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Supply Chain Management

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Understanding the fundamental drivers of wholesale electricity
prices in Greece

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Patras, Greece, January 2024

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Understanding the fundamental drivers of wholesale electricity prices in Greece

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“Acknowledgments and Dedication”

With the completion of this master thesis, I would primarily like to express my deepest gratitude to the Professor of the Hellenic Open University and Supervisor of my master thesis Mr. Thomaidis Nikolaos, for his guidance and his willingness to support me. His role as supervisor was very crucial for the completion of this dissertation.

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Abstract

The wholesale electricity market in Greece has changed greatly over the last 20 years. The liberalization of the market carried out by complying with the EU regulations and policies, led to the transition from the natural monopoly of PPC to the establishment of a highly competitive market. This has resulted in the entry of new players and the further development of the renewable energy sources in the sector of energy. In this way, the wholesale electricity market has become more complex, with a significant increase in the number of factors influencing it.

The main purpose of this study is by presenting an analysis of the functioning of the wholesale energy market in Greece, as established after liberalization took place, to create the framework for a better understanding of the main drivers involved in it, influencing the price of electricity. The ever increasing needs regarding the consumption of electricity by business and households have made it more imperative than ever to interpret the influence of these factors in order to understand how the price of electricity is determined.

In addition to the correlation of the various technologies of electricity production with the determination of the price, the energy mix of the market is also of essential importance, which is the total of the energy produced by plenty of energy sources and technology, in order for the supply to meet the demand and therefore to achieve the existence of balance in the market.

Finally, in order to better understand the structure of the electricity market and the conditions prevailing in it, through this study a historical review of the evolution of wholesale energy market is provided.

Περίληψη

Η λιανική αγορά ηλεκτρικής ενέργειας στην Ελλάδα άλλαξε σε μεγάλο βαθμό κατά τη διάρκεια των τελευταίων 20 χρόνων. Η απελευθέρωση της αγοράς που πραγματοποιήθηκε μέσα στο πλαίσιο της συμμόρφωσης με τους Ευρωπαϊκούς κανονισμούς και ρυθμίσεις οδήγησε στην μετάβαση από το φυσικό μονοπώλιο της ΔΕΗ στην δημιουργία μίας ανταγωνιστικής αγοράς. Αυτό είχε σαν αποτέλεσμα την είσοδο νέων παικτών και την περαιτέρω ανάπτυξη των ανανεώσιμων πηγών ενέργειας στον κλάδο της ενέργειας. Με αυτόν τον τρόπο, η λιανική αγορά ηλεκτρικής ενέργειας έγινε περισσότερο περίπλοκη, με τους παράγοντες που ασκούν επιρροή σε αυτή να αυξάνονται σημαντικά.

Κύριος σκοπός αυτής της εργασίας είναι μέσα από την ανάλυση του τρόπου λειτουργίας της λιανικής αγοράς ενέργειας στην Ελλάδα, όπως καθιερώθηκε μετά την απελευθέρωσή της, να δημιουργηθεί το πλαίσιο ώστε να υπάρξει καλύτερη κατανόηση των κύριων παραγόντων που συμμετέχουν σε αυτή, επηρεάζοντας την τιμή της ηλεκτρικής ενέργειας. Οι μεγάλες ανάγκες που υπάρχουν σχετικά με την κατανάλωση ηλεκτρικής ενέργειας από επιχειρήσεις και νοικοκυριά, έχουν κάνει πιο επιτακτική από ποτέ την ερμηνεία της επιρροής αυτών των παραγόντων, προκειμένου να γίνει αντιληπτός ο τρόπος με τον οποίο διαμορφώνεται η τιμή του ηλεκτρικού ρεύματος.

Εκτός από την συσχέτιση των πολλαπλών τεχνολογιών παραγωγής ηλεκτρικής ενέργειας με την διαμόρφωση της τιμής της, μεγάλη σημασία έχει επίσης και το μείγμα ενέργειας της αγοράς, το οποίο αποτελεί το σύνολο της ενέργειας που παράγεται από διάφορες πηγές ενέργειας και τεχνολογίες, προκειμένου η προσφορά να καλύπτει τη ζήτηση και να υπάρχει ισορροπία στην αγορά.

Τέλος, για να γίνει περισσότερο αντιληπτή η δομή της αγοράς ηλεκτρικής ενέργειας και οι συνθήκες που επικρατούν σε αυτή, μέσα από την εργασία αυτή θα παρουσιασθούν οι ανάγκες που οδήγησαν στις αλλαγές στον κλάδο της ενέργειας καθώς και η ιστορική εξέλιξή του.

Table of Contents

Abstract	vi
Περίληψη.....	vii
Table of Contents	viii
List of Figures	x
List of Tables.....	xi
List of Abbreviations & Acronyms	xii
1. Introduction	1
2. Historical evolution of the Greek wholesale electricity market	4
2.1 Introduction	4
2.2 The past monopoly role of PPC	4
2.3 Liberalization of electricity market	5
2.4 Hellenic Energy Exchange	6
2.4.1 Producers and Traders involved in the Greek wholesale energy market	7
2.4.2 The importance of IPTO as an operator	8
2.4.3 The role of RAE as a regulator of the energy market	8
2.4.4 The price formation within the Hellenic Energy Exchange	9
2.5 Conclusion.....	10
3. Literature Review	11
4. Empirical Study.....	14
4.1 Data selection	14
4.2 Relationship between Day Ahead Load and Price	14
4.3 The influence of wind and solar energy	17
4.4 Generation Mix	20

5. Conclusion.....	25
References	28

List of Figures

Figure 1: Demand and Supply Curves	16
Figure 2: Total percentages of each technology’s contribution to Energy mix	23

List of Tables

Table 1: Regression Model for Day-Ahead Load Forecast and Price	15
Table 2: Results of the Multiple Regression Analysis	18
Table 3: Comparison of R-square	20
Table 4: Total Hourly Energy Generation of each Technology	22

List of Abbreviations & Acronyms

ENTSOE: European Network of Transmission System Operators for Electricity

EU: European Union

HEnEx: Hellenic Energy Exchange

IPTO: Independent Power Transmission Operator

MCP: Market Clearing Price

PPC: Public Power Corporation

RAAEY: Regulatory Authority for Energy, Waste & Water

RAE: Regulatory Authority for Energy

RES: Renewable Energy Sources

TSO: Transmission System Operator

1. Introduction

The price of electricity is a very important factor of every country's economy. The households and businesses rely to a great extent on electricity for their daily operation, covering their basic and other needs through the use of electricity. Therefore, the price of electricity is a factor that concerns and affects all citizens of contemporary societies as well as the companies. As far as the price of electricity in Greece is concerned, it is very important to understand the factors that affect the price of electricity, since it is a subject of increased interest, especially in recent years, due to the rise in the cost of electricity which was caused mainly by the rise in the prices of crude oil and natural gas, which led to the emergence of the global energy crisis in 2021.

