et al. (2016).

With a fixed price structure, the electricity price is fixed for the duration of the contract. The price agreed upon is either connected or not to annual inflation, or during the contract term, a percentage rise in price is specified (Hedges et al., 2016).

In terms of floating price structure, the final price is determined based on a discount agreed in the contract over the wholesale market price. In this structure, ***Fig. 6***, a floor and cap price can also be defined to guarantee a minimum revenue for the developer and a maximum cost for the off-taker, respectively (Hedges et al., 2016). Other possibility is to define only a floor and cap price, removing the price discount over wholesale market price (Dominy & Zubair, 2021) .

A hybrid structure exists in addition to these two primary pricing schemes. For instance, a portion of the power is contracted at a fixed price and a portion is with a floating price structure. These two major structures are integrated in the hybrid structure (Dominy & Zubair, 2021).

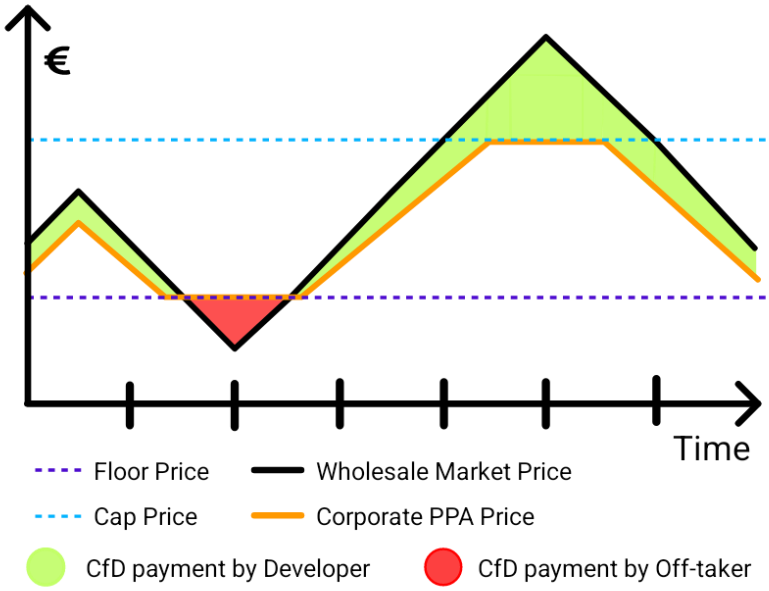

Fig. 6. *Floating price structure, adapted from* (Dominy & Zubair, 2021).

2.2. CPPA Inherent Risks

A CPPA contract also entails some risks, which must be determined and apportioned to the contract's various counterparties throughout the negotiating process.

The main risks allocated to a CPPA are related to the electricity prices in the wholesale market (price risks), the variability of renewable sources (supply risk), the meeting of obligations by counterparties (counterpart risk), the performance and development of the project (performance and development risk), and the instability at regulatory level (regulatory risks) (Brindley et al., 2020), **Table 1**.

Contracting a CPPA is primarily intended to reduce market volatility from the off-takers' standpoint as indicated by Jin et al.(2018), in order to make the electricity bill more predictable in the future (Hedges et al., 2016). 92% of the firms polled in a BayWa r.e. study of 1200 businesses in six European nations said investing in renewable energy will lower energy prices (BayWa r.e., 2019).

The decrease of a company's energy expenses in a CPPA setting comes from the reduction of financial risks. The financial risk is connected to the contract's financial performance.

This performance can be evaluated by the company through the Net Present Value (NPV) that quantifies the advantage of buying electricity at the PPA price during the agreed duration considering the wholesale market prices (Gabrielli et al., 2022). However, according to these authors, this analysis has a high degree of uncertainty since the financial risk is composed of price risk, supply risk and counterparty risk.

Price risk is characterized by the risk of wholesale market prices falling below the contracted CPPA price (Hedges & Kaufman, 2018). The exposure to this risk is substantial given that they are long-term contracts (Brindley et al., 2020).

This type of risk also includes a phenomenon known as the cannibalisation effect, which consists of a reduction of the wholesale electricity price, below the PPA price, during peaks in renewable electricity production in markets with high penetration of renewables (López Prol et al., 2020).

From the buyer's point of view, considering the available pricing structures, the best strategy to minimize price risk is to adopt a floating price structure, because it follows the movements of the wholesale market price in a certain way. The price risk is allocated to the buyer only when the wholesale market price of electricity is below the floor price (Dominy & Zubair, 2021; Tranberg et al., 2020).

The remaining amount of electricity that is not covered by the contract also carries a pricing risk. The price risk here is the possibility that electricity prices may rise, increasing the buyer's cost for that amount of electricity. Hedging the remaining electricity volume on the forward electricity market helps companies avoid unexpected future expenses (ACER, 2022; Brindley et al., 2020).

Considering now the variability of renewable energy production, one must deal with supply risk, which is broken down into three categories: volume, profile, and balance. Volume risk represents the probability that the renewable project's output will be less than the expected total output over a period, for example one year. Profile risk is related to changes in the hourly output of the renewable project during the day; and balancing risk is related to failures in forecasting electricity production (Hedges & Kaufman, 2018).

The volume and profile of the electricity structure selected for the contract affects how the supply risk is allocated between the buyer and the developer. With a baseload, a pre-defined profile or a pay-as-consumed PPA, the buyer can reduce his supply risk transferring it to the developer, because if the amount of electricity produced does not respect the amount established in the contract, the developer must compensate monetarily the buyer for the missing electricity, or buying the missing energy in the wholesale market and selling it to the buyer at the price agreed in the contract (Bruck & Sandborn, 2021).

On the other side, with a pay-as produced PPA, the supply risk is allocated to the buyer because when the generation output is not as expected, the off-taker will have to buy more electricity, then expected, at wholesale market price to meet its needs, which can increase the off-taker's expenses (Brindley et al., 2020).

In the case of a Virtual CPPA, the adoption of a Volume Firm Agreement (VFA) is common for reducing the buyer's supply risk . In addition to the CPPA, the buyer makes a VFA with an insurer for the amount of electricity contracted in the CPPA, transferring for a price, the supply risk to an insurer, who will diversify that risk across a portfolio of weather-linked exposures (Brindley et al., 2020). While this strategy will increase the final price of electricity, it will improve the hedging mechanism of the CPPA.

Authors such as O'Shaughnessy et al. (2021) or Roos & Bolkesjø (2018) concluded that the fluctuation in renewable electricity output has a detrimental impact on the grid's functionality, increasing the need for flexible non-renewable generation and making future grid planning more difficult. The mitigation of this risk for all (i.e, the buyer, the generator and the grid operator), is possible through the investment in demand response programs by the companies, in order to increase the flexibility of their electricity demand (Ghiassi-Farrokhfal et al., 2021a; Hedges & Kaufman, 2018; O'Shaughnessy et al., 2021), and the investment in storage by the developer (Ghiassi-Farrokhfal et al., 2021a; Strazzabosco et al., 2022).

Even though investment in storage minimizes supply risk, this investment must be limited to maintain a win-win contract. A high investment in storage is advantageous to the developer and disadvantageous to the off-taker because (Ghiassi-Farrokhfal et al., 2021a). Since it is an early stage technology, its high cost impacts directly the electricity price negotiated in contract. Furthermore, in addition to the company paying more for electricity, it is the developer that takes more economic advantage of this investment by being able to sell the energy surplus on the wholesale market at peak times.

Furthermore, Parlane and Ryan (2020) refer that investing in project reliability, such as increased installed capacity and performance, can also decrease the uncertainty supply risk. After an analysis of the practices of contractual counterparties in different scenarios, the authors concluded that if the buyer orders more electricity than it needs, it is able to increase the reliability of the project. Given that the cost of renewable power is continuing to drop and the buyer has the option of storing the electricity in their own facilities, this over-purchase of electricity by the developer is more cost-competitive than improvements in reliability. Yet the authors highlight that this strategy can cause grid congestion, a problem similarly highlighted by O'Shaughnessy et al. (2021).

Regarding project maintenance, Lei & Sandborn (2018) present a maintenance model for wind projects that enables the management of the various turbines' maintenance periods without endangering the PPA's energy supply contract.

A portfolio of technologies or multiple locations (multi-technology PPA) is also seen as a way to mitigate supply risk, for both buyer and developer (Gabrielli et al., 2022; Ghiassi-Farrokhfal et al., 2021a; Hedges & Duvoor, 2019). Additionally, Gabrielli et al. (2022) showed that using and optimizing portfolios of technologies or multiple locations minimizes financial risk as a whole. The optimization of portfolios is performed based on measures such as value at risk (VaR) and conditional value at risk (CVaR) (Aquila et al., 2021).

Related with development and performance risks, as PPAs are usually associated with the development of new renewable projects, the development risk is faced, i.e. the risk that exists if the project's development is delayed in a way that might influence the start date for the contract's electricity supply (Hedges & Kaufman, 2018). In order to mitigate this risk, the buyer should ensure that the contract provides guarantees to cover losses if construction delays occur (Brindley et al., 2020).

On the other hand performance risk is associated to the performance of the project, i.e. whether the project reaches an expected minimum level of output (Hedges & Kaufman, 2018). In some way, performance risk is also linked to supply risk, so, by choosing a baseload or a pre-defined profile, the buyer can transfer performance risk to the developer (Brindley et al., 2020; Hedges & Kaufman, 2018).

Table 1
CPPA Inherent risks (own elaboration).

