

EDUARDO MARTINS DE CAMPOS

COMPARATIVE ANALYSIS BETWEEN THE ITALIAN AND BRAZILIAN  
ELECTRICITY MARKETS, WITH A FOCUS ON ENEL'S AND ELETROBRAS'  
ACTIVITIES

Trabalho de Formatura apresentado à  
Escola Politécnica da Universidade de São  
Paulo para obtenção do Diploma de  
Engenheiro de Produção.

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To my parents and sister, for all their love and support



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Most of all, I cannot thank my parents enough. Their support and faith in me has never wavered and they have provided me with everything I could ever possibly need. If not for them, I do not know what would have become of me. They always encouraged me to learn, discover and experiment and that is what has brought me to this point.

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Somewhere, something incredible is waiting to be known.

(Carl Sagan)



## **ABSTRACT**

This paper's object is the comparison between Italy's and Brazil's electricity market liberalization reforms. Both these countries had government-controlled monopolies installed in the sector until the late 20<sup>th</sup> century, when a wave of liberalization reforms spread across the world. Due to vastly different contexts, the structure of these reforms varied greatly between the two countries, though both followed the same basic liberalization principles. Thus, the beginning sections of this thesis describe electricity markets in general, as well as the peculiarities of each country. These are used to explain the different market structures post-reform, as well as several key decisions made along the process. Later sections study the role of each country's former incumbent (ENEL for Italy and Eletrobras for Brazil) in this new paradigm.

The thesis finds that, while ENEL was privatized and entered into the market as another competitor, Eletrobras remains under federal control and is used as a public service, fulfilling political goals. Furthermore, it suggests that the Italian government could adopt the Brazilian physical dispatching model to ameliorate its transmission congestion issues. Brazil, in turn, could apply Italy's virtual power plant system to Eletrobras, which could ensure that the groups political function is served without greatly distorting competition. Finally, both countries could benefit from a more diverse generation mix: Italy would obtain lower marginal cost levels for its electricity, while Brazil would reduce its exposure to hydrological risks.

Key words: Liberalization reforms, State monopolists, electricity markets



## RESUMO

Esse trabalho compara as reformas de liberalização dos mercados de energia elétrica na Itália e no Brasil. Ambos mercados estavam sob monopólio estatal até o fim do século XX; quando uma onda de liberalizações se espalhou pelo mundo. Devido a contextos extremamente diferentes, o processo de reforma nesses dois países variou consideravelmente, apesar de seguirem os mesmos princípios básicos. Portanto, os primeiros capítulos dessa tese descrevem mercados de energia elétrica em geral, assim como as peculiaridades de cada país. Esses fatos são usados para explicar as diferentes estruturas dos mercados pós-reforma, assim como diversas decisões-chaves tomadas ao longo dos processos. Os últimos capítulos estudam o papel do ex-monopolista de cada país (ENEL para a Itália e a Eletrobras para o Brasil) nesse novo paradigma.

A tese mostra que, enquanto a ENEL foi privatizada e introduzida no mercado como mais um competidor, o Sistema Eletrobras permaneceu sob controle governamental e é usado como um serviço público, buscado objetivos políticos. Além disso, sugere-se que o governo italiano adote o modelo de despacho físico brasileiro para diminuir seus problemas com congestionamento do sistema de transmissão. O Brasil, por sua vez, pode aplicar o sistema italiano de usinas virtuais à Eletrobras, o que permitiria que o grupo cumprisse suas missões políticas com menores distorções afetando a livre competição. Finalmente, ambos países devem diversificar suas matrizes energéticas. A Itália obteria uma menor curva de custos marginais para sua geração, enquanto o Brasil diminuiria sua exposição a riscos hidrológicos.

Palavras-Chave: Reformas, liberalização, monopolistas estatais, mercados de energia elétrica



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## **LIST OF ABBREVIATIONS AND ACRONYMS**

<b>ACL</b>	Free Contracting Environment
<b>ACR</b>	Regulated Contracting Environment
<b>ANA</b>	National Water Agency
<b>ANEEL</b>	National Electricity Agency
<b>CCEE</b>	Chamber for Electricity Trading
<b>CCPE</b>	Coordinating Committee for Electricity Planning
<b>CHESF</b>	Sao Francisco Hydroelectric Company
<b>CMSE</b>	Monitoring Committee for the Power Sector
<b>CNPE</b>	Interministerial Council for Energy Policy
<b>ENEL</b>	National Entity for Electric Energy
<b>EU</b>	European Union
<b>GME</b>	Electricity Market Manager
<b>HHI</b>	Herfindahl-Hirschman Index
<b>IPEX</b>	Italian Power Exchange
<b>MAE</b>	Wholesale Electricity Market
<b>MGP</b>	Day-Ahead Market
<b>MME</b>	Ministry for Mines and Energy
<b>ONS</b>	National Systems Operator
<b>PUN</b>	Single National Price
<b>SMP</b>	System Marginal Price
<b>UK</b>	United Kingdom
<b>VPP</b>	Virtual Power Plant

**W** Watt, a unit of power or rate of energy production/use

**Wh** The amount of energy produce by one watt of power over an hour

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## 1. INTRODUCTION

Until the late 20<sup>th</sup> century, electricity markets tended towards a natural monopoly. Because of this, most countries operated under a State monopoly: one publicly owned company which was responsible for all aspects of energy generation, transmission and distribution. However, recent technological advances have made competition possible, especially in the generation stage. This has led many countries to enact liberalization reforms. Their goal is to introduce competition into the energy market in order to foster growth and productivity in the industry.

The European Union, specifically, enacted three European Electricity Directives. These directives aimed to guide EU countries towards a common market framework and, in the future, integrate them into a single European energy market. Each country was then responsible for translating them into national laws, with some leeway in interpretation to account for any national differences.

Brazil, on the other hand, started the liberalization process on its own, by analyzing successful international examples, mainly the British one. The first wave of reforms in the country was marked by a failure to attract enough private investment and resulted in the infamous 2001 energy crisis. The second wave of reforms corrected some flaws from the previous model, in a process of continuous improvement.

Nonetheless, one of the largest and most common problems in these transitions has been handling former State monopolists which, due to their history, tend to have enormous generation capacity and control over many different aspects of the industry. In order to foster genuine competition, these monopolists have had their businesses vertically unbundled and most of their capacity sold to competitors. This is a key aspect in electricity industry liberalization: ensuring that incumbents and entrants operate on a level field and that no one company has extensive market power to distort the industry's activities.

This paper focuses on the Italian and Brazilian side of this issue. More specifically, its objective is determining how each country's political and economic environments shaped their reform process and the way former monopolists were handled. The structure of the liberalized markets will be explained by each country's main needs and limitations. The role of the former

incumbents in this new scenario, which varied between the two countries, will be explained as well.

Section 1 of the paper introduces important technical features of electricity, along with the market designs and peculiarities that arise because of them. Section 2 and 3 discuss the Italian and Brazilian energy industries from a regulatory and market-based perspective, respectively. Section 4 gives a brief overview of ENEL's and Eletrobras' history before and during the liberalization reforms. Section 5 then analyzes the former monopolists' roles and importance in the current context. Finally, section 6 concludes with overall comparisons between the two cases and the next steps for each country.

### **1.1. Methodology**

In this paper, scientific literature and expert interviews were used in order to better understand the workings of electricity markets in general, as well as the specific histories of the Italian and Brazilian reforms. The relevant literature was procured mostly online, although ten of the articles were suggested by experts in the field.

Furthermore, secondary data was used, mainly from government websites and investor reports, with the aim of acquiring deeper knowledge into the status of the markets today. More specifically, data about price histories, generation capacity, source mix, and market shares were the most relevant for this study. With this data and literature, a comparative analysis was possible, both about the reform processes in each country and about the results of these processes.

## 2. ECONOMICS OF ENERGY MARKETS

### 2.1. Electricity technical peculiarities

An electricity system is made up of a network of transmission and distribution lines. These lines connect generators, who own and operate plants across the region, and consumers, who utilize electricity in either day-to-day activities or industrial operations. In physical terms, generators represent points where energy is introduced into the system and consumers where current is removed from it. Also, because of the nature of electricity, which follows all possible paths between two different points, any introduction and removal of energy tends to affect the entire network, even if on a small scale (Trabucchi, 2014).

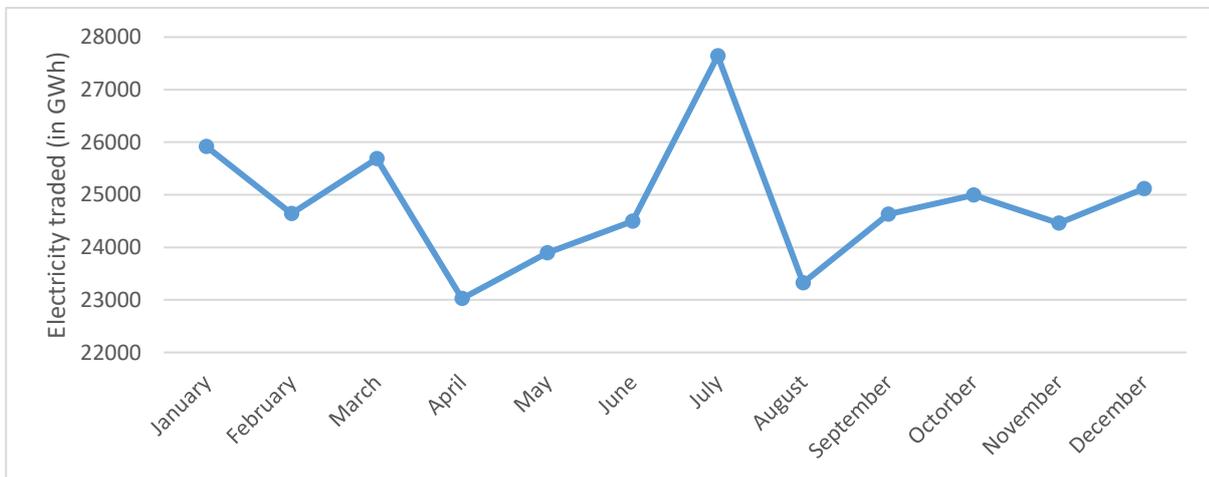
Electricity is different from most traded goods in a few important aspects. First, it cannot be efficiently stored. Batteries, for example, have limited capacity and very high costs at national scales. Efficient arbitrage is also impossible due to transmission congestion. Installed power lines have a limited ability to transmit electricity (called “transmission capacity”), due to overheating and other limitations given by their geometry and composition. Therefore, “moving” electricity can be costly, if not completely unfeasible in large scales. Therefore, supply and demand have to be extremely well coordinated in order to avoid wastes and black-outs. For the same reason, countries strive to install a dense, heavily interconnected transmission network, with the aim of ensuring service provision even in the case where local generators are unable to do so (Wolak, 2010).

As a result, electricity consumption is extremely difficult to modify in the short term, due to both the previous concerns and its essential role in day-to-day and industrial activities. Production is also limited in its adaptive capacity, because of ramp-up costs and time, as well as scheduling issues. Therefore, demand for electricity in the short-term is extremely price inelastic, with consumers essentially locked into a consumption level and suppliers unable to increase production in order to meet this demand (Bosco et al, 2012).

Finally, energy consumption shows very intense seasonality and mean-reversion aspects. This happens over the course of both days, weeks and years. Daily, higher consumption tends to occur between 9:00 and 13:00 and between 17:00 and 21:00 (see Figure 2.2), with some variance between countries. Weekly, reduced industrial activity on weekends leads to lower average consumption levels. And yearly, usage of air-conditioning and heating units increase electricity demand during summer and winter months, with the emphasis depending on the country’s geographical location (Trabucchi, 2014).

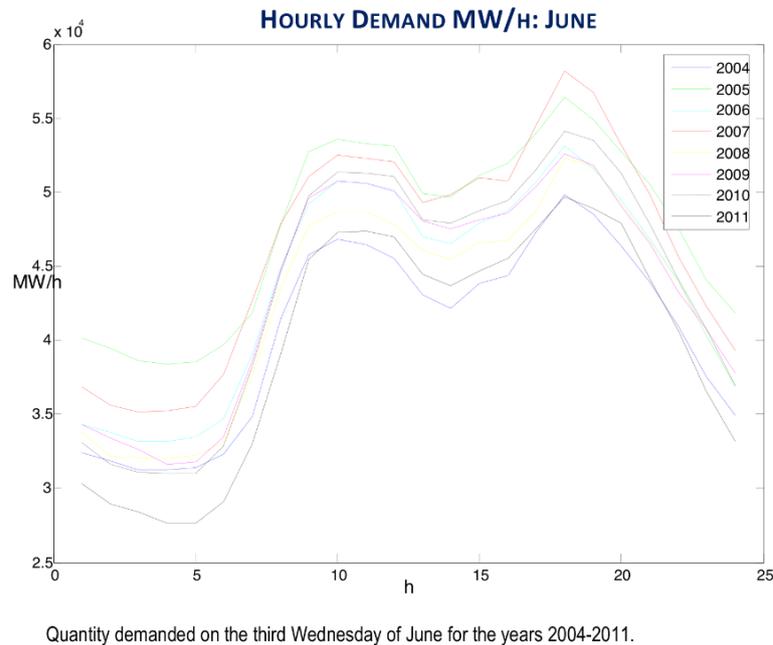
In Italy's case specifically, a sharp reduction in energy consumption occurs in August, even though it is a summer month, because of mass school and work vacations. Although April presents even lower consumption, this is more in line with other countries' figures, given that it is a spring month. Figure 2.1 shows average energy traded in the Italian day-ahead market for each month, from 2010 to 2015. The peaks in July (summer) and January (winter), as well as the drop in August, are clearly seen in the picture. Figure 2.2 focuses on hourly variations. It plots out electricity demand on the third Wednesday of every June, from 2004 to 2011. The two peaks are consistent and clear around 10:00 and 20:00 (Bigerna et al, 2014).

Figure 2. 1. Average monthly electricity trade in the day-ahead Italian market (2010 – 2015)



Source: GME Summary Statistics (2015)

Figure 2. 2. Italian hourly demand on the third Wednesday of June (2004 – 2011)



Source: Bigerna, Bollino (2014)

All these aspects combine to form a very specific industry, which in turn requires careful market design and operation.

## 2.2. Market design

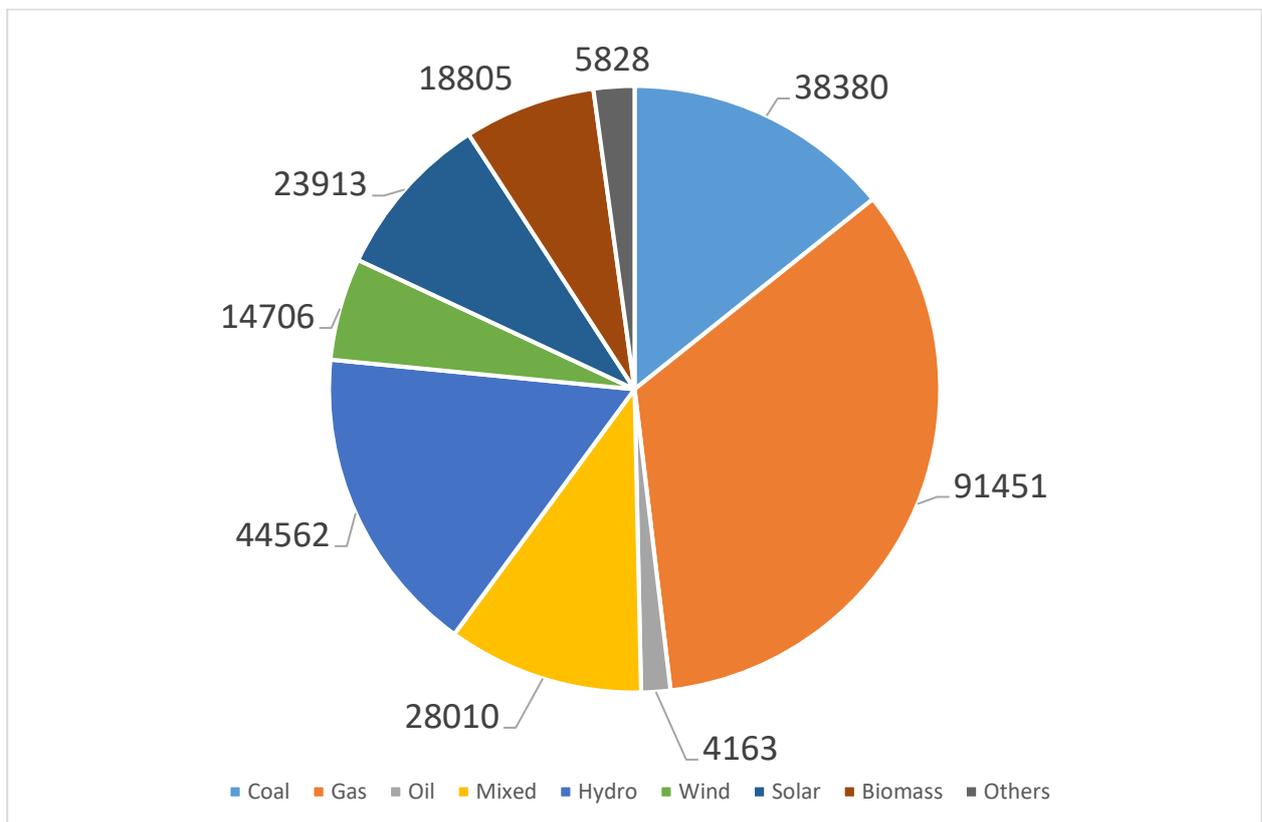
Electricity markets, whether they have gone through liberalization or operate under a monopoly, are naturally divided into three sectors: generation, transmission and distribution. Generation consists of power plants which generate electricity from other energy sources. Generally, these sources are divided into fossil fuels, uranium, water, and other renewable sources (such as wind, solar and biomass) (Bosco et al, 2011).

These sources have a significant impact on the structure of specific markets, because of the variance between their fixed and variable costs, caused by their unique dispatching and operational features. Capital intensive and low-variable cost plants, such as hydro, nuclear, wind farms and solar panels, are useful for meeting base demand. They are willing to accept lower prices in the short-term and volume is considered important for profitability. As such, these are called “Baseload Plants”, as they service the country’s basic electricity needs. Low investment and high-variable cost plants, on the other hand, such as coal and gas fired plants, are best suited for meeting peak demand and are called “Peak-level plants. Their cost structure allows them to rely on lower volume strategies. Between those two, we have “Mid-Merit

Plants”. In auction-based markets, these types of power plants are especially important. Because of their status, they are often found to determine the eventual market-clearing price. Consequently, owners of mid-merit plants have considerably more control over price levels than most others (Bosco et al, 2011).

Unfortunately, Italy’s current market is serviced disproportionately by thermoelectric plants and therefore does not best utilize this differential. Figure 2.3 shows Italy’s energy source mix in 2015, where it can be observed that fossil fuels are responsible for around 60% of Italy’s annual production. For clarity’s sake, note that “Mixed” sources are thermoelectric plants with multiple fuel sources (ENTSO-E, 2015).

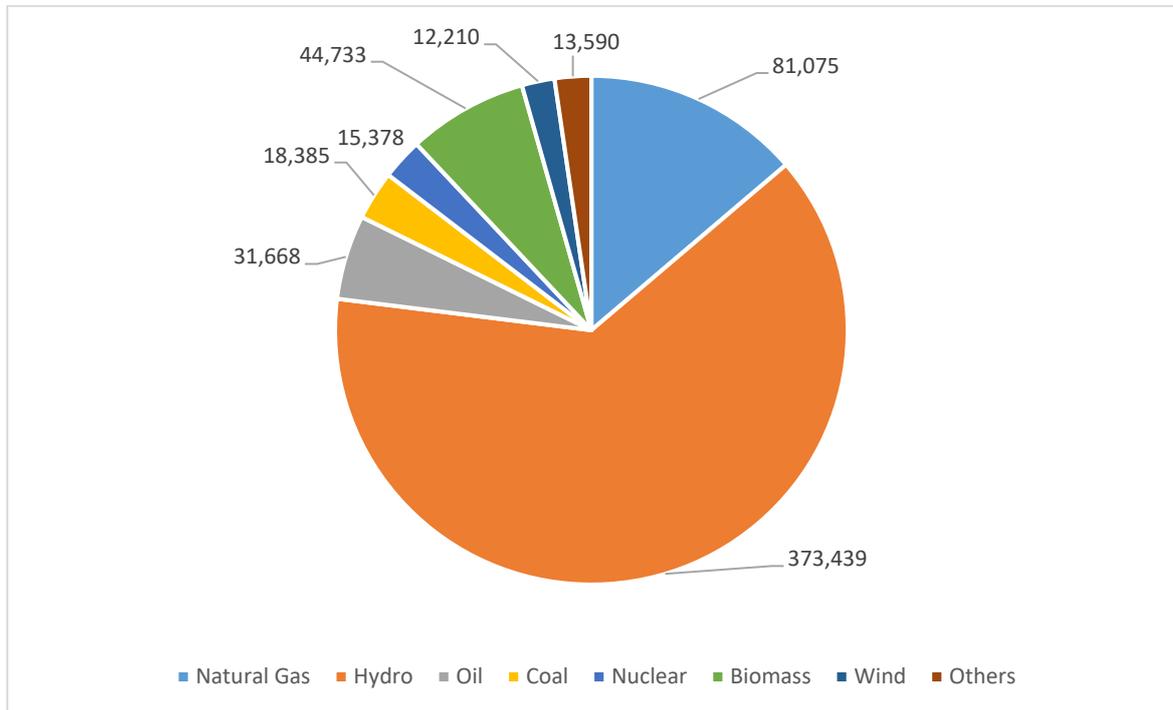
Figure 2. 3. Italian Energy Source Mix in 2015 (in GWh/year)



Source: ENTSO-E Country Packages (2015)

Brazil’s system, on the other hand, is dominated by hydroelectric plants. It also fails, therefore, to optimize its generation mix, though its main energy source has low variable costs (compared to Italy’s high). Figure 2.4 details Brazil’s electricity generation in 2014. Notice that hydro plants are responsible for 63% of production, followed by fossil fuels, nuclear energy and wind-based energy. This subject is further explored in section 3 of this thesis (EPE, 2015).

