ISTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SOCIAL SCIENCES

GENERATION COSTS AND MARKET POWER IN THE TURKISH ELECTRICITY MARKET

M.Sc. THESIS

Gamze CAN

Economics Department

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GENERATION COSTS AND MARKET POWER IN THE TURKISH ELECTRICITY MARKET

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Gamze CAN, a **M.Sc.** student of ITU Institute of Social Sciences student ID 412101009 successfully defended the thesis entitled "**GENERATION COSTS AND MARKET POWER IN THE TURKISH ELECTRICITY MARKET**", which she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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To TÜBİTAK,

FOREWORD

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SUMMARY

Price volatility and market manipulability lie at the heart of the debates over electricity economics all around the world. The associated uncertainty undoubtedly creates an inefficient environment for the economy to operate.

Knowing these concerns, this thesis primarily aims at estimating the short-run supply function of electricity generation of EUAS, the producer responsible for %40 of Turkish electricity generation, in order to provide a basis for the analysis on the ongoing electricity market characteristics of the country. While doing so, it uses the fundamental models, i.e., competitive pricing and competitive benchmark model as the main tools and it follows the lead of Wolfram(1999) and Müsgens(2004)as methodological guides.

The findings present an opportunity to discuss whether there is exercisable market power in Turkish electricity generation or not and if yes what might be done to mitigate it. This study also cracks open the door for future research on evolving Turkish electricity market.

TÜRKİYE ELEKTİRİK PİYASASINDA ÜRETİM MALİYETLRİ VE PİYASA GÜCÜ

ÖZET

Bütün dünyada dalgalı fiyatlar ve manipülasyona açık market yapısı elektrik ekonomisi tartışmalarının merkezinde bulunmaktadır. Fiyatlar ve market yapısıyla ilişkili belirsizlikler piyasanın çalışması için verimsiz koşullar yaratmaktadır. Bu verimsiz çevreyi değiştirmek adına son 20 yıldır çeşitli ülkelerde atılan adımlar rekabetçi piyasa yapısının sağlayabileceği faydaları, marketi yeniden yapılandırmak suretiyle, elektrik endüstrisine sunmayı amaçlamaktadır. Yeniden yapılandırmanın ilk öne çıkan örneklerini sergileyen İngiltere ve İskandinav ülkeleriyle 1990'larda başlayan bu çalışmalar kısa zamanda dünyayı etkisi altına almıştır. Bir zamanların devlet tekeline muhtaç addedilen elektrik endüstrisini rekabetçi bir piyasaya kavuşturmada bugüne kadar ciddi yol kat edilmiş olsa da bu başarının derecesi hala tartışmaya açıktır ve daha çok ülke bazında değerlendirmeye tabi tutulması gereken bir husustur.

Temelde araştırılan konular, şimdiye kadar ne boyutta bir rekabetleşmenin gerçekleştiğinin ölçümüne ve rekabetleşme sürecini hızlandırmak için daha fazla neler yapılabileceği üzerine yoğunlaşmaktadır. Bu sürecin önünde engel teşkil edebilecek, elektrik piyasalarının dizaynında göze çarpan bazı kusurları tespit etmek ise kritik önem taşımaktadır. Bu noktada, elektrik arz ve talep mekanizmasının nasıl çalıştığı önce teşhis edilmelidir. Bu tezde Türkiye'nin elektrik üretiminin 2011 yılı itibariyle %40'ını gerçekleştiren EUAS'ın kısa dönemli arz fonksiyonu inşa edilecektir. Bunu yaparken de Wolfram'ın 1999 yılında İngiltere ve Wales üzerine yazdığı çalışmadaki yöntem ve rekabetçi gösterge modeli benimsenecektir. EUAS'ın monopoli gücünü ölçmek için de bir dizi konsantrasyon ve market gücü ölçüsü içinden Lerner Index seçilmiştir.

Elektrik enerjisinin bütün çağdaş üretim teknolojilerinde ana girdi olması, fiyatlarındaki kontrolsüz iniş çıkışların ve manipulasyona açık piyasa karakteristiklerinin direkt olarak bütün sektörleri, hatta bütün piyasa unsurlarını etkileme gücüne sahip olduğuna işaret etmektedir. Diğer enerji ürünleriyle karşılaştırıldığında da elektrik enerjisinin daha çok sorunla başa çıkmaya çalıştığı aşikârdır. Elektrik depolanamaz olmasıyla bile birçok stratejik davranışa maruz kalabilmektedir. Bu sebeplerle, elektrik ekonomisini problemli ve şeffaf olmayan bir şekilde işlemekten kurtarmak amacıyla elektrik arzı üzerine talebi üzerine olandan daha çok çalışma yapılmasına ihtiyaç duyulmaktadır. Türkiye elektrik piyasası literatüründeki bu noktada karşılaşılan eksiklik ise bu tezin konusuna karar vermede itici güç olmuştur.

Elektrik arzını daha iyi tanımak için öncelikle elektrik endüstrisinin alt dallarını bilmekte fayda vardır. Yapısal olarak bu endüstri dört segmentten oluşmaktadır. Bunlar, üretim, iletim, dağıtım, ve perakende sektörüdür.[1] [2] Bu dörtlüden üretim segmenti bu tezde arzı en iyi yansıtan taraf olarak mercek altına alınmıştır. Maliyet kelimesinden ifade edilmek istenen de üretim maliyeti olmuştur. Geri kalan üç segment, toptan elektrik fiyatları üzerinde hatırı sayılır etkileri olabilmelerine karşın analizden hariç tutulmuştur.[3]

Bu tezde analize başlarken yapılacak ilk iş EUAŞ termik elektrik üretiminin marjinal maliyetlerini hesaplamak olmuştur. Bunun için ilgili elektrik üretiminde kullanılan yakıtın ısıl kalite bilgisi, birim fiyatı ve elektriği üreten jenaratörün verimliliği bilgileri kullanılmıştır. Hidroelektrik santrallerde ise marjinal maliyet hesaplamasına gidilmemiştir. Birçok akademik çalışmada söz konusu olduğu gibi hidro kaynaklı elektrik üretiminin marjinal maliyeti yok denecek kadar az olmasına dayanarak yok kabul edilmiştir. Marjinal maliyetler elde edildikten sonra ise arz eğrisi çizimine geçilmiştir. Artan marjinal maliyetlere göre kümülatif olarak hesaplanan EUAS arz eğrisi noktalarının oluşturduğu basamak fonksiyonlar 12 ay için ayrı ayrı yorumlanmış ve EUAS'ın ülkenin elektrik tüketiminden payına düşen talep edilen gerçekleşmiş miktarlarla kesiştirilmiştir. Bu kesişimden gelen fiyatlarla piyasada ilgili dönem için gerçekleşmiş fiyatlar karşılaştırılmak suretiyle yürütülen analiz

[1] Türkiye'de dağıtım ve perakende sektörü şimdilik birlikte çalışıyor olsa da kısa zaman içinde bunların ikiye ayrılması beklenmektedir.
[2] Bu listeye bazı diğer segmentler eklenebilir, comisyonerlik ve finansal tacirlik gibi.
[3] Bağlantılılık analizleri için bkz: Gilbert, Neuhoff, ve Newbery (2002) ve Mohtashami and Mashhadi (2009).

neticesinde EUAS'ın (hidroelektrik gücü kapasite kullanım oranıyla termil gücü ise emre amadelik oranıyla değerlendirildiğinde) eğer piyasada rekabetçi bir yapı hükmediyor olsaydı 2011 yılının on ayında piyasa fiyatından yüksek maliyetle çalışan santrallere sahip olmuş olacağı görülmüştür. Lerner Index değerleri hesaplandığında ortaya çıkan yüksek market gücü potansiyeli ise EUAS'ın piyasa gücünü elinde bulundurmasına rağmen bunu çok fazla kullanmadığına, fiyatı sadece kontrollü olarak yukarı çekiyor olabileceğine, hidroelektrik gücü azımsandığında yılın bazı dönemlerinde zarar etmeyi bile göze alarak çalışabileceğine, fiyatları yukarı çekme eylemini de piyasaya yeni giren küçük çaplı ve yüksek marjinal maliyetli özel elektrik firmalarına destek sağlamak amacıyla yapıyor olabileceğine işaret etmiştir. Bu yorumların hepsinin 2011 yılında Türkiye elektrik üretimi piyasasında rekabetçi bir piyasa yapısı söz konusu olsaydı anlamlı olacağı da çalışma boyunca akılda tutulmuştur. Bu tez Türkiye elektrik piyasasının geleceği ile ilgili net bir önerme sunamamakla birlikte, özelleştirmelerin neticesinde oluşacak olan yeni üretici tablosunun hidroelektrik ve doğal gaz üretimi arasında üretim kaynakları açısından nasıl bir kompozisyona sahip olacağının maliyet ve dolayısıyla fiyat yönetimi açısından büyük önem taşıyabileceğini ortaya koymuştur.