	Definition	Buyer's Mitigation Strategies
Price risk	The risk of wholesale market prices falling below the contracted CPPA price.	Price structure - Floating price with a cap;
Supply risk	The risk linked with the variability of renewable energy production.	Multi-technology PPA; Volume and profile structure - baseload, pre-defined profile, or pay-as-consumed; Demand response programs on company; Investment in storage;
Development risk	Delays on construction phase of a new renewable energy project.	Contractual guarantees to cover losses resulting from construction delay;
Performance risk	The risk associated with the capability of the renewable project to achieve an expected minimum level of output	Volume and profile structure – baseload, or pre-defined profile;
Counterpart risk	The likelihood of the one contract part fails it obligations.	Multi-buyer PPA; Financial institution as a third part default guarantee; Clearing House;
Regulatory risk	Changes in law or in the regulatory framework during the CPPA duration.	Prevention of possible regulatory changes through clauses in the contract;

Counterparty risk are associated with the likelihood of counterparties failing to meet their obligations under the contract, the delivery of electricity on the seller's side, and the payment of electricity on the buyer's side (Brindley et al., 2020; Edge, 2015).

The bankability of a renewable project depends heavily on the buyer's creditworthiness (Hedges & Kaufman, 2018). So minimising the counterpart risk is possible through PPAs with multiple buyers, or using a third party default guarantee party, such as a financial institution or a clearing house (Douglas et al., 2020; Rademaekers et al., 2021; Sustainable Energy Authority of Ireland, 2021).

Regulatory risk includes changes in law and in regulatory framework. Law and regulatory changes, during the contract duration, can affect negatively the balance between benefits and risk among contract parts, such as the economic competitiveness of the contract (Brindley et al., 2020).

2.3. PPA Price negotiation

Negotiation of a PPA is a process influenced by some factors like the electricity forward prices, the levelized cost of energy (LCOE) of the project, the risk allocation and the individual appetite of counterparties (Dominy & Zubair, 2021; Hedges & Duvoor, 2019; Mendicino et al., 2019; RE-Source, 2022c).

For new renewable projects the LCOE is a common tool used as a reference to define the price of a CPPA . This price guarantees that the project is bankable, a critical point for lenders, but it is only a starting point for negotiating the price during the contracting of a CPPA.

Another way to establish the price starting point for negotiating of a CPPA is the forward curve of electricity prices (RE-Source, 2022c).

During the CPPA terms discussion, the risk inherent to the contract, mostly price risk and supply risk, are allocated to the counterparties. This allocation occurs by choosing CPPA volume and profile of electricity supply, and the pricing structure (Brindley et al., 2020; Dominy & Zubair, 2021; Hedges & Duvoor, 2019).

Based on this risk allocation, the final CPPA price is established, **Fig. 7**. If the buyer secures more risks than seller, the CPPA price will decrease during negotiation; on the other hand, if the seller secures more risks, the CPPA price will increase (RE-Source, 2022c).

Furthermore, if the delivery of GOs by the developer to the off-taker are present in the contract, this will to contribute to increase the CPPA value (Dominy & Zubair, 2021).

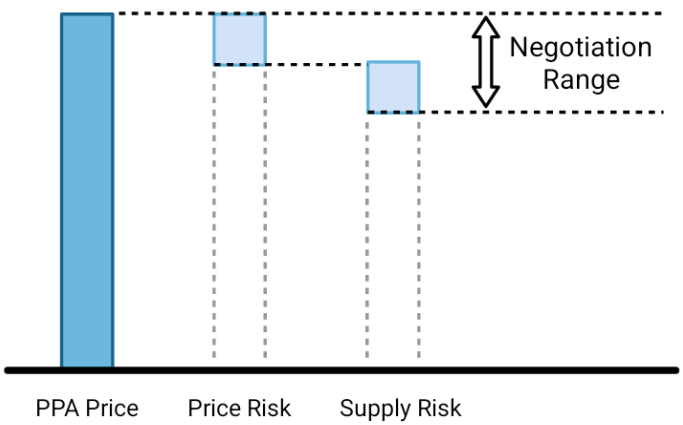

Fig. 7. *CPPA price negotiation – risk allocation, adapted from* (RE-Source, 2022c)

Companies seeking PPAs for sustainability-related reasons are ready to take on more risks, while energy-intensive sectors frequently use PPAs to control their base cost of energy, thus they search for PPAs with fewer risks (Dominy & Zubair, 2021).

2.4. Drivers and Barriers of Corporate PPA

Several elements that can be categorized as drivers or obstacles, respectively, encourage or restrict the adoption of PPAs by businesses for the purchase of power, as follows in the next subsections.

2.4.1. Drivers

For businesses, one motivation to enter into a CPPA is to reduce indirect CO2 emissions (ENGIE, 2023). Chang & Lo (2022) concluded that companies' targets for emission reductions are positively correlated with the adoption of renewable energy.

Besides that, the reinforcement of corporate social responsibility (CSR), the hedging of electricity prices, and the competitiveness of electricity prices, are also drivers for companies to contract a CPPA.

Although there are various business models for companies to purchase green electricity (ANNEX B), these factors are also significant drivers to boost the companies' demand for PPA (Baringa Partners, 2020; European Wind Energy Association, 2013; Favaloro et al., 2016; Hedges et al., 2016; Sustainable Energy Authority of Ireland, 2021).

Companies are increasingly emphasizing CSR in order to attract investors with green ambitions and to improve the marketability of their products (European Commission,

2022b; Hedges et al., 2016). Contracting a PPA allows companies to have "additionality", which means that the PPA contracted by the company is the reason for the development of a new project, boosting the energy transition (Baringa Partners, 2020; Favaloro et al., 2016; Hedges et al., 2016). Having “additionality” shows the company commitment to energy transition (European Commission, 2022b).

A PPA is a hedging mechanism that reduces the volatility of power costs, which is highly helpful for long-term planning, especially energy-intensive companies (ACER, 2021b; RE-Source, 2021b).

In terms of price, CPPAs gives companies the opportunity to have access to a competitive electricity price, increasing their competitiveness against their direct competitors (European Commission, 2022b).

Apart from all the factors mentioned above, as a market, the demand for CPPA can only grow if there is sufficient supply. As a result, stimulating the supply of CPPA can act as a demand-side driver (Baringa Partners, 2020).

Considering that, the withdrawal of government subsidies for renewable energy is the key factor influencing developers' desire for PPA (Rademaekers et al., 2021).

PPAs have been the most used market instrument in a liberalized market for renewable projects (Baringa Partners, 2020). The removal of government subsidies for innovative renewable technology exposes the developer to commercial risk (Hedges et al., 2016).

In case of a low-risk appetite by developers, the supply of developers open to contract a PPAs increases, because a PPA ensures greater predictability in their future revenues (Baringa Partners, 2022), and regarding new renewable projects, without government subsidies, the only way to make the project bankable to get financing is through a PPA (Baringa Partners, 2020).

2.4.2. Barriers

The financial performance of firms, the asymmetric knowledge between the contract parties, the countries’ laws, the energy grid infrastructure, and the CPPA administration are the primary obstacles that prevent the development of a CPPA market on the demand-side (Hedges et al., 2016; Rademaekers et al., 2021). Although some of this barriers are more correlated with the supply side of the market, under market logics, these are also obstacles for the development of CPPA on the demand-side.

The European Commission (2022) argues that most businesses are not creditworthy entities when considering their financial performance. This trait prevents them from being able to make a new renewable project bankable from the perspective of investors, which makes a credit guarantee, from a National Promotional Bank or an International Financial Institution, necessary (European Commission, 2022a; RE-Source, 2021b). To maximise

the impacts of these guarantees, they should be directed to companies that do not have a credit rating but fit the energy profile of a CPPA, such as heavy and manufacturing industry (Baringa Partners, 2022).

A clearing house can also be included in the contract in order to cover counterparty risk, however both parties, buyer and developer, must pay a collateral, usually around 3% to 15% of the total contract value, depending on the size and duration of the contract, and the volatility of the wholesale market (Brindley et al., 2020). However, companies with low liquidity ratios can not afford this option (Weber, 2022).

The complexity of a CPPA's accounting is another hindrance to financial success since a CPPA is frequently merely a financial instrument (Virtual PPA). Considering the International Financial Report Standards (IFRS), this instrument is considered as a lease which has negative impacts on the solvency ratio as well as on other financial indicators of the company (Brouwer & Goei, 2018; Hedges et al., 2016).

Regarding the existence of asymmetric information, generators have much more technical knowledge about the operation of their project and about the negotiation of a CPPA (Baringa Partners, 2022; Davis-Sramek, 2021). This situation forces the off-takers to look for specialised know-how, dedicating a team or consulting advisors in order to guarantee that after the negotiation, the contract is win-win for both parties (Hedges et al., 2016). One way to facilitate this negotiation process is through a model contract (RE-Source, 2021a)

In terms of national laws, there are various obstacles. Certain frameworks forbid the transfer of GOs between the developer and off-taker if the project is behind-the-meter, requiring businesses to buy GOs in addition to their CPPA to guarantee the use of renewable electricity (Brindley et al., 2021; Rademaekers et al., 2021). Furthermore, GOs need to be more granular, on an hourly basis, making it simpler to consistently match the energy demands of companies with clean energy, and working on a framework for equitable GOs across Europe is essential for supporting the CPPA across borders (Brindley et al., 2021; RE-Source, 2021b). GOs are highly important for the well-functioning of the CPPAs, because it is the way to trace the “green” electricity in the power system, mostly when a company want to achieve a 24/7 renewable energy goal (RE-Source, 2021b, 2022e).

Moreover, in some regulatory frameworks the existence of aggregators or multiple-buyer CPPA is not possible. The aggregators or multiple-buyers are essential, in both sides, demand and supply, because they represent a way to reduce the CPPA risks (credit and supply risk), aggregating small electricity consumers, and also making projects bankable (Hedges et al., 2016; Hedges & Kaufman, 2018). In countries where the market is more developed and big companies have already signed CPPAs, the aggregation is a crucial step (Rademaekers et al., 2021). However, it is important to highlight that with aggregation, the difficulty of satisfying the interests of all parties is higher (Gamache & Shapiro, 2021).