The purpose of this dissertation is to contribute to the understanding of the structure and the way in which the electricity market operates, as well as to the analysis of the factors that influence the wholesale electricity prices in Greece. The importance of dealing with this issue is great, mainly because of the complexity that characterizes the industry of electric power in Greece, especially after the liberalization of the electricity market and the ever greater development of the culture that focuses on the increase in the use of renewable energy sources.

Regarding the methodology and the general approach that has been used during the preparation of this thesis, it could be described as a combination of a quantitative study with empirical study, which is based on the processing of various data that have been collected and are related to the factors that affect the price of electricity.

More specifically, with the application of simple and multiple regression models as well as other statistical tools, an attempt is made to interpret the influence that some of the most basic parameters have on the prices in the electricity market. However, in order to further understand and analyze the results obtained through this process, we also have to refer to the main characteristics, the structure and the legal and regulatory framework that is connected with Greek electricity market.

After the processes carried out, the results that have been obtained help us to achieve a better understanding regarding the subject being examined. Among the many conclusions which we can draw from the results of the methodology that has been used, it is worthy to mention some of the most fundamental, such as the fact that there is a positive relationship that connects the daily ahead price of electricity with the forecasted load. Another finding that emerged through the analysis of the appropriate data is the complexity that characterizes the way in which the price is formed, influenced by many factors at the same time, such as the generation of electricity through different technologies and renewable energy sources.

In addition, it should be noted that there are some limitations related to this work. For example, the data used to derive the final conclusions, refer to a sample and it extent to a limited period of time, as the collection and processing of all historical data related to the subject of this dissertation is practically impossible. Thus there is a reasonable limitation regarding the range of the data and related information used. Concerning the historical data used, there is a possibility that there are not accurate, leading to confusion and false outcomes. Also, the wholesale electricity market in Greece is vulnerable to great changes and it can be easily affected by unexpected phenomena and circumstances. A typical example of such unpredictable phenomena is the outbreak of the Covid-19 pandemic, as well as the war in Ukraine. Another potential limitation is that the electricity market contains a lot of indicators or drivers, which results in the subject becoming more complex, since only a part of the total amount of the fundamental drivers can be selected and used in order to reach a conclusion.

In the second chapter of this dissertation, the evolution of the electricity market in Greece will be presented, through the historical retrospect of the significant events that took place and forced these changes. Reference will also be made to PPC and its monopoly role and the transition to the liberated market that was adopted based on the regulations of the European Union. An analysis of the role of RAE will be then followed as well as an explanation of how the price is being set under the Hellenic Energy Exchange (HEEnEx).

This will be followed by the third chapter which deals with the literature review, which consists of the reference to previous work, articles and analysis that have been done in the

past and which are related to the subject of this dissertation. This chapter in combination with the 2nd chapter aims to enable the reader to gain the background knowledge needed to understand the issue and the empirical study that follows in chapter 4.

The empirical study is presented in the fourth chapter, in which there is an analysis of the relationships between different factors, such as the relationship between Load and Renewable energy sources with the price of electricity. The analysis of these relationships that result from data processing applying regression model and statistical methodology leads useful conclusion to be made. Finally, from the interpretation of the results of the 4th chapter, the main conclusion that emerged regarding this topic is presented.

2. Historical evolution of the Greek wholesale electricity market

2.1 Introduction

In order to better understand the changes that took place in the energy market in Greece, it would be useful to present a historical analysis in this topic, which extent from the role and operation of PPC as a natural monopoly to the current situation that is formed after the liberalization of electricity market. This historical review will contribute on clarifying the reasons that create the imperative need for the transition to a new modern era in the energy branch, as well as to better interpret the way in which this branch operates nowadays.

2.2 The past monopoly role of PPC

Electricity appeared in Greece in 1889. Initially, small private companies were responsible for the production of electricity. This resulted in high prices of electricity due to the high cost of production. Thus, the need to reduce the high cost of production came into sight, which would result in the reduction of the price that the consumers had to pay In order to have easier access to that product. This situation led to the establishment of PPC in 1950 by the Greek government. (Karampalikas, 2006)

Since its establishment, PPC's main goal was the production of electricity that would cover the ever-increasing requirements and demands of the residents of the Greek territory. In addition to the production of electricity, PPC took over the responsibility of the transmission of electricity throughout Greece, with the gradual connection of urban areas to its network, which until then did not have access to electrical energy. Responsible for the effective way in which PPC was operating as a public company was the Greek government. The reason for the government's involvement in supervising the smooth operation, production and distribution was the fact that electricity is an economic good of primary importance for all consumers and businesses and therefore its price should be maintained at low level, in order all citizens can make use of this precious commodity.

The presence of PPC in the electricity sector of Greece, gained even greater significance through the large investments in very important projects and technologies that took place, and which resulted in the existence of economies of scale in the electricity market. This means that the greater the increase in production, the greater the decrease in costs per unit that is produced. Therefore, the existence of economies of scale led to a decrease in the

price that consumers and companies had to pay for electricity. (McGee, 2014) The most essential investments in the field of electricity concerned the construction of power plants for the generation of electricity from the burning of lignite, as well as the construction of hydroelectric dams. Thus, having the possibility to invest in big projects and technologies in order to reduce the cost of production, PPC established itself as a natural monopoly in energy production, transmission and distribution.

2.3 Liberalization of electricity market

The role of PPC as a natural monopoly with the supervision of the Greek state changed since the need for the liberalization of the energy market became imperative. In 1996, the European Union (EU), through the publication of legislative packages, began making efforts to create an energy market in which competition would arise. The regulatory framework on which the smooth transition to the liberalization was based was very important, in order for the entry of new stakeholders to take place, resulting in increasing the competition. Also, these EU regulations aimed to the implementation of the perception focuses on the protection of the environment and the reduction of pollution.

According to Directive 96/96/EC, the energy market had to be led towards liberalization, so that consumers could choose among many providers those who are in their best interest. This condition would strengthen the entry of new companies in the energy sector, which could deal with the production and supply of electricity, while transmission and distribution could be implemented through the already existing network of PPC. (Alexis Meletiou, 2018) The legislative package was formatted and voted by the Greek parliament with the law 2773/1999.

Afterwards, the second energy package published in 2003. The purpose of this package was to accelerate the pace of market liberalization in relation to the first package, with encouraging the entry of even more participants in the competitive electricity market. With the application of this package, EU aimed at further security in the existence and efficient operation of the balanced market and at upgrading the importance if appropriate control by the regulative authorities of each country, which have been responsible for the application of these regulations. Also, with these legislative measures EU encouraged the expansion of markets from national to cross-border level. It is worth mentioning that through the second energy package, such specific targets were adopted for the first time in terms of environmental protection. With the 20-20-20 program, the EU set as a goal the variation of 20% in the reduction of carbon dioxide emissions, 20% in the increase in the participation of renewable energy in the energy mix, as well as the 20% increase in the efficiency regarding the energy sector. (A.Ispolinov, 2013)

In Greece, the adoption of the provisions of the second energy package took place through the passing of the law 3426/2005 by the Greek parliament, in accordance with which the role of Regulation Authority for Energy (RAE) was significantly strengthened as a control mechanism for compliance with the relevant law.