Figure 2. 4. Brazil's energy source mix in 2014 (in GWh/year)



Source: EPE (2015)

Transmission is responsible for the bulk transport of electricity across large distances. National power grids with very high capacity are used for this purpose. In Italy, two types of transmission lines are most commonly used: 380kV and 220kV, indicating their capacity. The installation of these lines is usually a responsibility of the government or an Independent Systems Operator (ISO), which behaves monopolistically (GME, 2015).

Brazil, on the other hand, uses mainly 230kV and 500kV lines. Installation of these lines is determined by an ISO, but usually conducted by private companies. Auctions are held where companies pledge to install and maintain the lines in return for a pre-determined yearly revenue. The auction is won by the player willing to accept the lowest revenue (Araujo et al, 2012).

Finally, distribution operates on smaller scales and is responsible for supplying electricity to households and small businesses. For this purpose, smaller, cheaper power lines are used, as less transmission capacity is needed at this scale. There are three main types of consumers of electricity markets: Large industrial consumers are energy intensive industries, such as the aluminum industry, and are usually serviced directly by transmission lines. Smaller industrial consumers can receive their electricity from either transmission or distribution lines.

Households and small businesses are then supplied by distribution companies, who operate most distribution lines (Trabucchi, 2014).

### **2.3. Status of natural monopoly**

This heavy need for cooperation and high level of market complexity involved in the industry, contributed to making it so that energy markets were considered natural monopolies until very recently. However, the main reason behind setting up a State monopoly was the dominance of Keynesian Economic Theory in the early 20<sup>th</sup> century. This branch of macroeconomics gained prominence after the 1929 financial crisis, reflected in the American New Deal. According to Keynes, the government plays a major role in regulating and intervening in the economy. Following this theory, a State monopoly was set up, which facilitated coordination and introduced economies of scale that were seen as vital for efficient operations. On top of that, regulations were seen as necessary, given the captive nature of most consumers, especially residential ones, and the vital nature of the resource being provided. (Rego, 2012)

However, the late 20<sup>th</sup> century experienced a politics. The oil crisis and stagnation of the global economy led to the fall of Keynesian theory and the dissemination of neoliberalism. Margaret Thatcher led the way in England, by privatizing many industries formerly under government control. With the idea that competition might foster innovation, efficiency and productivity in this vital industry, many countries have undergone extensive liberalization reforms, starting in the generation sector. Distribution has also been liberalized, although more recently, and transmission remains under State control in most places. (Rego, 2012)

Nonetheless, as pointed out in Araujo et al (2011), real-time coordination needs, large maturation lags and asset specificity all mean that electricity market reform remains a challenging prospect. As a result, most reforms require iterations and adaptations after the fact. Brazil will be shown to be an important example of this phenomenon.

The main steps in liberalization processes have been consistent across many different applications:

- 1) Restructuring: The vertical unbundling of generation, transmission and distribution sectors within the national monopolist.
- 2) Competition and markets: Allowing new entrants into the generation sector and incentivizing usage of the wholesale market for this purpose.
- 3) Regulation: Establishing an independent regulator, with a focus on transmission, distribution and network concerns.
- 4) Ownership: Allowing the entry of private capital into the business. Privatizing the former monopolist.

In Europe, the general design of these new markets has also been consistent and seems to hinge on wholesale trading and/or bilateral contracts. Wholesale trading occurs in a central pool, which may or may not be mandatory. This pool is run by the Market Operator, who receives offers from generators and bids from consumers. These are then ordered to form aggregated demand and supply curves. Once the equilibrium is found between these two curves, equilibrium prices and quantities can be established and electricity may be dispatched. Depending on the system chosen, supplies may be paid according to a uniform-price rule (where all suppliers are paid the same, equilibrium price) or a pay-as-bid rule (where they are paid what their offer asked for in the first place). Auctions occur every hour or every half hour and the actual supply of traded electricity occurs at the same period of the following day. A national agency is then responsible for ensuring the availability of transmission capacity (Trabucchi, 2014).

This is where Brazil's system differs greatly from Italy's. Hourly auctions have been shown to not adequately fit the country's context (an immature, expanding market dominated by big players). Araujo et al (2011) points out that Brazil's hydro-based, expanding market, creates a significant risk of supply scarcity if investments are carefully planned. Therefore, auctions in Brazil have three main goals: Creating a long-term contract market that generates efficient price signals for future installed capacity, ensuring affordable energy prices (especially to captive consumers), and using clear and easy-to-audit trading rules, in order to simultaneously attract investments and avoid collusion (Dutra et al, 2005).

Instead of Italy's system, Brazil's spot market is responsible for month-long energy contracts. Furthermore, most transactions are not conducted in this environment. Rather, most contracts happen either in the Free Contracting Environment ("Ambiente de Contratacao Livre", or ACL – Brazilian Acronyms) or in the Regulated Contracting Environment ("Ambiente de Contratacao Regulated", or ACR – Brazilian Acronyms). The first is mainly

used by energy-intensive industries, which constitutes free consumers and has contracts of up to four years in general. Meanwhile, the second serves to supply electricity to captive consumers with 15 to 30 year contracts. Both of these environments, their structure and mechanisms will be detailed in section 3.2 (Dutra et al, 2005).

### **3. THE MARKET FRAMEWORKS**

This section provides a simple description regarding Brazil's and Italy's production, transmission and consumption of electricity. Historical trends are analyzed, along with the most important issues facing each country's industry at present. A brief look is also given to international activities and a sub-section is devoted to comparisons between both countries.

#### **3.1. Italy**

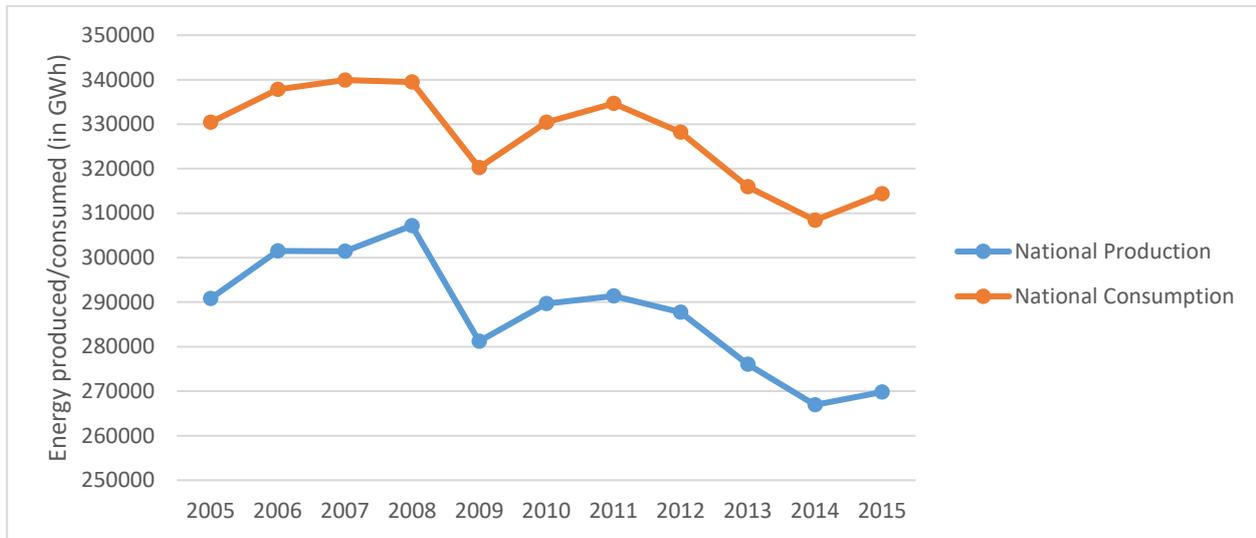
Italy is a developed European country with around 60 million people and an area of 301,338 km<sup>2</sup>. This means that the country's energy needs are relatively small, but most importantly, stable. As the following section explains, this means that ensuring availability and affordability of energy are the country's main concerns (ISTAT, 2016).

##### **3.1.1. National production and consumption**

Production levels in Italy have seen a slow but steady decline in recent years, which many attribute to the European recession that has been in place since 2008. Indeed, a sharp fall can be seen from 2008 to 2009. However, from 2010 to 2014, annual production has again fallen from around 290TWh to 267TWh, a decrease of close to 8%. Only in 2015 did production start increasing again. Consumption has exhibited similar behavior, decreasing from 330TWh to 308TWh in the same period. As can be seen in figure 3.1, the curves mostly resemble each other and Italy's production to consumption ratio has been relatively stable at around 85% to 88%. The difference between the two curves is due to imported electricity, which is talked about in more detail in section 3.1.5 (ENTSO-E, 2015).

Among zones, the North consumed 64% of the country's total in 2006, with the rest of mainland Italy consuming 35% and the islands, 11%.

Figure 3. 1. Italian production and consumption levels (2005 – 2015)



Source: ENTSO-E Country Packages (2015)

### 3.1.2. Energy source mix

In 1963, 63% of Italy's energy came from hydro sources, but its government invested heavily in fossil fuels in hopes of avoiding overdependence on water levels. In the 1970's, a then-monopolist ENEL also planned to develop several nuclear plants to circumvent the oil crisis of that decade, but only one was eventually built. The problem was aggravated further after the Chernobyl nuclear disaster of 1987 and a referendum banned further investments in nuclear energy. Since then Italy has depended heavily on fossil fuels, transitioning from oil to gas during this time. Meanwhile, coal has remained a secondary but still important fuel for the country (ENTSO-E, 2015).

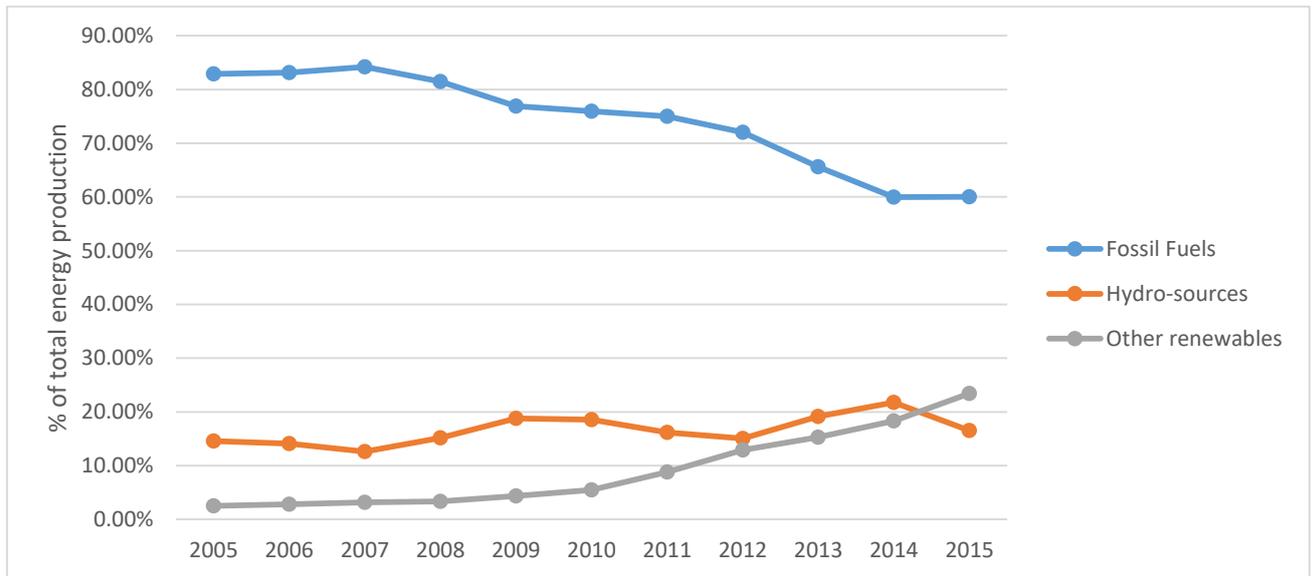
#### a. Green energy projects

Given the current importance of the subject, the following sub-section is dedicated to exploring green energy projects in Italy (and later, Brazil). Indeed, the International Energy Agency (2015) expects fossil fuel reserves to be exhausted in less than 100 years (47 for oil, 60 for gas, 131 for coal), and oil prices are supposed to reach \$133/barrel in 2035. Nevertheless, and although efforts are being made, both countries have had limited success in expanding the availability of green energy (Jong et al, 2015).

In 2008, specifically, Italy experienced a "green boom", characterized by sharp increases in wind and solar capacity. This phenomenon, which was focused in the South zone, decreased prices in the area. As we've seen in Section 2.1, prices in the region were historically

higher than in the North, but the condition was reversed after this boom. Since then, renewable energy sources have continued to increase in capacity, eventually surpassing contributions from hydro sources in 2015. This can be seen in Figure 3.2 below (Clò et al, 2014).

Figure 3. 2. Italian energy source mix (2010 – 2015)



Source: ENTSO-E Country Packages (2015)

However, even with this “boom”, fossil fuels still dominate energy generation, with a share above 60%, as seen previously.

### 3.1.3. Transmission concerns

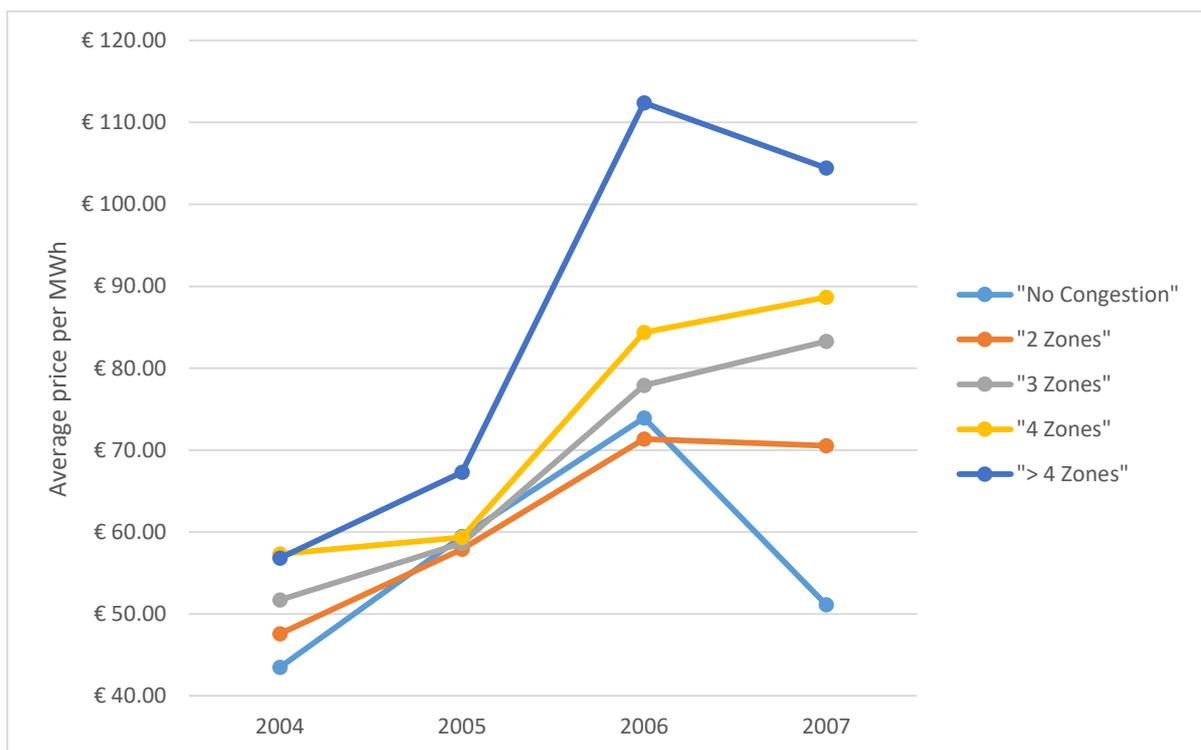
When congestion occurs in the Italian market, the relevant zones are separated and the SMP is re-calculated. This separation gives more power to local generators, increasing prices and reducing consumer surplus. It also prevents more efficient use of capacity by each operator. Despite these issues, and even with the increase in demand and production that happened before the recession of 2008, installed transmission capacity has stagnated in Italy. In fact, in 2010, Italy had 10560km of 380kV lines and 11380km of 220kV one. Four years later, these values had had minimal change: an increase to 10899km of 380kV line and even a decrease to 10920km of 220kV ones. Furthering this problem, the liberalization process has put proper dispatching as a clear priority over the utilization of local plants (Boffa et al, 2009).

As a result, zone separation has become more and more frequent over the years. From 2005 to 2011, periods of no congestion went from 23% of hourly auctions to 15.5%, while three-zone configurations have increased in frequency from 25.8% to 31.6% of auctions. Four-zone

configurations also became more common: from 3.35% to 6.56% of periods. The most common division has consistently been between the islands (Sicily and Sardinia) and mainland Italy, and between North and Center-North (Bigerna et al, 2014).

Because of these issues, we have observed increased measurable market power to local oligopolists (who would have little power in the national market) and larger price increases when congestions do occur. The last consequence can be exemplified by comparing average prices (between 2004 and 2007) in the case of no congestion and in the case of a four-zone configuration. In the former case, prices increased from €44/MWh to €51/MWh (a relatively moderate 14% increase), but in the latter, prices went from €57/MWh to €89/MWh – a 49.4% hike. Figure 3.3 presents a more complete picture, where the increase in the differences between configuration prices can be clearly seen (Bigerna et al, 2015).

Figure 3. 3. Italian average prices according to zonal configurations (2004 to 2007)



Source: Bigerna, Bollino and Polinori (2015)

Another consequence of insufficient transmission capacity is price differentiation between the different zones. For example, price in the islands (especially Sicily) tends to be 25% higher than in the mainland and, as mentioned previously, differences also occur between the North and South regions. In Figure 3.4, we can see the evolution of prices in these different

zones, including the switch between South and North prices after the “green boom” of 2008 (GME, 2015).

Figure 3. 4. Average yearly prices in different zones (2005 – 2014)



Source: GME Summary Statistics (2015)

Boffa, Pingali and Vannoni (2009) have analyzed this further and proposed a counterfactual scenario of perfect inter-zonal transmission. The study found that such a scenario would have saved €10 million for end-users in March of 2004. This value represents 6% of all expenditure during hours of congestion. But perhaps more importantly, the study also noted that even small increases in transmission capacity could lead to considerable savings. Table 3.1 shows that the relationship between installed capacity and consumer savings is not linear, but closer to logarithmic in its shape.