The stability of the regulatory system of a country is the final barrier into the countries' laws. Long-term contracts require stability, thus regulations governing the energy market must be clear, consistent, and predictable to assure investors' confidence on future financial returns from renewable energy projects, and to provide companies and developers more assurance when establishing long-term contracts (RE-Source, 2022d, 2022a). According to the Renewable Energy Directive[1] (RED II) it is the Member States' responsibility to analyse, identify and overcome these regulatory barriers, facilitating the realization of CPPA.

A CPPA may be established in a new or existing project, but when considering a new renewable energy project off-site, it must be connected to the grid through a connection point. However, due to the slow development of grid infrastructure and the rapid development of renewable projects, these connection points are in short supply (RE-Source, 2021c). This does not mean that there is no capacity available to receive new connections; there are connection points available, but there are few, and some of these points are allocated through government auctions for renewable projects reducing the CPPA potential market of the countries (McIntyre, 2022b). Besides the government auctions, the renewable projects driven by PPAs are crucial to meet or even exceed the European 2030 targets (McIntyre, 2022b), so increasing investment in grid capacity arises as absolutely crucial.

Finally, related with CPPA administration barriers, some companies, particularly the less experienced electricity users, lack the ability to handle the risks associated with a CPPA as stated in Baringa Partners (2022). Furthermore, in case of new renewable projects, the estimated start date for the project is a barrier, since companies with a short planning cycle are not available to wait years to start receiving renewable electricity[2]. Only global big corporations are willing or can afford to wait (Baringa Partners, 2022).

2.5. Research Gaps and Challenges

The majority of the currently available scientific research on CPPA approaches the subject from the standpoint of the renewable energy developer, with the scientific literature that approaches it from the company's point of view being scarse (Ghiassi-Farrokhfal et al., 2021a). On the buyer's perspective, the scientific literature mostly covers the management of CPPA risks by companies (Gabrielli et al., 2022; Ghiassi-Farrokhfal et al., 2021a; Mendicino et al., 2019).

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG&toc=OJ:L:2018:328:TOC

[2] Offshore wind projects are the projects that take the longest time to start producing electricity, followed by onshore wind and solar PV (Baringa Partners, 2022).

There has not been any empirical research conducted to date on factors that influence companies to get into CPPAs. Only one survey of this kind was conducted by the consulting firm PWC in 2016 to North American companies (PWC, 2016).

Furthermore, relevant material on the Portuguese CPPA market is almost inexistent, since the Portuguese CPPA market is in its early stages of growth.

Once again, the goal of this dissertation is to develop scientific knowledge that will enable to fill the gap in the scientific literature, by addressing the two research questions that were initially posed: "What are the factors driving and impeding the establishment of a CPPA market in Portugal from demand-side perspective?" and "What are the factors that Portuguese corporate decision-makers consider most important when deciding whether to enter into a CPPA?".

3

Methodology

The lack of empirical research in the field of CPPA led to consider which approach would be the most appropriate to fulfil the dissertation's major objective of defining strategies that allow the expansion of CPPA.

For this, it was necessary to divide the methodological approach into two distinct stages, taking into account the characteristics of the two research questions that were initially submitted.

First, a qualitative technique appeared to be adequate to answer the first research question, with the aim of exploring and adapting the results drawn from the literature review to the Portuguese context. A qualitative methodology aims, through non-numerical data, to provide a deeper understanding of a given topic, in an eclectic way, by gathering the opinion of experts in the field (Jennings, 2005; Lewis-Becks et al., 2004). Focus groups and Interviews are two examples of qualitative type methodologies (Lewis-Becks et al., 2004). However, considering the difficulties pointed by Landeta et al. (2011) in gathering all the experts for a group discussion on the topic, interviews were the qualitative methodology that proved to be the most suitable in this context.

Second, a quantitative approach was found to be the most appropriate to obtain solid opinions in order to answer the second research question (Sheard, 2018; Snedaker & Rima, 2014). According to Lewis-Becks et al. (2004), the quantitative methodology is the process of acquiring data from a specific population using surveys, for example, and statistical tools to analyze them subsequently.

A search for published works that have used procedures with these characteristics for questions comparable to those studied in this dissertation, was carried out in the light of the aforementioned factors in order to ensure the scientific validity of the methodology. This search yielded papers that exclusively used interviews or questionnaires. For example, Leinauer et al. (2022) applied semi-structured interviews to compare the conclusions drawn across the literature review on obstacles to corporate adoption of demand response programmes. On the other hand, in Ho et al. (2018) a Delphi survey was carried out to obtain expert opinions on the criteria for locating offshore wind farms.

The combination of these two methodologies was however discarded. Although a Delphi questionnaire would allow the anonymous discussion of which variables weigh most

when contracting a CPPA, according with Landeta et al. (2011) the expected difficulty in retaining the participation of companies in the various rounds that this methodology requires, led to discard this method.

In a later search, the papers by Rogers et al. (2008) and Du et al. (2014) integrated simultaneously questionnaires and interviews in their methodology. Rogers et al. (2008), through the use of a questionnaire and semi-structured interviews, aimed to understand the opinion of population from a rural area in accepting to participate in a renewable energy community project. On the other hand, Du et al. (2014) used a questionnaire and semi-structured interviews to study fifteen barriers to the adoption of energy saving technologies identified in the scientific literature.

Reasons such as the use of a literature review as a starting point for the methodology's implementation and the use of a likert scale on the questionnaire for the barriers ranking, led to the conclusion that of the two methodologies examined, the one that best fits the problem under study is the methodology implemented by Du et al. (2014), which consists of semi-structured interviews, a questionnaire, and subsequent statistical analysis of the data collected.

3.1. Semi-structured Interviews

The most often used method in qualitative research is interviewing (Polkinghorne, 2005). An interview's purpose is to learn more about a subject through the interviewee's perspective and experience (Schultze & Avital, 2011).

This method is composed of different types of interviews such as structured interviews, semi-structured interviews, or group interviews. Focusing just on the first two categories, the key distinction between structured and semi-structured interviews is that the script is not precisely followed in the case of semi-structured interviews (Myers & Newman, 2007). Furthermore, these authors also highlight that in semi-structured interviews, instead of including specific questions, the script should focus on the subjects or areas that will be covered during the interview.

The main goal of semi-structured interviews, using an incomplete script, is to ensure a high level of flexibility and interactivity throughout the conversation, enabling the sharing of the interviewee's experience and perspective on the issues presented during the interview (Lewis-Becks et al., 2004). The results of each semi-structured interview therefore depend, in the end, on the experience and the perspective of the interviewee, enabling the emergence of unexpected topics during the discussion (Myers & Newman, 2007).

For this dissertation, twenty-five stakeholders with various perspectives on the issue were invited to be interviewed. However, only twelve invitees accepted the interview invitation. The twelve interviews, which were done via video-call discussions with an average duration of thirty minutes, examined the topic from the perspectives of the firm, the regulatory environment, the power market, and lastly from the position of renewable energy producers.

The script for the semi structured interviews was developed according to Myers & Newman (2007). The interviewee was initially given a brief overview of the study topic and the goal of the interview. The interview was then carried out, in accordance with the topics described in ANNEX C. Finally, to complete the interview, the interviewee was asked for permission to make a follow-up call if a new question arose.

In the case of stakeholders representing the companies perspective, sectoral associations of electro-intensive sectors[3], were asked to share a questionnaire with their associates at a posteriori stage of the research. Six of the seven sectoral organisations contacted agreed to participate. Additionally, as an exception to the rule, one sectoral association agreed to distribute the questionnaire with its members while declining to participate in the interview for reasons unrelated to the study, making a total of seven sectoral associations that were open to doing so.

[3] The selection of the electro-intensive sectors was based on the study of industrial electricity consumption available at https://meesi.pt/.

To collect data for further analysis, the audio of the interviews was recorded with the permission of the interviewees.

3.2. Questionnaire

According to Snedaker & Rima (2014), questionnaires are an efficient way to collect data and opinions from companies; however, to ensure a high response rate, the questionnaire needs to be well contextualized about its purpose, easy to understand, and quick to complete, not taking more than 10 minutes to complete.

For this dissertation, the questionnaire aimed to collect the opinion of companies on the variables that weigh most in the decision to adhere to a CPPA, as well as analyse how companies contract electricity.

The questionnaire was divided into four sections, following Lewis-Becks et al. (2004), and its design based on the findings drawn throughout the literature review and semi-structured interviews (ANNEX D).

In the first section of the questionnaire, the respondents were asked to characterize the company they represent and its current way of contracting electricity, through multiple choice questions. Five true-false questions were used in the second phase of the survey to gauge the respondents' understanding about CPPAs. In the third section, respondents were asked to rate through a ten level Likert scale (1 - not important, 10 - extremely important) the importance of each decision variable when contracting a CPPA. Finally, in the fourth section, respondents were asked to define their function in the company and role in contracting electrical, as well as their degree of education and background area, using an open-response question.

Following the advice of Lewis-Becks et al. (2004), the questionnaire was created and then sent to other researchers in the area to get their input on the questionnaire's clarity and organization.

The questionnaire was shared with the companies through the intermediation of the sectoral associations interviewed previously, by sharing an email with their associates. In addition to a brief explanation of the objective of the research, it was emphasized in the

email that the questionnaire should be answered by a member of the company participating in the electricity contracting process, to guarantee the necessary knowledge to answer the questionnaire.

In total, seven sectoral associations agreed to share the questionnaire with their members.