The strengthening of the role of regulatory authorities and the adoption of an even stronger environmental perception by the markets, were the main areas of interest as mentioned in the 3rd and 4th energy packages. With the adoption of these packages, the effort to increase the participation of renewable energy sources in the energy mix was further increased. In addition, through these energy packages, long term environmental goals were set.

The environmental goals set by the 3rd and 4th energy packages, were also the main topic of the 5th energy package. More precisely, the 5th package, otherwise known as "Fit for 55", set even more specific and ambitious environmental targets, which extend to 2030. These targets relate to the reduction of the carbon dioxide emissions, the increase of the influence of RES in the energy market and the imposition of additional measures for the compliance in these targets as determined by the EU's environmental legislation. (Nouicer, 2020)

2.4 Hellenic Energy Exchange

In order for Greece to adapt to the policies of the European Union and to the contemporary reality that was formed in the energy sector after the significant changes created as a result of these policies, the need to effectively implement these changes in a national level became of essential importance. For this reason, the Hellenic Energy Exchange S.A (HEnEx) was established in 2018, in order to contribute to a better organization of the market after the entry of various new participants into it. Its establishment was a consequence of the participation of Greece in the European energy market, which was formed through the directives of the EU, with the aim of organizing the operation and coordination of cross border trading and increasing transparency and competition.

The existence of different electricity generation technologies in each European country, as well as the increased penetration of RES in the energy branch, contribute on offering the ability of achieving the balance between demand and supply, This indicates the importance of cross border trading. Moreover, cross border trading provides to the European countries the possibility of having access to networks of remote countries, thus reducing the cost of meeting the ever increasing demand by utilizing the energy produced by the RES that operate in other European countries. For this reason, cross border trading reinforces the percentage increase in the participation of RES in the energy generation, in relation to conventional technologies, through the adoption of common regulations and rules between the countries that participate in it. (Bahar, 2013) In addition to the increase

in energy production by using more and more RES in European countries, storage possibilities are also increased, especially in periods where there is a surplus of energy due to the fact that supply exceeds the demand. The access to storage facilities is very important for countries, because energy storage is very costly and presupposes the existence of specific projects and technologies.

Therefore, the establishment of the HEnEx took place in order to take on the role of increasing competition in the liberalized market and creating the context for the efficient connection with the countries participating in the European energy market. It is also worthy to note the main players participating in the Greek wholesale energy market, which among others is HEnEX , EnEX Clear which are operators, energy producers using RES or producers using non-renewable energy sources, suppliers, traders, TSOs and of course consumers. All these factors actively participate in shaping electricity prices, influencing the operation of the market with their actions and the decisions they make.

2.4.1 Producers and Traders involved in the Greek wholesale energy market

A fairly large number of companies are involved in the production of energy and its trading. In Greece, the main part of the production is held by PPC, which in the past, as a physical monopoly, had invested in important projects and therefore has the ability to produce significant amounts of energy. PPC owes its large production capabilities mainly to the power plants that are used for the burning of lignite in order to generate electricity. It also has an active participation through the production of wind and solar energy, as well as other RES. Nowadays, PPC is partially private, with the Greek government having less influence in its operation than in the past, as it occupies the minority of its shares. The reasons for its privatization mainly relate to the compliance with the regulations of the EU, related to the liberalization and the increase of its economic efficiency. (Errunza, 2000)

Apart from PPC, many other large companies play a significant role in the development of the energy sector. The most important of them are Mytilineos S.A, Protergia, GEK Terna and Elpedison. The involvement of these companies with renewable energy sources to a large extent made them the main factors in the energy production in Greece. It is also indicated by their presence, their contribution in the successful development of the competitiveness in the industry, by being complied with EU directives and policies, with the aim of creating low carbon economies. With the entry of these players, after the liberalization of the energy market, significant changes were observed in the energy mix of the Greek wholesale energy market, proving the importance of their economic activities.

Specifically, from statistics conducted, a 147% increase in energy production by using RES from 2014 to 2023 was noted, while RES are responsible for the 57% of the total energy generated in Greece for the year 2023. This percentage has a steady in the recent

years, thus leading to the Decarbonization of the production and decrease in the use of lignite and other conventional sources of energy. (IPTO, 2024)

2.4.2 The importance of IPTO as an operator

IPTO S.A is a transmission system operator (TSO) that operates in Greece by complying with the 2009/72/EK Directive of EU. According to this directive, IPTO's action concerns electricity transmission by shaping the transmission system and owning the necessary assets needed to achieve this, as well as the appropriate human resources to support its operation. IPTO, which is also called ADMIE, is also in accordance with the European regulation responsible for maintaining equal terms and conditions for all interested and already existing users, ensuring transparency and objectivity. In these ways, the competition and the efficiency of TSOs such as IPTO are strengthened. (Vale, 2021)

Another indicator that shows how important IPTO is, is that it operates in such a way as to achieve balancing demand and supply in the wholesale electricity market, by making sure that it has at its disposal all the necessary resources to continue meeting the demand. Also, within the context of its role, decisions on long term investments are included, so that the company will continue to ensure the smooth functioning of the market. (IPTO)

In addition to what was previously mentioned in relation to the operation of the IPTO, a specific reference must be made to another significant part of its operation. Specifically, IPTO is responsible, as a member of ENTSO-E to publish every day the schedules of Day Ahead market as well as the schedules for the Intra-day market. The importance of publishing these schedules is primary, because with this way the public is provided with the possibility of accessing information regarding the Day Ahead Load or the levels of production of electricity during the day. Information is also published relating to the price of electricity per hour. (ADMIE)

For all these reason, the operation of IPTO maintains a major role in the Greek wholesale energy market. In order for it to operate in term of transparency, the supervision of its operation by regulatory authorities such as RAE is necessary.

2.4.3 The role of RAE as a regulator of the energy market

RAE is a regulatory authority which operates in Greece and its main responsibility is the effective supervision of the market, in matters related to the production and supply of electricity and gas. Its operation is regulated EU policies, aiming to the separation between transmission and distribution of the electric energy.

Additionally, RAE or RAAEY as it is otherwise called, within the framework of its competences, has among others, the responsibility of the proper supervision of TSOs through which the compliance of TSOs with a combination of EU and Greek government regulations is ensured. This results in creating the appropriate conditions for the development of competition under forming fair terms for all participants. These

regulations concern trading, control of the market operation, as well as waste management and water supply. Also, they allow equal access to information and data for all of those who are participating in this market. (RAE)

2.4.4 The price formation within the Hellenic Energy Exchange

The participation of various factors with energy activity in this market, results in the need of a proper coordination, in order for the market to function independently and efficiently. For this reason, RAE gave this authority to the Hellenic Energy Exchange in 2018. HEnEX's responsibilities include the compliance with the "Target Model", which have to be efficiently adopted by all European Union members, based on the respective regulations regarding cross border trading. The Target Model refers to the combination of 4 submarkets which leads to the formation of a single price for the energy mix of the European market. It is worth mentioning these 4 markets, which are the Day Ahead market, the Intra Day market, the Balancing market and the Forward Market.