1. INTRODUCTION

Price volatility and market manipulability lie at the heart of debates over electricity economics all around the world. The associated uncertainty creates an inefficient environment for the economy to operate. All attempts to eliminate these problems, beginning with the reforms first launched in Great Britain and Scandinavian countries by the year 1990, have targeted the provision of the benefits of competition to the market through restructuring of electricity industries. Yet, the degree of accomplishment has remained controversial and as a country-specific phenomenon (IEA, 2011).

The major discussions on the issue concentrate on the possible answers to the question of to what extent electricity power industries have recovered from these volatility and manipulability problems so far and what else can be done for further improvements[4]. Thus, it is critically important to be able to measure the level of competitiveness in these markets and comment on some basic flaws in the market design. For this purpose, how the electricity supply and demand mechanism works must be diagnosed first. The present thesis primarily aims at estimating the supply function of electricity of Turkey a la Wolfram (1999) in order to provide a basis for the analysis on the ongoing market characteristics of the country. While doing so, it uses the fundamental models, i.e., competitive pricing and competitive benchmark model as the main tools.

The discussions on competition in electricity markets would be unwarranted if they had been suggested long ago. However, with the increased electricity consumption, decreased optimal scale in electricity production and the inability of the state to govern the changing patterns of production and consumption, the transformation process -from state-owned monopolies to privately held enterprises- has begun in

[4] Some recent discussions in media can be found on the following links:
http://www.economist.com/node/18959084
http://www.marketwatch.com/story/resa-encourages-consumers-to-include-shopping-for-energy-as-part-of-black-friday-and-holiday-shopping-rituals-2011-11-21
http://www.lancastereaglegazette.com/article/20111113/NEWS01/111130304/Power-options-growing-central-Ohio

1990s. In this relatively new era, privatization, deregulation, and vertical disintegration have been presented as the remedy for volatile prices and insecure market models by policy-makers whereas once the reverse features were deemed as the building blocks.

Along the two decades, the world has witnessed both success and failure stories in terms of adjusting to the new system and reaching efficient outcomes using these remedies for these markets. In this context, several electricity liberalization programs have been implemented throughout the world. Certain deregulation and restructuring packages that are all for the sake of cheaper prices for consumers and higher production efficiency for the producers have been introduced gradually. The electricity market results have been directed to converge to the ones of the competitive counterparts in order to overcome the monopolistic threats to the market efficiency and thus the obstacles confronting the consumers' wellbeing. With these kinds of efforts, it has been alleged that the market would turn itself into a more competitive form despite the intrinsic structural impediments and eventually it would get rid of the undesired outcomes wholly and for good. However, many countries have faced serious challenges during these liberalization stages[5]. Turkey, the focus country of this study, as many other countries, has gone and will be going through these stages as well, along with the sufferings stemmed from thorny adjustment processes.

Given the fact that electricity is a prominent input for almost every contemporary production process, it is salient that its volatile prices and manipulation-prone market characteristics directly influence all sectors and all kinds of agents in the economy. In other words, the malfunctioning of electricity markets has repercussions for most of other markets no matter how irrelevant they may seem. Besides, they are more inclined to have the aforementioned troubles than any other energy market (Borenstein, 2000). Electricity, unlike gas or oil, cannot be stored or rather it is too expensive to store it. This feature renders it more vulnerable to the abuse of market power since there is no chance to incorporate inventories into the picture as is in other markets when a producer attempts to employ strategic behaviors to increase the prices above the competitive levels. Hence it is crucial to investigate and supervise

[5] For California, UK, Norway, Alberta experiences see Woo C., Lloyd D., and Tishler A.(2003).

electricity markets deeply to reveal information on the market design and to protect the overall economy against the diverse problems incurred.

Structurally, electricity industry is composed of four functions: generation, transmission, distribution, and retailing[6]. Among these four major components of the industry, the one represents the supply side expediently is mostly the generation component as standing for the main determinant of cost. Through the course of this thesis, the supply side comprises solely electricity generation sector and what is meant by the cost is the generation cost. The other three are excluded from the analysis keeping in mind that they may have a considerable effect on the wholesale price formation in the electricity markets[7].

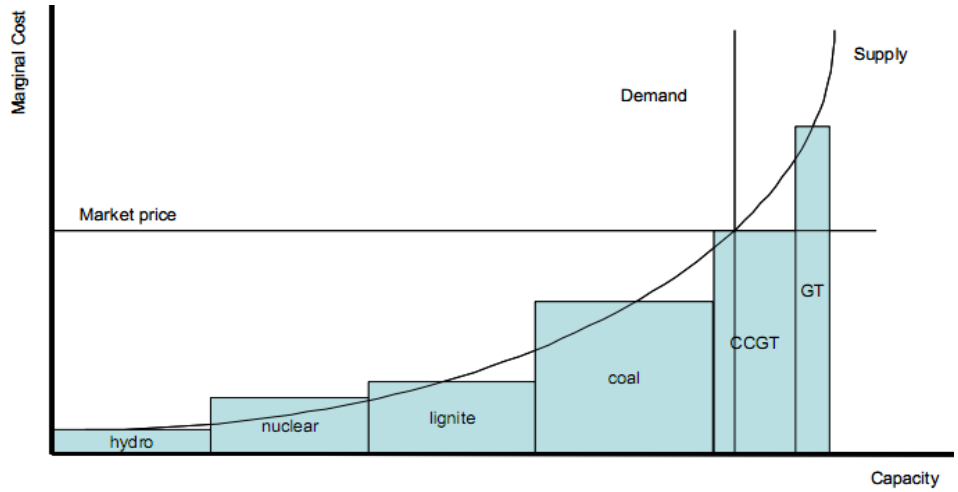

Figure 1.1: Price formation in competitive short-term electricity markets.[5]

Moreover, pricing in electricity markets is a complex process (Figure 1.1). As long as wholesale electricity trade is concerned, there are two traditional ways that the market sets a price for generated electricity: single price model and dual price model. In single price model, the price of electricity at which the system operator purchases electricity from generators is determined by the intersection of supply and demand at a given hour in a day-ahead market[8] and it is the same for all generators. In dual price market model, again there is a spot market but discriminatory pricing is allowed so that each producer may get a different amount of money determined

[6] Some other components can be added to the list such as commissioning and financial trading.
[7] For interconnectedness analyses see Gilbert, Neuhoff, and Newbery (2002) and Mohtashami and Mashhadi (2009).
[8] Day-ahead markets are the electronic organization where suppliers and demanders meet and in which hourly auctions take place as bids are presented for the each hour of the following day by the two parties.

accordingly to its cost structure. But this method is very open to speculations. It depends on good faith which is quite hard to monitor. A producer with a low marginal cost level may announce a price higher than it deserves to get. Monitoring process of these actions is very difficult to operate but once it is managed properly, this method may be superior to the single price auction one (Obuz and Yavaş, 2011). After all, it tenders more efficiency. Therefore, to find out some clues about the fairness of the price levels the pricing mechanism quest is the secondary objective of this market power analysis.