3.3. Data analysis

The methodologies implemented to analyse data from semi-structured interviews and the questionnaire were independent from each other.

In the case of semi-structured interviews, the recordings were analysed, and drivers and barriers identified by the interviewee regarding the Portuguese reality of the CPPA market were transcribed.

On the other hand, the data collected through the questionnaire shared with the companies was statistically analysed, in a first phase through descriptive analysis and in a posterior phase using non-parametric tests.

In view of the use of a Likert scale, since it is an ordinal scale (Harpe, 2015), it was considered as a measure of central tendency the median ranking value of each category. In this particular case, from the median value, a comparison between variables was performed in order to conclude which are the decision variables that companies value most when it comes to contract a CPPA.

In addition, data consistency of the Likert scale was assessed by applying Cronbach's alpha test (Cardoso et al., 2023). After its application, it was possible to obtain an alpha value equal to 0.81, which allows to conclude that the level of consistency of the collected data is good.

Based on the type of data present in the analysis, non-parametric tests (Robinson, 2020), showed to be the most adequate, considering the fact that part of the data was characterized by intervals of variable amplitude, and that some of these intervals did not have a maximum limit. Based on Guimarães & Cabral (2007) two types of non-parametric

tests were considered for the evaluation of the collected data. First, the chi-square test was used for the comparison of independent sub-samples with the purpose of assessing whether the sub-samples would be similar or not. From the total sample, sub-samples were categorised based on the company's annual electricity consumption, as well as on the weight of the electricity bill has in the company's total costs. Second, in order to verify the dependency between variables, the chi-square test based on the contingency table was considered.

4

Results and Discussion

The findings from semi-structured interviews and the questionnaire given to businesses in the electro-intensive industries will be presented and analysed in this chapter.

The results obtained through semi-structured interviews are based on twelve interviews conducted with several relevant players in the Portuguese electricity market. The main purpose of the interviews was to understand which drivers and barriers are identified on the development of the CPPA market in Portugal.

The questionnaire was issued to the associates of the sectoral associations who were interviewed. A sample of 93 responses to the questionnaire was ultimately gathered. The major goals of the questionnaire were to characterize the demand side of the CPPA market in Portugal, as well as to determine the most significant decision criteria for organizations seeking to hire a CPPA.

4.1. CPPA Market – drivers and barriers

From many angles, **Table 2** displays the main factors influencing and impeding the CPPA market development in Portugal.

The main drivers in the Portuguese context, identified throughout the semi-structured interviews, were the price of electricity, the hedging that CPPA allows, and sustainability reasons.

Given that the interviews were conducted during a period of high electricity costs, between September and October 2022, owing to the energy crisis, the price was viewed as the primary driver for the adoption of CPPA by businesses.

With the maturity of renewable technologies, CPPA prices can be competitive compared to wholesale market prices, mainly in regions where the weather conditions are good for renewable energy production, which is the case of the Iberia Peninsula (Bellini, 2022; BloombergNEF, 2022). However, some factors have contributed to the increase in electricity prices contracted through CPPAs, **Fig. 8** (Giorgi, 2022; Guichard, 2022; Maisch, 2022a). Among these factors are high levels of inflation, higher interest rates, problems with supply chains, growth in corporate demand for CPPAs, and high prices in the electricity wholesale market.

Table 2
Semistructured Interviews - Results

	Drivers	**Barriers**
Developer Perspective	Electricity price; Hedging strategy; Sustainability;	*Grid infrastructure;** *Excess of Bureaucracy;** Creditworthiness of companies; Non-standardization of CPPA contracts; Contract duration; Regulatory instability;
Regulator Perspective	Hedging strategy; Sustainability;	Creditworthiness of companies; Illiquidity on future and forward markets; Contract Duration;
Electricity Market Perspective	Sustainability; Hedging strategy;	Creditworthiness of companies; Illiquidity on future and forward markets;
Companies Perspective	Sustainability; Electricity Price; Hedging strategy;	Companies' low know-how about CPPA; Contract Duration;
* Although these barriers are more related to the development of the supply side of the CPPA market, it also affects the development of the demand side of the market.		

Inflation has a double impact on the negotiation price of CPPAs because it not only increases the capital expenditure (CapEx) required for new renewable projects, but also makes them more expensive to finance, because Central Banks change monetary policy by raising reference interest rates in order to reduce inflation (Giorgi, 2022; Guichard, 2022). In addition to inflation, problems with supply channels also contribute to the increase in CapEx from new renewable projects (Maisch, 2022a; McIntyre, 2022a).

However, as the demand for CPPAs by companies increased, but the supply did not follow, there are fewer developers available in the market, which increases the developers' negotiation power (Giorgi, 2022; Maisch, 2022b). Some of the reasons for this shortage of supply are the high electricity prices that have been seen in the wholesale market, which rise the merchant price risk appetite of developers and investors (Maisch, 2022a; Maritina Kanellakopoulou, 2022), as well as regulatory instability at the European

level, due to the windfall profits of infra-marginal technologies (Giorgi, 2022; Maisch, 2022b; RE-Source, 2022b).

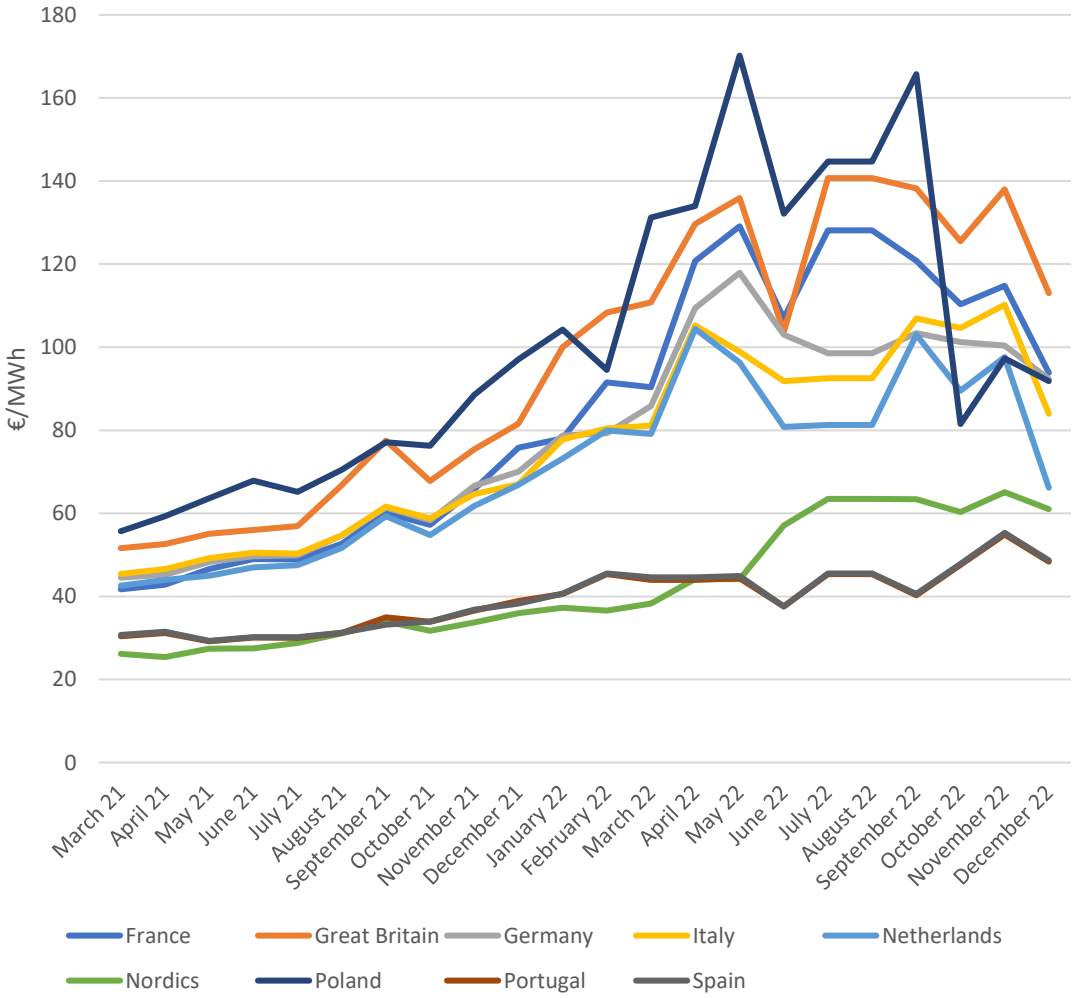

Fig. 8. *European 10 years PPA index prices, source: Pexapark – PPA Times (https://pexapark.com/blog/)*

According with WindEurope[4], the year 2022 put an end to a trend of constant growth in the volume of electricity contracted through CPPAs in Europe, but the upward trend in the number of CPPAs negotiated annually continued. In other words, because of the increase in the merchant price risk appetite of developers and investors during 2022, CPPAs were closed with lower volumes, in order to increase the percentage of electricity traded in the wholesale market by renewable projects.

[4] https://windeurope.org/intelligence-platform/product/the-corporate-ppa-tool/

However, with the abundance of renewable energy at the end of 2022, the stabilisation of European gas reserves, a less harsh winter than expected, and the reduction in the trading price of electricity futures, reduced the price index of the European CPPA market (Molina, 2023). According to Pexapark's 10-year European CPPA price index, the Iberian Peninsula was the region with the lowest reference prices at the end of 2022, **Fig. 8**.

Aside from electricity prices, avoiding wholesale market volatility was mentioned as a driver as well as the adoption of renewable energies to boost company sustainability, with a focus on industries with high export levels.

