



UNIVERSIDAD PONTIFICIA COMILLAS

ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA (ICAI)

OFFICIAL MASTER'S DEGREE IN THE  
ELECTRIC POWER INDUSTRY

Master's Thesis

ANNEX A

ANALYSIS OF THE FUTURE IMPACT OF RENEWABLE  
ENERGY IN ELECTRICITY MARKETS

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Madrid, May 2024

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# 1. INTRODUCTION

The electricity market, also known as the pool, sets prices through a marginalist system, which means that the last and most expensive technology needed to cover demand sets the price of all the others every hour of the day. Some generation technologies known as infra-marginal (renewables, nuclear and hydroelectric) enter the market at their production price, so when the production of these energies is sufficient to cover all the expected consumption, the price sets at negative or zero euros. And that is what has been happening on more and more occasions over the last year.

Spain has embarked on a massive deployment of new renewable plants in recent years and is preparing for an even greater avalanche in the coming years. The green revolution has already caused a shake-up in the country's electricity production (last year the Spanish electricity system managed to generate more than half of all its energy with renewables) and has boosted the total generation park to a record installed capacity of more than 125,000 megawatts<sup>3</sup> (MW) in the country. There is more and more capacity to generate electricity and there is increasing investment in new green plants (which will eventually replace other technologies in the future, such as nuclear or gas-fired plants), but the boom in production is colliding with a decline in electricity consumption.

Furthermore, the electricity market in Spain and Europe is changing. The new IDA proposal is going to start this summer and it will change the way companies and markets operate. To summarize it, the IDA (IntraDay Auction) proposal intends to make a European Intraday market 3 times a day in a way to unify the European network completely. Right now, the day-ahead market and the continuous intraday market work on a European level, but the intraday operated separately. With the IDA proposal this is going to change.

Combining all what is going to take place around electricity markets, makes this theme something to talk about for the next years.

## 2. MOTIVATION

The electricity market is in constant change, and it is necessary to keep up with it to be prepared and take advantage. This summer a new proposal is taking place and it set to try and unify the European network in a way that was missing right now.

The IDA proposal will set 3 Intraday auctions throughout the day and will involve many European countries to get a step closer to the total unifications of the European network. The motivations were clear as in that this is something that has not even started yet, but that will change the way the prices in the network behave and it is necessary to try and acknowledge everything as soon as possible.

In this thesis it will be interesting to try and understand how the changes in the markets will change with the IDA proposal and how it will deal with all the renewable technology that is supposed to be implemented in the network.

Europe is a leader in the clean energy transition and has set some optimistic objectives for this century and it is interesting to see how this increase in renewable technology will cope with the available capacity of the network and the lowering of the market price. In Spain for example, this past semester has been one with the lowest prices in history because of the exceed of renewable technology availability in the system. It will start to be seen as common to see negative prices in the Day-Ahead auctions.

The main motivation of this thesis is to see how all this combination of unification of the electricity markets and the introduction of more renewable energy will affect the prices.

### **3. OBJECTIVES**

The objectives as described in the motivation are clear:

***Analyze the impact of IDA proposal on market dynamics.***

This objective aims to provide a broader perspective on how the implementation of the IDA proposals will affect and reshape the current dynamics of national and European electricity markets. Through an intensive and comprehensive research and analysis process, we understand how three intraday auctions impact market prices and pricing mechanisms, trading patterns, and how market participants respond to assess what is expected. We will also consider the impact of this proposed new arrangement. Changes in efficiency, liquidity and competition among market participants are investigated.

***Evaluate the integration of renewable energy technology.***

This objective raises an interesting study on the comparison of the renewable energy production mix introduced in the system in the framework of the European electricity market integration. It investigates how the increasing penetration of renewable energy sources, such as solar and wind, affects market supply and demand dynamics, grid stability and average device reliability. It will also explore the challenges and opportunities associated with integrating variable renewable energy technologies into existing municipal infrastructure, which includes strategies for managing grid bottlenecks and containing outages.