HEnEx gives the opportunity to wholesale market participants to submit their bids and offers related to the purchase and sale of electricity on its platform. In more details, with regard to the formation of the price of electricity in the Day Ahead market, the participants submit their bids and offers for delivering power in any of the 24 hours of the following day. Thus, in this way the quantity demanded and offered as well as the price level that satisfies demand and supply are determined.

Subsequently, the role of HEnEx is to process the data resulting from the total supply and demand of energy for the following day. This is how the Market Clearing Price (MCP) is determined, which is the point where the supply curve intersects the demand curve. The supply curve has been shaped by the bids from energy producers, while the demand curve has been shaped by the offers of consumers and companies that are active in the supply of electric energy. This sequence of events is taking place for every hour of the Day Ahead Market and HEnEx is responsible for ensuring transparency and equal treatment of the participants, for whom the same prices apply. (Georgikakis, 2006)

In the case of the Intra Day market, the participants are able, after accessing the data obtained regarding the Day Ahead market, to make the decision of changing their bids and offers using the forecasts that have been performed. Therefore, adjustments are also made considering the price within the day.

Another submarket that is regulated by HEnEx is the Balancing Market, which is also the subject of IPTO, as mentioned in the relevant subchapter. IPTO contributes on balancing the supply and demand throughout the day, so that there is no shortage or surplus at the market.

Finally, the fourth submarket is the Forward market, which was launched in 2020 and which allows wholesale market players to sign long term contracts, in order to avoid the

risk of a potential increase in the price of electricity in the future. Therefore, the participants can protect themselves from price fluctuations by negotiating a fixed price. (Makrygiorgou JJ, 2023)

2.5 Conclusion

The development in the Greek energy market in recent years, have been significant. From the monopoly of the electricity generation and supply, the market led to the liberalization of the wholesale market and the entry of various participants. Also, with the adoption of EU regulations and policies, as well as the increased implementation of RES into the production of energy, the reality in the energy branch changed to a great extent.

All these important changes made more imperative than ever the need for a transparent and smooth functioning market, controlled by the HEnEx, in which all the participants determine with their decision, their bids and offers the levels at which the price will fluctuate.

3. Literature Review

The formation of the price of electric energy through its influence by various factors has been a very interesting topic since the liberalization of the market. A lot of researchers are involved in the study of the relationships between price and those factors. Karakatsani and Bunn, through the use of regression models, drew the conclusion that in order any model to contribute on providing accurate forecasts about the price, other factors affecting the electricity price should also be taken into account. (N.Karakatsani, 2008)

A very important effort to evaluate the main models used for electricity price forecasting was made by Aggarwal et al. This study is a continuation of the comparison efforts made in the past regarding the best price forecasting model. It includes the comparison of the results of the heuristic, statistical and simulation methods of forecasting regarding the electricity prices. The conclusion drawn is that the models used for the short term forecasts of price need further development and that none of them have a clear advantage over the rest. (Aggarwal, 2009)

Wallace and Fleten were involved in the study of effectiveness in the use of the stochastic dynamic programming in the production of electricity, in the context of regulated markets. As far as deregulated markets are concerned, they argued that the entry of new participants in the competitive energy market has led the deregulated market more complex. Also, a reference was made in the absence of an ideal methodology for electricity price forecast. (Stein W. Wallace, 2003) In the efforts to find an efficient forecasting model, the study of Quaresma et al is also very useful. By using mainly autoregressive models and by processing hourly data of electricity prices, they led to the conclusion that the quality of the price forecasts would be improved if the forecasting models will be used separately for each hour of the day. (J. Contreras, 2003)

Knittel and Roberts contributed significantly with their study, in which they refer to the inverse leverage effect, which concerns the increase in price volatility when positive shock in price is occurred. Also, with the use of ARMA and EGARCH models, the conclusion that is drawn is that in order to develop better forecasts models for electricity price, other factors affecting the price must be taken into account too. (Knittel & Roberts, 2005) Niimura also conducted a study regarding forecast methods of electricity price, by collecting data for the methods used in the British market from 1990 and after. This study considered to be of primary importance as it contains a large volume of papers, which refer to the forecasting models that were used to predict electricity prices. (Niimura, 2006)

Another important study was conducted by Weron and Misiorek with the use of parametric and semiparametric methods, in order to examine the differences and

similarities of their results. In addition, a noteworthy conclusion came out of this study is the importance of taking into account factors related to weather conditions. (Rafał Weron, 2008)

Many studies have also contributed to the analysis of the wholesale electricity market in Greece. Such an important study is that of Adrianesis, where the Greek market is separated in relation to the results concerning other countries as it is considered to be a special case. Reference is made to ancillary services as an important factor in the energy market. Greek wholesale energy market is further analyzed with an emphasis on its special conditions, as well as the growing influence of RES in the energy field. (Panagiotis Andrianesis, 2011)

In the same direction concerning the analysis of the Greek energy market was also the study of Papaioannou et al. They made a significant contribution with the use of SARMAX and GARCH models, which are used for time series analysis, with the possibility of integrating exogenous variables, in order to conclude that the price is correlated with the time. Also, that study was very useful as an effort of analyzing the influence of the main drivers into shaping the wholesale electricity prices in Greece, after the implementation of new regulations. (George P. Papaioannou, 2018)

Useful conclusions have also emerged from the study of fundamental drivers by Setaridis et al. In the context of this study, an analysis was made of the main drivers in the energy markets of countries such as Belgium, Italy, France, Poland, Spain and Portugal. Specifically, with the use of forecasting models for hourly data, significant results are provided about the formation of the Day Ahead Price, through its relationship with the Day Ahead Load Forecast as well as the forecasted production of wind and solar energy. The conclusion reached is that the forecast of renewable energy generation negatively affects the hourly price, while it has a stronger effect on the determination of the price. Reference is also made to the importance of energy production through RES in terms of reducing the risk of large fluctuations in price. (Seitaridis MI, 2021)

It is worth mentioning that the study conducted by Thomaidis and Biskas made a great contribution to the understanding of the rules governing the pricing of electricity in Greece. Using panel models, they reached the conclusion on the way in which the price is affected from the influence of the main drivers in the wholesale energy market. Additionally, with the creation of an alternative form of panel model, the responsiveness of the price to possible changes in the conditions in the energy market was estimated. The main conclusion that emerged from this alternative type of panel model is that linear models are not the most suitable method for estimating the responsiveness of the price in possible changes in the energy market. (Nikolaos S. Thomaidis, 2021)

Finally, the present work confirms the complexity of the contemporary Greek wholesale electricity market and focuses on the study of the main drivers that affect price. Through

the reference to the relationships between Day Ahead Price and the main drivers such as Load and energy generated by RES, as well as the technologies of energy production participating in the energy mix, useful conclusions emerge, which will be further analyzed in the following chapters. With the conduction of this empirical study, it becomes evident that there is a need to develop methods that could accurately estimate responsiveness of the price to any type of change that may occur in the energy market.

4. Empirical Study

4.1 Data selection

In order to develop the conditions of reaching the safest possible conclusions, it is of essential importance to choose the appropriate data. In this case, the online site of ENTSOE was used to collect the respective data. ENTSOE refers to the participation of 40 Transmission System Operators (TSOs) in the European energy market. It refers to a collective effort of member companies that operate as a single entity with the common goal of the transmission of high voltage power, providing the opportunity for participants in the wholesale electricity market to make a better use of information and data.

To be more specific, the data provided by ENTSOE is a reliable source of information, as ENTSOE is complied with the legislation established by the EU, thus ensuring the transparency and accuracy of the data. (ENTSOE) Due to the fact that a very large volume of historical data is available, it is inevitable to use a part of the total data which help us derive the most accurate results. For this reason, the range of the data used during this empirical study is 4 years, and more precisely, it concerns hourly data collected for the period from 1st January 2020 to 31th December 2023. The main criteria for the selection of this time period, was the data to be representative of the total population of the data. By choosing a sample which includes data of 4 years, it has been taken into account that the examined quantities vary hourly, seasonally and during periods where various unexpected events occur that affect the price of electricity. Some examples of such an event was the rise in COVID 19 pandemic, the war in Ukraine and the trend of de-escalation of the electricity prices in 2023.

4.2 Relationship between Day Ahead Load and Price

The first topic that will be analyzed in this empirical study is the relationship between Day Ahead Load and Price. To be more specific, the relationship of these two variables concerns the influence that the Day Ahead Load Forecasts have on the determination of the price of the Day Ahead Market. The reason we deal with the Day Ahead market is that due to the high and ever increasing competition between companies that are active in the electricity production and distribution market, the possibility of these companies to have access to reliable forecasts for the next day's electricity price, is more important than ever. For this reason, many efforts have been made so that with the use of the most modern and developed technology, the prediction can be more accurate. (Li, 2021) Also, due to the high cost and difficulty of storing electrical energy in the wholesale electricity market, it is inevitable in this market that there is a balance between supply and demand, a fact which made the possibility of accurately prediction regarding the next day's price a matter of primary interest. (Reinier A.C. van der Veen, 2016)

As far as the Day Ahead Load Forecast is concerned, it is a short term forecast and the way it is determined refers to the historical data of corresponding days of the year. Also, for this forecast, a few other factors are taken into account, such as the weather, the conditions formed through the relationship and interaction between the countries, as well as the expected energy production and consumption levels. The variable Forecasted Load actually refers to the demand and it is a matter of great interest for the companies and other players that are participating in this market, as it is connected to their profitability which is the main purpose of all companies. (Lorenz Jan C. Crujido, 2023)

Using the hourly data that have been collected for the Day Ahead Forecasted Load and Price regarding the period from 1st January 2020 to 31 December 2023, we apply 24 Regression models, one for each hour of the day. The results that are exacted from the 24 Regression models are combined and presented in Table 1.

Hours	Coefficient of Day-ahead Total Load Forecast	P-Values	R Square
00-01	0,0203	0,000000003	0,024
01-02	0,0182	0,000000223	0,018
02-03	0,0172	0,000000147	0,019
03-04	0,0166	0,000002782	0,015
04-05	0,0145	0,00011	0,010
05-06	0,0145	0,00040	0,009
06-07	0,0184	0,000002024	0,015
07-08	0,0182	0,000000675	0,017
08-09	0,0165	0,000000588	0,017
09-10	0,0135	0,000004199	0,014
10-11	0,0121	0,00001	0,014
11-12	0,0132	0,0000001	0,019
12-13	0,0151	0,0000000004	0,027
13-14	0,0172	0,00000000000002	0,039
14-15	0,0166	0,00000000000003	0,036
15-16	0,0158	0,0000000001	0,028
16-17	0,0167	0,000000001	0,025
17-18	0,0162	0,0000001	0,020
18-19	0,0148	0,00002	0,013
19-20	0,0118	0,00451	0,006
20-21	0,0087	0,03467	0,003
21-22	0,0127	0,00054	0,008
22-23	0,0154	0,00001	0,013
23-00	0,0197	0,000000003	0,024

Table 1: Regression Model for Day-Ahead Load Forecast and Price

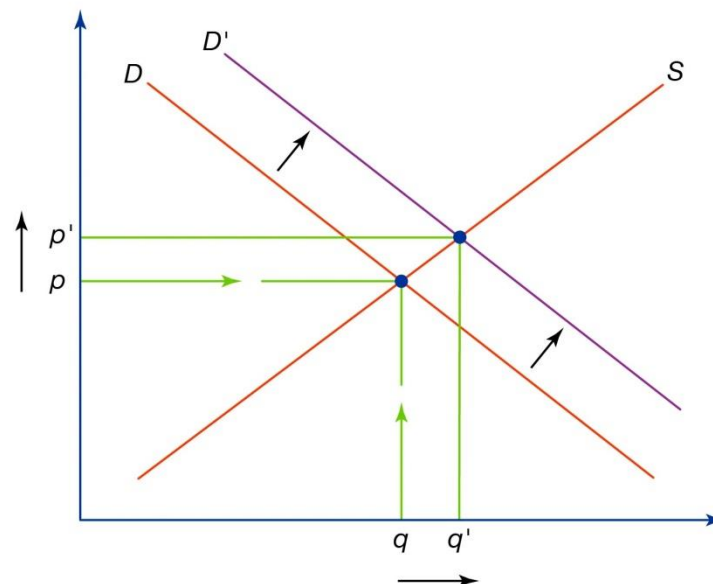
The function of this Regression model is: $y = a + b \cdot x$, where y is the dependent variable (Day Ahead Price), x is the explanatory variable (Day Ahead Forecasted Load), a is the intercept point between y and x axis, and b is the slope of the function. (Norzima Zulkifli, 2012)

What we observe by analyzing the results of the Regression mode as presented in Table 1, is that for all hours of the day the correlation between these two variables is statistically significant at a p-value of 5%, since the p-value per hour is much smaller than 0.05. Consequently, the probability of a correlation between the dependent variable, which is the Day Ahead price, and the explanatory variable, which is the Day Ahead Load Forecast, is strengthened.

From the values of the coefficient of Load Forecast we conclude that the relationship between price and demand is positive because the slope is what determines the relationship between two variables. Therefore, the higher the expected demand for electricity, the higher the expected price in the corresponding hours.

The positive relationship between Load and Price can also be interpreted through the law of supply and demand. As a result, the prices tend to move towards the equilibrium point, where the demand curve intersects the supply curve. At this point, energy consumers are willing to absorb the amount that producers are willing to produce. (Buzoianu, 2005)

A shift in demand



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Figure 1: Demand and Supply Curves (Britannica, 2024)

As we can observe from Figure 1, if demand increase then the demand curve moves to the right and as a consequence intersects the supply curve S at a new point, which is the new equilibrium point. At new equilibrium point, the price is increased in comparison with the price in the previous equilibrium point. Therefore, we reach the conclusion that an increase in demand leads to an increase in price.

Having confirmed the positive relationship that connects price and demand, it is important to mention the fact that there are many factors that affect the price of electric energy to a great extent, apart from Load. This is demonstrated by the fact that the coefficient of determination R-square has relatively small values, which means that the price is not absolutely related with the demand and there are various factors that must be also considered.

4.3 The influence of wind and solar energy

Due to the conclusion that price and load are not absolutely correlated and in combination with the fact that there are differences in this relationship depending on the time, it would be useful to examine hidden variables that affect the price of electricity. Such factors are, among others, RES that are responsible for the production of electrical energy through various technological methods and more specifically those related to weather phenomena, such as the production of solar and wind energy. Wind energy is harnessed using various technologies such as solar, thermal and photovoltaic technologies, which take advantage of the sun, its heat and radiation, for the production of electricity. There are many different technologies that utilize the sun, which are useful in production as well as in saving natural resources and protecting the environment from ecological destruction. (Maniatis, 2022)

Wind energy refers to the production of energy resulting from the utilization of the wind through the use of turbines that are placed on land. There are many benefits from the development of wind farms. The most important are the ease of installation of the wind turbines, the relatively low cost of the development of such farms, as well as the very low percentage of carbon dioxide emissions resulting from their activities. (Belachew Desalegn, 2023) For these reasons, it seems that in the future, wind energy sources will obtain an even greater share in the production of electrical energy, which will further expand with the introduction of new technologies. (Şahin, 2004)

By introducing these two variables, the influence of the weather conditions on demand and Price is taken into account. As a consequence, we will use the Excel tools to perform Multiple Regression models for the dependent variable of the Day Ahead Price and the explanatory variables of Day Ahead Load Forecast and hourly Forecast of Day Ahead Renewable Energy Generation, which is the sum of the Day Ahead Forecasts for the generation of wind and solar energy. The results obtained from the Regression Analysis are presented in table 2.

Hours	Coefficient of Day-ahead Total Load Forecast	Coefficient of Day-ahead Renewable Energy Generation	Day-ahead Total Load Forecast (p-value)	Forecast of Day Ahead Renewable Energy Generation (p-value)	R Square	Significance F
00-01	0,0200	-0,0043	0,00000001	0,2562	0,0246	0,00000001
01-02	0,0178	-0,0060	0,00000041	0,0949	0,0201	0,00000037
02-03	0,0171	-0,0061	0,00000019	0,0659	0,0210	0,00000019
03-04	0,0163	-0,0075	0,00000394	0,0202	0,0186	0,00000115
04-05	0,0144	-0,0073	0,00012311	0,0254	0,0136	0,00004770
05-06	0,0147	-0,0058	0,00033127	0,1066	0,0103	0,00051723
06-07	0,0184	-0,0006	0,00000201	0,8738	0,0154	0,00001244
07-08	0,0181	0,0073	0,00000086	0,0806	0,0188	0,00000095
08-09	0,0165	0,0106	0,00000054	0,0041	0,0225	0,00000006
09-10	0,0137	0,0080	0,00000277	0,0081	0,0191	0,00000076
10-11	0,0124	0,0057	0,00000375	0,0278	0,0172	0,00000321
11-12	0,0133	0,0038	0,00000010	0,1214	0,0205	0,00000029
12-13	0,0151	0,0027	3,43E-10	0,2686	0,0273	1,669E-09
13-14	0,0172	0,0010	2,5E-14	0,6823	0,0394	1,9E-13
14-15	0,0167	-0,0016	2,4E-13	0,5386	0,0362	2,15E-12
15-16	0,0160	-0,0037	8,74E-11	0,1939	0,0290	4,83E-10
16-17	0,0169	-0,0051	1,03E-09	0,1496	0,0261	4,12E-09
17-18	0,0162	-0,0037	0,00000007	0,4278	0,0201	3,728E-07
18-19	0,0147	0,0031	0,00001915	0,5777	0,0127	0,000088321
19-20	0,0117	0,0064	0,00467493	0,2697	0,0063	0,00964867
20-21	0,0088	0,0025	0,03317411	0,6416	0,0032	0,09649203
21-22	0,0126	-0,0013	0,00059304	0,7897	0,0082	0,00243173
22-23	0,0154	0,0008	0,00001180	0,8524	0,0131	0,00006710
23-00	0,0197	-0,0011	3,98E-09	0,7893	0,0239	2,21E-08

Table 2: Results of the Multiple Regression Analysis

The coefficients of the Day Ahead Load and Day Ahead Renewable Energy Generation indicate the sensitivity of Day Ahead prices to changes in these variables. This means that for the period 00:00am to 01:00am, as far as the Day Ahead Load is concerned, if the predicted value of this variable increases by 1 MWh, the Day Ahead price of electricity is expected to be increased by 0.02€/MWh. The exact same explanation can be used for the Day Ahead RES Generation. If Day Ahead RES Generation for the same period of time increases by 1 MWh, then the Day Ahead Price is expected to decrease by 0.0043€/MWh. Also, from the data of the above table, it is evident that the p-value of the overall model obtains values smaller than 0.05 during each hour of the day, with the sole exception of

the interval 8pm to 9pm, where the p-value is 0.096 which is greater than 0.05. This means that with the exception of this hour interval, during the rest hours of the day, the model is statistically significant. Therefore, the Null Hypothesis is rejected, because according to the Null Hypothesis there is no relationship that connects the examined variables. So, the alternative hypothesis is accepted. The alternative Hypothesis is the exact opposite from the Null Hypothesis, which means that there is a relationship connecting the aforementioned variables.

Regarding the p-values of the individual explanatory variables, the p-value of the Day Ahead Load Forecast receives values that are lower than 0.05 during all hours of the day. That leads to the conclusion that the explanatory variable of Load is statistically significant regardless of the hour interval, in predicting the explanatory variable of Day Ahead Price.

Furthermore, the p-value of the explanatory variable of Day Ahead Renewable Energy Generation is greater than 0.05 during most hours of the day. This fact indicates that this variable is not statistically significant in terms of the interpretation of the Day Ahead Price variable.

For all these reasons, it would be useful to compare the values of the coefficient of determination R-square for each of the 2 regression models that have been performed and whose results were presented in tables 1 and 2. By comparing those two results, we can find out whether the variation of the Day Ahead Price variable, which is explained by the explanatory variables has increased or decreased. The comparison of the coefficients of determination of each model is presented in Table 3. (Figueiredo, 2011)

Hours	R Square (Table 1)	R Square (Table 2)
00-01	0,0237	0,0246
01-02	0,0182	0,0201
02-03	0,0188	0,0210
03-04	0,0149	0,0186
04-05	0,0102	0,0136
05-06	0,0086	0,0103
06-07	0,0154	0,0154
07-08	0,0168	0,0188
08-09	0,0170	0,0225
09-10	0,0144	0,0191
10-11	0,0139	0,0172
11-12	0,0188	0,0205
12-13	0,0265	0,0273
13-14	0,0393	0,0394
14-15	0,0359	0,0362
15-16	0,0279	0,0290

16-17	0,0247	0,0261
17-18	0,0197	0,0201
18-19	0,0125	0,0127
19-20	0,0055	0,0063
20-21	0,0031	0,0032
21-22	0,0082	0,0082
22-23	0,0131	0,0131
23-00	0,0238	0,0239

Table 3: Comparison of R-square

Interpreting the data presented in Table 1, the first observation one can make is that the coefficient of determination shows a relatively small increase in the second Regression model (Table 2) in relation to the values of R-square of the first model. This implies that there are other factors that must be taken into account in order to create a model which will be characterized by a strong predictive value.

As far as the slopes of the two variables are concerned, after observing the data analysis presented in Table 2, it appears that Forecasted Load has a positive effect on next day's Prices. This observation confirms the results presented in Table 1, where the results regarding the relationship between Load and Price were the main topic. However, it should be noted that the explanatory variable related to the generation of energy from solar and wind sources, in some cases has a positive relationship with the price, while in some other cases it has a negative relationship. One of the main reasons why this happens is that the generation of solar energy is higher during morning hours and until the afternoon, reaching its peak mainly during 1pm to 2pm. The production of wind energy is higher usually until early afternoon and is influenced to a great extent by the prevailing climatic conditions and seasonality.

In order to interpret the result which refers to the existence of both positive and negative relationship between the production of RES and the price, further analysis should be conducted regarding the existence of other RES which actively participate in energy production, affecting Price.

4.4 Generation Mix

Electricity generation mix is a very essential term which refers to the total of the energy sources that participate in the production of electricity. These sources also consist of fossil fuels, such as natural gas, lignite and anthracite. Lignite is a fossil fuel that has an important role in the Greek electricity production. It represents a large part of the production since the foundation of PPC. However, the increase in carbon dioxide emissions caused by its use is a significant disadvantage comparing to most coals. For this

reason, brown coal, as lignite is also called, is considered a fuel with a significant environmental impact, and efforts are being made through legislation to reduce the pollution caused by its combustion. (Kavouridis, 2008)

Another fossil fuel that is responsible for large percentages of energy production is fossil gas, which is extracted through drilling and then converted into energy. Its use is widespread, because its price is lower compared to other fuels. However, its use leads to the same disadvantage as lignite, which is the pollution of environment caused by CO₂ emissions.

Apart from fossil fuels, renewable energy sources participate significantly into shaping the generation mix, occupying a large share of the total energy production in the market. With not including wind and solar energy, which have been further analyzed in the previous subchapter, other important RES are Hydro pumped storage and Hydro pumped water reservoir.

Hydro pumped storage refers to the use of two water reservoirs with the main purpose of storing the energy produced, in order to be utilized for future conversion into energy. Thus, these two reservoirs gather water which is converted into energy by using technology, when there is a need for more electricity. So, it plays a key role into covering the demand through the increase in supply of electric power, when it is needed. (Hunt JD, 2020) Therefore, hydro pumped storage has a great contribution on achieving balance between demand and supply in the energy market, providing stability in the energy sector especially during peak hours. Its ability to quickly adapt to a possible increase in demand is vital in order to avoid blackouts at business and households, which rely on the use of electricity to a large extent. (Lazar Šcekic, 2020) Despite all these benefits and solutions offered by the existence of this RES, the construction of water reservoirs and the rest of the supporting structures in quite time consuming and requires large investments to be completed. (Zvirgzdins, 2020)

As far as the reservoir hydroelectric power is concerned, it is a RES that deals with the production of electricity through the use of turbines and the release of water, the flow of which is controlled by the hydroelectric dam. It is a RES with many advantages such as the reduced carbon dioxide emissions caused by its operation. However, there are some disadvantages that impede its development to a large scale. The most important disadvantages are the high cost required for the construction of such a project and the fact that it causes flooding in its surrounding areas, worsening the quality of live for the citizens who live near them. (Askari, 2015)

Having analyzed the importance and some fundamental characteristics regarding the operation of some of the most basic energy sources that participate in the Energy mix, the results that indicate the total hourly energy production of each of these technologies, including wind and energy sources, are presented in Table 4.

Hours	Fossil Brown coal/Lignite	Fossil Gas	Hydro Pumped Storage	Hydro Water Reservoir	Solar	Wind Onshore
00-01	865.742	2.914.596	7.861	203.126	279	1.450.635
01-02	847.667	2.621.119	6.956	181.297	271	1.462.511
02-03	841.684	2.472.080	6.962	166.390	254	1.482.772
03-04	839.176	2.402.834	7.304	171.910	213	1.503.697
04-05	837.425	2.408.177	8.129	207.644	6.527	1.520.501
05-06	849.100	2.548.786	12.908	319.980	17.959	1.531.127
06-07	875.494	2.909.403	58.177	563.683	187.872	1.523.869
07-08	895.570	3.148.733	109.290	729.604	834.585	1.479.570
08-09	899.772	3.149.376	116.104	746.367	1.750.204	1.441.337
09-10	895.727	3.026.827	82.335	649.482	2.506.189	1.419.193
10-11	887.378	2.906.962	55.135	518.329	2.993.433	1.417.878
11-12	885.366	2.874.581	40.709	462.999	3.212.336	1.426.781
12-13	889.351	2.880.774	37.285	444.482	3.187.670	1.447.106
13-14	888.674	2.854.315	34.577	393.976	2.938.609	1.468.633
14-15	889.099	2.960.158	35.789	396.537	2.455.077	1.487.129
15-16	903.090	3.176.604	47.512	460.858	1.779.993	1.502.471
16-17	917.675	3.492.995	96.170	654.331	1.087.599	1.504.946
17-18	934.690	3.836.590	221.460	934.196	503.404	1.486.718
18-19	947.944	4.046.258	359.772	1.184.936	139.457	1.468.582
19-20	954.282	4.116.993	430.594	1.306.591	21.049	1.464.202
20-21	951.258	4.048.259	374.545	1.190.564	5.787	1.458.818
21-22	937.069	3.831.542	241.670	905.203	71	1.445.049
22-23	916.860	3.617.541	98.853	625.537	82	1.441.556
23-00	892.887	3.253.157	26.474	339.737	300	1.443.837

Table 4: Total Hourly Energy Generation of each Technology

The data referring to these energy production technologies are collected by ENTSOE, which provides via its platform all users with valuable data, in order to ensure transparency. (ENTSOE) From the data of Table 4, we can draw conclusion about the percentage of participation of each technology in the energy mix.