Table 3. 1. Possible savings in consumer expenditures from increased inter-zonal transmission

Increase in Transmission	Savings in March/2004	Equivalent yearly savings
50MWh	€5 million	€60 million
150MWh	€8.5 million	€102 million
200MWh	€9.1 million	€109 million
446MWh	€10 million	€120 million

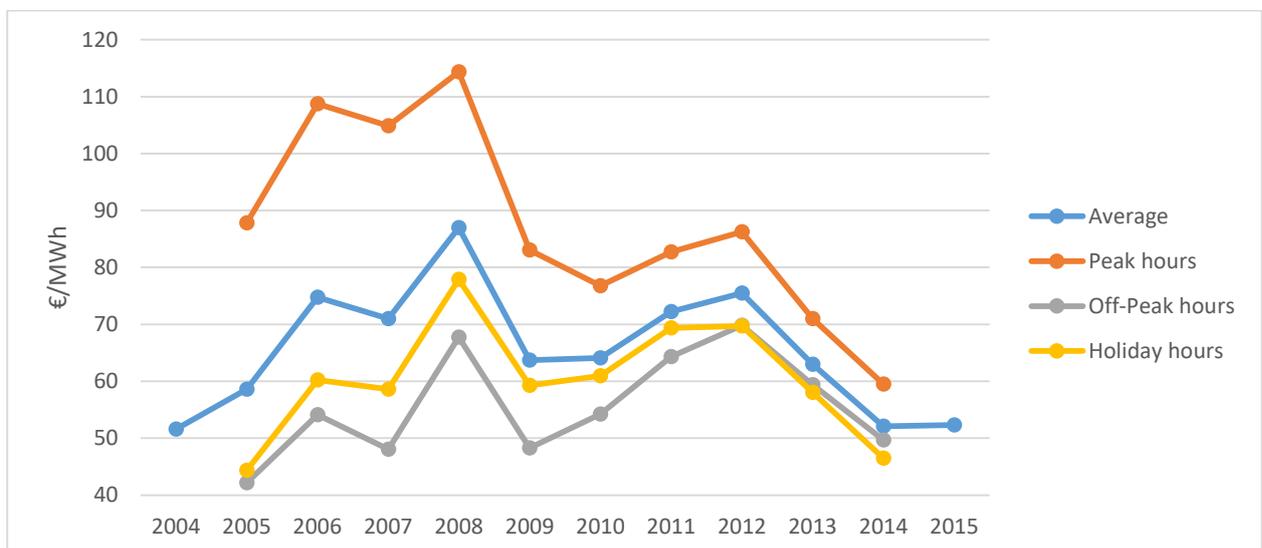
Source: Boffa, Pingali, Vannoni (2009)

### 3.1.4. Price History

Electricity prices in Italy have been considerably higher than that of most other European markets. This is largely attributed to a physical separation from other markets, exercise of market power by a few dominant players (mainly ENEL) and Italy's fossil fuel-dominated generation mix. Furthermore, despite attempts by authorities to limit abuse and stimulate competition, the country's average price level is still similar to that of 2004 and 2005, when the market first opened. This can be partly justified by the recession of 2008, which drove prices upwards, and a slow recovery after the fact. Despite this similarity, variance in prices has decreased significantly in the past decade. The difference between peak, average and off-peak hours has shrunk, which means less uncertainty and less scheduling difficulties for generators (GME, 2015).

The evolution of the Single National Price since the opening of the wholesale market can be seen in Figure 3.5. As for the future, Credit Suisse (2015) analysts expect energy prices to fall to around €44/MWh in 2016 and 2017, followed by a slight increase to €48/MWh in 2017.

Figure 3. 5. Evolution of the Single National Price (2004 – 2015)

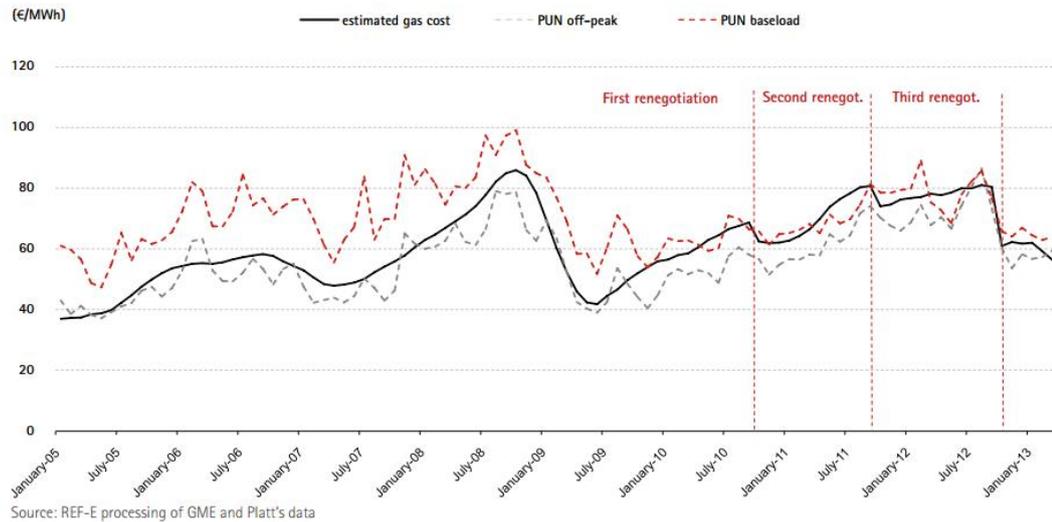


Source: GME Summary Statistics (2015)

It should also be noted that, according to Bosco et al (2011), Italy's current system acts essentially as a cost-plus regulation scheme, where energy prices follow gas prices very closely, due to the country's heavy reliance of this source for its electricity generation. A 2012 GME report corroborates this analysis by including Figure 3.6, which compares the evolution of gas

prices to that of the Single National Price. It would also explain the failure in Italy's effort to reduce energy prices by curbing market power and incentivizing energy efficiency.

Figure 3. 6. Gas and electricity prices in Italy

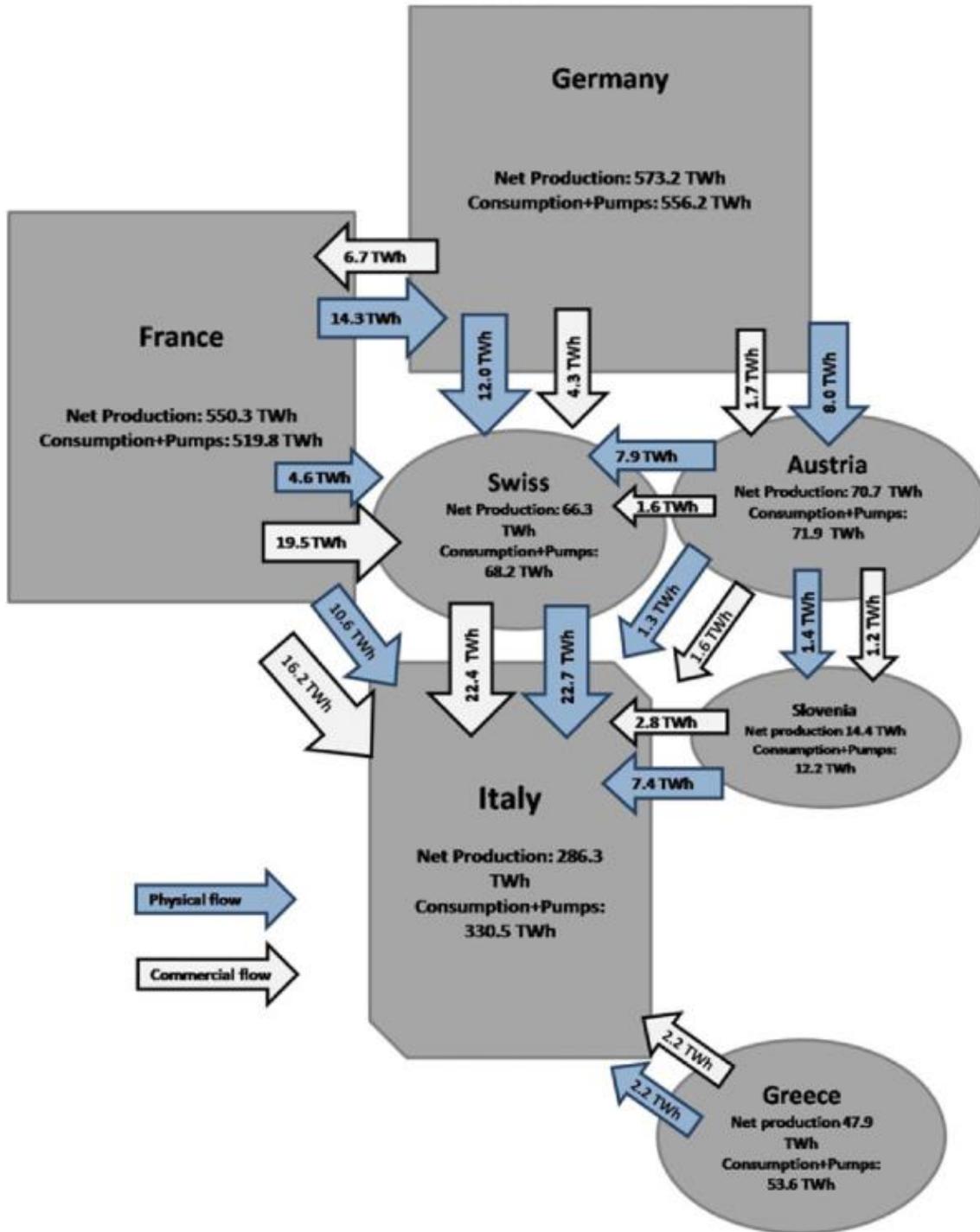


Source: REF (2012)

### 3.1.5. International trading

As noted before, Italy produces only around 85% to 88% of its national consumption. The rest of this demand is obtained internationally. In 2004, Italy had an import capacity of 6500MW, trading mainly with Slovenia, Germany, France, Austria, Greece and Switzerland. All but Switzerland comprise the Central South Europe Regional Initiative, due to their relatively high level of trading. In fact, as Figure 3.7 shows, Italy is a net buyer among these countries, buying mainly from Switzerland (net flow of 22.4TWh in 2010) and France 16.2TWh. In the figure, commercial flows represent traded energy, while physical flows represent actual electricity currents. We concern ourselves mainly with commercial flows, as there are many efficiency measure that distort physical flows (Pellini, 2012).

Figure 3. 7. Electricity flows in the Central South Europe Regional Initiative (2010)



Source: Pellini (2012)

In addition to that, Italy has also had a market coupling mechanism in place with Slovenia since 2011. Market coupling is intended to replace explicit auctioning of transmission capacity, in the case of international trading. Instead, players compete directly in each other's markets. This mechanism requires very similar markets (in terms of auction schedules, bidding process, deadlines, etc.), but in turn provide gains in efficiency in the use of national and international transmission lines, a reduction in operational and trading risk and increased liquidity, especially in the case of less mature markets. A study by Pellini (2012) has in fact shown that establishing a market coupling mechanism within the Central South Europe Regional Initiative could lead to significant gains in net welfare for Italy.

The study suggests that, in the case that generation costs and demand remain relatively stable, Italy could experience a €3 million yearly gain in net welfare. If costs and demand increase, this amount could jump to €132 million per year. On top of that, increased pressure from international competitors could force players in the North zone into competitive behavior, as opposed to their current oligopoly status. In this scenario, welfare increases range from €396 million for stable demand and costs and €741 million for increased ones.

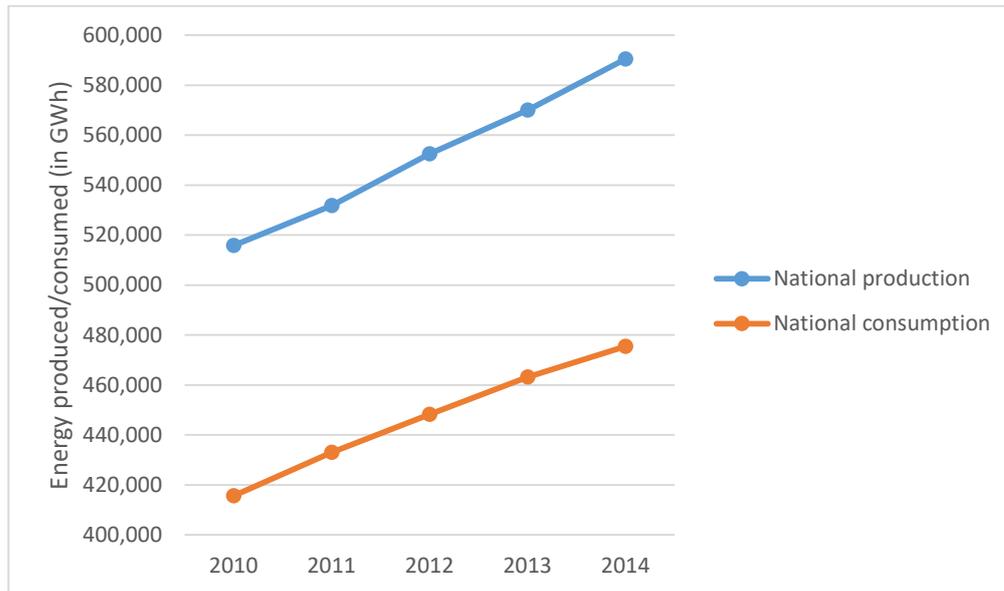
## **3.2. Brazil**

Brazil is the fifth largest country in the world in terms of area (8.5 million km<sup>2</sup>), with a population of almost 200 million people. It is an emerging nation with rapid GDP growth located in South America, with a high and rising energy needs. As the following section explains, affordability of electricity has often been relegated to a secondary goal, compared to guaranteeing sufficient supply (Pereira et al, 2012).

### **3.2.1. National production and consumption**

Brazil's production and consumption levels are much higher than Italy, due to the country's larger population. Unlike its European counterpart, however, these figure have been growing steadily over the past few years and production seems to consistently outweigh consumption. As can be seen in figure 3.8, national production levels have increased from 516TWh in 2010 to 590TWh in 2014 (around 15%). Consumption has increased similarly, from 416TWh to 475TWh in the same period. Indeed, this rise in energy requirement is one of the main reasons for the different market regulations in the two countries (EPE, 2015).

Figure 3. 8. National energy production and consumption in Brazil (in GWh)



Data source: EPE (2015)

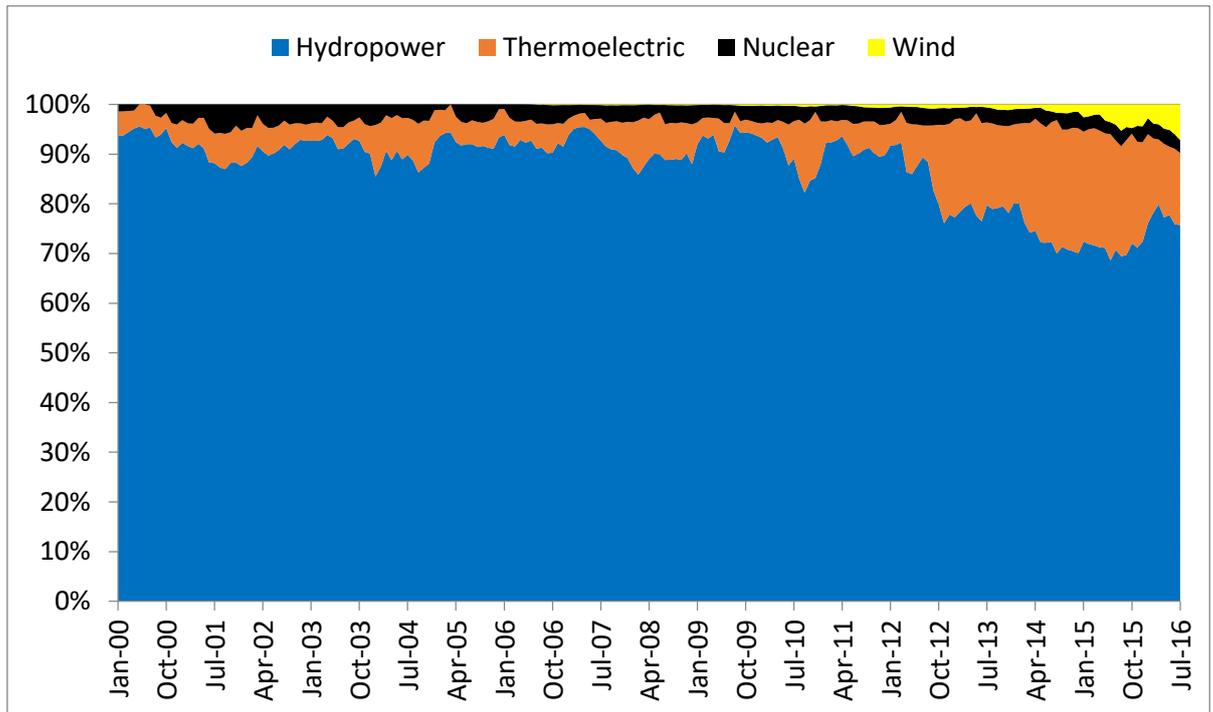
However, a per capita analysis reveals that Italian citizens have a much higher energy requirement, given that the country has roughly half of Brazil's total generation, but less than a third of its counterpart's population. Around 5.1MWh per capita in the European nation, compared to 2.4MWh in its developing counterpart, both in 2014. This is to be expected, given Italy's more mature and developed economy, compared to Brazil's emerging nature.

### 3.2.2. Energy source mix

Brazil's energy production has been dominated by hydroelectricity for a long time. Out of its installed capacity of 134GW in 2014, the largest in Latin America, 63% came from its 140 hydro plants. These range from relatively small (at 30MW of capacity) to 14GW in the case of Itaipu (Barroso et al, 2007). This situation is similar to Canada's and Norway's, but unlike them, Brazil obtains most of its energy from large reservoirs and engages in very little international trading. Considering actual electricity generation, these plants' importance is even more significant, 73% of total national generation from 2010 to 2014. (EPE, 2015)

Natural gas was the second most important source at 14% of actual generation in 2014, followed by biomass at 7.6% and oil at 5.4%. A more comprehensive breakdown can be found in the figure below:

Figure 3. 9. Brazil's energy source mix from 2000 to 2016 (in % of total production)



Source: ONS (2016)

However, capacity for hydro generation is nearing its maximum in most industrialized regions in the country (Jong et al, 2015). Though the Amazon and the Cerrado offer some potential, transmission and environmental costs are great, for low energy density. The Belo Monte plant, for example, being planned in the state of Amazonia, will be able to supply the Northeast region of the country, but through extremely long transmission lines.

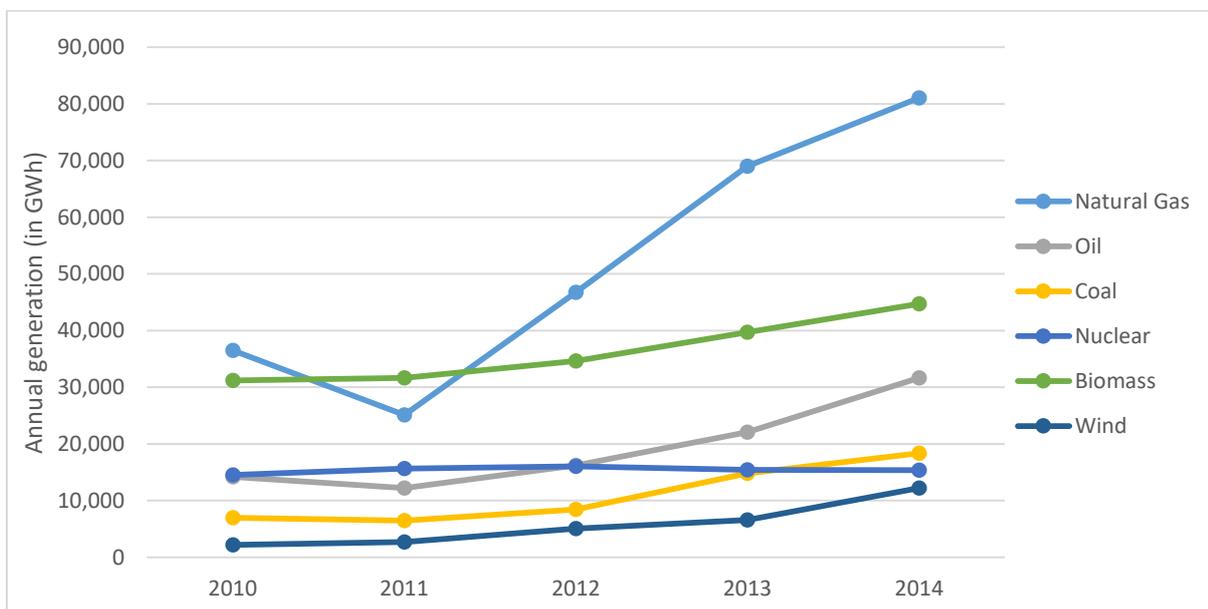
Therefore, the country faces an urgent need to diversify its mix in order to secure supply. This project is currently hindered by a lack of good projects being identified and studied, as well as Brazil's convoluted and often criticized environmental legislation. One alternative suggested by Pereira et al (2012) is the use of smaller hydro plants (between 1MW and 30MW). There are currently 397 of those in operation, growing annually at 10%. In fact, according to the Brazilian Association of Small and Medium Scale Producers of Electricity, there are 3.5GW of potential in this area, and ANEEL has encouraged its growth by guaranteeing free access to the interconnected grid via legislation starting in 1998.

### a. Green energy projects

Brazil has had greater success than Italy in expanding green energy sources, especially wind. Although hydro plants are considered “green” by some metrics, their environmental impact (especially in large scale, as is the case in Brazil) is large enough that it cannot be disregarded. In order to combat this the EPE’s (“Empresa de Pesquisa Energética”, or Energy Research Company) has made provisions for R\$28.2 billion in investment for renewable energy in its Ten Year Expansion Plan from 2010 (EPE, 2010).

As Figure 3.10 shows, these investments started to show progress around 2013. Wind generation had remained relatively stagnant beforehand, while natural gas and oil showed large increases in generation, but started growing more quickly after 2013. The figure excludes hydroelectric generation in order to better illustrate the relationship between other sources. Furthermore, the Brazilian Association for Wind Energy (2016) has forecasted much higher growth in the coming years, reaching 18GW of installed capacity in 2020.