Regarding barriers, the low credit ranking of companies was the most mentioned barrier throughout the interviews, mainly due to the predominance of small to medium enterprises in the Portuguese industrial sector (Baringa Partners, 2022; PORDATA, 2022). With low credit ranking, companies do not have the necessary conditions to make a new project bankable from the investors' point of view.

According to the entities interviewed from the perspective of the electricity markets, including in the contract a third party that assumes this counterparty risk, i.e. a clearing house, is difficult as it implies the constitution of guarantee by the companies, even if there is a guarantee of reimbursement at the end of the contract. Given that the value of initial margins is correlated with the volatility of the energy wholesale market (Brindley et al., 2020), the values of these initial margins significantly rise during times of high volatility. For example, this occurred during the energy crisis caused by the conflict between Russia and Ukraine.

In a questionnaire conducted by ACER, considering the evolution of prices for 2021 and the first quarter of 2022, a period of energy crisis and price volatility, the increase in the value of guarantees is very significant (ACER, 2022). This rise in guarantees puts pressure on companies in the short term due to the fact that they do not have liquidity, or cannot obtain the needed financing to cover the amount of guarantees that is requested by the clearing house (Weber, 2022).

For businesses with the classification of electro-intensive customers, the Portuguese government offers a risk management system, similar to earlier efforts in Spain[5] or

[5] https://www.cesce.es/es/coberturas-electrointensivos/informacion-coberturas-electrointensivos

Norway[6]. This mechanism, coordinated by *Banco Português de Fomento*, covers the payment of guarantees in PPAs with a minimum duration of 5 years, that represents at least 10% of the company's annual consumption (Mendes et al., 2022).

According to the developer's perspective, regulatory instability exists in the Portuguese context, owing mostly to the implementation of the Iberian compensation scheme designed to mitigate the consequences of the energy crisis, but it has a direct impact on CPPA in Portugal (European Commission, 2022c). Fitting to Decree-law 33/2022[7], all CPPA made in Portugal after 26 April 2022 must cover part of the cost of this mechanism until it is ceased, causing uncertainty to players in the CPPA market.

In addition, the revenue cap established by the EU to deal with high electricity prices also adds some regulatory unsteadiness. To begin with, regulatory stability is an important criterion for the growth of the CPPA market in order to attract private investment and support long-term planning (RE-Source, 2022d). Secondly, despite the 180 EUR/MWh cap established by the EC, member states may set higher caps, resulting in regulatory disparity between member states that hinders the growth of the cross-border CPPA market (Maisch, 2022b; RE-Source, 2022d).

Although one of the drivers considered for the development of the CPPA market in Portugal is hedging and the consequent decrease in electricity price volatility, the lack of liquidity of the energy forward markets and the duration of the contract is considered a barrier to the development of this market.

The lack of liquidity in the energy forward markets, as is the case of the Iberian Electricity Market (MIBEL) (ACER, 2022), combined with the low liquidity of the CPPA market, results in a barrier for companies to contract CPPAs. This lack of liquidity does not allow companies to have a solid long-term perspective on electricity prices, increasing uncertainty when negotiating the price of electricity.

The majority of businesses only enter into power contracts for short to medium durations, which is a hurdle given that CPPAs are a contracting tool primarily for long-term planning, according to the analysis of semi-structured interviews.

[6] https://www.eksfin.no/en/industries/energy/
[7] https://dre.pt/dre/detalhe/decreto-lei/33-2022-183432853

Given the realities of renewable energy producers in Portugal, such as the impending end of feed-in tariffs (Gaivo, 2021), the growing risk of cannibalization due to the high penetration of renewables in the Portuguese electricity mix (Prado, 2023), and the high price volatility in the wholesale market, it is expected that renewable energy producers will be willing to make CPPA with shorter durations.

Furthermore, it is important to consider the signals that wholesale market prices provide to the CPPA market. High electricity prices increase the demand for CPPA by companies, looking for cheaper electricity, but also increase the developer's interest in conducting short-duration CPPAs with the aim of approximating the negotiation price of electricity to the high wholesale market prices (Maisch, 2022b). On the other hand, low prices increase the supply of developers willing to sign a long-term CPPA and decrease the number of companies interested in signing a CPPA due to the lack of a long-term strategy aimed at minimizing the impact of electricity price volatility.

In addition, there are considerable obstacles to the development of new renewable energy projects in Portugal. The semi-structured interviews revealed that the lack of injection points in the country's electricity grid and the heavy red tape surrounding the approval of new renewable energy projects rank as the highlights.

The scarcity or non-existence of injection capacity points in the grid, both for electricity transmission and distribution is due to the slow development of the grid compared to the rapid development of renewable electricity production facilities (DGEG, 2022). This shortage of injection capacity points on the grid, results in the available points being allocated to the auctions of renewable electricity production managed by the Portuguese State (PNEC 2030, 2019), leaving no points available for the implementation of renewable projects free of subsidies, through CPPAs. Likewise, when comparing the planned grid capacity, considering the projects approved but not yet implemented, with the capacity needed to achieve the goals set in National Energy and Climate Plan (PNEC) 2030, the grid capacity is still insufficient, which shows the urgency to accelerate grid development projects (REN, 2021).

The deployment of CPPA behind the meter, which is ideal for smaller consumers, can avoid power grid incapacity; nevertheless, it is insufficient for the electro-intensive industrial sector.

In relation to the excess of bureaucracy, this reflects in long waiting periods to obtain the license to install new renewable energy projects. However, after completing the semi-structured interviews, a new diploma[8] was approved with the goal of speeding up the authorization processes of new renewable energy projects, by simplifying the environmental processes. The approval of this diploma was positively accepted by *Associação Portuguesa de Energias Renováveis* (APREN), although in response to this diploma APREN referred that the creation of a single point of licensing, the increase in the number of teams responsible for these processes and its digitalization, are also important steps to take (APREN, 2022).

According to Simes et al. (2023), twelve percent of the country's land area permits the development of new renewable energy projects with minimal environmental impact. The licensing procedure for new renewable energy projects can be streamlined according to this study, which is supported by LNEG (Laboratorio Nacional de Energia e Geologia).

Finally, and still according to the semi-structured interviews, a major impediment in the Portuguese CPPA reality is the firms' lack of understanding of how CPPAs function. According to the literature review, contract standardization is a technique to improve access to CPPAs for enterprises with limited knowledge of the subject. Yet, in order to protect their interests, developers choose to use their own contracts to carry out a CPPA.

4.2. Sample characterization

According to PORDATA (2022), the majority of Portuguese industrial enterprises are small and medium-sized businesses (SMEs). This is reflected in the survey sample, where 86 percent of the companies are SMEs.

Companies with this dimension are more vulnerable to the existing barriers of contracting a CPPA due to its low creditworthiness, the low levels of electricity consumption, the lack of long-term perspective of electricity demand resulting from short- to medium-term

[8] https://www.portugal.gov.pt/download-ficheiros/ficheiro.aspx?v=%3d%3dBQAAAB%2bLCAAAAAAABAAzNDYxMgEA7NxbVwUAAAA%3d

planning, and finally, because of the poor know-how that SMEs have regarding this type of contract (Rademaekers et al., 2021).

In this questionnaire 93 responses were collected from various industrial sectors such as metallurgic sector, moulding sector, foundry sector, textile sector, cement sector, and food sector.

Regarding the role of the respondent in the company's electricity contractualization process, according to **Fig. 9** it is possible to observe that the large majority of respondents participate directly in this process.

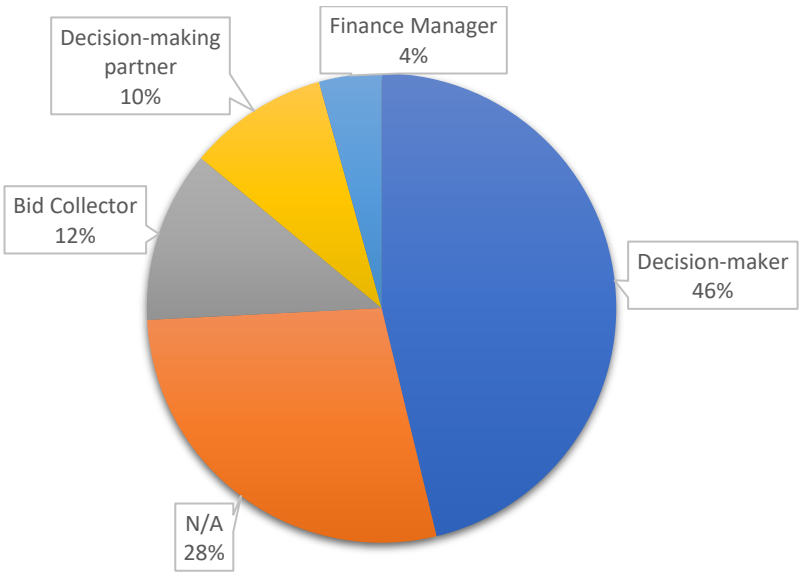

Fig. 9. Respondent's role in the company's electricity contracting process

To begin with, 43 percent of the enterprises examined have a consumption of less than 250 MWh/year, while only 3 percent have a consumption of more than 5 000 MWh/year (**Fig. 10**).