In this thesis, the supply side of the electricity market, as a predominant component of energy markets, will be scrutinized in order to demonstrate the current market formation and the pricing trend in Turkish electricity markets. Taking into account the fact that electricity market is peculiar in its economic characteristics, it is quite impractical to investigate it with the usual understanding of demand and supply. The primary task is basically twofold: to estimate the marginal cost function of electricity generation process at given production levels and to estimate the demand function for electricity to find out the prevailing prices. In doing so, one shall have the opportunity to calculate the market power which is inherently indicated by the price cost margin (i.e. (p- mc) / p). Also, comparing the results of the estimations with the actual ones provides the analytical framework to evaluate the existing prices properly. Then it is time to discuss the market structure that informs on whether there is exercisable market power in Turkey or not and what might be done to mitigate it. But before tumbling into all of these detailed examinations, there is a small part on Turkish Electricity Market that aims at presenting its historical background and thus introducing its main features to the reader.

2. TURKISH ELECTRICITY MARKET

Having observed various phases of worldwide restructuring in electricity markets, Turkey has undergone the first big venture into the liberalized electricity industry by the year 2001 with Turkish Electricity Law (Table 2.1).[9] The establishment of Energy Market Regulatory Agency (EMRA) with this law changed the whole profile of the sector. Public investment in electricity was prohibited and the need for new private investments was uttered strongly. Yet, the startup period has been marked by Electricity Sector Reform and Privatization Strategy Paper in 2004. Since then successive surges of privatization have been exhibited.

Table 2.1: Turkish Electricity Market (1970-2001).

1970	1984	1993	1994	1997	1999	2001
The Establishment of a Vertically Integrated Public Monopoly Company (TEK)	The Outset of Liberalization with the Law of Transfer and Operating Rights	TEK → TEAS TEDAS (both state owned enterprises)[10]	The Build-Operate-Transfer Law	The Law of Build Own Operate	The constitution allowed international arbitration in electricity generation	TURKISH ELECTRICITY LAW (The Establishment of EMRA)

Structural changes gained speed with the establishment of a Balancing Market (BM) in 2006 (Table 2.2). Day Ahead Planning Market (DAPM) followed BM. DAPM, which were in effect until December 2011, had a mechanism in which the market operator organized all hourly bids according to the predicted hourly demand for the following day. It also served as a preparation phase to ready the market for DAM.

Table 2.2: Turkish Electricity Market (2003-2012).

2003	2004	2006	2008	2009	Dec.2011	July.2012
Start of Financial Settlement	Virtual Application of Balance and Settlement Legislation (BASL)	**Financial Application of BASL**	Revised BASL	Day Ahead Planning Market and Privatization of Distribution	**Day Ahead Market**	Agreement with the European Energy Exchange on Forming the Turkish Electricity Exchange Market

[9] The milestones that paved the way for this law to be enacted illustrated in the Table 1.
[10] After 2003, the current state-owned bodies are: EUAS(generation), TEIAS(transmission), TETAS(wholesaler).

With the introduction of Day Ahead Market (DAM) in December 2011, demand side also joined the price determination process and the market operator stopped caring about the meeting of the demand and supply sides except for the balancing market which coordinates the real time balancing with the extra demand or extra supply in 15 minutes after the hourly auctions got settled (Figure 2.1).

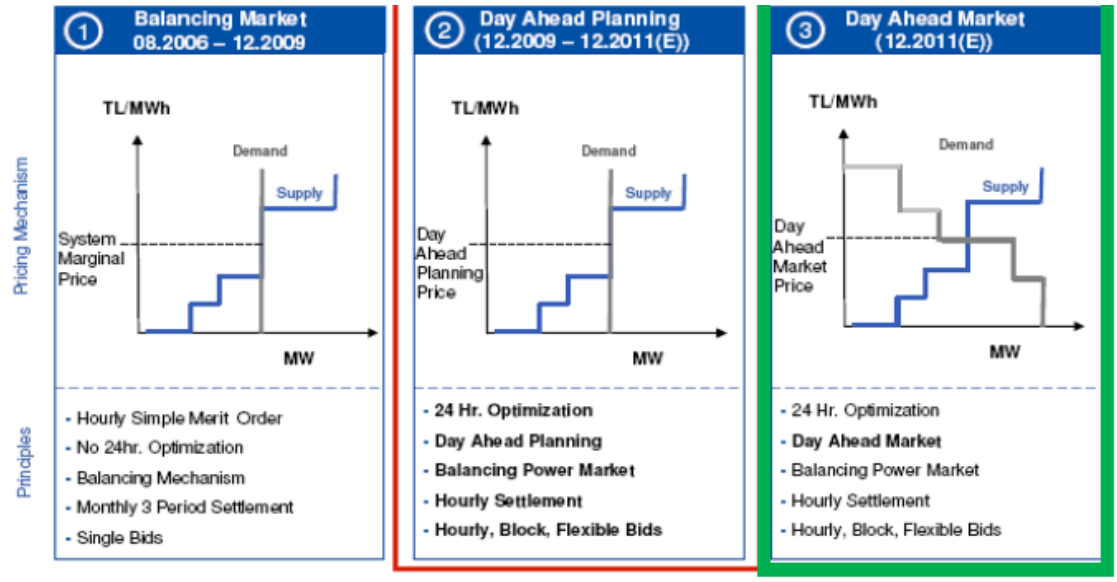

Figure 2.1: Market features in three different stages after 2006.

The monthly average price realized in DAM in December 2011 was 8.03 USc/kWh which was quite similar to the previous month's. This success proved DAPM's accuracy in price auctions.

While the competitive market is the focus of this thesis, it needs to be noted that bilateral contracts, signed out of the DAM, are still the main trade instrument in the market. Only about 25% of the trade is conducted via DAM.[11] On the other hand, over-the-counter applications are still so little and on the way to progress.[12]

At this point in time, financial aspects are of great concern. Turkish policymakers, appreciating the importance of private sector in meeting the increasing demand for electricity, made an agreement with European Energy Exchange to build a thorough energy exchange market in Turkey in July 2012.[13] It is expected that, once a financially viable and purely transparent energy exchange market is introduced, competition then will bring about good quality electricity at low prices to consumers.

[11] EUAS 2011 Yearly Report.
[12] VOB (Turkish Derivatives Exchange) started electricity trade with future contracts in September 2011.
[13] Turkish Electricity Transmission Corporation (TEIAS) signed the agreement.

Other than financial considerations, market power issue occupies the priority seat in the agenda. Turkey has experienced for last seven years a pricing system that has been heavily criticized on the grounds that it has served as a channel for the transfer of producer surplus to private producers (Erdoğdu, 2010). State-monopoly over the market is often blamed for high prices. EUAS tried to weather the critiques by expressing its sincere efforts to privatize the electricity production and distribution sectors. Some of these efforts bore fruits fast, especially at the distribution side. As of 2011, 43% of the electricity production has been carried out by private sector (Figure 2.3). It is planned that, at the end of the day, just 8000 MW-hydro electrical power of the industry will stay state-owned. Yet, not just that of Turkey, but most prices worldwide are still said to be above the level at where they are supposed to locate according to competitive market theory. The reason may not be necessarily the existence of market power but it is always a usual suspect. Hence, the ultimate goal of Turkey is to liberalize them all –except for some biggest hydroelectric power plants such as Atatürk and Keban due to strategic reasons- but the time span required for this to get fulfilled is quite unpredictable. The privatization of EUAS's thermal power-plants has begun in May 2009. Privatization process of the whole electricity distribution sector though is completed by 2011.[14]

Figure 2.2: Annual Turkish Electricity Generation and the Share of EUAS(GWh) .[13]

With fundamental portfolio privatizations of the power plants owned by EUAS, the share of EUAS in electricity production is declining gradually (Figure 2.2, 2.4). In 2011 EUAS's installed capacity change turned negative as desired. If privatization

[14] Distribution sector comprises retailing sector in Turkey. Recently they are planned to split into two.

plans come true without delays, negative rates will be the case for the coming years (Table 2.3).