Figure 3. 10. Energy generation per source (2010 – 2014)

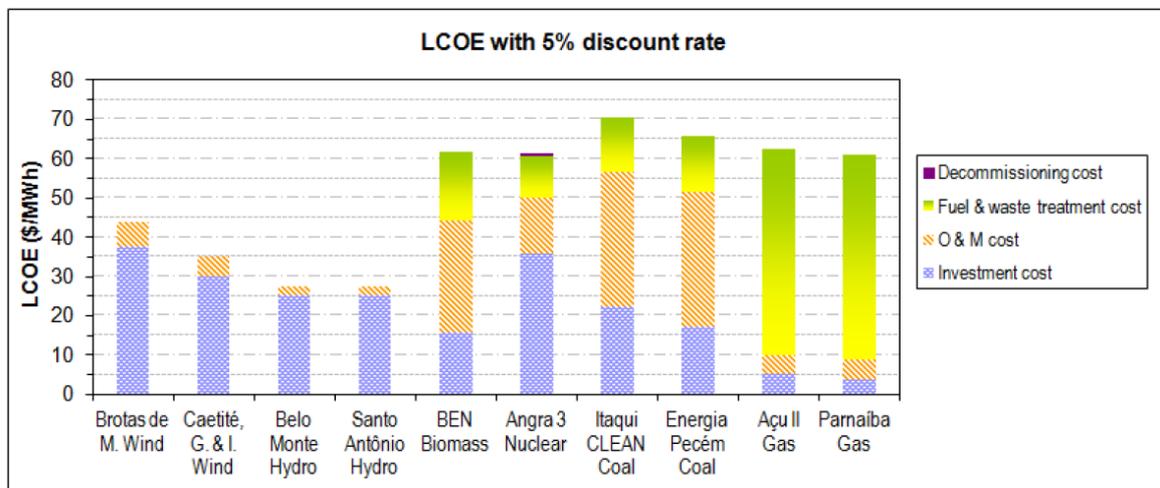


Source: EPE (2015)

Indeed, Brazil has a much larger potential for green energy generation than its European counterpart, especially when it comes to wind and solar energy. Jong et al (2015) suggest that, instead of the current focus on thermal plants as substitutes for hydro generation, a focus on these two sources would be much more beneficial to the country. The authors conduct a

levelised cost of electricity analysis (LCOE)<sup>1</sup>, which compares life-cycle costs for different energy sources. They find that wind generation ties with hydro as the cheapest alternatives, even without accounting for externalities. When these are considered, wind generation emerges as the clear best option. The authors go on to suggest that the country's low participation of wind energy in the national mix is due to the absence of economic incentives until the 2010s. The figures below show LCOE values without and with externalities, respectively:

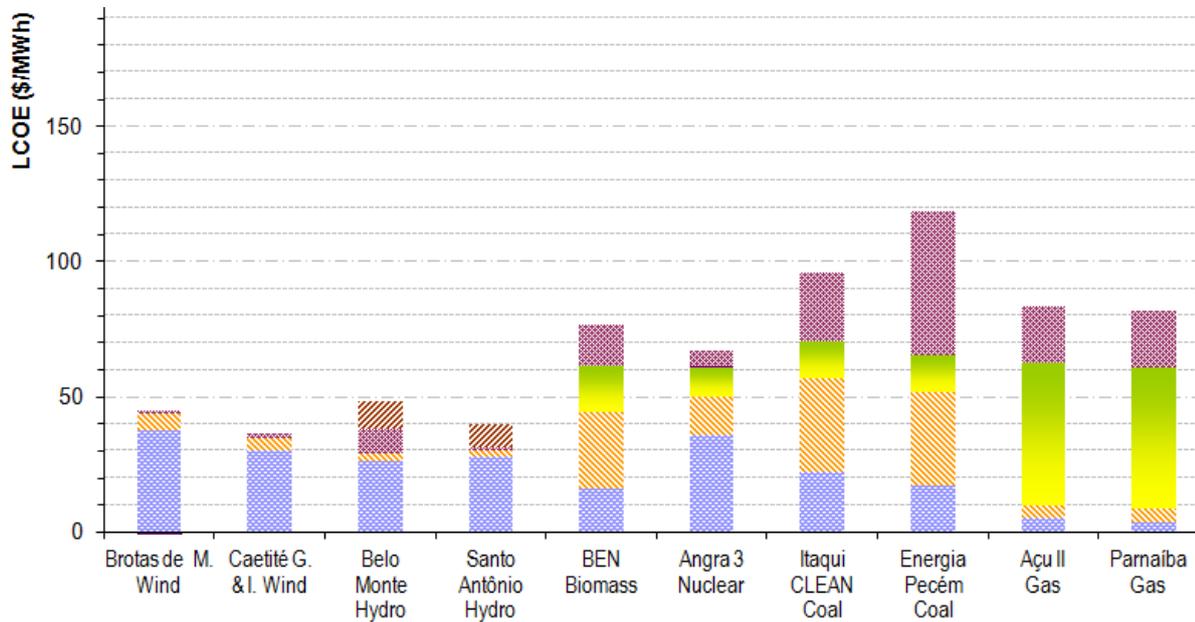
Figure 3. 11. LCOE analysis in Brazil, without considering externalities



Source: Jong et al (2015)

<sup>1</sup> The LCOE is a useful tool for comparing the unit costs of different technologies over their operating life. These costs are discounted to the commercial operation of an electricity generator. LCOE remains a transparent consensus measure of generating costs and a widely used tool for comparing the costs of different power generating technologies in modelling and policy discussions. The calculation of the LCOE is based on the equivalence of the present value of the sum of discounted revenues and the present value of the sum of discounted costs. Another way of looking at LCOE is that it is the electricity tariff with which an investor would precisely break even on the project after paying debt and equity investors, after accounting for required rates of return to these investors

Figure 3. 12. LCOE analysis in Brazil, considering externalities



Source: Jong et al (2015)

Most potential for wind farms lies in the Northeast region, representing over half of the national potential capacity of 880GW. With their low cost, which are predicted to fall even more in recent years, wind is considered a promising source for Brazil's future needs. In order to capture this potential the Ministry of Mines and Energy's PROINFA (*"Programa de Incentivo às Fontes Alternativas"*, or Alternative Energy Sources Incentive Program) had taken on a leadership role. The program is now responsible for around a third of wind power installation in Brazil, although it was discontinued in 2004 and replaced by new energy auctions, discussed further in section 4.2 (FAPESP, 2016).

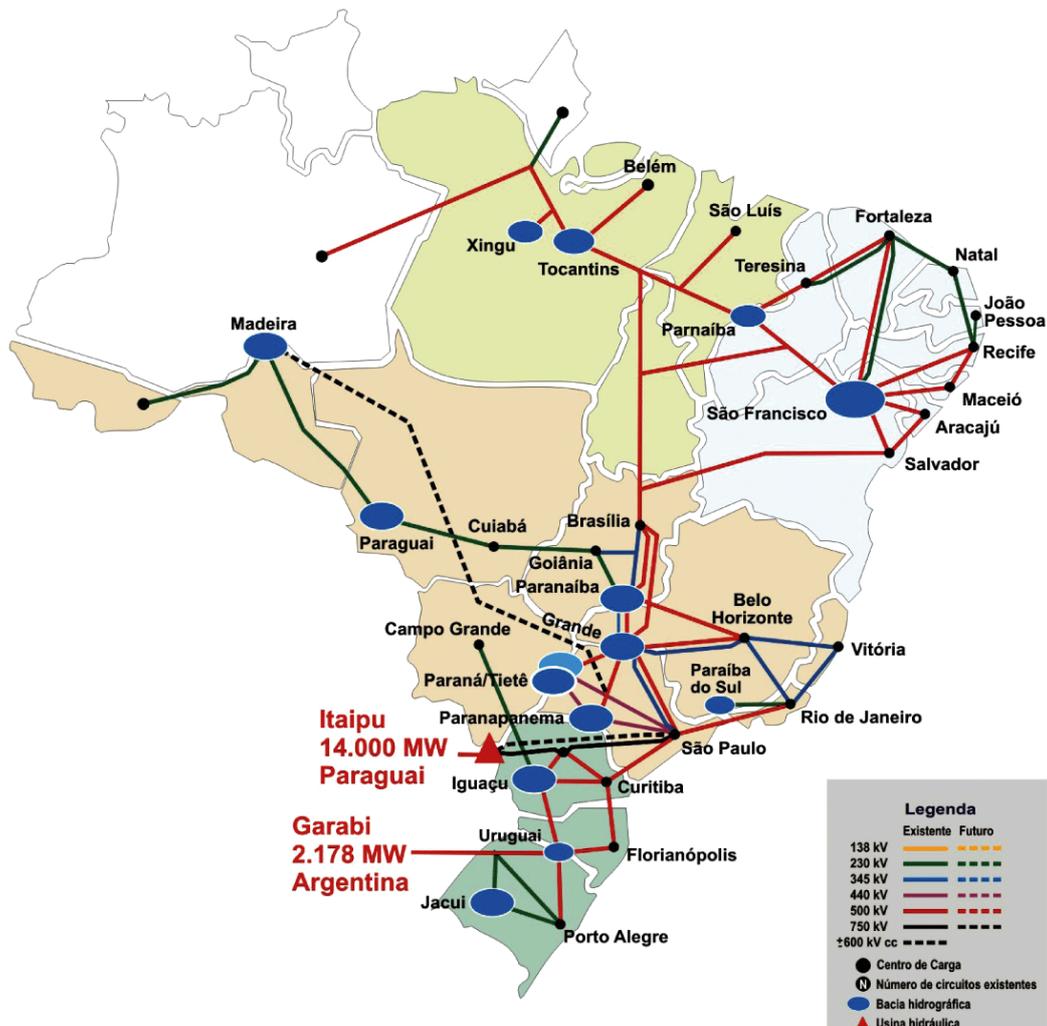
Solar energy, however, has much higher cost levels, three to five times that of wind farms, due large investment costs. One big advantage this source possesses is its size flexibility. Small solar panels may be fit onto roofs or other small surfaces. According to Pereira et al (2012), the optimal use of this technology would be to have many, isolated plants generating energy for small communities. These communities, usually in less developed regions, often lack access to the national interconnected grid and therefore struggle with electricity availability.

### 3.2.3. Expansion concerns

Unlike Italy, Brazil does not suffer from serious transmission congestion issues. A hydroelectric generation system depends heavily on hydrological patterns. As a consequence, it is often necessary for plants to supply electricity to consumers across the country. This has

led to a historically robust transmission system, with over 90 thousand kilometers of transmission lines, which is augmented by Brazil's carefully planned centralized dispatching. Figure 3.13 illustrates this grid:

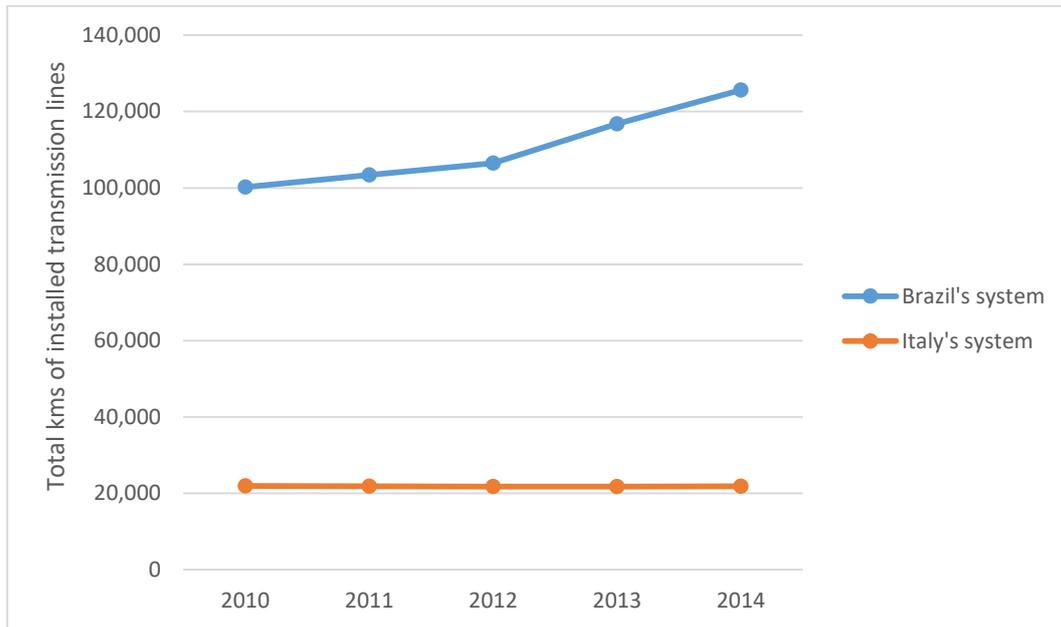
Figure 3. 13. Brazil's main interconnected grid



Source: ONS (2016)

For comparison, while there was very little change in Italy's transmission structure from 2010 to 2014, data from Brazil's National Systems Operator ("Operador Nacional de Sistemas", or ONS) reveals a 25% increase in installed lines during the same period (measured by total kilometers of installed transmission lines). Figure 3.14 makes this comparison even clearer, showing Brazil's transmission infrastructure evolution compared to Italy's. Even given the country's much greater area, the difference is significant (Barroso et al, 2007).

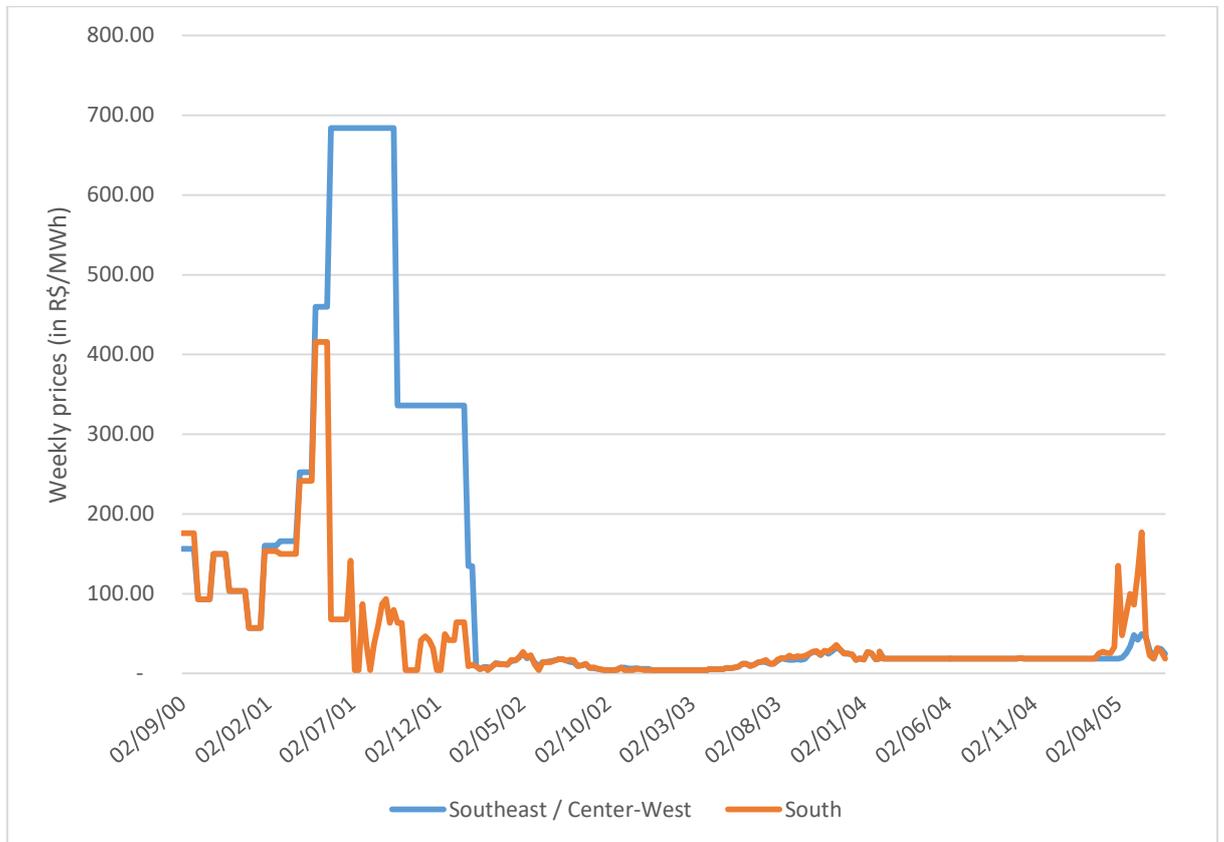
Figure 3. 14. Total installed transmission lines in the Brazilian and Italian systems



Sources: ONS (2015) and Italian Energy Authority Annual Report (2015)

Instead, Brazil's main challenge lies in generation expansion. In fact, the main goal of the liberalization process in the country has been attracting private investment in order to keep up with the country's growing need for electricity. It was a failure in this area, among other things to be explained in section 4.2, which led to the 2001 rationing crisis. As figure 3.15 illustrates, the rationing led to extremely high energy prices, as well as occasionally brown-outs across the country. The southern region, however, was spared as a result of favorable hydrological conditions, as can be seen in its much lower price levels, compared to the southeast and center-west regions (Araujo et al, 2011).

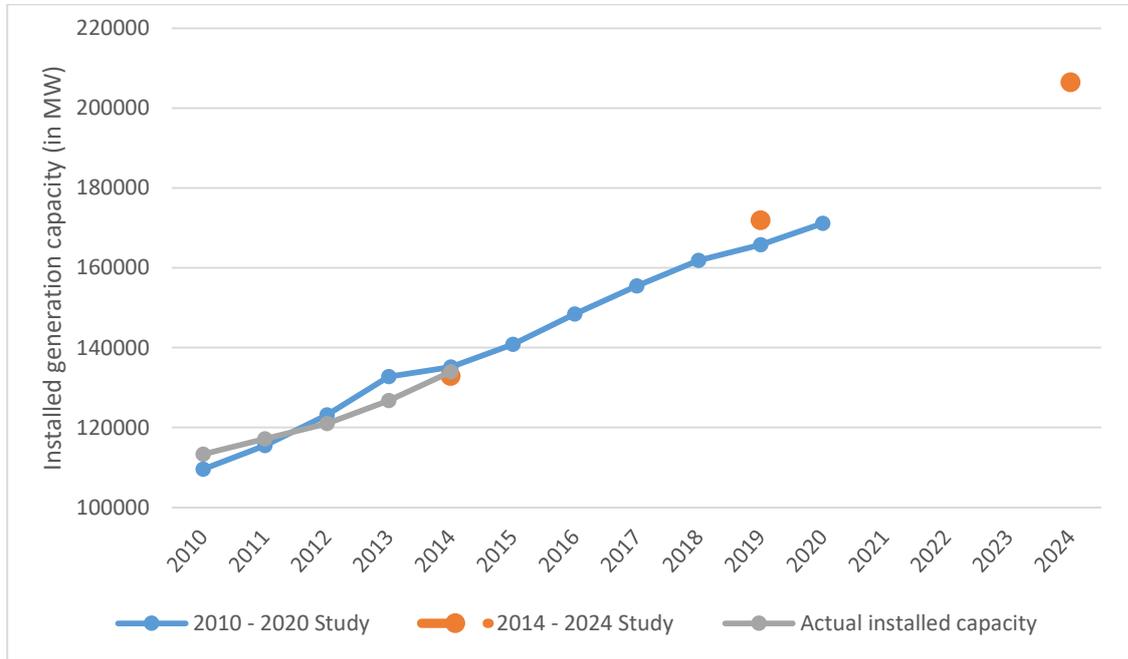
Figure 3. 15. Energy prices in the Brazilian wholesale market (2000 – 2005)



Source: CCEE (2015)

In order to plan future expansion investments, the government created the EPE. This entity conducts yearly studies looking 10 years ahead and forecasting expansion requirements. Since the second decade of the 2000's, studies by the EPE have been relatively successful in their implementation. Figure 3.16 compares expansion forecasting from 2011 (looking ahead to 2020) and from 2015 to 2024 with actual capacity increases during these years. One can see that the 2010 plan is followed very closely by actual expansion, which implies that the 2014 plan should also be accurate. This would mean an installed generation capacity of 206GW by 2024 (EPE, 2015)

Figure 3. 16. Installed capacity: planned vs actual



Data source: EPE (2011, 2015b), EPE (2015)

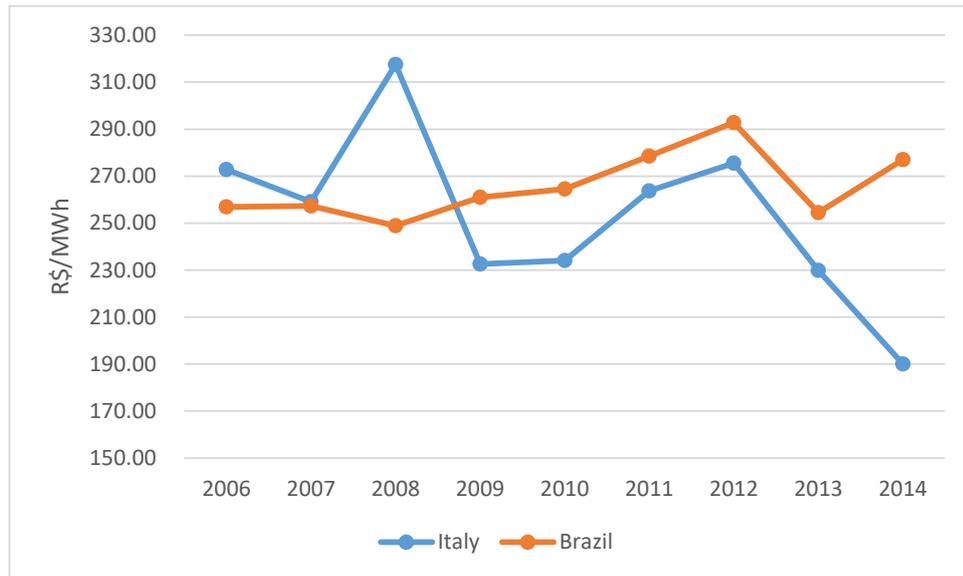
### 3.2.4. Price History

Despite its generation mix with lower marginal cost sources, Brazil's energy prices have been similar to Italy's in recent years. The following figure compares the two from 2006 to 2014, using a R\$3.65/€ exchange rate (obtained in 26/09/2016). Brazil's figures represent national yearly averages for consumer tariffs, ranging from R\$257/MWh in 2006 to R\$293/MWh in 2012.