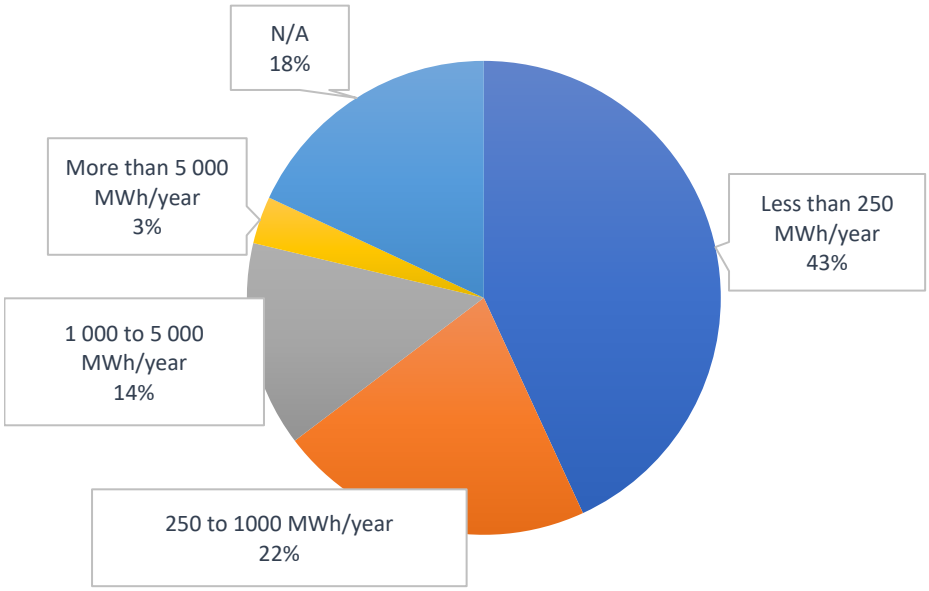

Fig. 10. *Annual electricity consumption.*

It is possible to conclude with a 95 percent degree of significance that the variables consumption and number of employees are dependent on one another when comparing businesses with consumption levels lower than 250 MWh/year (n=40) and higher than 250 MWh/year (n=36). As expected, businesses with higher consumption level have higher number of employees (**Table 3**).

However, it would be expected that the duration of the contract would be related to variables such as the company's level of consumption and the weight of the power bill in the total costs of the company. Contracting electricity for longer periods of time allows companies to secure future electricity supply as well as increase the predictability of future electricity expenditure. With a 5% significance level, statistically, it is not possible to draw conclusions on the relationship between contract duration and variables such the company's level of consumption and the weight of the power bill in the total costs of the company.

Table 3
Employees versus electricity consumption - comparison between two sub-samples.

	<250MWh/year	>250MWh/year
Up to 10 employees	17.5%	5.6%
10 to 50 employees	67.5%	25.0%
50 to 250 employees	15.0%	52.8%
More than 250 employees	0.0%	16.7%

Fig. 11 shows that 86 percent of the companies surveyed have power contracts for less than two years and none perform contracts for more than ten years.

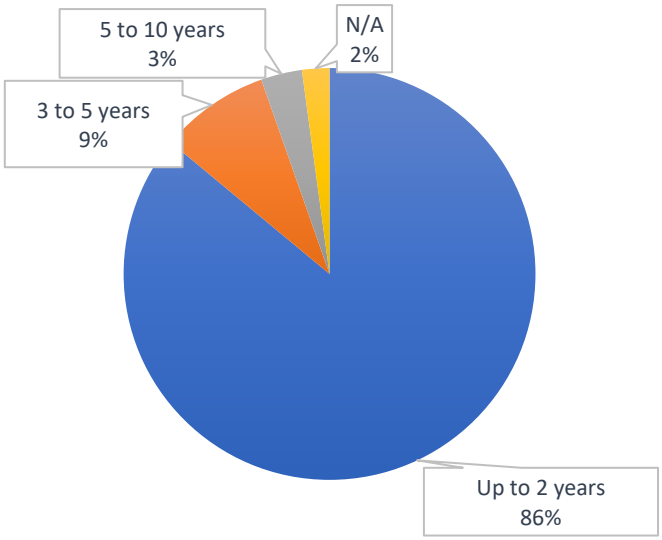

Fig. 11. *Electricity Contract Duration.*

The study also shows that the questioned companies are more vulnerable to changes in wholesale power prices, which increases their financial risk. According to the survey results, **Fig. 12**, 68% of the companies report a weight less than 5% for the electricity bill in the total costs, for 9% of the companies (n=8) the weight in the total costs is equal to or greater than 10%.

With the energy crisis caused by the supply cut of Russian gas to Europe, the Portuguese companies were strongly penalized by the escalating electricity prices, in particular, the electro-intensive companies (APIGCEE, 2022). However, the energy crisis had a small positive impact on the perspective of companies regarding the periods for contracting electricity. Of the businesses surveyed, 29% admit that as a result of the energy crisis, they began to contract electricity for longer durations.

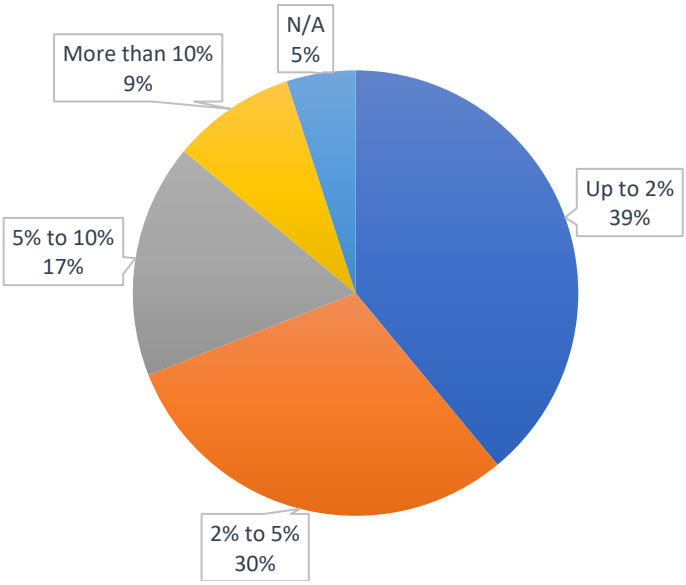

Fig. 12. *Weight of the electricity bill in the company's total costs*

In addition to planning for short- and medium-term energy consumption, it is a challenge for enterprises to have adequate credit ratings to access capital, especially an SME, that allows them to enter into a CPPA. Considering the Portuguese risk management mechanism for companies with the status of electro-intensive customers[9], five respondent companies claimed to have this status; however, when cross-referencing their statement with the response of annual electricity consumption, which must be greater than or equal to 20,000 MWh/year, it was possible to conclude that in reality, only one company has this status. These results raise concerns regarding the firms' knowledge of the requirements for being classified as an electro-intensive client in the first place and about the applicability of this measure considering the traits of Portuguese businesses that were represented in the research sample.

The low financial credibility of companies can be eliminated by aggregating several companies to contract a multi-buyer PPA (Hedges & Kaufman, 2018). This type of contract allows not only to make a project bankable, but is also optimal for companies whose electricity consumption is not very high, such as SMEs (Benjumeda, 2021; Rademaekers et al., 2021).

[9] Decree-law n.º 15/2022, Chapter XII, Section III.

Since just 23% of the enterprises in this sample were able to pass the knowledge test included in the questionnaire (**Fig. 13**), it is also conceivable to draw the conclusion that companies had low energy literacy about CPPAs. Additionally, the data gathered reveals that just 15% of businesses are inclined to enter into a CPPA to supply their electrical needs.

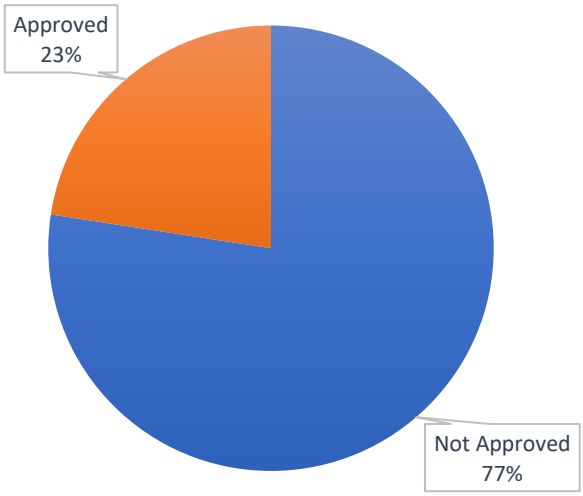

Fig. 13 *– CPPA knowledge test – results.*

Regarding the data collected on companies that have contracted CPPAs, this data raises some doubts, since, of the 15 companies that claim to have contracted a CPPA, all of them have electricity contracts with a maximum duration of 2 years, a much shorter duration compared to the 10 years average duration of CPPAs. Furthermore, of the fifteen companies, only two were able to pass the knowledge test on CPPAs.

Contracting with an energy retailer and investing in self-consumption are the most popular ways for enterprises polled to meet their electricity needs.

4.3. CPPA – Decision Variables

Figure 13 represents the ranking of decision variables, assessed by companies. The ranking of each variable is presented through a quartile graph where the horizontal axis is the Likert scale considered. The line separating the orange box (2nd quartile) from the blue box (3rd quartile) represents the median, the central tendency considered, and the asterisk represents the arithmetic mean.

According to **Fig. 14**, it is feasible to draw the conclusion that the price of electricity and the security of electricity supply are the two factors that have the most influence on the choice to enter into a CPPA.

Security of electricity supply is directly related to the risk of default of the terms agreed in the contract by the counterparty, in this case, the renewable energy producer. This leads to the conclusion that the credibility of renewable energy producers with companies is an important factor for them to participate in a CPPA.