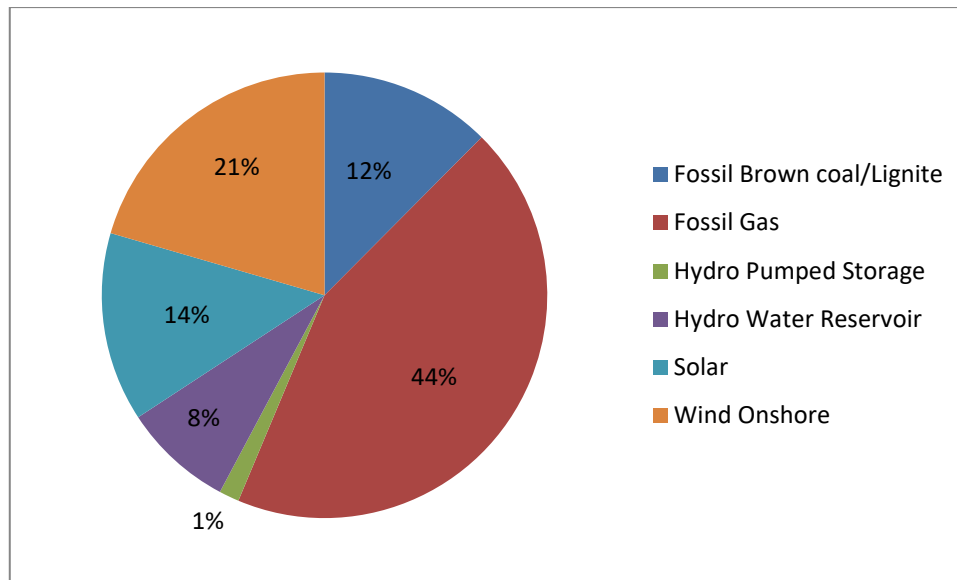


Figure 2: Total percentages of each technology's contribution to Energy mix

One of the conclusions that emerged from the analysis of the statistical results of Table 4 is that the fossil gas is the factor that has the highest percentage of energy production(44%), throughout the duration of the day and consequently in total too. The production of electricity by utilizing the wind energy is responsible for the 21% of the total percentage of production in the energy mix, based on the data collected for the period 1/1/2020 to 31/12/2023. Hence, wind energy is an important factor in the energy market, with high percentages in energy contribution during all day.

Solar energy has quite an influence on the energy market, being responsible for the 14% of the total production. Despite that, its production during the day is characterized by significant fluctuations. According to the results of Table 2, the influence of electricity generation from wind and solar sources to the formation of the Day Ahead prices alternates between positive to negative. The reason why this happens is that the large share of energy production through solar and wind sources leads to variability in the electricity prices, because the production from wind and solar farms is significantly affected by the weather conditions and seasonality. For example, during summer months where due to

high temperatures peak demand is observed, the sunny weather allows the increased generation of energy from solar sources, which results in solar energy generation having a crucial role in meeting the increased demand. Therefore, in that situation, the generation of solar energy has a negative effect on Day Ahead prices, which means that an increase in energy generation from solar farms leads to a decrease in price. With the same way, generation of wind energy is influenced by weather conditions.

Energy production through the combustion of lignite is very important as it has an active participation (12%) in the energy mix during the day, which is mainly due to the investments that have been made in the past from PPC and some private companies. Renewable energy sources such as Hydro pumped storage and hydroelectric reservoir seems to contribute relatively less than the rest of the energy sources participating in the energy mix. Even so, their presence in the energy market is useful, due to the fact that these RES contribute significantly to balancing demand and supply.

Consequently, we come to the conclusion that the relationship between the Forecast of Day Ahead Renewable Energy Generation and Day Ahead Price varies from positive to negative, mainly because of the fact that there are many production technologies available, which sometimes are affected by different phenomena such as weather conditions. Also, some of these technologies are characterized by fluctuations in terms of hourly energy production. This indicates that these factors affect the total production of energy in a different way during the day.

5. Conclusion

The present work is an original study of the wholesale electricity market in Greece, in which an analysis of the main drivers that affect the price of electricity is made. Firstly, an analysis of the current situation in the energy market has been made, including the changes that took place in the energy market during the last 15 to 20 years. The main reason for these changes was the need for the separation of the activities such as production, transmission and distribution of electricity, as well as the transition to an energy market characterized by the participation of companies who would invest more in renewable energy sources. This transition started with the voting of the EU directives by the Greek parliament. In these directives, some of the main points of emphasis were the imperative need for the liberalization of energy market and the participation of EU countries in a combined network in order to achieve a better organization of the energy production, through the adoption of an approach towards the increased participation of renewable energy sources in the production of electricity. The main goal behind the implementation of this approach was the effort of EU to navigate EU countries towards the reduction in the carbon oxide emissions, which are mainly created due to conventional methods of energy production, such as the combustion of lignite in Greece, during the time in which PPC had a monopolistic role in energy production and distribution.

In the effort of this transition towards a market where the primary role on the energy production would be obtained by renewable energy sources, the encouragement for the entry of new players in the electricity market had a positive impact. Competitiveness is of great significance for the wholesale energy market, as it contributes a lot to the formation of lower prices, which benefits both consumers and businesses. In Greece, although there has been considerable improvement regarding the decrease in the use of lignite and the development of renewable energy sources, a great deal of effort is still needed in order to achieve the goals that have been set until 2030. These goals are related to the achievement of an increased efficiency in the production, reduction of CO₂ emissions and enhanced participation of renewable energy sources in the energy mix.

In the context of achieving the goals set by the directive of EU, an effort has been made to separate production from distribution, through the operation of IPTO, which mainly

contributes to the effectiveness in electricity transmission and the transparency in providing equal terms to all interested participants. The operation of IPTO is supervised by RAE, which has been established by the Greek government to oversee compliance with the directives and policies of the EU and, at the same time, with Greek legislation. RAE has given HEnEx the responsibility of implementation of the transparent way in which the drivers in the electricity market competing with each other. As a result, the drivers of the Greek wholesale electricity market developed their activity by competing with each other on the basis of providing better quality and prices, driving electricity price to decrease.

Some very important conclusions emerged from the empirical study regarding the influence of the fundamental participants on the price. Initially, by studying the influence of the forecasted Load on the Day ahead price, the conclusion which was reached is that the greater the Load, the greater the price. So, these two variables are connected with a positive relationship. However, observing the values of the coefficient of determination, it became evident that there is no absolute correlation between these two variables, a fact that indicates that there are latent variables that affect Day Ahead Price. A possible latent variable that affects electricity price is the weather conditions. In order to investigate the effect of this variable to the formation of the price, wind and solar energy are integrated in our study. The outcome of this integration indicates that the forecasted production of wind and solar energy combined, has a dual effect on the price of electricity, as it can either affect the price positively or negatively. With the last part of the empirical study, in which the energy mix is the main topic of interest, it became apparent that the reason of the existence of this dual effect is the differences in the participation of various technologies and energy sources in the generation of electricity throughout the day.

Finally, the overall conclusion of this study is that energy market is very complicated and any attempt to interpret the relationship between a factor of energy market with the price without taking into account the rest of the parameters related to the energy mix, is strongly possible to be led into drawing conclusions that are not absolute and therefore characterized by uncertainty.

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