The figure shows that prices had been similar until 2014, when a drop in gas prices resulted in lower energy prices for Italy. Authors have suggested that Brazil's high prices are intended as an incentive for private investment, given the importance of expansion explained previously. Given Brazil's low liquidity levels (0.88, compared to the EU's 31.82<sup>2</sup>), this incentive in prices is even more important. (Araujo et al, 2011).

<sup>2</sup> Liquidity is calculated as the ration between daily over the counter transactions and daily GDP in each region.

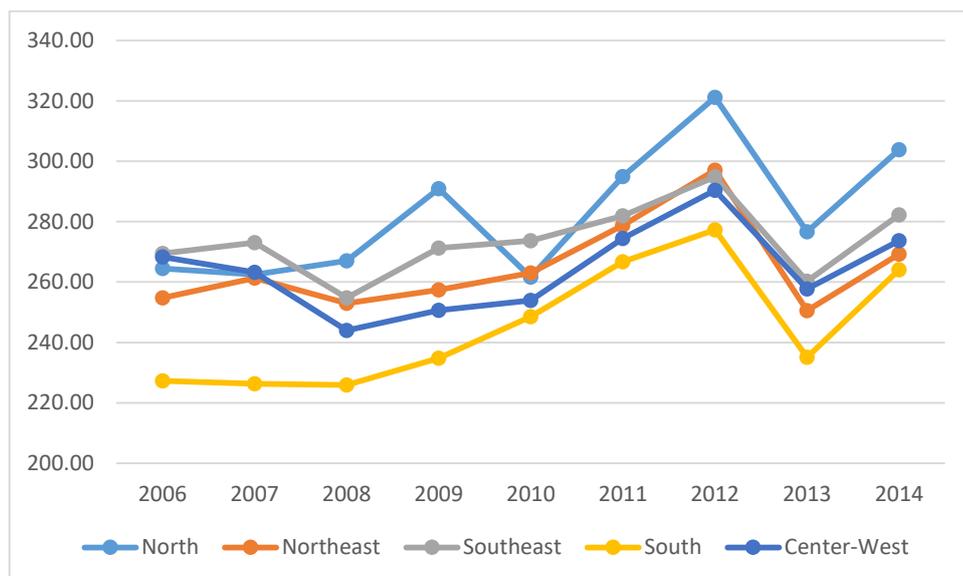
Figure 3. 17. Consumer tariffs in Brazil and Italy (regional averages)



Data Sources: ANEEL (2015), GME Statistics Summary (2015)

When comparing different regions, similar prices are observed, as seen in figure 3.18. This lends further evidence to the fact that Brazil's transmission system is more robust and reliable than Italy's, which experiences severe price differentials across zones.

Figure 3. 18. Average yearly prices in different regions (2006 – 2014)



Data source: ANEEL (2015)

### **3.3. Comparisons**

Section 2.2 shows clear differences in the countries being studied. On one hand, Italy is a small developed country with stable demand and supply of electricity. It relies heavily on fossil fuels, mainly natural gas. As a result, the country's main worries relate to affordability. This factor is dependent on its energy mix and competition levels, which are then related to zone interconnection. Therefore, a liberalization reform should focus on ensuring fair competition among generators through a simple wholesale market, and on incentivizing investments in the Italy's lagging transmission infrastructure.

Brazil, on the other hand, is a big (in both population and area) emerging country with rapidly rising levels of electricity consumption. It relies mostly on large-scale hydroelectric plants, which leaves it exposed to hydrological risks. As a result, the country must focus on obtaining enough investments in expansion and diversifying its energy mix. Its liberalization reform, therefore, should provide enough incentive for private investors, while promoting alternative energy sources, especially green ones.

## **4. REGULATORY HISTORIES**

Unlike the previous section, the regulatory histories of Italy and Brazil will be divided in significantly different structures. This is necessary in order to adequately explain the similarly different reform processes in these countries. Nevertheless, sub-section 3.3 will include comparisons between the two reform cases.

### **4.1. Italy**

#### **4.1.1. European Electricity Directives**

Before the EU started its continent-sized reform, a few countries were already experimenting with competitive electricity markets. The UK introduced competition in 1990, Norway in 1991 and the United States started reforms in 1992. Then, in 1996, the EU Directive 96/92/EC (also known as the First European Electricity Directive) was passed with the goal of fostering competition in national energy markets and, later on, unifying them into a single European market. For this purpose, it mandated the vertical unbundling of the generation sector from the transmission and distribution ones. The first was seen as potentially competitive, while the last two were still considered natural monopolies. At this stage, only an accounting separation was required. It also made necessary the creation of an independent systems operator (ISO), responsible for transmission activities (Trabucchi, 2014).

However, some countries were lagging in their liberalization process, and the Second European Electricity Directive was considered necessary to ensure a level evolution. EU Directive 2003/54/EC mandated a legal separation between the generation sector and the other two, although both companies could still operate under the same umbrella. It also introduced new member-countries into the process.

Finally, Regulation 1228/2003/EC, 713/2009/EC, 714/2009/EC and Directive 2009/72/EC comprised the Third Legislative Package. This last piece of legislation introduced measure to encourage cross-border trading and further increased incentives to accelerate liberalization reforms (Bosco et al, 2012).

Individual countries were expected to translate these directives into national law. The process had some leeway, considering the differences in context for each country (e.g.: in energy sources, production levels and transmission capacity). The EU's final goal, an integrated European Energy Market, would bring four main benefits to its members: greater economic efficiency through a diversified mix of energy sources; diminished market power (especially

by former monopolists); strengthened security of supply, given the vast international back-up system; and reduced need for excess capacity, for the same reason (Trabucchi, 2014).

#### **4.1.2. The Bersani Decree**

Italy converted the First European Electricity Directive into national law in 1999, via the Bersani Decree (or Law 79/99), which focused on the issue of the national monopolist: ENEL. It was determined that ENEL should hold no more than 50% of the national generation capacity. For this purpose, 15GW of capacity were sold into the private sector, by forming three new generation companies (Gencos) and auctioning them off. Eurogen (with a capacity of 7GW) was bought by Edipower, Elettrogen (5.5GW) by Endesa and Interpower (2.5GW) by Tirreno Power.

The company was also vertically unbundled, with its generation, distribution and transmission branches separated into ENEL Produzione, ENEL Distribuzione and Terna, respectively. These companies remained within the umbrella of the ENEL Group. Until 2005, the GRTN (“Gestore della Rete di Trasmissione” or “Transmission Network Operator” in English) was responsible for coordinating the transmission and dispatching of energy. But in November of that year, Terna was also privatized, spun off of the ENEL Group and assumed control of this function (Trabucchi, 2014).

Privatization, however, was still occurring too slowly. By early 2004, the Italian government still held majority shares in 60% of generation companies. In order to address this, the Marsano Decree was passed in 2002, which simplified the bureaucratic process for building and operating new power plants. This was also the year when it was decided that the Italian wholesale market would not be mandatory and bilateral contracting would be allowed in the country (Bosco et al, 2011).

#### **4.1.3. The Italian wholesale energy market**

##### **4.1.3.1. The three markets**

With laws 07/02 and 240/04, the national wholesale energy market and its Market Operator were established: the IPEX (Italian Power Exchange) and the GME (Gestore dei Mercati Energetici), respectively. The IPEX is divided into three different markets: the day-ahead market, the adjustment market, and the ancillary services market. The MGP (“Mercato del

Giorno Prima” or “day-ahead market” in English) is the one where most volume is traded. Hourly bids occur, representing energy production and consumption schedule for the same hour of the following day. The GME orders these bids according to a merit system which prioritizes, in the case of equal prices, energy from renewable sources. It then forms aggregated supply and demand curves and the point where their equilibrium point represents the System Marginal Price (SMP). Italy operates under a uniform price system, therefore generators are all paid the SMP for their supply. After market clearance, suppliers notify the GME about which of their plants will be responsible for producing the traded energy and consumers give an analogous notification (Ferrari et al, 2004).

The Adjustment Market allows generators to correct their scheduling. As mentioned previously, electricity production usually involves significant ramp up costs and times, which are not considered when deciding the optimal dispatch of electricity. The Adjustment Market, therefore, permits the trade of small amounts of electricity between suppliers, in order to suit their production schedules to the mandated dispatch. The Ancillary Services Market is simply a means for the System Operator to procure congestion relief and reserve marginal resources.

Finally, bilateral contracts may occur within the IPEX or “over the counter”. In both cases, there are variable durations (from weeks to years), quantities and prices. As mentioned above, these contracts may represent actual physical transfer of energy or be simple speculative in nature (Bollino et al, 2008).

#### **4.1.3.2. Zonal Division**

The transmission concerns raised in the previous section necessitate a subdivision of the Italian energy market into different zones. The transmission capacity between these zones is limited enough that congestion occurs often. However, it is rarely an issue within each zone. Until 2008, Italy was divided into North (NORD), Center-North (CNORD), Center-South (CSUD), South (SUD), Calabria (CAL), Sicily (SIC) and Sardinia (SAR), but Calabria was eventually incorporated into the South zone. The first five comprise mainland Italy, while the last two are islands. Figure 4.1 shows how these zones are shaped, geographically (Boffa et al, 2009).

Figure 4. 1. Zonal division across Italy



Source: <<<http://dataenergia.altervista.org/portale/?q=glossario>>>, accessed in 18/07/2016

After clearing the market and arriving at the optimal dispatching, the GME then checks the system for transmission capacity. If congestion occurs, equilibrium prices are re-calculated, but with a division between zones where the congestion manifested. Each zone, then, obtains a unique SMP, which is paid to suppliers. The demand side, on the other hand, pays a single price (called the “Prezzo Unico Nazionale”, or PUN), given by the weighted average of zonal prices (Bosco et al, 2012).

It must be noted that this is not an “all-or-nothing” phenomenon, where either the country is completely unified or separated. It is possible, for example, for mainland Italy to act as one market, while the islands comprise a second and third. This market division can be referred to as a “configuration”, according to Bigerna, Bollino, Polinori (2015). A two-zone

configuration, for example, occurs when two different markets form. Two possible scenarios are shown in Figures 4.2 and 4.3 for clarification purposes. In the former, Sicily (in green) has congestion issues and is therefore separated from the rest of Italy (in red). This is a two-zone configuration. In the latter, a north-south division occurs (red and green, respectively), as well as a division between mainland and the islands (which are in yellow). This represents a three-zone configuration.

Figure 4. 2. Two-zone configuration example



Source: <<<http://dataenergia.altervista.org/portale/?q=glossario>>>, accessed in  
18/07/2016

Figure 4. 3. Three-zone configuration example



Source: <<<http://dataenergia.altervista.org/portale/?q=glossario>>>, accessed in 18/07/2016

In any case, generators have the option of selling their energy to a different zone than they are located in. For this purpose, they must purchase transmission rights, which are given by the difference between the SMP at each zone.

#### **4.1.3.3. Demand-side bidding**

Until 2005, the demand side of the market consisted of a Single Buyer (“Acquirente Unico”, in Italian), who served all other consumers. As a rule set by the Italian regulator (AEEG), the Single Buyer estimated demand levels for the whole nation, then procured that

amount exactly, with zero elasticity. The price paid by consumers was given by the weighted average of the month's PUNs.

In January of 2005, demand-side bidding was introduced for eligible consumers. Just as suppliers, consumers submit price-quantity pairs to be ordered by the GME. Alternatively, they may simply offer a standalone quantity, signifying perfectly inelastic demand. This quantity is then associated with the price cap (€3000/MWh in 2010) when calculating aggregate demand. The Single Buyer remained in the market, serving distribution companies who internally supplied residential users, though its market share roughly halved between 2005 and 2009.

In November of 2007, retail liberalization was enacted. This reform allows residential consumers to choose their preferred distribution company. It exposed 85TWh of yearly consumption to competition, including 22 million families and 5 million other users (which amounts to 70% of clients and 30% of energy consumption). The objective was to somewhat increase the short-term price elasticity of demand, reducing the market power of generators and the need for distribution regulation. This was somewhat hampered by a lack of consumer awareness and perceived non-financial switching costs. In fact, a survey run by Nielsen-Bup in 2009 concluded that 31% of users were unaware of the reform and 36% of those who were aware still were not willing to change suppliers. Furthering this problem, it has been found that when retail is liberalized, Distribution companies become less willing to sign long-term contracts with generators. These contracts are an important way of reducing market power by large generators, including ENEL, because committing resources at a set price reduces the generator's gain from future price increases. In November of 2008, an Italian Physical Forward Market and a Market for Financial Futures were established with the aim (among other things) to incentivize further long-term contracting (Petrella et al, 2011).

#### **4.1.3.4. Other policy decisions**

##### *Price-Capping*

Price capping is standard practice in electricity markets. They allow governments to limit abuse by large players, who could – in principle – have extreme effects on price formation. Put simply, a price cap is the maximum price that suppliers are allowed to ask for each unit of energy. Implemented nationally and properly defined, they can foster (not diminish) competition in the industry by counter-balancing the lack of demand elasticity (Petrella et al, 2011).

### *Virtual Power Plants*

Virtual Power Plants are a form of mandatory forward contract that can be applied to companies with excess generation capacity in a given region. In this case, the large generator is obligated to “virtually” sell a percentage of its capacity to a local competitor. After actually selling this capacity in the market place, the seller pays the buyer an amount equal to the difference between the market price and the stipulated contract price. If the SMP is instead larger than the contract price, the buyers pays the difference to the seller. The practice of Virtual Power Plants is better applied at regional levels and successful implementations can be seen in Sicily and the Center-South zone (Bosco et al, 2012).

### *White Certificates*

White certificates are tradeable certificates granted for distribution companies who engage in initiatives to improve energy efficiency. This can be done by assisting residential and industrial consumers in reducing their energy spending. They are part of legislation that establishes energy savings targets for distributors with over 100 thousand end-users (this number was changed to 50 thousand in 2007). Companies who surpass these targets are granted White Certificates, which may be trade to underperformers or saved for future use. The ultimate goal is to decrease national energy demand and, consequently, energy prices (Petrella et al, 2011).

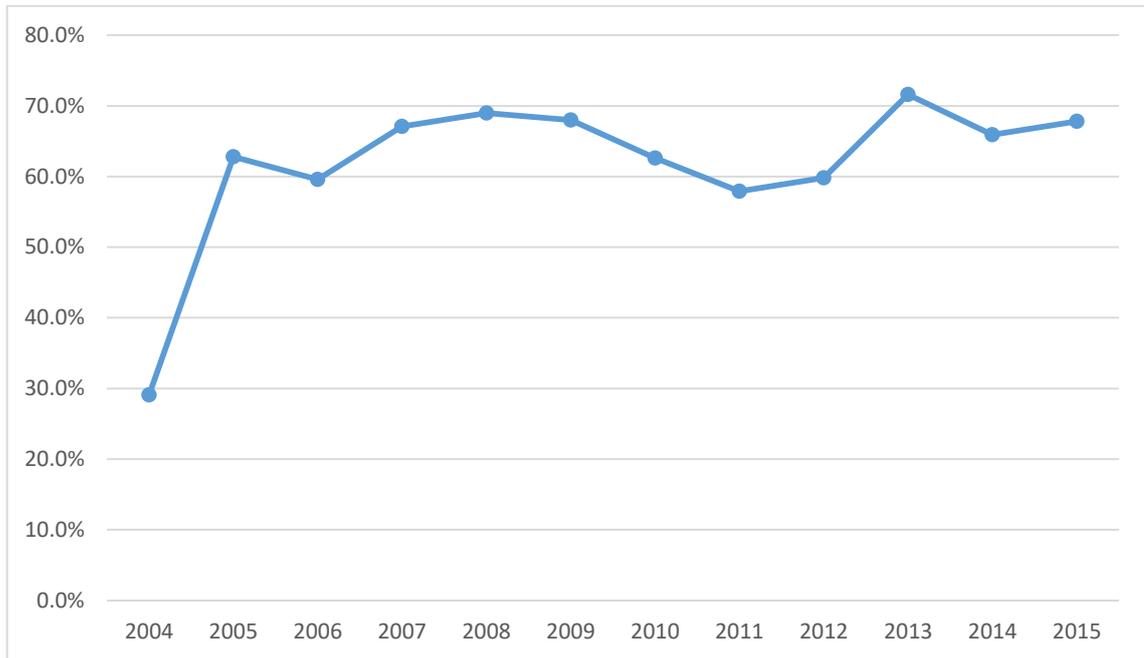
### *Contracts for Differences*

Contracts for differences are hedging contracts introduced specifically for renewable energy sources. The party taking the long position pays the difference between the asset’s current price and its price at the specified time in the contract. The party in the short position pays if the opposite case occurs. They can be used to reduce price volatility and allow generators to better manage their production schedules (Petrella et al, 2011).

#### **4.1.4. Results**

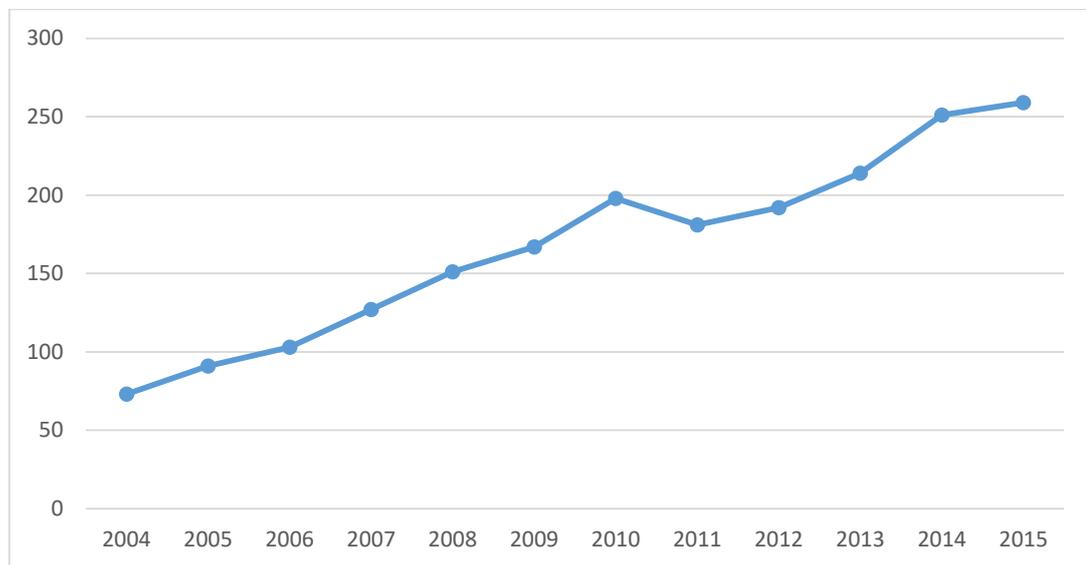
Overall, the IPEX can be considered a success. Since 2005, a year after its introduction, it has had liquidity levels higher than 55%, given by the ratio between energy traded in the IPEX and total energy traded in Italy. The number of participants over time has steadily increased, from less than 100 in 2004 to over 250 in 2015. Figures 4.4 and 4.5 show these values from 2004 to 2015.