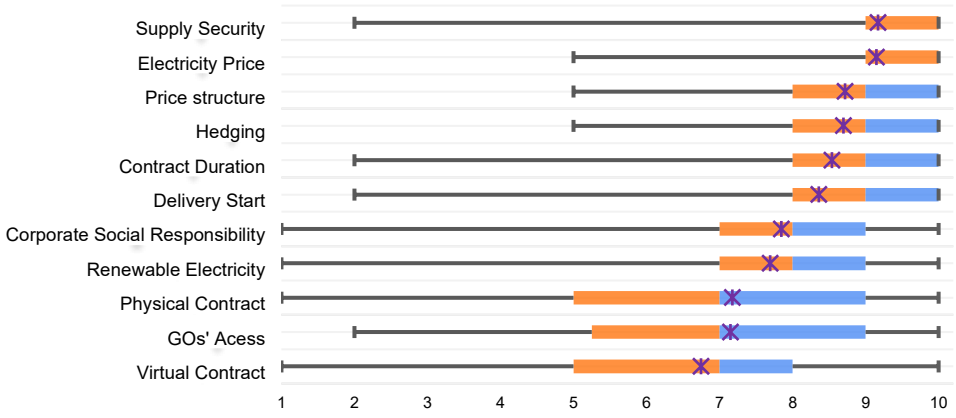

Fig. 14. *Ranking of business decision variables to contract a CPPA.*

Concerning electricity prices, ensuring that the company is competitive in comparison to its direct competitors requires offers to supply electricity at the lowest price.

The results show that, despite the pressing need to decarbonize the economy, the companies polled believe that pricing is still a more significant factor than the source of

renewable electricity. This highlights the significance of making renewable energy affordable in comparison to the wholesale market costs.

It is possible to draw the conclusion that the variables "Renewable Electricity" and "Corporate Social Responsibility" are dependent, as well as the variables "Renewable Electricity" and "Go's Access," with a 5% level of uncertainty. This confirms the idea that businesses are more interested in price than any variable that is in any way related to the sustainability of their energy source.

With “Electricity Price” being the most valued variable along with “Supply Security”, by comparing the Portuguese day-ahead electricity prices with the Portuguese 10 years PPA index price from Pexapark from March 2021 to December 2022, ***Fig***. 15, it is possible to observe that it is advantageous for companies to enter a CPPA. However, in the survey only 15% of the companies stated that they considered a CPPA as a way of contracting electricity. The lack of information about this method of contracting electricity, as well as the size of Portuguese companies, may explain why companies in Portugal are less likely to contract CPPAs.

The most crucial factors after pricing and supply security are the "Price Structure” agreed in the CPPA, the hedging, the length of the contract, and the speed at which contract transactions begin after the negotiation (“Delivery Start”).

By highlighting the relevance of the variable "Delivery Start", it is important to consider that one of the barriers that characterize the Portuguese CPPA market is the excessive bureaucracy to carry out new renewable projects. For this reason, simplifying bureaucratic processes is an important contribution to the development of the CPPA market in Portugal. Besides that, is also relevant to consider that the actual scenario of high levels of inflation, rising interest rates and supply chain disruption are impacting negatively the delivery start of renewable projects (Schneider Electric, 2023) .

Furthermore, the same importance was attributed to "Contract Duration" variable and "Hedging" variable. Enterprises highlight the fact that the contract time is adequate to their expectations in the questionnaire; nonetheless, data obtained shows that 86 percent of the companies contract power for durations of shorter than two years. Performing hedging for such short periods is possible through CPPAs, although it is not common. This implies that the contracted electricity price is higher compared to a long-term

contract, which is relevant especially in times of high prices in the wholesale market, such as nowadays.

In contracts with short durations, developers try to bring the electricity price negotiated closer to wholesale market prices, which decreases the competitiveness of contracted electricity prices, and the predictability of long-term electricity costs typical of a long-term CPPA.

This research highlights two key benefits for businesses hiring CPPAs: lowering long term electricity price and volatility. This demonstrates that businesses should enter into CPPAs with a long-term vision, if they want to benefit from the advantages they offer. As a result, increasing the contractual terms of CPPA is critical for enterprises to build the CPPA market in Portugal while maximizing the benefits on the demand side.

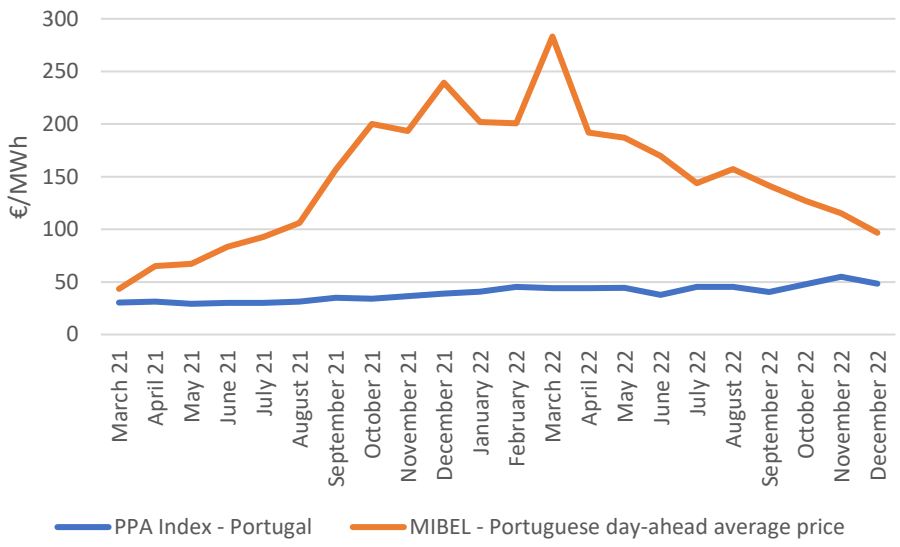

Fig. 15. MIBEL – Portuguese day-ahead average price vs Portuguese 10 years PPA index price (https://www.omie.es/en/market-results/interannual/daily-market/daily-prices?scope=interannual)

It is also possible to draw the conclusion that the variables "Renewable Electricity" and "Corporate Social Responsibility" are dependent, as well as the variables "Renewable Electricity" and "GO's Access," with a 5% level of significance. This confirms the idea that businesses with the focus on social responsibility, either for marketing purposes or management orientation, are prone to have also a more sustainable mind set. As expected,

companies willing to contract renewable energy will require access to the corresponding GOs.

Finally, the variables related to the structure of an off-site contract, "Virtual Contract" and "Physical Contract", proved to be the variables with the highest non-response rate among the companies surveyed. Knowing this type of structure and understanding its advantages and disadvantages requires a good knowledge of the topic. This information confirms one of the findings from the questionnaire and the semi-structured interviews that businesses had little knowledge about CPPAs. Therefore, investing in companies' CPPA education is the first step in developing the Portuguese CPPA market.

5

Conclusion

Given the importance of PPAs in the energy transition and the potential of the CPPA market, this dissertation was carried out with the goal of analysing and defining strategies to encourage the growth of the Portuguese CPPA, given a market demand side perspective. In order to understand the CPPA market in Portugal from a demand side perspective, it was first necessary to identify its drivers and barriers. Next, it was required to ascertain the factors that company decision-makers consider most important when deciding whether to contract a CPPA.

Through semi-structured interviews with relevant players in the Portuguese electricity market, it was possible to conclude that the main drivers for companies to contract a CPPA are the price of electricity, electricity price hedging, as well as access to electricity from renewable sources. On the other hand, the barriers are mostly present in the reduced creditworthiness of companies, in their low literacy on this type of contracts, in the lack of a long-term strategy for contracting electricity by companies, in the regulatory instability that the energy sector has been facing, and finally in the difficulty of developing new non-subsidised renewable projects, which reduces the supply of developers willing to enter into a CPPA.

In response to the second research question, based on questionnaire findings, it was reasonable to conclude, using a Likert scale, that the variables that company decision makers most evaluate when contracting a CPPA are supply security and electricity price. Along with these two factors, the contract's price structure, electricity price hedging, contract term, and the time between contract signing and the start of electricity supply are other factors that should be considered while making decisions. However, variables related to the sustainability of the electricity consumed by businesses showed not to be so relevant as expected.

Furthermore, as would be expected the vast majority of Portuguese electro-intensive companies are SMEs and as a consequence do not consume large amounts of electricity. With the questionnaire it was also possible to conclude that the culture of short-term electricity contracts is strongly present among companies, and that contracting electricity directly with a retailer and investments in self-consumption are the companies' preferential ways of contracting electricity.

As limitations related to the work carried out along this dissertation it is important to consider three points. First, there is a clear limitation in accessing more advanced knowledge on the topic, due to the fact that the information is concentrated in consulting firms in the area with no free access. Secondly, semi-structured interviews as a methodology are associated with possible situations of information bias during the interactions between interviewer and interviewee (Myers & Newman, 2007). Finally, a higher number of semi-structured interviews and a larger number of questionnaire responses would have helped to improve the results obtained.

In conclusion, given the major goal of this dissertation, it is possible to recommend some solutions to promote the growth of the demand side of the CPPA market in Portugal based on the results obtained from the two research questions formulated.

First, encouraging initiatives to raise corporate awareness of CPPAs so that they have the knowledge they need to explore CPPA as a means of obtaining electricity. In collaboration with trade groups, associations devoted to the promotion of renewable energy in Portugal may carry out this action.

Second, the present paradigm in the Portuguese industrial sector regarding short-term electricity contracts must be changed. This activity can be carried out in conjunction with the previous one by discussing with businesses the benefits of contracting electricity in the medium and long term.

Third, to expand the number of developers qualified to enter a CPPA off-site, enhancing the capacity of grid injection points designated to renewable energy projects receiving no subsidies. Hybrid off-site projects are the best option considering their capacity on supply risk management.

Fourth, supporting Portugal's green hydrogen industry's expansion. Considering green hydrogen industry as an electro-intensive industry that must consume green electricity, the deployment of green hydrogen production plants will increase the demand for CPPA.

Fifth, expand the number of cross-border interconnections via undersea cables or land to boost international company demand for cross-border CPPA with renewable energy output allocated in Portugal.