Table 2.3: Development of Installed Capacity and Generation by EUAS.

Years	Installed Capacity (MW)	Installed Capacity (% Change)	Generation (GWh)	Generation (% Change)
2002	21,058	-0.03	77,332	-10.46
2003	21,785	3.45	63,097	-18.41
2004	21,790	0.02	68,018	7.80
2005	22,584	3.65	73,462	8.00
2006	23,716	5.01	84,530	15.07
2007	23,875	0.67	92,327	9.22
2008	23,981	0.44	97,717	5.84
2009	24,203	0.93	89,454	-8.46
2010	24,203	0.00	95,532	6.80
2011	24,150	-0.22	92,351	-3.33

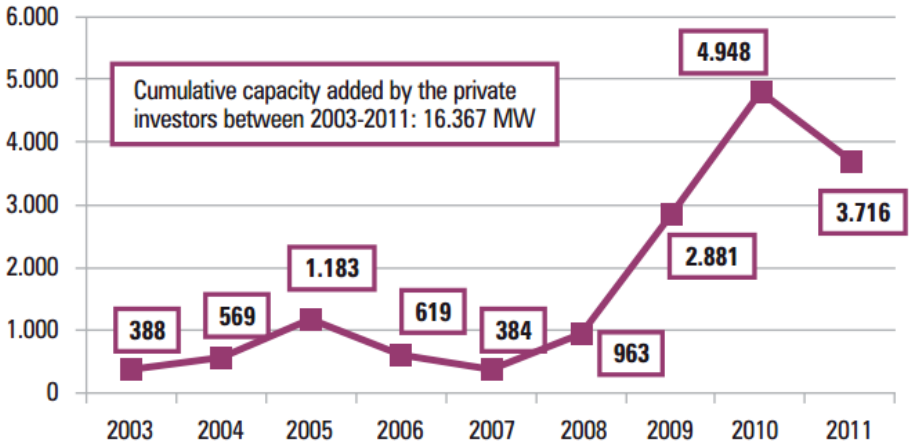

Figure 2.3: Capacity Added by Private Sector (MW, 2003-2011) .[13]

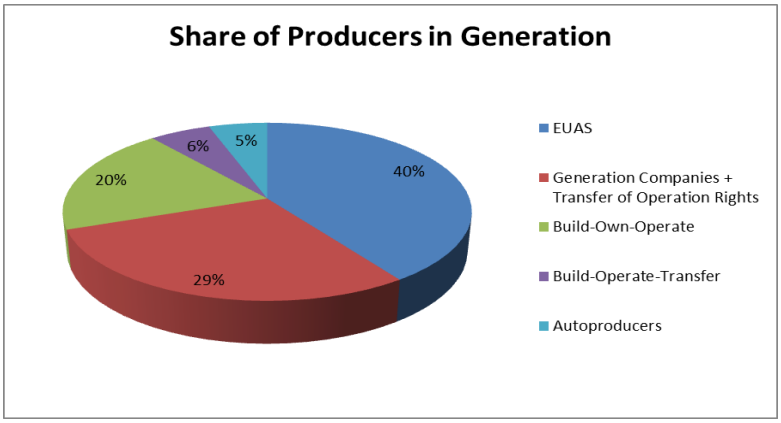

Figure 2.4: Share of producers in Turkey Electricity Generation (2011) .[13]

High prices cannot be just a consequence of manipulative behaviors. Production resources should also be investigated. In the case of Turkey, natural gas is a primary source of electricity production (Figure 2.5). As a natural-gas poor country, Turkish policymakers plan to reduce this share of natural gas in the generation to pull down the prices. They promote alternative generation techniques. A nuclear power station is on the way.

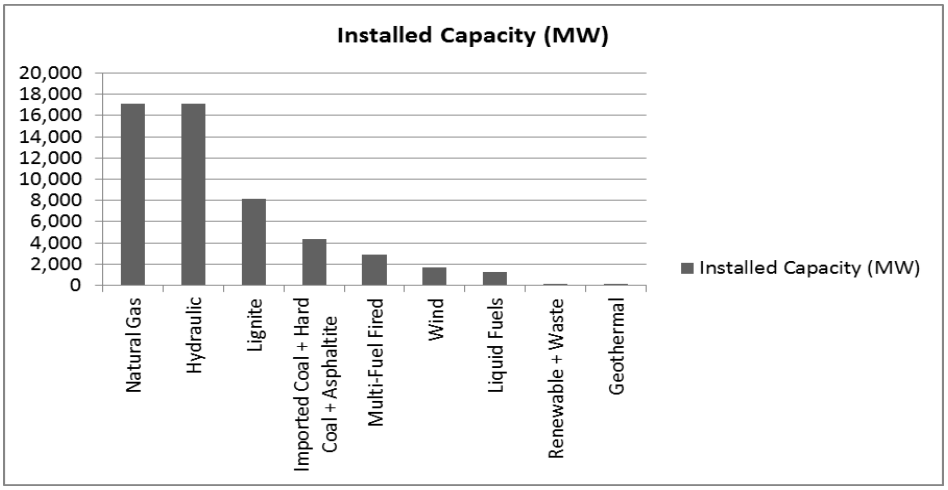

Figure 2.5: Share of the Resources in Turkey's Installed Capacity (2011).

There are few studies which discuss the probable consequences of further restructuring in Turkish electricity sector. Akkemik and Oğuz (2011) examined effects of liberalization on prices with conducting a general equilibrium analysis. They found that full liberalization, if political processes are ignored, would result in efficiency gains. The sector experiences around the world indicate that price increases are what is got after liberalization mostly because of the transformation process surrounded by the political processes mentioned. Hence Turkish policymakers will face a tough test while trying to reach the promised efficiency gains in the coming years.

3. LITERATURE REVIEW

Along with the deregulation and privatization stages, the move towards a competitive electricity market has been stimulated by reductions in the optimal scale in production and demand expansion (Dahl, 2004). Before, high sunk costs and demand uncertainty had discouraged potential investors and left the market as monopolistic for decades and average cost pricing -to cover these costs and risks- was mostly the case. As the market grew and evolved, restructuring mechanisms provided the producers with more eligible costs. The cost reductions associated with technological progress are also welcomed by the market participants (Christensen and Greene, 1976).

These improvements of economies of scale and demand expansion have culminated in the removal of the monopolistic trends. Once competition entered the picture, the question of the intensity of competition arose. Also, in this process, production efficiency is affected in such a good way that under-utilization of capacity of generation companies which accounts for speculative behaviors has lost its charm to a large extent (Maloney, 2001). In other words, in most cases, increasing competition means increasing use of idle capacity. Therefore, one may expect that growing competition results in a higher level of output.

Despite this promising progress towards the achievement of competitive targets, some sector specific features go on to seal the market's fate. According to Müsgens (2004), there are three critical points distinguished on the issue. First, electricity production is still capital intensive. Second, it has a quite inflexible and volatile demand. Third, it cannot be stored, or rather it is too expensive to store. Even today, the number of players is insufficiently small. Also, firm specific supply function creates extra problems such as worsening the already existing asymmetric information.

As is the case in this thesis, cost estimation has been the main task of the studies intended to measure the level of competitiveness in electricity generation. Since electricity production is capital intensive, much previous research has been predicated on the idea that average total cost was a better instrument to construct a zero economical profit condition (Cowing and Smith, 1978: Stewart, 1979). However, this approach has been abandoned in the cause of average variable cost as capital costs were subordinated and operating costs gained importance due to the capacity utilization concerns (Maloney, 2001). With flourishing competition, higher capacity utilization is supposed to result in a decline in the average variable cost. That is why Maloney (2001) reminds that any expansion in capital-based utilization affects the efficiency price via influencing production –variable- costs. Besides, Leuthold et al. (2008) claim that countries mostly produce more electricity than they need. This means in the short run, marginal cost, rather than average variable cost, can be a better estimate for a competitive market price due to the high possibility of peak demand periods with huge economic profits which are supposed to cover long-run costs in turn. Therefore, this thesis makes use of marginal cost calculations while estimating the short-run cost of generation.

One of the first studies that introduce the methodology of this thesis is the study of Wolfram on the electricity market of English and Wales in 1999. Wolfram, adopting the competitive benchmark model, constructed short-run supply functions of electricity for the years 1992, 1993, and 1994. She used cost information on fuel prices, heat content of fuels, available capacities of generators to find out the marginal costs of electricity production. Then she calculated price-cost markups and compared them with the ones produced by previously conducted Cournot and Supply Function Equilibrium Models. She concluded that other models had exaggerated the supposed market power and Lerner Index performed better at carrying out this task.

Following Wolfram, Borenstein et al.(2002) embraced this methodology to present a paper on California's structured electricity market. Also, the research of Joskow and Kahn (2002) deserves to be mentioned at this point on the grounds that it has also adopted Wolfram's approach and used the competitive benchmark model to find out the extent of market power in California. These successive studies help one understand the feasibility of the methodology of ex-post market power analysis.

Since the conclusions are based on not estimations but actualities, they can be used to make policies and prevent the current problems from festering.

As long as the cost determination in wholesale electricity markets is concerned, according to many, generation and transmission segments of the market should not be investigated separately. For instance, if there is no capacity left for electricity to get transmitted to the regional distributor, generator has nothing to do but to not to produce electricity and electricity prices will inevitably go up at least locally. However, due to lack of information on transmission constraints, this thesis will just afford to investigate the generation segment alone.

4. DATA

Data comprises all EUAS thermal (19) and hydroelectric (80) power stations in Turkey and it amounts to 24,150 MW installed capacity (Figure 4.1).

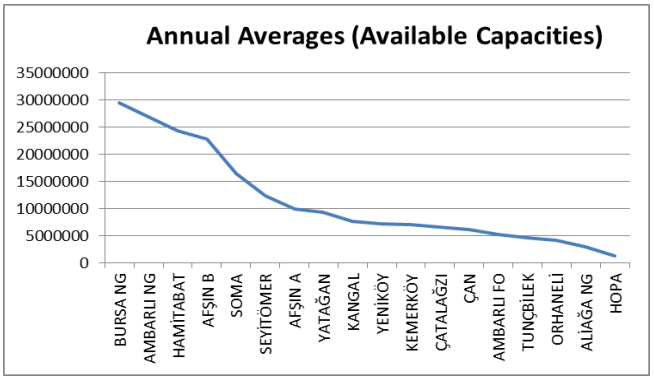

Figure 4.1: Available Capacities of EUAS Thermal Power Plants in 2011 (kWh).

As literally stated, market power is the ability to pull prices away from competitive levels with the intention of increasing profit (Mas Collel et al., 1995). Therefore, to decide on the extent of market power, the first task is to find out right competitive level for the price. This task requires estimating marginal costs of producers after obtaining related cost information on the production process. According to the cost function constructed in this thesis, the required data comprises unit fuel prices, the heat content of the fuels, generators'efficiency, installed capacities and available energy production levels for each day in 2011, the year of interest.

For the demand side, as a proxy for quantity demanded on the Turkish wholesale electricity market, KGUP stands for the best choice available for this thesis (Figure 4.2).[15]

[15] Source: Personal connections made with the authorities of EUAS.

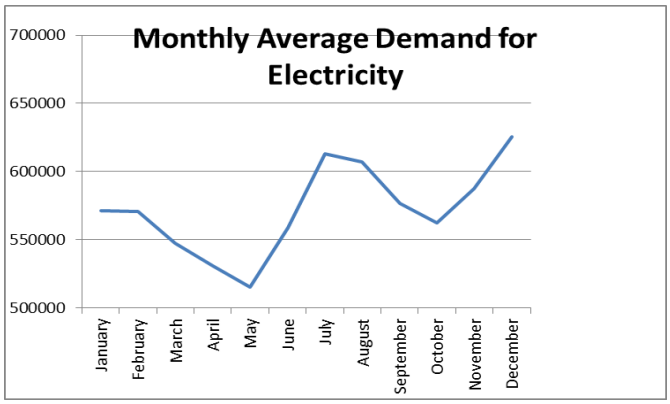

Figure 4.2: Monthly Average Demand for Wholesale Electricity in MWh(2011). [14]

5. MODEL & METHODOLOGY

The model calculates marginal costs of electricity generation using the method of competitive benchmarking. After estimating marginal costs, they are compared with observed prices. The spread between marginal cost estimates and observed prices accounts for the possible extent of market power. While measuring market power, several techniques are available. Among the traditional market power measures, such as Herfindahl-Hirschman Index (HHI) and the concentration ratio, Lerner Index (LI) is used to determine the extent of market power in this thesis.

Structurally, electricity industry is composed of four functions: generation, transmission, distribution, and retailing[16]. Throughout the course of this thesis, the supply side comprises solely electricity generation sector and what is meant by the cost is the generation cost. The other three are excluded from the analysis keeping in mind that they may have a considerable effect on the price formation in the electricity markets.[17]

In this thesis, conventional steam generation - coal, gas, and oil as fuel- is taken into account. In this respect, data on nineteen thermal power stations in Turkey is handled to model the cost function of electricity generation.[18] Also, hydroelectric power generation is included in the analysis with the assumption that they have zero short-run marginal cost.[19]

In this thesis, the value of 'heat rate times fuel price over heat content of fuel' constitutes the short run variable cost. In the light of marginal costs calculated from short run variable costs, the findings will enable one to make a comparison between the competitive price and the actual price and comment on the market power issue. Therefore, in terms of plant characteristics, one has to have information on heat rates, fuel prices, and energy contents of fuels burnt. Capacity factor is represented by the

[16] Other components can be added to the list such as commissioning and financial trading.
[17] For interconnectedness analyses see Gilbert, Neuhoff, and Newbery (2002) and Mohtashami and Mashhadi (2009).
[18] Data Source: EUAS.
[19] Reference to Talat Genç

generator’s available capacity at the time of interest while heat rate reflects the efficiency of electricity generation process and it is negatively related to it.

To sum up, the model calculates marginal costs of electricity generation and constructs a short-run supply function using the method of benchmarking (Fig.1). After determining the marginal costs, they are compared with observed prices. The spread between marginal cost values and observed prices accounts for the possible extent of market power.

6. RESULTS

EUAS has hydroelectric power generation which potentially has a paramount effect on prices. Its market power is higher at peak demand periods as expected. When the demand is moderate, its market power lessens a little bit. At low demand times, its market power diminishes to very low levels but it is still higher than zero (Table 6.1).

Table 6.1: Price-Cost Margins.

	(P-MC)/P		(P-MC)/P		(P-MC)/P
Peak Times		Moderate Demand Times		Low Times	
By Price Level		By Price Level		By Price Level	
Jul-11	0.528	Aug-11	0.506	Apr-11	0.250
Nov-11	0.451	Oct-11	0.430	May-11	0.270
Dec-11	0.444	Jan-11	0.498	Jun-11	0.242
Sep-11	0.459	Feb-11	0.425	Mar-11	0.385
By Quantity Level		By Quantity Level		By Quantity Level	
Dec-11	0.444	Sep-11	0.459	May-11	0.270
Jul-11	0.528	Jan-11	0.498	Apr-11	0.250
Aug-11	0.506	Feb-11	0.425	Mar-11	0.242
Nov-11	0.451	Oct-11	0.430	Jun-11	0.385

If available capacities for both thermal and hydroelectric power plants are used, there appears the absolute advantage of EUAS in determining prices. Since marginal cost of production is close to zero in hydroelectric power plants, market prices stay considerably higher than competitive prices during each month of the year. Besides, even though hydroelectric power plants' available capacity ratio is 90%, capacity utilization ratio dwells in 46%. Keeping in mind that hydroelectric power plants have the ability to store electricity with keeping water behind a hydro dam, EUAS may take advantage of its hydro sources in smoothing or increasing prices. In order to subdue hydroelectric power's potential effect on prices, hydroelectric installed capacity is multiplied by capacity utilization of these power plants in this thesis. In other words, rather than considering available capacity in the case of hydroelectric power plants, the real capacity is used throughout the year. Since there is no information on monthly electricity production levels of hydroelectric power plants, annual production is divided into 12 while conducting monthly calculations. As EUAS claims that it is trying to protect the high-cost private producers and new entrants from low prices, the capacity utilization ratio then may perform better to

reach a realistic market power exercise analysis. Hydroelectric power plants' huge effects are minimized to accomplish that goal.

Except for February and March, EUAS faces lower prices than its marginal cost of production.[20] This means that it goes on to stay on task at even shut down conditions if one ignores that the hydroelectric production is underestimated (Figure 6.1). Also it should be added that these high marginal cost levels are basically due to high unit natural gas prices.

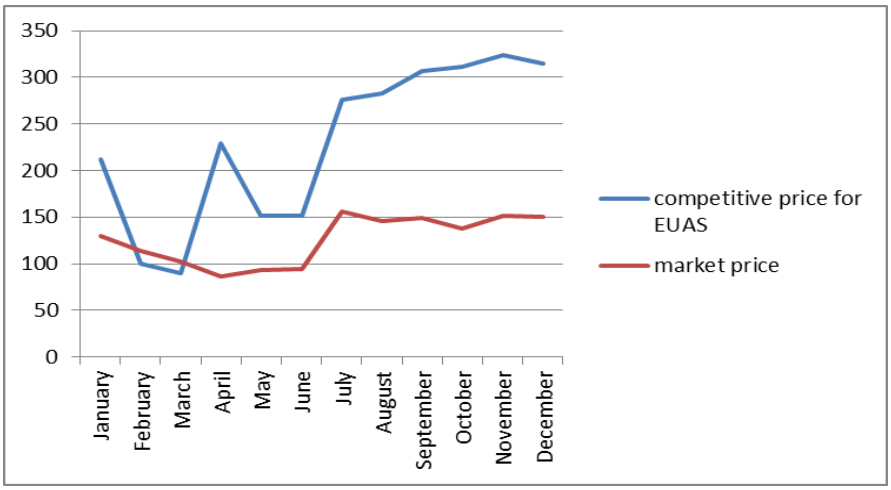

Figure 6.1: Marginal cost of EUAS and the actual market prices (2011).

As seen in the figure below, even at peak demand months, given the hydroelectricity production presumed according to capacity utilization ratios, EUAS has no power at all (Figure 6.2, 6.3). It carries the burden of its natural gas backed power plants. Market price realized in July is 156 TL/MWh whereas the price on the short run supply curve of EUAS electricity generation at that month corresponding to the associated demand for EUAS electricity is 276 TL/MWh.

[20] An overall marginal cost is calculated by using weighted averages of marginal costs (weighted according to each installed capacity of thermal and utilized capacity of hyrdroelectic power stations).

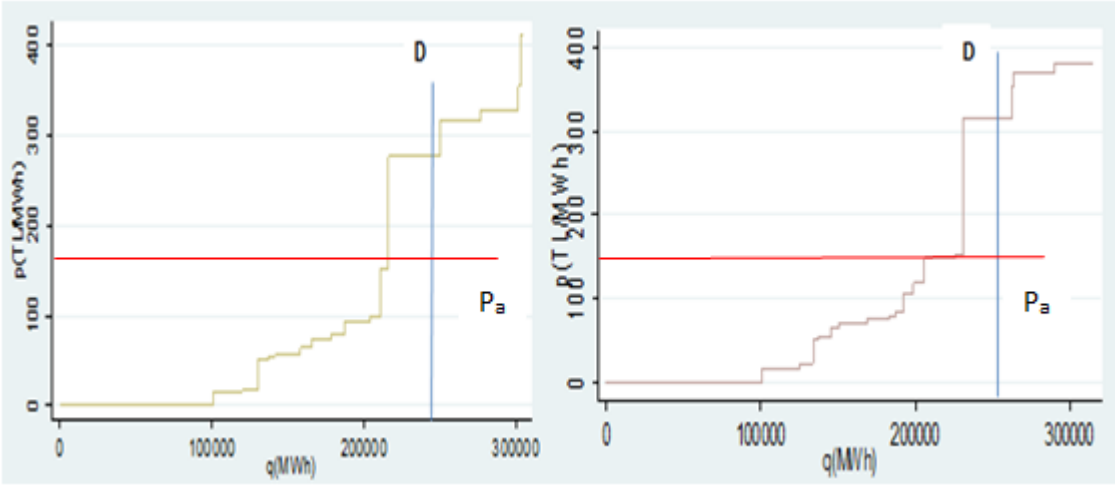

Figure 6.2: July and December (EUAS Supply and EUAS Demand). [14]

The spread between the actual market prices and EUAS marginal cost of the last unit produced becomes larger as demand contracts. This can be inferred from the comparison of July and August graphs. Its hydroelectric electricity power helps EUAS overcome this situation. Yet, the low levels of capacity utilization ratios of hydroelectric plants act as a capacity withdrawal that threatens the market efficiency.

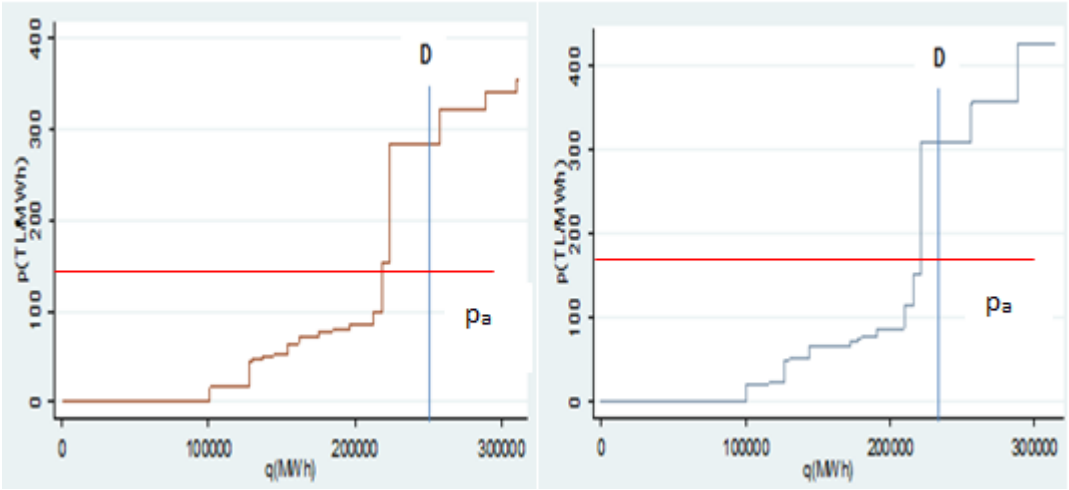

Figure 6.3: August and September (EUAS Supply and EUAS Demand).

In April, while the market price is just 86 TL/MWh the EUAS marginal cost of the last unit produced is 229 TL/MWh (Figure 6.4). Hence, the spread reached its highest level in April when demand was relatively very low.

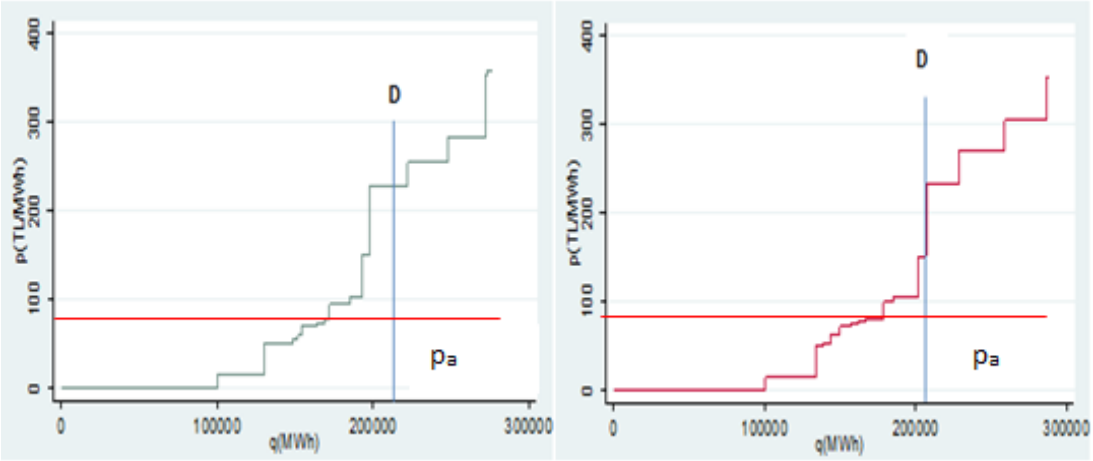

Figure 6.4: April and May (EUAS Supply and EUAS Demand).

7. POLICY IMPLICATIONS

A lot of changes lie ahead for the Turkish electricity market. In a bunch of years, the share of bilateral contracts will be reduced significantly, to even zero maybe. A big transformation process like this requires knowledge of financial attributes of the electricity market. To acquire that knowledge market participants should wait until EUAS's market power disappears. These prices that are found have little to do with leading the way towards full liberalization. But they are protecting the private producers which have relatively higher marginal costs than EUAS. They are making the transition period easier for all market participants.

Whatever happens next in the Turkish electricity market, what will remain obvious is the growing consumption and hence the growing production (Table 7.1). Turkey is in need of new generation capacities. The limits set for potential free producers of electricity are being lowered every year (Figure 7.1). As long as new capacities are added to generation by small players, the market will get closer to the 'infinitely many market participants' phase. Along the way, monopolization must be hindered as promised by the political authorities. All in all, the market will surely embrace more competitiveness in a few years by expanding beyond its current borders.

Table 7.1: Electricity Generation and Consumption in Turkey (2011).

	2009	2010	2011	2009-2010 % Change	2010-2011 % Change
Installed Capacity (MW)	44,761	49,524	53,235	10.64	7.5
Generation (GWh)	194,813	211,208	228,431	8.42	8.2
Import (GWh)	812	1,144	4,747	40.89	315.0
Export (GWh)	1,546	1,918	3,833	24.06	99.8
Consumption (GWh)	194,079	210,434	229,344	8.43	9.0

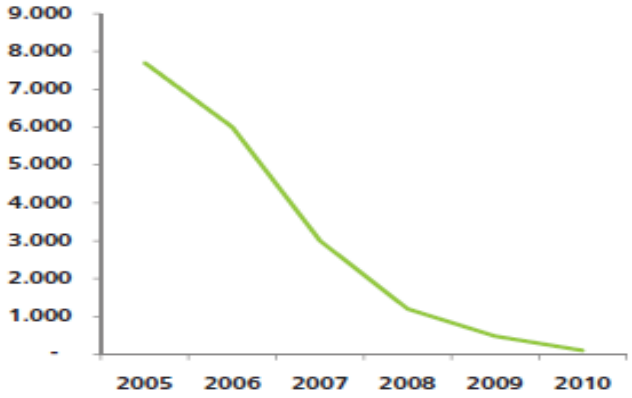

Figure 7.1: The Development of the Limits to Free Producers. [19]

8. CONCLUDING REMARKS

Before stating the conclusions of the thesis, there are many limitations that need to be discussed. One of the limitations of this thesis is that the data does not include cost information on the private power stations at the time. Supply and demand analyzed here is limited to EUAS. To see the big picture, all generation potential should be included to the analysis. Yet, it casts no shadow on its credibility in the sense that there is not a big producer yet that deserves to be examined separately. All producers are still small scale producers. Furthermore, it only takes a possible extension with collecting new data or performing estimation to eliminate this drawback.

When it comes to the other potential elements of short run variable cost function, there is this issue of environmental taxes vs. tradable permit schemes. However, this thesis has no say in that issue. Lack of data, again, constitutes the major impediment to this environmental extension. For now, there is no information available even on the carbon taxes imposed in Turkey.[21] After all, its existence is quite doubtful.

As mentioned before, the widely accepted view is that marginal costs cover all costs in the long run, i.e., production costs and the producer surplus needed for investment protection. However, supply security concerns are still present in some marginal cost analyses. In this thesis it is assumed that marginal cost is the sufficient amount to guarantee the long-run cost coverage and no worry about supply security is stated.

After constructing the short run supply curves of EUAS electricity production for each month of the year 2011 from the power plant data obtained from EUAS and KGUP and market price data obtained from PMUM, the outputs of this thesis indicated that high price levels, if there is any, do not have something to do with EUAS market power. In fact, electricity prices in Turkey are highly dependent on hydroelectric generation and natural gas prices. If there has to be some factor to blame, it can naturally be natural gas prices instead of EUAS monopoly.

[21] There is now no carbon trade in Turkey but it will be set in 2015.

Even though there is more than enough opportunity for EUAS to exercise market power, it acts like a devoted mother in the market.[22] It gives priority to support private investments to secure electricity supply in the future and works on its portfolio privatization plans to keep its hands off the competitive market as far as possible.

[22] Yet, it was the fourth profitable company in Turkey in 2011.

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[23] Also see: Stewart (1979), Stevenson (1980), Joskow and Schmalenseel (1983), Betancourt (1986), and Nelson (1989).

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APPENDICES

APPENDIX A.1

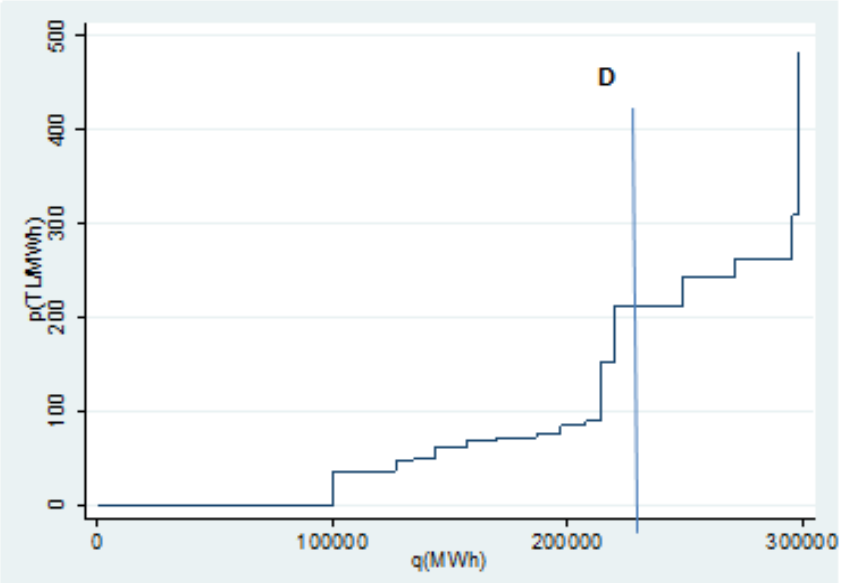

Figure A.1: January (Supply and Demand).