Figure 4. 4. Liquidity Levels in the IPEX (2004 – 2015)



Data Source: GME Summary Statistics (2015)

Figure 4. 5. Number of Participants in the IPEX (2004 – 2015)



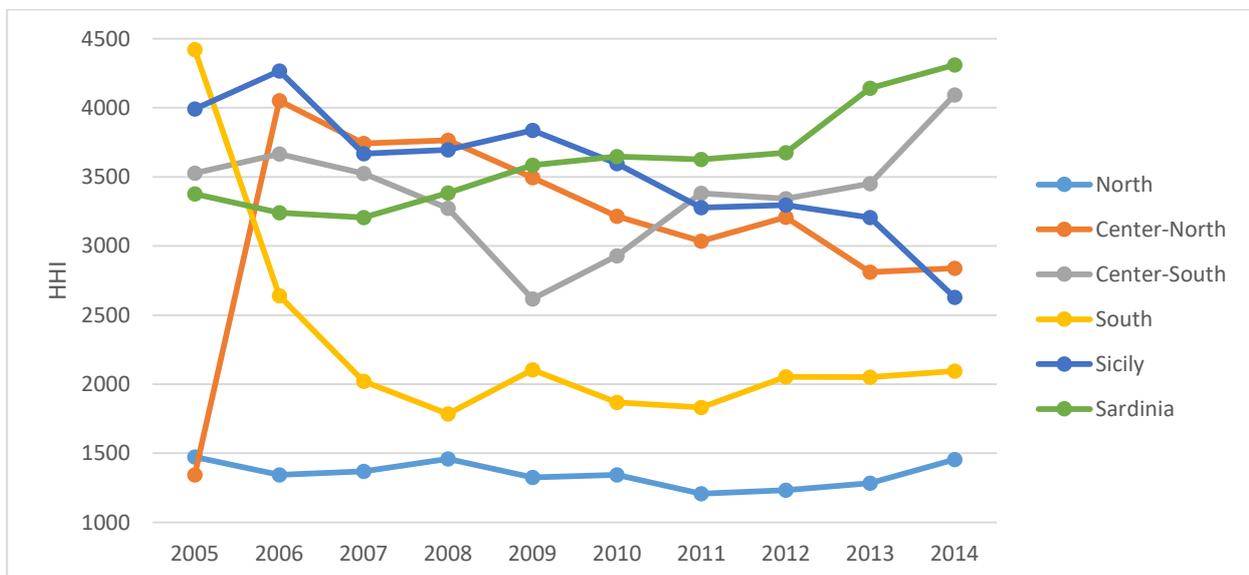
Source: GME Summary Statistics (2015)

Its main failures, however, were a lack of investment in transmission infrastructure, and its ineffectiveness in promoting effective competition. The former led to the increasingly frequent and inefficient zone separations discussed previously, while the latter means that ENEL, along with other big players, still possesses significant market power, especially in specific zones.

An analysis by Bigerna (2014) shows that both Sicily and Sardinia experienced effective duopolies from 2004 to 2007. In the former, ENEL and Edison held enough market power to become price-makers, and in the latter, a similar situation occurred for ENEL and Endesa. In addition to that, when Italy was divided (due to congestion) into Sicily, Sardinia and Mainland Italy, ENEL, Edison and Endesa had sufficient market power to influence prices in the entire country.

The Herfindahl-Hirschman Index (HHI), introduced by Herfindahl and Hirschman (1950), can also be used to measure of market concentration. It is given by the sum of the squares of all suppliers' market shares in a given market (written as percentages). Therefore, in the case of a monopoly, the HHI assumes its highest level: 10000 and, as supply gets more scattered, it approaches zero. According to figure 4.6, concentration in the Center-North and Sicily has decreased, but it has instead increased in the Center-South and Sardinia. These two zones now show the highest concentration values in the country.

Figure 4. 6. HHI Values for sales according to zone (2005 – 2014)



Source: GME Annual Reports (2006 – 2015)

Lending further credence to this situation, analyses by Boffa et al (2009) and Floro (2007) determine that the Italian market does not operate under perfect competition. The former, studying the situation in 2004, determines that the most fitting model would consider ENEL as a “Dominant” firm, faced only with a fringe competition. This model indicates an effective monopoly, with the fringe competition simply taking the price set by the monopolist. The latter study, conducted in 2007, finds that model to no longer be accurate. Instead, ENEL

acts as a first mover in a multi-player game-theoretical model. Other players, namely Edison, Endesa and Enipower, also behave strategically and are able to affect price levels. Nonetheless, an oligopoly of only four players remains, instead of the desired perfect competition status.

Finally, Pellini (2012) studies how these factors affect price levels. Using engineering data from the *Ricerche per l'Economia e la Finanza*, the author estimates marginal cost levels and uses this curve to simulate perfect competition (given that at perfect competition, prices are equal to the firms' marginal costs). The paper finds that a perfect competition scenario could have led to a net welfare gain between €641 million and €936 million in 2010, depending on marginal costs and demand assumptions.

#### **4.2. Brazil**

Brazil's liberalization process has gone through three distinct phases: a period of no coordination between regulatory reform and privatization between 1995 and 2002, an attempt at mending things until 2003, and a more substantive "reform of the reform" in 2004 (Araujo, et al, 2011). The first two phases occurred under the President Cardoso administration and combine to make the commonly known first reform, while the third and last phase occurred under President Silva. The first reform, along with the reasons for its failure will be explained below, but greater detail will be given to the workings of the second reform, given that it is the system under which the country is currently operating. Ferreira et al (2015) also provide a summary of the country's workings pre-liberalization and during the first and second reform.

Table 4. 1. Summary of Brazil's three market models

Characteristics	Old model (until 1995)	Free market model (1995 – 2002)	New model (from 2003)
Financing	Public resources	Public and private resources	Public and private resources
Structure of businesses	Vertically integrated	Generation, distribution, transmission and commercialization	Generation, distribution, transmission and commercialization
Public vs. private relationship	Predominantly State-owned businesses	Opening and emphasis on privatization	Coexistence between State-owned and private businesses
Market structure	Monopolies – non-existent competition	Competition in generation and commercialization	Competition in generation and commercialization
Consumers	Captive	Captive and free	Captive and free
Tariff structure	Regulated in all segments	Prices freely negotiated in generation and commercialization	Regulated and free contracting environments
Market	Regulated	Free	Coexistence between the regulated and free markets
Expansion planning	Coordinating group for the planning of electrical systems	National Council of Energy Policy (CNPE)	Energy Research Company (EPE)
Contracting	100% of the market	95% of the market	100% of the market and reserve

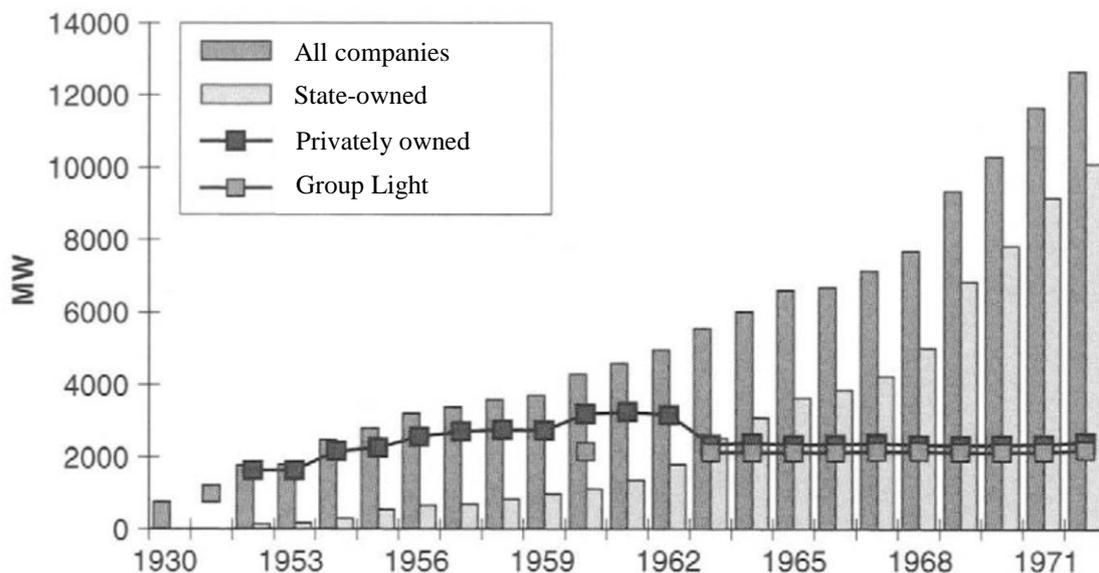
Source: Ferreira et al (2015)

#### 4.2.1. Pre-liberalization

Until the 1930s, most activities in the energy sector were conducted by private groups, mainly the American-Canadian Group Light (acting in the Southeast region) and the American Foreign Power Company (in other capitals and mid-sized towns). In smaller, poorer regions, a collection of public and private groups were responsible for supply (Araujo, 2006).

During the Vargas administration, the public sector expanded its role. At first this was done by regulating the sector, followed by investments in State-owned installations. The availability of large-scale hydro projects, which require high levels of investment with long maturation lags, contributed to strengthen nationalization efforts. Figure 4.7 shows the evolution of generation ownership during this time. It is clear that nationalization was a long term process. Although it started in the 1930s, public companies only overtook Group Light in 1963. Indeed, international private capital also dominated distribution in the states of Sao Paulo and Rio de Janeiro until the mid-1970s, when the federal government purchased Group Light's Brazilian operations.

Figure 4. 7. Generation ownership evolution (1930 – 1972)



Source: Araujo (2006)

With the creation of Eletrobras in 1962, the sector experienced significant success, obtaining financing from sources like the World Bank and investing it into capacity expansion. It exploited coordination and interconnection economies in order to keep up with demand growth (which reached an 11% annual growth rate during the 1970s).

However, the 1973 oil crisis, combined with costly investment decisions over the decade and high interest rates, contributed to severe financing issues. These were exacerbated by the 1980s debt crisis and the abolishment of the Federal Electrification Fund by the 1988 Constitution (Ferreira et al, 2015).

Furthermore, equalized national tariffs, also in the 1970s, de-stimulated efficiency among competitors and the depletion of hydrological basins close to consumption centers hindered investments even more. As a result, the State could no longer perform the necessary investments to follow the country's growing demand. By 1992, six different bills were being debated in Congress, aiming increasing the role of the private sector in energy generation and introduce decentralization (Araujo, 2006).

#### **4.2.2. The first reform (1995 – 2003)**

##### **4.2.2.1. Objective and legislation**

The first reform, under President Fernando Henrique Cardoso, followed the model of the British Pool, with the aim of attracting private investment and promoting free competition in the generation sector of the industry. In this system, marginal costs were used to determine pool prices. This works under the thermal-based British grids, but fails to attract sufficient investment in a hydro-dominated system (due to their low marginal costs), as shall be seen below.

The Law of Concessions (Law 8987) was passed in 1995, creating conditions for greater private capital participation in the electricity industry and regulating bidding systems for these concessions (Ferreira et al, 2015). At the same time, Law 9074 forced utility companies to give up concession for power plants that had not started to be built and to present concrete plans for those under construction. It also mandated the opening of grid access to large consumers (characterized by demand levels of 10MW initially, but 3MW after the year 2000), who were free to choose their own suppliers. This last move created room for the entrance of independent power producers, who formed partnerships with large, free consumers. These initial reforms led utilities to look to private partners for help with their concessions.

In 1996, the Restructuring Project was initiated to unbundle generation, transmission and distribution, incentivize competition in generation and commercialization, and regulate transmission and distribution. It was complemented by a study aimed at divesting all of generation, transmission and distribution in the country (with the exception of Itaipu and

nuclear plants). Initial distribution assets were sold without a surrounding regulatory framework, causing considerable regulatory backlogs (Araujo et al, 2011).

In December/2006, Law 9427 created ANEEL (“Agencia Nacional de Energia Elétrica” or National Electric Energy Agency), a regulating agency for the energy sector. ANEEL is an independent agency, responsible for granting concessions, organizing auctions, as well as other regulatory functions. It performs with administrative and financial autonomy, though its board of directors are appointed by the president and approved by the Senate.

In 1998, the ONS (“Operador Nacional de Sistemas”, or National Systems Operator) was created by Law 9468, responsible for operating the physical systems. The ONS is a private association, divided into GENCOS (centrally dispatched generation), TRANSCOS, DISTCOS, large consumers, power importers & exporters, MME, consumer councils (with representatives indicated by ANEEL) and other producers and distributors. In addition to that, the MAE (“Mercado Atacadista de Energia”, or Wholesale Energy Market) was created in conjunction with it, with the purpose of handling the bulk of power market transactions, though it only started operations in 2000 (Ferreira et al, 2005).

ANEEL also assigned contracts between generators and distributors in 1998, which were to be progressively discontinued starting in 2002. Generators were obligated to supply the specified amount of electricity, buying it in the spot market if necessary. The goal was for these assigned countries to be replaced with freely placed ones, providing a smooth transition into a fully liberalized market.

However, the operation of the MAE proved slow and awkward, according to Araujo et al (2015), due to conflicts between generation and distribution companies. Though a preliminary agreement was reached in 1999, creating governance and administrative structures, it was followed by further delays, then drastic changes in 2001 and 2002. Specifically, Law 10433 of 24/April/2002 reorganized MAE and gave it special legal status. It became a private non-profit entity, subject to regulation and monitoring by ANEEL. Its governance model was also changed, though many disputes among agents remained. In addition to that, spot prices after the 2001 crisis were so low that distribution companies preferred that to entering in long-term contracts with generation companies. As a result, generator revenues fell drastically, reducing the attractiveness of investments (Araujo et al, 2011).

Also in 1999, the MME created a Coordinating Committee for Electricity Planning (CCPE), tasked with preparing indicative plans for generation expansions and mandatory ones for transmission expansion.

On the privatization side, Eletrosul (previously owned by Eletrobras and providing electricity to the South region) was divided into a transmission company (which remained named Eletrosul and under federal control) and a generation one named Gerasul, which was privatized. In São Paulo, CESP (“Companhia Energética de São Paulo”, or São Paulo Energy Company) was split into a State-owned transmission company (now called Transmissão Paulista) and three generation companies, two of which were privatized. Overall, roughly 23 enterprises, valued at around US\$22 billion, were sold into the private sector. Many generation companies, however, remained under government control, due to political infighting (from states run by rival parties), the drying up of international capital at the time, and the presence of large-scale hydro plants (with extremely low marginal costs). Furthermore, according to Araujo et al (2011), the prospect of federal divestment slowed down investments in new energy generation (given their slower returns), which contributed to a lack of capacity expansion (Araujo, 2006).

Figure 4.8a provides a summary of first reform legislation and 4.8b details the structure of the Brazilian electricity supply industry in 1995, both from Araujo (2006). It should be noted that some of the laws outlined in 3.7 have not been detailed in this section, as they are not relevant to this particular analysis.

Figure 4. 8a. First reform legislation summary

Event	Date	Comments
Law 8631	1993	Ended guaranteed remuneration, tariff equalization, annulled intra-sector debts
Decree 915	1993	Allowed public and private consortia for power generation
Decree 1009	1993	Created SINTREL to allow third-party access
Law 8987	1995	Introduced price cap and competitive bidding for concessions
Law 9074	1995	Forced utilities to let go of projects not started and present financial plans for finishing ongoing projects. Also forced open access to large consumers and gave space to independent producers
RE-SEB started	1995	Project for restructuring and privatizing the ESI. Commanded study to consortium led by Coopers and Lybrand
ESCELSA divested	1995	First privatization, on ad hoc bases.
LIGHT divested	1996	First large DISTCO privatization, also on ad hoc bases
Law 9427	December 1996	Created ANEEL; first board appointed 1 year later
Law 9478	1997	Created CNPE, but first activities in November 2000
Law 9648	1998	Created ONS (System Operator), MAE (Bulk Market)
Initial contracts	1998	Assigned by ANEEL to existing generators, to expire in 2005
MAE agreement	1999	Provisional agreement for the bulk market
CCPE created	1999	Organism charged with transmission planning, plus indicative for generation, replacing GCPS
ANEEL Resolution 178	2000	Limits to market shares
MAE begins operation	September 2000	Definition on rules; "NV"
Divestment ceases	2000	
ANEEL Resolution 290	2000	Required changes in market rules
Rationing starts	May 2001	Creation of GCE; Kelman report commanded
Intervention in MAE	2001	MAE restructured; COEX replaced by COMAE
Kelman report	July 2001	Diagnosed management and investment problems
Rationing ends	March 1, 2002	GCE changed into CGSE. Risk aversion curves introduced into reservoir operation
Law 10433	April 2002	Restructured MAE, changing governance
Laws 10847, 10848	March 15, 2004	New electricity arrangements, after 10 months of negotiation
Decree 5184	August 2004	EPE; CMSE replaced CGSE; CCEE replaced MAE
Created EPE		
First auction of "existing energy"	December 2004	Prices below what was expected

Source: Araujo (2006)

Figure 4.8b. Structure of the Brazilian ESI (1995)

Level	Roles	Companies
Binational	Generation	Itaipu
Federal	Holding, planning	Eletrobrás
	Generation and transmission	Furnas, CHESF, Eletrosul
	Generation and distribution	Eletronorte
	Nuclear engineering; research	NUCLEN; CEPEL
State	Generation and distribution	CESP, CEMIG, COPEL, CEEE
	Distribution	23 companies
Municipal	Distribution	5 companies
Private	Distribution	25 companies

Source: Araujo (2006)

#### 4.2.2.2. Results

In general terms, the Brazilian ESI faced troubles after its first market-oriented reform, failing to attract sufficient investment in generation and leading to higher consumer tariffs and the 2001 crisis (Araujo et al, 2011). According to Araujo (2006), this was mainly due to misalignment between the restructuring, regulation and privatization processes. This misalignment increased risk to investors, resulting in contracts with inefficient clauses, difficulty and difficulty in regulation.

Although it had most ingredients from standard liberalization literature (a regulator, an independent systems operator, a wholesale market, open access, a spot market, bilateral contracting and regulation of transmission and distribution), many ideas “imported” from success cases were not adapted to the Brazilian context of expansion and hydro-domination. It deviated from the literature, however, by conducting regulation and privatization in parallel, instead of finishing the former before starting the latter. This also served to increase investor risk and reduce investment attractiveness.

In the distribution sector specifically, privatizations were relatively successful. In fact, in 2003, 66% of distribution revenues went towards investor-owned companies (Araujo, 2006). Concessions were based on highest offer, for a set tariff. Complications only occurred in 1999, due to the Real devaluation. At the time, the companies involved experienced significant financial difficulties and consumer tariffs rose above the rate of inflation. Furthering this problem, the 2001 crisis (which shall be examined next) caused consumption to fall 25% and self-production to increase, leading to more losses for distribution companies.

As a result, the federal government was asked for compensations and granted them. Tariffs were increased and restrictions on vertical integration were softened. Even so, some companies returned their concessions, which were located mostly in the North and Northeast and were bought by the Eletrobras Group.

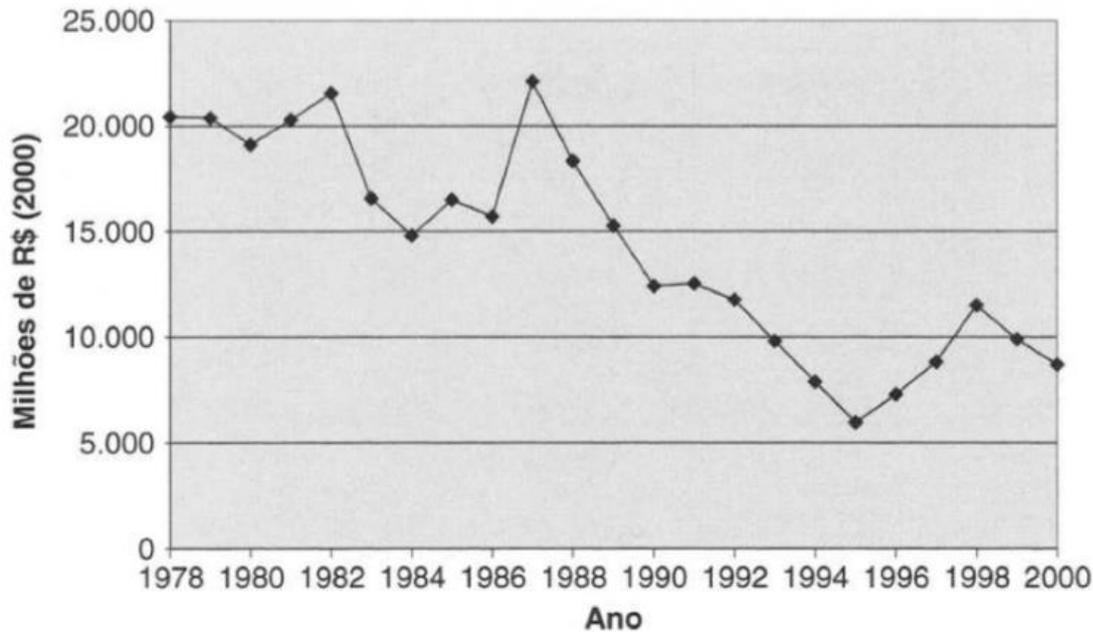
The transmission sector experienced the smoothest process. Auctions for transmission lines went for companies accepting the lowest yearly revenue, in return for installing and maintaining the lines. This system led to adequate competition by both national and international agents. It also allowed the ONS to plan grid expansions and have these plans met by private investment.