And sixth, to increase the confidence of participants in the Portuguese CPPA market, providing regulatory stability in the energy industry.

Considering the originality of this scientific study in Portugal, it is not possible to make any type of comparison with results obtained by other authors. Although there is a study with some similarities, conducted by the consulting firm PwC in the United States of America (Favaloro et al., 2016), in addition to not being a scientific study, the reality assessed by the study is not comparable with the Portuguese reality.

In the end, through the semi-structured interviews it was possible to observe a few sectoral associations looking to buy or already buying electricity from retailers for their members, working as an aggregating entity. Given the substantial presence of SMEs in the Portuguese business environment, and in light of their lack of credit credibility and low power usage, it could be relevant, as an avenue for future research, to build a SMEs aggregation model, that could make a renewable project bankable, and to use it in a practical instance, with a sectoral association being the aggregating entity. As a starting point, an analysis of CPPA markets in countries where this aggregation contract is already happening could be useful.

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ANNEX A

Literature Review

		CPPA Characterization	Price Negotiation	Risks	Drivers	Barriers
Articles	(Chang & Lo, 2022)				●	
	(Dong et al., 2021)		●			
	(Edge, 2015)			●		
	(Gabrielli et al., 2022)			●		
	(Ghiassi-Farrokhfal et al., 2021b)			●		
	(Mendicino et al., 2019)	●	●			
	(Miller et al., 2018)	●				
	(Parlane & Ryan, 2020)			●		

Additional articles	(Aquila et al., 2021)			●		
	(Bruck & Sandborn, 2021)			●		
	(Davis-Sramek, 2021)	●				●
	(Jin et al., 2018)			●		
	(Lei & Sandborn, 2018)			●		
	(López Prol et al., 2020)			●		
	(O'Shaughnessy et al., 2021)			●		
	(Strazzabosco et al., 2022)			●		
	(Tranberg et al., 2020)			●		

Grey Literature	(ACER, 2021b)			●	●	
	(ACER, 2022)			●	●	
	(Badissy et al., 2016)	●	●	●	●	●
	(Baringa Partners, 2013)	●				
	(Baringa Partners, 2020)	●			●	
	(Baringa Partners, 2022)				●	●
	(Brindley et al., 2020)	●	●	●	●	●
	(Brindley et al., 2021)					●
	(Brouwer & Goei, 2018)					●
	(Dominy & Zubair, 2021)	●	●		●	
	(Douglas et al., 2020)	●		●		
	(European Commission, 2022b)				●	●

	(European Wind Energy Association, 2013)				●	
	(Favaloro et al., 2016)				●	●
	(Hedges et al., 2016)	●	●	●	●	●
	(Hedges & Duvoor, 2019)	●	●	●		
	(Hedges & Kaufman, 2018)	●		●		●
	(Iberdrola, 2022)	●				
	(Kobus et al., 2021)	●				
	(McIntyre, 2022c)					●
	(Peter Swank et al., 2020)	●		●		●
	(Rademaekers et al., 2021)				●	●
	(RE-Source, 2021a)					●
	(RE-Source, 2021b)				●	●
	(RE-Source, 2022a)					●
	(RE-Source, 2022c)		●			
	(RE-Source, 2022d)					●
	(RE-Source, 2022e)					●
	(Sustainable Energy Authority of Ireland, 2021)	●			●	●

ANNEX B

Business model to get green electricity

- **Power Purchase Agreement**

Corporate Power Purchase Agreements are bilateral contracts where the energy is sold directly by the renewable generator to a company. The companies have access to green electricity, the generator has a guaranteed revenue and both are not dependent on the volatility price of the wholesale market (Douglas et al., 2020; Hedges et al., 2016).

- **Leasing**

Leasing enables the company to install renewable energy equipment in their facilities without the need to make an upfront investment. During the duration of the contract, the company pays a periodic leasing fee to the company owner of the equipment (Stunning, 2022). The leasing could be offered by an ESCO or by a technology provider that leases their equipment, and will be responsible for any maintenance and monitoring the system requires (Douglas et al., 2020; Folk, 2021).

- **Unbundled GOs**

Guarantees of Origin are electronic documents which provide end consumers with proof that a given amount of power was produced using a certain type of technology. The access to GOs is made by an auction organized by the entity responsible for the management of it (Douglas et al., 2020; REN, 2022).

- **Green Tariff**

A green tariff is a utility program that allows customers to source up to 100 percent of their electricity from renewable sources. In this case, the management of GOs is done by the retailer and not by the company (Douglas et al., 2020; Tawney & Ryor, 2014).

- **Self-Owned Investment**

The company makes its own investment in renewable energy, and is responsible for finance, installation, and maintenance (Douglas et al., 2020)

ANNEX C

Semi-structure Interviews - Key Topics

A1 - Developer perspective

- Are there companies looking for green electricity?
- Barriers and drivers to establish a PPA.
- Decision variables that affect the decision of business decision-makers whether to contract a PPA.

A2 - Regulator perspective

- What is the regulatory framework regarding CPPA?
- Barriers and drivers to establish a PPA.
- Decision variables that affect the decision of business decision-makers whether to contract a PPA.

A3 - Electricity Market perspective

- What is the role of a Clearing House in a PPA environment?
- Barriers and drivers to establish a PPA.
- Decision variables that affect the decision of business decision-makers whether to contract a PPA.

A4 – Companies perspective

- Are there companies looking for green electricity?
- Do companies know what are a CPPA?
- Barriers and drivers to establish a PPA.
- Decision variables that affect the decision of business decision-makers whether to contract a PPA.

ANNEX D

Questionnaire

1. **Please indicate the most representative Industrial Activity Code of your company's activity _____**

2. **Does the firm qualify for SME status?**
    - Yes
    - No
    - N/A

3. **What is the number of permanent collaborators in 2021?**
    - Less than 10 collaborators
    - Between 10 and 50 collaborators
    - Between 50 and 250 collaborators
    - More than 250 collaborators
    - N/A

4. **Does the company benefit from the status of electro-intensive customer, as defined in Decree Law nº 15/2022 of 14th January?**
    - Yes
    - No
    - N/A

5. **What is the voltage level of electricity contracted by the company?**
    - Normal low voltage
    - Special low voltage
    - Medium voltage
    - High voltage
    - Very high voltage
    - N/A

6. **What is the company's average annual electricity consumption?**
    - Less than 50 MWh/year
    - Between 50 and 100 MWh/year
    - Between 100 and 250 MWh/year
    - Between 250 and 500 MWh/year
    - Between 500 and 1 000 MWh/year
    - Between 1 000 and 5 000 MWh/year
    - More than or equal to 5 000 MWh/year
    - N/A

7. **What is the average percentage in 2022 that the annual electricity bill represents in the company's total costs?**
    - Less than 1%
    - Between 1% and 2%
    - Between 2% and 5%
    - Between 5% and 10%
    - More than or equal to 10%
    - N/A

8. **What alternatives does the business often consider when purchasing electricity?** (Select all options considered)
    - Investment in renewable electricity sources for self-consumption
    - Contracting with a retailer in the liberalized energy market
    - Contracting Corporate Bilateral Contracts
    - Other:
    - N/A

9. **The company is seeking to enter electricity supply contracts with a usual duration of:**
    - Up to 2 years
    - Between 3 and 5 years
    - Between 5 and 10 years
    - More than 10 years
    - N/A

10. **Has the current energy crisis had an impact on the duration of these contracts?**
    - Yes, before the energy crisis the company had electricity contracts with shorter durations
    - Yes, before the energy crisis the company had longer electricity contracts
    - No change in the duration of the contracts
    - N/A
    - Other:

11. **Has the company ever entered into a Bilateral Corporate Electricity Agreement?**
    - Yes
    - No
    - N/A

II

12. Classify the following statements as True or False:

a. Corporate bilateral power contracts are contracts made directly between a renewable energy producer and a company.
b. In a corporate bilateral contract, the price of electricity is variable.
c. A corporate bilateral contract is exclusively performed between two parties, and there can be no other parties participating in this same contract.
d. A corporate bilateral contract provides only the company's baseline electricity consumption.
e. To perform a corporate bilateral contract in Portugal, it is necessary for the company to establish itself as a Market Agent with the energy market operator (OMIE).

III

13. Assess the importance of the following variables in the decision to establish Bilateral Contracts as a way of contracting electricity:

For that purpose, use the Likert scale, assigning a value between 1 and 10, where 1 means not important and 10 means extremely important. If you do not know or do not want to answer (N/A), rate the variable with the value 0.

Decision Variables	0	1	2	3	4	5	6	7	8	9	10
The electricity supplied be 100% renewable											
The possibility of having access to Guarantees of Origin (GOs) of renewable energy											
The price of electricity is adjusted to the company's expectations											
There is no volatility in the contracted unit cost of electricity											
The contract duration is adjusted to the company's expectations											
The price structure (fixed or variable) established is adequate for the needs of the company											
Being a contract with a physical structure, i.e., a bilateral contract whose electricity delivery is carried out in a physical manner											
Be guaranteed the security of the supply of electricity to the company											
Immediate availability for the supply of electricity (start of operation of the renewable energy project)											
Be a contract with a virtual/financial structure, i.e. a bilateral financial contract, identical to a contract for difference, relative to the spot market electricity price											
Provide compliance with social responsibility commitments											
Other options (please specify):											

IV

14. Please describe your role in the company's electricity procurement process:

15. What is the highest level of education you have completed?

- 1st Elementary School Cycle
- 2nd Elementary School Cycle
- 3rd Cycle / 9th grade
- High School / 12th grade
- Bachelor's degree
- Graduation Degree
- Masters' Degree or Post Graduation
- PhD

16. Please indicate your educational background:

- Engineering
- Business or Economics
- Law or Literature
- Other: