MÁSTER EN INGENIERÍA EN TECNOLOGÍAS INDUSTRIALES

TRABAJO FIN DE MÁSTER

A Decision-Making Tool for Investment, Procurement and Operation of Aggregators in Electricity Markets

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Content

Introduction

Solar energy consumption is experiencing high demand and is leading an energy transition among households and small business, reducing reliance on carbon-based fuel energy suppliers [10].

Solar Energy outperforms other renewable energy sources as Solar Photovoltaic (“PV”) is the only energy source that can produce energy on its own, while the other options require energy consumption as gas or electricity. In addition, PV is the easiest renewable energy technology to implement for self-consumption [2].

In the EU, solar PV energy generation increased from 25TWh in installed capacity in 2010, to 160TWh in 2021. Solar PV and onshore Wind represented the biggest investment focus among all renewable generation sources globally. In addition, Western Europe remains one of the largest areas of investment for renewable energy. Self-consumption is in high demand because it allows lower energy prices, reducing monthly electricity instalments [3].

Electricity markets are recognised as high volatility markets, with strong increases in prices and in energy demand. Some changes in electricity prices come from gas and carbon participation in the electricity mix-generation. The mix-generation is also strongly connected to climate changes as they include renewable energy, what involves more uncertainty on prices and generates more volatility when predicting the energy that is going to be produced.

In order to reduce volatility of prices, there are PPA contracts (Power Purchase Agreements) which fix the price per MWh.

Power Purchase agreement (“PPA”) is generally the primary contract between a public sector purchaser "offtaker" and a privately-owned power producer.

Therefore, the structure and risk allocation regime under the PPA is central to the private sector to raise finance for the project, recover its capital costs and earn a return on equity.

Related to the sale of capacity and energy, the PPA may require the project company both to make available to the purchaser an agreed level of capacity at the power plant and deliver the energy generated in accordance with its provisions [3][5][7].

In addition, pricing regime in the PPA has two components:

- A capacity charge: which is payable by the offtaker in consideration of the power plant operator making generation capacity, which sold to the offtaker whether it actually offtakes electricity from the power plant. This component is typically designed to provide a revenue for the project and is the primary channel through which each project proponent would recover its fixed costs (including its capital investments, financing costs and a return on equity).
- Output charge**:** this is usually referenced to the volume of electricity delivered and is intended to cover the project company's variable costs.

Private project proponents and lenders will require the PPA to run for a long term to guarantee investment recovery. PPA contracts will last between 10-25 years, where the promoter of the agreement will oversee operational costs and maintenance for power plants [6][8][9].

State of the Art

The way of consuming and producing energy is changing due to higher prices, political instabilities, and CO2 emissions. Most of the companies are charged big amounts of money due to CO2 emissions when producing energy with fuel, coal, or gas. As the European Union encourages companies to produce a minimum amount of CO2 emissions. Any excess that is above of the limit imposed by the EU will be charged, in order to promote the renewable energy generation.

Multiple efforts have been made to develop supported algorithms focused on generators, traders and distributors in order to optimize their way of operating and reduce their costs. A smaller number of studies aimed to evaluate the perspective of consumers, retail suppliers or aggregators.

The problem is with electricity procurement by aggregator or consumer, given the long-tail and unpredictability of electricity prices. In addition, most of methodologies are focused on shorter-term horizons, not considering the possibility of agents for longer term. This concept of the longer period is of total relevance as self-consumption installations are usually taking high performance for around 20 years. Making predictions 20 years from now, would not make sense as models would lose accuracy, but focusing on 3-5 years of contract periods can make models find the balance between accuracy and longer prediction [8].

Every model should consider as detailed as possible, avoiding simplifications, in energy demand, pricing and renewable generation. The problem when estimating the renewable generation is that with the increase of self-consumption, model predictions may change their inputs, as the energy predicted in order to be consumed varies, due to people consuming their own energy produced.

When estimating pricing for consumers two ways of modelling can be considered. From one hand, as it has been mentioned, by fixing a price per MWh, (PPA contracts) or considering the volatility of the energy prices due to the market. To obtain a prediction of the volatility of the prices it is needed to take as reference the historical data and daily changes [1] [2].