The generation segment was the most problematic. Divestment was difficult for reasons outlined previously (political infighting and the presence of low marginal cost plants) and the MAE, the main incentive for competition in generation, was paralyzed by disputes for over 4 years. However, Araujo et al (2011) speculate that, even without the paralysis of the wholesale market, the 2001 crisis would still have happened, due to flawed regulations and governance structures at the time.

Thermal plants had more specific issues. Given the country's ample availability of low marginal cost, hydro-based electricity, thermal plants were rarely needed in order to meet demand. This meant that, although necessary for times of peak demand or hydrological scarcity, these plants did not perform consistently enough to satisfy investor needs. A program allowed these plants to establish "inflexible energy", that is an amount of energy to be dispatched regardless of merit order. These generators were then paid the system marginal price, which was the main issue with the program. Cost or bid based systems would have worked to encouraged investments, but system prices were often below the operational costs of thermal plants. As a result, inflexibility clauses went largely unused.

Figure 4.9 outlines investment levels during the first reform. One can see that they never reached the levels from the 1980s and in fact started to fall, starting in 1998.

Figure 4. 9. Investment in the Brazilian ESI (1978 – 2000)



Source: Araujo (2006)

Araujo (2006) also points to a specific positive aspect of the first reform: ANEEL's performance and transparency as a regulating agency, despite its complex mission and double-reporting structure (to both Congress and the MME). That, combined with the investments in distribution and transmission, can be considered important gains from this first wave of reform.

#### 4.2.2.3. The 2001 crisis

Some immediate causes for the 2001 rationing crisis include 40 straight rainless days in February/2001. At the time, the government denied the possibility of rationing while conducting meetings on possible courses of action. Another issue was the excessive production cuts by federal generators, led by inflated expectations of private investments. However, low investment levels as outlined above are considered the most important causes for the crisis (Araujo, 2006).

In May, the Chamber for Management of the Energy Crisis was created and emergency measures introduced. These included rationing, exceptions to regulations and ad hoc contracts with investors. The rationing itself started in June/2001, causing huge losses to generators and raising consumer tariffs significantly. Prices in the MAE were held at the ceiling (R\$684/MWh)

and free auctions for surplus energy were held. At the time, the South was the only region free from rationing, due to favorable hydrological conditions.

Supply for advertisement and ornamental purposes was suspended, along with a 35% decrease in public lighting. Other measures aimed to reduce consumption by 20% start June 1<sup>st</sup>. Tariff bonuses were set for consumers who could achieve the reduction goals. These were reached a month into the rationing in both the North and the Southeast. Combined with a new rainy season, this ended the rationing in March/2002.

However, consequences from the crisis were dire for the sector as a whole. Adjustments and emergency measures were often conflicting with long-term goals and eventually required in-depth revisions. These included overly costly contracts with merchant companies. As a result, many private and public distribution companies in the North and Northeast became insolvent (and were forced onto Eletrobras), many generators experienced heavy losses and self-production was forced to increase. Nationally, GDP was stagnant in 2001 (only a 1.3% growth) and electricity consumption fell 6.6%. To compensate for utility companies' losses, tariffs were increased (as seen above), further aggravating final consumers.

A task group headed by Jerson Kelman (Chief regulator for the National Water Agency - ANA) published the Kelman Report in 2001. Its main conclusions were: the crisis could have been averted if expansion goals had been reached for generation. Construction delays and non-implemented plants accounted for 62TWh of non-generated energy (22 and 40TWh, respectively) and assured energies in initial contracts were overestimated, giving the government a false sense of security of supply. Federal generators were constrained by macroeconomic policies (fiscal surplus, reduced spending) and attempts to encourage thermal generation were resounding failures. Furthermore, there was a serious lack of communication between government agencies (ONS, ANEEL, MME, the Presidency) and no clear or stable rules, creating a lack of faith in contracts.

#### **4.2.3. The second reform (2004 – now)**

In 2004, the President Silva administration implemented a "reform of the reform", consisting of competitive bilateral contracts between consumers, traders, distributors and producers, combined with auctioned contracts between generators and distributors (Araujo et al, 2011). The reform consisted of three main objectives: to create an efficient mechanism for the contracting of electricity on behalf of captive consumers, to ensure security of supply at the lowest possible prices, and to provide universal access to electricity (Dutra et al, 2005).

The reform was characterized by greater government involvement and centralization, as well as auction-based contracting for distribution companies serving captive consumers. It also consolidated the vertical separation started in the first reform and centralized decision in the MME. This means that government decisions carry greater weight than before (though less than they did under the monopoly model). In order to ensure security of supply, four main mechanisms are used: requirements for distribution companies to contract for 100% of forecasted demand in the next five years; realistic estimates of guaranteed energy from plants; contracting a mix of hydro and thermal plants that balances cost and security; permanent monitoring of security of supply, in order to guarantee early intervention and fixing. In addition to that, privatization efforts were greatly slowed down. In fact, companies in the Eletrobras Group were taken off the privatization list and Eletrosul was allowed to invest in generation once again.

Nonetheless, seeking to attract private investment, 15-30 year contracts were auctioned using a least price mechanisms, to reduce investor risk while stimulating economic efficiency. Hydro and thermal plant contracts are auctioned separately, to mitigate the domination of hydro energy. Distribution companies form a pool to contract from each winner, in order to divide risks/rewards and smooth prices across different regions. These auctions often require distribution companies to forecast their demand 5 years in advance, which has raised objections. For this reasons, adjustment auctions were created, with the aim of minimizing this problem. To get around the environmental licensing issue, which many perceive to be unduly burdensome, specific government-chosen projects come with a preliminary license, aimed at encouraging investors (Araujo, 2011).

In this new system, independent and self-producers are small, but plentiful, as well as organized into large associations, so that their influence is not negligible. Overall, in 2007, the generation sector of Brazil's electricity industry had more than 1259 agents operating in it. Figure 4.10 shows an equivalent agent list for 2005.

Figure 4. 10. Brazilian ESI structure (2005)

Type	Activities	Enterprises
Binational Federal ownership	Generation	Itaipu
	Holding	Eletróbrás
	Generation	Eletronuclear, CGTEE
	Generation, transmission	Furnas, Chesf, Eletrosul <sup>a</sup>
	Generation, transmission, distribution	Eletronorte
	Distribution	Boa Vista, Manaus <sup>b</sup>
	Nuclear Engineering	NUCLEN
State ownership	Research	CEPEL
	Generation, transmission, distribution	CESP, CEMIG, COPEL, CEEE
	Transmission	Transmissão Paulista
Municipal	Distribution	11 companies
	Distribution	5 companies
Private <sup>c</sup>	Generation	23 companies <sup>d</sup>
	Distribution	40 companies <sup>b</sup>

Source: Araujo (2006)

Despite this large amount of players, the industry remains very concentrated. The Eletrobras Group has over 30% of total installed capacity, with strong region dominance. CHESF (Companhia Hidroelétrica do Sao Francisco) has 38% capacity in the North and Northeast, with Eletronorte holding another 32%. This means that no effective competition can possibly occur in those regions. Meanwhile, Furnas has 15% capacity share in the South, Southeast and Center-West.

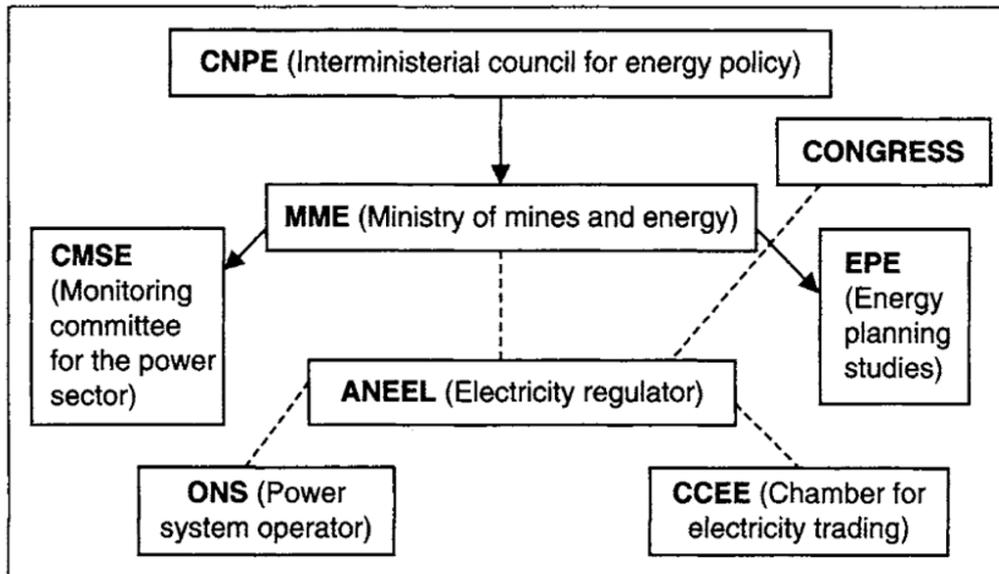
Similarly to Italy, Brazil's system is divided into separate zones, as following: North, Northeast, South, and Southeast + Center-West. However, unlike its developed counterpart, Brazil's zones are not much different from each other, in terms of final prices. Another important difference between the Brazilian second reform's system and the Italian one is the formation of system prices. While in the European country, this price is given by the equilibrium between demand and supply, Brazil's system prices are determined using computer models (Araujo, 2006).

#### 4.2.3.1. Main federal organisms agents

Federal organisms are classified into three categories: executors of government activities, executors of regulatory activities, and entities of private right which execute special activities. In the first category, the National Energy Policy Council (CNPE), the Ministry of Mines and Energy (MME) and the Electrical Sector Monitoring Committee (CMSE) act above the following bodies. In the second, you have ANEEL, which regulates and monitors the industry, aside from conducting concession auctions. In the third, EPE, ONS and CCEE. Figure 4.11

illustrates these relationships, where solid lines represent hierarchies and dotted ones represent communication. This section, however, will focus on the third category of agents (Araujo et al, 2011).

Figure 4. 11. Federal organisms in the Brazilian ESI



Soure: Araujo et al (2011)

The main functions of the Brazilian government after the second reform are: expansion planning, operational planning & programming, and determination of the spot price. These are done, respectively, by the Energy Research Company (EPE), the National Systems Operator (ONS), and the Chamber of Electric Energy Commercialization (CCEE) (Ferreira et al, 2015).

The EPE was created by Decree 5184 and authorized by Law 10847, in order to perform long-term planning for the energy sector, reclaiming this function for the Federal government. One of its main responsibilities is producing yearly reference plans. These plans have a 10-year horizon and are used to carry out actual dispatching plans, conducted by both the EPE and the ONS, with a 5-year horizon. Along with it, the Monitoring Committee for the Power Sector was created to evaluate and monitor security of supply. Both of them respond to the MME.

The ONS is responsible for maintaining transmission systems and planning expansion of their infrastructure. ANEEL conducts transmission line auctions, which are given to those willing to accept the lowest yearly revenue in order to install and operate these lines. This winner will form a special purpose company (SPC) for this task. The system is then managed by the ONS in order to guarantee open access (Barroso et al, 2007).

Most importantly, however, the entity determines and carries out optimal energy dispatching. This is done via intricate computer models, partly in order to take advantage of seasonal rain variations. Aside from that, there are the inherent problems in planning power flows (limited transmission capacity, the necessity for real-time coordination, etc.) and some unique to Brazil, due to the continuous expansion and hydro-dominance of the system (Barroso, 2007). Specifically, in hydro-heavy systems, physical dispatching affects not only present costs, but future costs and availability. The computer model's goal, in broad terms, is to rely on as little thermal energy as possible, given its higher marginal costs. Optimization involves spreading out thermal use in order to preserve reservoir levels and balance present costs with future ones. In addition to that, it must respect demand, transmission and capacity constraints.

In the medium-run, the entity must also reconcile expansion planning with the above decisions. The ONS model operates on both of these time scales, defining operational planning on a 5-year horizon. As with most forecast systems, the shorter-term analyses can use more deterministic values, while longer-term ones present more uncertainty.

Finally, the CCEE was created as a replacement to the first reforms' MAE. It is responsible for administering contracts of energy sales and purchases by public authorities, conducting energy purchase auctions for distribution utilities (under ANEEL's authorization), and performing accounting and settlement functions in its trading environments. For this purpose, it utilizes the Free Trading Environment (ACL – Brazilian acronym) and the Regulated Trading Environment (ACR – Brazilian acronym). In the latter, the CCEE mediates contracting between buyers and sellers, and calculates supply tariffs for distribution utilities (which ANEEL then uses to calculate final consumer tariffs). In broad terms, the ACL operates with freely negotiated contracts, while the ACR uses a mixture of auctions and regulated pooled contracts, though a more detailed analysis is present in sections 4.2.3.2 and 4.2.3.3.

An important point lies in the separation between the commercialization of energy (carried out by the CCEE) and actual physical dispatching (by the ONS). For example, a generator may not be called on to produce by the ONS; despite having contracted some of its capacity. These differences between contracted and actually produced/consumed energy are settled by the CCEE in the spot market, valued at the Liquidation Price of Differences. This LPD is determined weekly for each load level and submarket, based on marginal cost estimates. It is also limited by minimum and maximum prices, to prevent abuse and avoid overly punishing agents who make use of the system.

Separation between market transactions and physical dispatching allows the ONS to more carefully optimize the use of hydro basins, thermal plants and transmission lines. Furthermore, it allows thermal plants to grow, as they can simply buy hydro energy from the market and re-sell it during low-price seasons. Overall, despite causing some coordination issues (such as the existence of both physical and financial equilibrium points), this separation allows for a more efficient use of the country's energy reserves and transmission infrastructure.

#### **4.2.3.2. The free contracting environment**

The ACL is responsible for hosting freely negotiated contracts between producers / merchants / importers and large, free consumers. These contracts must still be registered with the CCEE, though they are not regulated by it. In a way, the ACL is how the first reform hoped the market as a whole would operate (utilities were expected to contract 95% of their forecasted demand in this fashion). Due to the failure of the reform, captive consumers were instead shielded in the ACR, where distribution companies must now contract their energy needs.

Nonetheless, free bilateral contracts can be important tools for shielding parties against volatility and securing supply for large consumers. As connection to the interconnected grid increases, the definition of a free consumer has expanded (Araujo et al, 2011). When before one needed 10MW of load to enter this category, the limit was eventually lowered to 3MW. As of 2011, the second reform had 18% of total consumption coming from free contracting.

#### **4.2.3.3. The regulated contracting environment**

The ACR consists of auctions conducted by the CCEE, supplying energy to distribution companies who serve captive consumers. It aims to (1) shield consumers from abusive practices by utilities and (2) ensure the existence of long-term contracts which favor private investment. In this environment, the auctioneer and auction rules serve as a proxy for actual competition, by forcing generators to bid as close to their marginal cost levels as possible (as seen in the Italian part of this section, in perfect competition, price and marginal cost levels are equal).

Three types of contracts exist in the ACR. New energy contracts represent projects which are not year in activity. These contracts may bind parties for 15 or 30 years, starting 3 or 5 years ahead of contract date (for thermal or hydro plants, respectively). A preliminary environmental license is needed for projects to participate in these auctions. The EPE may select specific thermal and hydro projects for participation in the auction, which often already come with this preliminary license.

Existing energy contracts work from already functioning projects. Distribution companies must forecast their demand for the next 5 years, which is aggregated by the government in order to create 8-year demand curves. These contracts represent energy to be delivered one year ahead of contract date. By law, distribution companies must forecast 100% of their short-term demand (5 years) through these contracts.

Finally, Adjustment Auctions for existing energy are available, for generators or distributors who must adjust their supply/demand in the face of unforeseen conditions. These contracts must last no longer than two years. They are needed because of the obligation outlined above, where companies must attempt to contract 100% of forecasted demand up to five years in advance. These contracts are not done in a pool, but between two parties only.

A second distinction between generation and availability contracts also exists. The former case is a standard context, where the supplier is paid according to energy generated. In the second, the generator receives simply for the availability of capacity. This type of contract is especially important for thermal plants. This is because their high marginal costs preclude them from acting consistently in the market, but their existence is still necessary to guarantee security of supply.

In broad terms, existing and new energy auctions are won by generators who accept the lowest price for the lot. Lots are defined as 1MW of capacity, times the length of the contract in hours (resulting in a MWh value). Winners are joined to every single participating distribution companies in a pool. This is done by the CCEE (who prepares and settles a host of two-party contracts for this purpose) in order to spread risk amongst distributors, proportionally to their demand, and discourage strategic behaviors by them. On the generation side, a pay-as-bid system is used, meaning that generators are paid according to their final offer, not the equilibrium price. Finally, consumer tariffs depend both on the price paid by distributors and the ultimate source of energy. This allows the government to prioritize specific sources.

More specifically, the auctions follow a two-stage scheme. Prior to the auction, the MME sets an initial price and price ceiling for each product, total demand and reference supply. This last factor is given by total demand, multiplied by a factor larger than one. It also determines price decrement and demand reduction rules. All these factors, except for initial prices, are unknown to bidders.

In the first stage, generators bid the quantity they are willing to supply at the set price. If there is an excess of supply, the price decrement rule is applied, reducing the set price and

leading to a second round of bidding. In this next round, bidders may switch from products where there is excess supply to those where there is excess demand. Bids are subject to operational and financial constraints, and total amount bid cannot increase from one round to the next. The first stage iterates until reference supply exceeds total amount bid. In this case, if a specific product's price is still above the price ceiling, rounds continue until the amount bid is between reference supply and total demand. If a price is still too high, demand reduction rules are applied until the price ceiling is reached.

In the second stage, bidders see which products are open (demand higher than supply) or closed (the opposite). Generators then bid at which price they are willing to provide the determined amount, which must be lower than the prices at the end of stage 1. This is a simultaneous stage and an option for closed products exists. This means that any energy not sold in a closed product may be transferred to an open one and compete there.

Dutra et al (2005) point out a flaw in this auction system. It may result in inefficient outcomes due to the information imbalance (which, the author grants, may be needed in order to avoid collusion) and to the option system in stage 2. For example, when an option is used, displacing previous bids in an open product, these displaced bids may not then be transferred to a third product. Instead, they are discarded, even if they would have won the third auction. Finally, the system lacks a bid revision mechanism, which has led to at least one instance of a generator dropping out of the auction entirely.

#### **4.2.3.4. Preliminary Results**

According to Araujo et al (2011), the second reform was successful in that it returned gains to consumers after losses in the 2001 rationing. It also served to signal adequate prices for new energy and increase the value of energy companies. After the first auctions, the value of electricity-related stocks increased above IBOVESPA rates. In addition to that, Barroso et al (2007) point out that regulatory risks are seen as low, following the reform.

Whether or not the arrangement will be deemed a final success will depend on the results of auctions for generation expansions. The two existing energy auctions, as of 2006, have occurred in an environment with plentiful supply and little incentive for buyers to enter into long-term contracts, so that judgment at this stage would be premature.

Dutra et al (2005), study two different auction results. The auction of December/2004 presented big dispersion in prices, leading the author to conclude that it had inefficient

outcomes, as similar products should have similar prices. They also argue that single-price systems might be more adequate, while granting that the choice is still unresolved in literature. Furthermore, the auction resulted in 90% of total demand being fulfilled. Furnas, CHESF and Eletronorte (all Eletrobras subsidiaries) were responsible for 65% of this result, even though their capacity only amounted to 48% of the total. Private generators got % of the contracts and state-owned ones for 29%. In the end, many participants considered final prices to be too low.

The April/2005 auction allowed bidders to submit a two-price supply curve in the second stage. The first stage consisted of 59 round and fulfilled less than 50% of demand. In fact, demand reductions led to a complete exhaustion of the 2009 contract. Barroso et al (2007) argue that low starting and ceiling prices were responsible for the underwhelming result. It became clear that generators refused to participate in the auctions. The authors further argue that generators must believe that unmet demand would have to demand auction again later, possibly at higher prices. They are, therefore, unwilling to accept the current, low prices. An ex-ante determination of the consequences for unmet demand could have averted, or at least mitigated, this issue.

Overall, Araujo (2006) and Araujo et al (2011) find three main topics with potential for improvement. First is the need for environmental licenses. Brazil is seen as slow to grant hydro and gas pipeline licenses, though quicker when it comes to oil and coal sources. The authors worry that this could shift the energy mix towards more polluting, non-renewable sources. Procedures are considered slow and often ad hoc, discouraging investors. Indeed, out of 17 projects submitted for the first expansion auction, only one had obtained a preliminary license from IBAMA, as of 2006.

Secondly, they find remaining problems in investment financing. The authors suggest that joint action between the BNDES and the private sector is necessary to stimulate investments to a desirable level. In fact, a failure in this regard led to an eventual crisis in 2013 to 2015, with extremely high prices and deficit risks.

Thirdly, gas-fired plants represent an issue as well. Araujo (2006) predicts that hydro generation will not be sufficient in 15-20 year horizons. New plants are also slated to have much smaller reservoirs, for environmental reason. As a result, Brazil will require investments in thermal generation – or wind/solar, according to Jong et al (2005) – but its gas industry is very immature. There is very little existing infrastructure and no secondary market for natural gas.