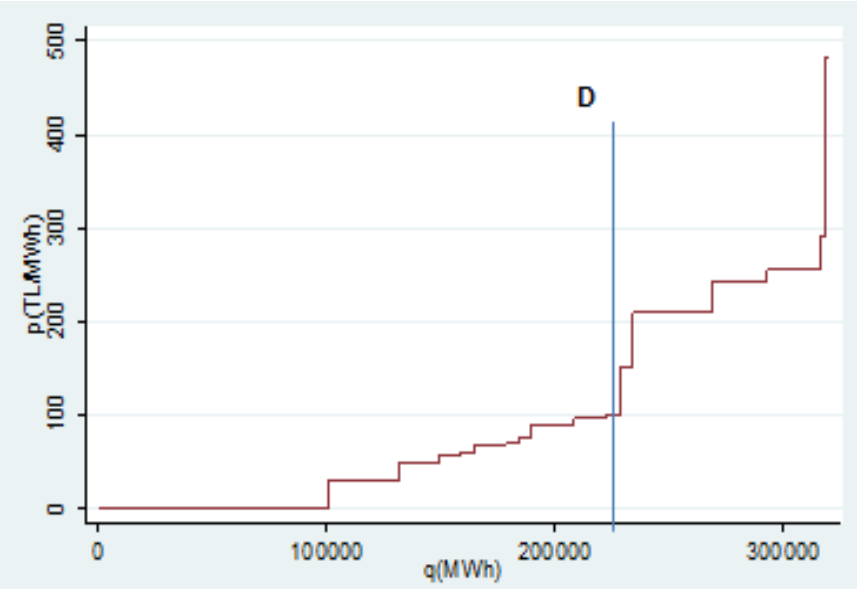

Figure A.2: February (Supply and Demand).

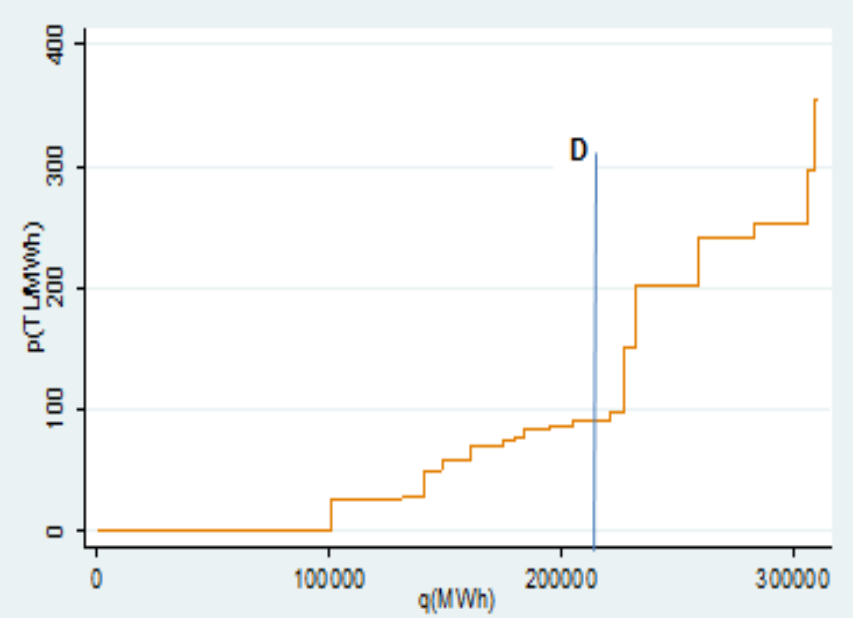

Figure A.3: March (Supply and Demand).

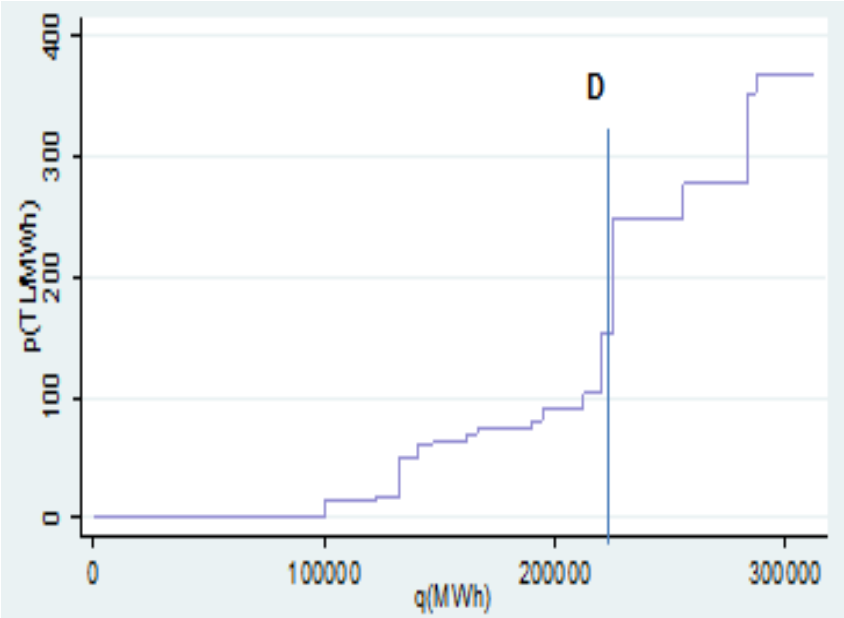

Figure A.4: June (Supply and Demand).

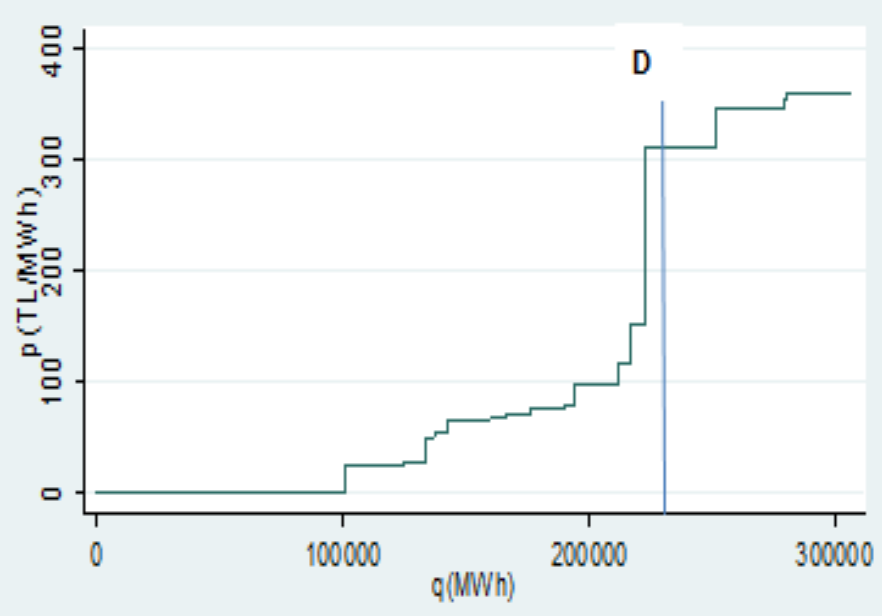

Figure A.5: October (Supply and Demand).

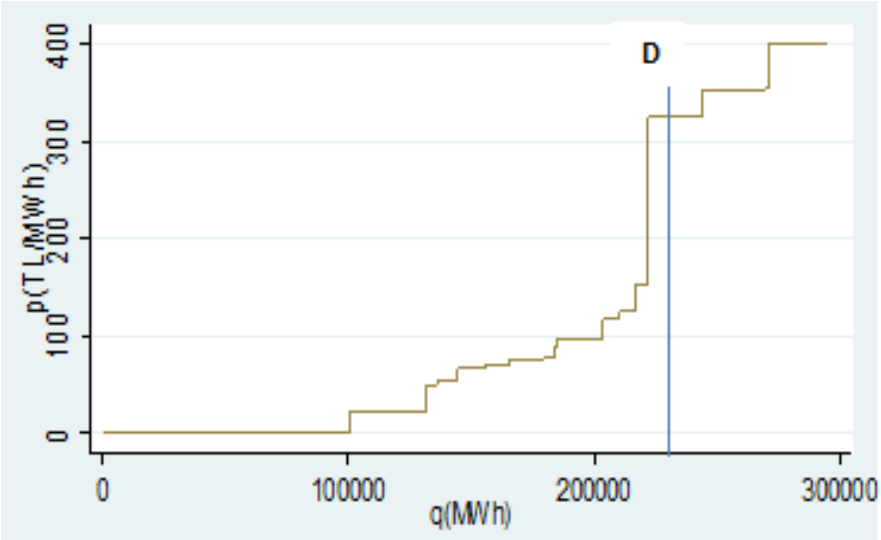

Figure A.6: November (Supply and Demand).

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