***Forecast price trends and market outcomes.***

The objective of this study is to predict the evolution of the capacity factor and its impact on the market due to the convergence of FDI concepts and the increase of renewable energy technologies. Through quantitative modeling and scenario evaluation, it is possible to determine how the creation of an IDA auction and the expansion of renewable energy potential will affect energy costs, market volatility and revenue streams for market participants.

## **4. PRELIMINARY TABLE OF CONTENTS**

A possible preliminary table of contents could be:

### Chapter 1. Introduction

- 1.1 Background
- 1.2 Problem Statement
- 1.3 Objectives of the Study
- 1.4 Scope and Limitations
- 1.5 Structure of the Thesis

### Chapter 2. State of the art

- 2.1 Overview of Electricity Markets
- 2.2 Intraday Auctions in Electricity Markets
- 2.3 Renewable Energy Integration
- 2.4 Market Dynamics and Price Trends

### Chapter 3. Methodology

- 3.1 Research Design
- 3.2 Data Collection
- 3.3 Data Analysis Techniques
- 3.4 Quantitative Modeling
- 3.5 Scenario Evaluation

### Chapter 4. Impact of IDA Proposals on Market

- 4.1 Overview of IDA Proposals
- 4.2 Market Prices and Pricing Mechanisms

4.3 Trading Patterns

4.4 Response of Market Participants

4.5 Changes in Efficiency, Liquidity, and Competition

Chapter 5. Integration of Renewable Energy Technology

5.1 Renewable Energy Production Mix

5.2 Impact on Market Supply and Demand Dynamics

5.3 Grid Stability and Device Reliability

5.4 Challenges and Opportunities in Integration

5.5 Strategies for Managing Grid Bottlenecks and Outages

Chapter 6. Forecasting Price Trends and Market

6.1 Evolution of the Capacity Factor

6.2 Impact on Market due to Renewable Energy Technologies

6.3 Energy Costs and Market Volatility

6.4 Revenue Streams for Market Participants

6.5 Scenario Analysis and Predictions

Chapter 7. Discussion

7.1 Summary of Key Findings

7.2 Implications for Policy and Practice

7.3 Limitations of the Study

7.4 Recommendations for Future Research

Chapter 8. Conclusion

Chapter 9. References

## 5. METHODOLOGY

The methodology for the completion of this Master's thesis will be to follow established market research techniques and use current Python models adapted to the current situation. First, the impact of the IDA proposal on market dynamics will be analyzed by incorporating the proposed adjustment to a current model. This includes modifying the econometric model and market simulation framework to create three intraday auctions, as well as performing scenario analysis to simulate specific market conditions.

Then it will compare the upcoming renewable energy mix by integrating renewable energy production data into the model and modifying the grid simulation model to account for variability and intermittency. This step consists of optimizing the use of renewable energy resources, assessing the impact on grid stability and reliability, and analyzing the effectiveness of current grid management techniques. Finally, it will extend current econometric or system dominance models to predict price trends and market impacts by including studies on renewable energy integration and past trends. To do this, it will be necessary to leverage historical market records and renewable energy technology styles, perform scenario analysis to predict future price trends, and validate model robustness through out-of-sample testing and sensitivity analysis.

Results will be communicated through visualizations and numeric results to represent in the most comprehensive way the data obtained. This integrated approach will leverage the flexibility and scalability of Python for evaluation and information modeling tasks in the energy market domain.



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## 7. WORK PLAN

	13-19 may	20-26 may	27 may-2 june	3-9 june	10-16 june	17-23 june	24-30 june	1-7 july	8-14 july	15-21 july	22-28 july	28 july-4aug	5-11 aug
Preliminary research													
Methodology planning													
Data Collection													
Methodology execution													
Data Analysis													
Results Compilation													
Discussion of results													
Conclusion and finishing													