Motivation

The problem is described and solved for three different aggregators business models (Integrated Supply Aggregator, Delegated Independent Aggregator, and Consumer Aggregator), each one with a different objective function.

Whereas aggregator, the project refers to a new type of energy service provider which can increase or moderate the electricity consumption of a group of consumers according to total electricity demand on the grid. An aggregator can also operate on behalf of a group of consumers producing their own electricity by selling the excess electricity they produce.

Promoting competition across the energy market finds that, consumers should be free to engage with the independent aggregator and supplier of their choice, without facing contractual obstacles from either type of company.

The main objective of this work is the development of an integrated tool to optimize investment, procurement, and operation decisions of an aggregator in electricity markets, capable of coupling the short and long-term horizons. The tool will be developed in GAMS, as a stochastic optimization model and its validation will be based on some case studies using real data from the Spanish electricity market.

In the energy sector there are many regulatory laws that in certain cases limit economic growth and its expansion, what makes the project and the study more beneficial trying to increase the profit to the maximum getting more out of the electricity markets.

By the time, the project as part of consumer aggregators will be focused on self-consumption installations for customers, as the market is growing notoriously in Spain, and several ways of financing are emerging, where the optimization of the project can be adjusted.

This project is also commitment to the economic optimization of a clean and green energy that will boost more and accelerate growth of renewable energies.

There will be also a focused-on uncertainties and volatility of the electricity markets, related to climatological changes and prices, so that they become near-constant variables for the model.

Project Objectives

1. To develop optimised investment strategies as well as procurement and enhancement in the electricity sectors from different aggregators points of view, integrating short and long-term horizons.

2. To learn the use of GAMS deeply as an optimization tool that allows to shuffle several scenarios and comparing them making differentiation between different situations in the electricity current market.

3. To understand and develop a deep analysis of the three different aggregators, Integrated Supply Aggregator, Delegated Independent Aggregator, and Consumer Aggregator, and where can each of them be maximized looking for a common benefit between the three different scenarios.

4. To study the uncertainties and volatility of the energy market variables, by executing a deep analysis of the historical data, and how pricing, climatological changes and energy demand have been fluctuating according to different factors.

ESG Factors

Sustainable Development Goals ("SDG") are an initiative promoted by the United Nations to give continuity to the development agenda after the Millennium Development Goals.

The SDG are the blueprint for a sustainable future for all. They interrelate with each other and incorporate the global challenges we face every day, such as poverty, inequality, climate, environmental degradation, prosperity, peace and justice. In order to leave no one behind, it is important to manage to meet each of these goals by 2030.

The project is mainly related with the following SDG, as promotes renewable energy, considering a clean ang green energy. In addition, as it will optimise several models, more people will have the opportunity to have access to these renewable energies, contributing to climate change, inclusion, and sustainable consumption and energy production [5].

- 7, "Ensuring access to affordable, reliable, sustainable and modern energy for all".
- 8, "Promoting sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all".
- 9, "Developing resilient infrastructures, promoting inclusive and sustainable industrialization, and foster innovation".
- 12," Ensuring sustainable consumption and production patterns".
- 13, "Taking actions to combat climate change and its effects".

Working Methodology

Process	Step 1	Step 2	Step 3	Step 4
To study the uncertainties and volatility of the energy market variables, by executing a deep analysis of the historical data				
To execute GAMS code analysing the output obtained and optimising the model, comparing different scenarios				
To implement the model adding uncertainties and considering new variables to create new scenarios, taking into consideration a real example based on the electricity demand of a top-10 retailers in Spain				

To study and analyse the regulatory changes of the PVPC and its impact for retailers and consumers				
To provide a Deep analysis based on the output result achieved, comparing two different solutions for the retailer (acquiring energy through PPAs contracts vs buying electricity in the SPOT market)				

Resources

The main resources of the project will be GAMS. The license would have to be solicited as the free trial won´t last for the whole duration of the project.

Other tools could be considered to develop the optimisation analysis.

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