Both of these factors hinder investments in thermal plants, reducing security of supply. Nonetheless, the author presents cautious optimism in relation to the new reform.

### **4.3. Comparisons**

The differences between the Italian and Brazilian reforms are most evident in three aspects: their history, their auctions, and their physical dispatching systems. Brazil's regulatory history is a lot more convoluted, considering its two reforms and many small adjustments in between them. Italy's, on the other hand, is simpler. There is only one major liberalization process, with most new regulations relating to incentivizing green energy and fostering further competition. These new rules do not drastically change the Italian system. This can be seen as a political failure of Brazil's process, a technical failure in translating international examples, or (more generously) as the consequence to a more complex electricity industry operating in a larger, more diverse country.

Auctions between the countries show an analogous situation. While Italian auctions occur hourly and work as simple demand and supply curves, Brazil's consist of many rounds divided into two stages. Furthermore, Italian auction contract energy in the spot market for the same hour of the following day, an extremely short time horizon. Brazil's, on the other hand, may form contracts of up to 30 years. This is a clear reflection of the country's need for constant capacity expansion. While Italy's demand is stable and its only worry is affordable pricing, Brazil must create an environment that is attractive to private investments. For this purpose, creating longer-term, reliable contracts is much more favorable than a reliance on volatile, hourly price signals.

Finally, Brazil and Italy's physical dispatching systems are vastly different. Italy's Terna tends to honor market transactions when setting their dispatching mechanisms. Only in the case of congestions does it favor transactions occurring within a given region. Even in those cases, auctions are run again, ensuring that the market is aligned with physical dispatch. Brazil's ONS, on the other hand, is much more willing to separate physical dispatching from the completed market transactions, in order to reduce transmission levels and optimize energy usage. This is optimization process is further aided by robust computing models. This means that, in Italy, physical dispatching much more constrained than in Brazil. While Brazil requires this separation to a greater extent (due to its need to coordinate use of hydrological resources), it also helps the country with transmission efficiency. Given the transmission issues outlined in sections 2 and 3 for Italy, this model of physical dispatching model could be greatly beneficial to the country, eroding zonal differences and increasing competition levels.

## **5. FORMER MONOPOLIST HISTORIES**

In section 5, we go over ENEL's and Eletrobras' history before, during and after their respective markets' liberalization. We analyze not only their national activities, but also their main energy sources and the Group's performance in foreign markets, such as Spain in ENEL's case and Latin America for both companies. A comparison between the two companies will be left for section 6, where their roles in the liberalized markets is analyzed in more detail.

### **5.1. ENEL**

#### **5.1.1. Pre-Liberalization**

In 1958, Amintore Fanfani opened Italy's third legislature with the goal of establishing a national electricity company, to be called "Ente Nazionale per l'Energia" (ENE, or "National Energy Entity" in English). There was heavy opposition from private groups operating in the industry at the time, but ENE ended up being founded nonetheless. It expropriated plants from local private groups and indemnified these previous owners. Management of the company was given to Finelettrica, the former biggest player in the electricity market. All of this was done through the Electricity Industry Nationalization Act, approved in December of 1962. ENEL, as it came to be called, started operations on January 1<sup>st</sup>, 1963 and held a monopoly over Italy's electricity industry until 1999.

Among other objectives, this nationalization allowed ENEL to create the National [Transmission] Grid, reducing price differences between the different Italian regions and installing enough capacity to support the economic boom of the 1960's. To further reduce the chances of black-outs and the need for energy rationing, ENEL also successfully coordinated production among its many power plants across Italy.

In 1992, seven years before the Bersani Decree and the company's privatization, ENEL produced 81.2% of Italy's national production of 226TWh. This production consisted of 177TWh from thermoelectric sources, 45.5TWh from hydro sources and the remaining 3.5TWh from geothermal plants.

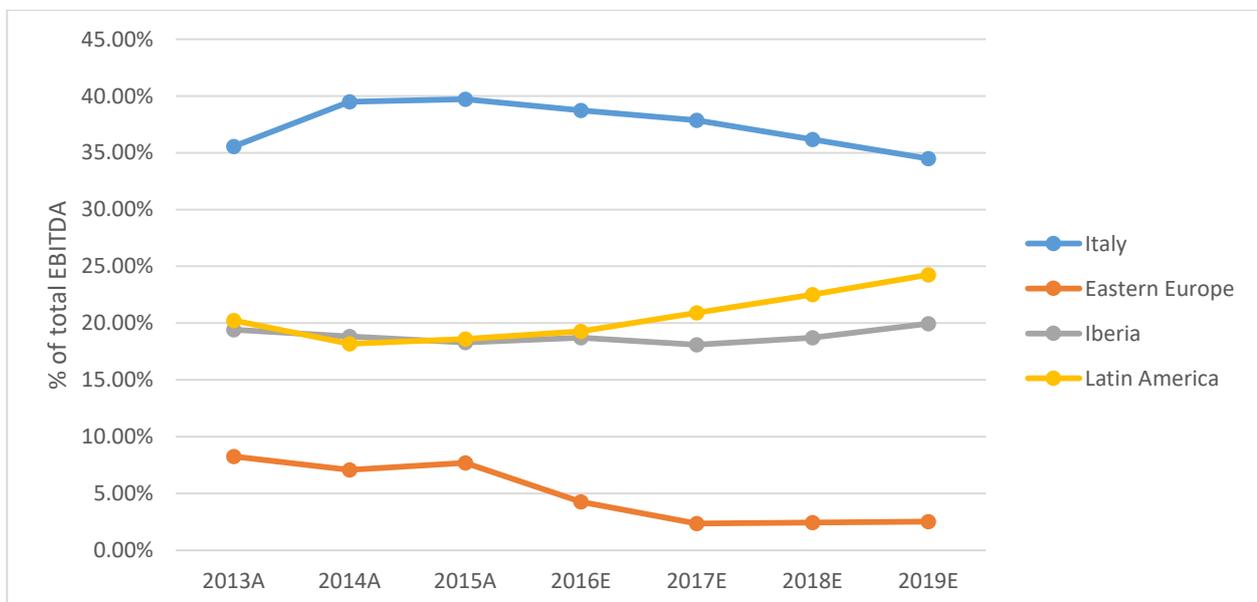
#### **5.1.2. Privatization and diversification**

As seen in Section 4.1, the Bersani Decree vertically unbundled ENEL's generation, transmission and distribution activities, besides mandating the sale of 15GW of capacity in the form of three generation companies. This last act accompanied a legal limit of 50% of national capacity for any one company. For comparison, even a 10% market share in electricity markets has been shown as sufficient for market power abuse to occur. However, despite the supposed

privatization of the company, the Italian government still held a majority share in ENEL until 2004. Ferrari and Giulietti (2004) have suggested that, although State-ownership does not necessarily prevent efficient competition (as has been observed in some Scandinavian countries), Italy's culture of government interventionism makes this much more likely in the case of ENEL.

As a newly somewhat privatized and legally limited company, ENEL decided to expand internationally in 2002. It sold off its short-lived telecommunications investments in order to fund this new venture. Today, ENEL's main markets outside of Italy are Eastern Europe, Latin America and Spain. Its position in the last two markets was solidified by the acquisition of rival generator Endesa, a big player in the Spanish and Chilean electricity industries. Figure 5.1 shows the evolution of ENEL's sources of EBITDA (Earnings before interests, tax, depreciation and amortization) from 2013 to 2015, as well as predictions by the bank Credit Suisse (2015) for the years of 2016 to 2019. The company is expected to increase its focus on Spain/Portugal and Latin America, while reducing activities in Eastern Europe and even Italy, where its action are more restricted by regulations.

Figure 5. 1. Sources of ENEL's EBITDA (2013 – 2019)



Source: Credit Suisse (2015)

Overall, the group's EBITDA is expected to grow in the coming years. The same analysis by Credit Suisse suggests an increase from €14.7 billion in 2016 to €17.3 billion in 2019, coming from a €17 billion investment in growth activities. As a group, ENEL currently operates in 40 different nations and employs over 74 thousand people.

### 5.1.3. Market share in Italy

Table 5.1 shows the division of generation capacity among companies in 2004, right after the opening of the Italian wholesale energy market. ENEL had clear control peak-demand plants, but more importantly, it also held over 60% of mid-merit plants, those responsible for setting prices during the hourly auctions. In addition, the company also held a large market share when it came to actual energy generation: 43.4% of national production. For this reason, the Italian competition authority enacted Decision 254, ordering ENEL to sell a further 3.7GW of capacity in the Center-South zone and 150MW in Sicily, through Virtual Power Plants. In 2008, another decision by the Competition Authority mandate a sale of 1GW of generation capacity, this time in the South region.

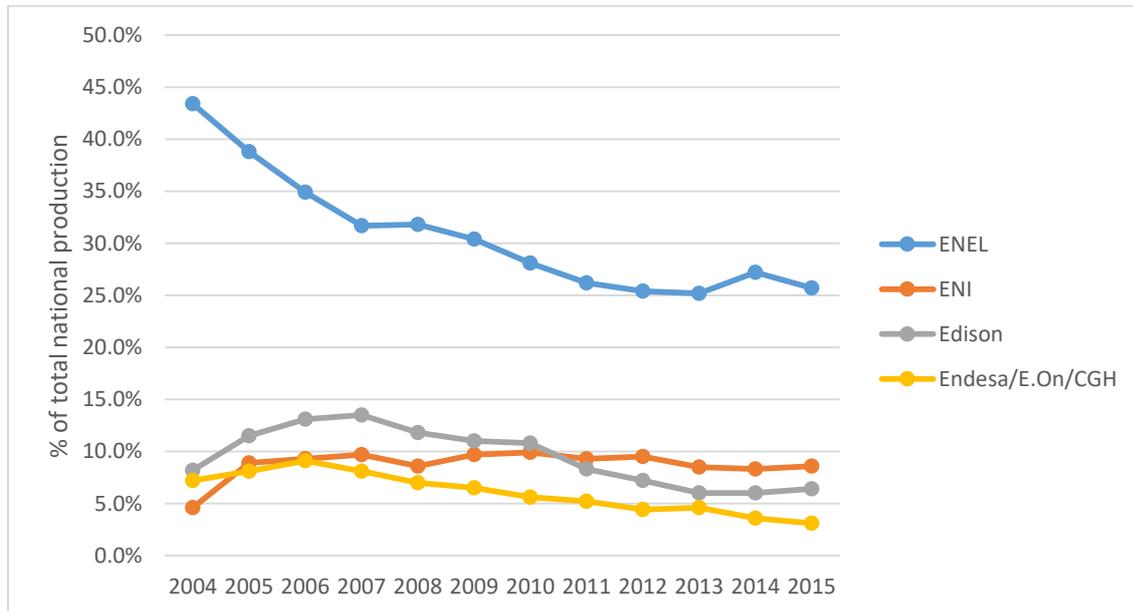
In great part due to these decisions, the company's market share decrease sharply until 2011, when it seems to stabilize. Figure 5.2 also presents the market share of ENEL's main competitors: Eni Power, Edison and Endesa Italia. Despite ENEL's decreased capacity, it still retains over three times the share of national production as its next big competitor, Eni Power.

Table 5. 1. Generation Capacity by Merit in 2004

Operators	Baseload (%)	Mid-Merit (%)	Peak (%)
ENEL	46.30%	62.80%	95.90%
GRTN	21.90%	1.60%	
Edipower	8.50%	13.80%	
Endesa Italia	7.00%	8.80%	2.40%
Edison Trading	4.50%	3.20%	
AEM Trading	2.70%	2.20%	
Tirreno Power	2.80%	1.70%	
ACEA Electrabel	1.70%	0.90%	
Others	1.40%	0.60%	

Source: AEEG-AGCM (2005)

Figure 5. 2. Market share of major generators as a percentage of total national production



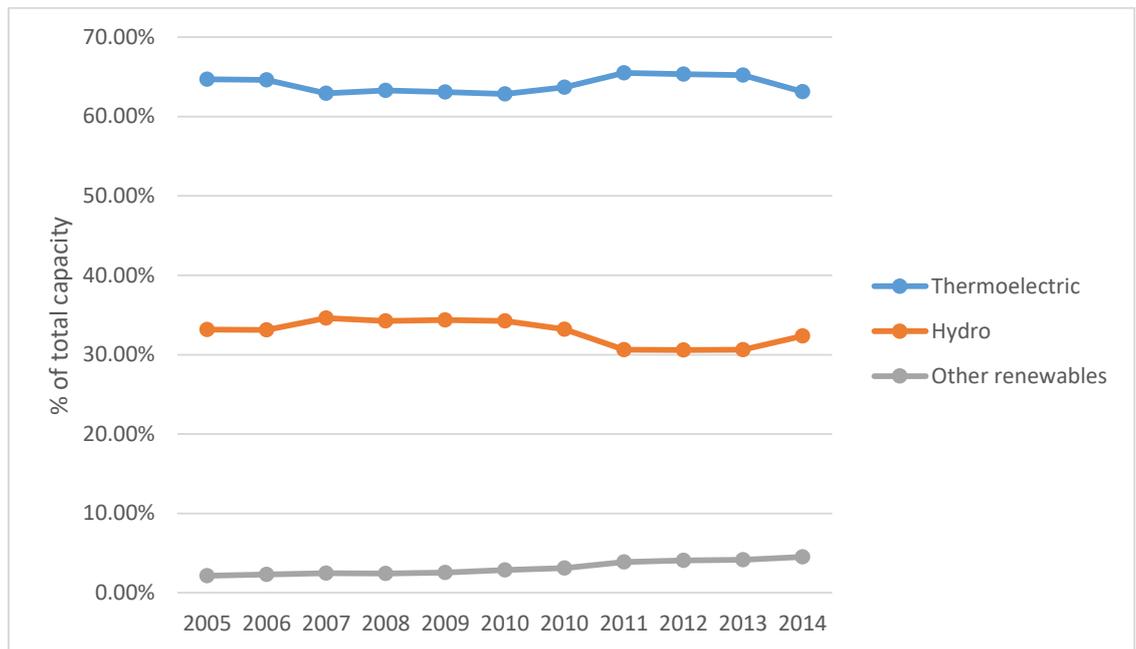
Source: Italian Energy Authority Annual Report (2015)

It should be noted that, when ENEL acquired Endesa in 2008, its Italian plants were actually sold to the E.On group, as it would have increased ENEL's capacity above the legal limits. Then at the end of 2014, Czech Gas Holding N.V split from the E.On group and retained control of its Italian plants. Therefore it is important to realize that Endesa/E.On/Czech are represented by the same line as they in turn represent the same physical power plants.

#### 5.1.4. Energy Mix

Much like Italy as a whole, ENEL's installed capacity in the country consists mainly of thermoelectric sources. In terms of physical power plants, the company ran 534 hydro-powered ones in 2010, compared to 37 running on fossil fuels and 52 on other renewable sources. However, during the same year, over 63% of ENEL's actual capacity came from the few thermoelectric plants (26.6GW out of a total of 41.6GW). Despite a small increase in generation from renewable sources in 2010, ENEL's Italian production has consistently relied on fossil fuels, as can be seen in figure 5.3.

Figure 5. 3. Source of ENEL's generation capacity (2005 – 2014)



Source: Italian Energy Authority Annual Report (2015)

Out of these thermolectric plants, the group seems to focus on natural gas. Data from Perekhodtsev and Baselice (2010) points to table 5.2, which shows gas to be responsible for over 50% of ENEL's fossil fuel-based production in 2004. Though the data is somewhat outdated, the lack of change in the company's generation mix over the years lends credence to the assumption that it remains valid.

Table 5. 2. ENEL's Thermolectric Installed Capacity (2004, in MW)

Plant Type	Fuel Type	ENEL's Capacity	As a % of total
Combined Cycle	Natural Gas	4831	19.8%
Mixed	Natural Gas	-	-
	Oil	-	-
Repowered	Natural Gas	6583	26.9%
Traditional	Coal	4566	18.7%
	Natural Gas	65	0.3%
	Oil	6478	26.5%
Turbine	Diesel	353	1.4%
	Natural Gas	1567	6.4%

Source: Elaboration of GME and GRTN data by Perekhodtsev and Baselice (2010)

It is clear that ENEL relies on much the same energy sources as Italy in its national operations. Internationally, on the other hand, the group seems to heavily favor green, non-emission sources. It founded ENEL Greenpower in 2008, a company responsible for the operations of its renewable power plants, as well as related R&D. While this new company initially had only 2.5GW of installed solar and wind capacity, ENEL today produces 46% of its electricity without emissions of any type. In fact, Greenpower's contribution to the group's EBITDA is expected to increase from 11% to 19% (a 70% hike) and out of its €17 billion of planned growth-related investments, 53% are focused on renewables. Furthermore, while ENEL operates a single nuclear plant in Italy, due to the country's long-lasting ban on the technology, nuclear energy plants amount to 50% of the group's international capacity.

## 5.2. Eletrobras

### 5.2.1. Pre-Liberalization

The creation of Eletrobras was proposed by then President Getulio Vargas in 1954. At the time it faced heavy opposition and was only approved after 7 on the Congress floor. In 1961, President Jânio Quadros signed Law 3890/A, authorizing the company's creation, though it only officially opened in June/1962, under the Goulart Administration.

At the time, Eletrobras was charged with conducting studies and construction projects, as well as operating generation plants and transmission lines. As mentioned in section 4.2, the company had a significant role in the capacity expansion from 1960 to 1990. During these years, it also developed important expertise on hydro plants and transmission infrastructures.

After its creation, Eletrobras owned CHESF, Furnas, CHEVAP and thermal plants from Charqueadas. In 1968, Eletrosul was created to provide generation and transmission services to the South region. In 1974, Eletronorte was created as an analogous company for the North region. By the late 1970s, the Eletrobras Group was responsible for 20% of national installed capacity. In addition to that, Eletrobras also participated in state-owned utilities as a minority shareholder, representing another 20% capacity in the 1960s. Then, in 1982, Itaipu opened. This huge hydroelectric plant was built in conjunction with the government of Paraguay. It is officially owned by Eletrobras and was considered the largest hydro plant in the world.

As for its other responsibilities, the group controlled sector planning and financing, previously done by the BNDE (*Banco Nacional do Desenvolvimento*). This was done through the Federal Electrification Fund, which came from taxes applied to electricity tariffs and a compulsory loan charged to large consumers. However, the group never obtained full centralized control. Even within the Eletrobras Group, nominal control of power plants did not translate directly into effective control. Its subsidiaries and utilities had considerable autonomy and always maintained their original names. As a result, conflicts of interest sometimes arose, especially with state-owned utilities. Consequently, Eletrobras exerted what control it had in two main ways: via the Electrification Fund, which it managed, and by heading the key energy committees of the time (for interconnected operation, north-northeastern operation and system planning) (Araujo, 2006).

### **5.2.2. After the reforms**

Eletrobras is now a mixed, open capital company, owned by both the State and private parties, and its capital is traded openly on the stock exchange. However, as of 2015, the government still controls over 54% of ordinary shares, giving it effective control over the company's operations.

The Group acts in generation, transmission and distribution through its 14 subsidiaries: Furnas, CHESF, Eletronorte, Eletrosul, Eletronuclear, CGTEE, Amazonas Geração e Transmissão, Distribuição Amazonas, Distribuição Roraima, Distribuição Alagoas, Distribuição Piauí, Distribuição Rondônia, Distribuição Acre e Celg-D. Most of the latter companies were transferred to Eletrobras' control, along with many thermal plants and distribution lines, in the late 1990s, during the first reform. Eletronuclear was created in 1997 in order to handle the government's nuclear energy operations. In addition to these generation and distribution companies, the Eletrobras Group also owns a research center (CEPEL) and a participations company (Eletropar).

After the 2004 reform, new regulations removed Eletrobras from the PND (“Programa Nacional de Desestatização”, or National State Divestment Program). Then in 2008, Law 11651 allowed the group to act internationally. It is currently focused solely in Latin America, looking for opportunities mainly in hydroelectricity. Its operations, as of 2016, include a hydro plant in Nicaragua with 253MW of capacity, operating the Binational Complex Garabi-Panambi in Argentina (2200MW of capacity) and 500km of transmission lines in Uruguay.

### 5.2.3. Market share in Brazil

Table 5.3, from ANEEL’s Generation Information Bank, lists the 10 largest generators acting in Brazil currently, by installed capacity. Out of these 10, four belong to the Eletrobras Group and all four are in the top 5 rankings. CHESF, discussed previously, is the largest of them, dominating generation activities in the North and Northeast.

Table 5. 3. Largest Brazilian generators, by installed capacity

Company	Capacity (in GW)	As a % of total
CHESF*	10.61	7.19%
Furnas*	9.41	6.37%
Eletronorte*	9.22	6.24%
Engie	7.32	4.96%
Itaipu*	7.00	4.74%
Petrobras	6.24	4.22%
CEMIG	5.31	3.59%
Rio Parana Energia	5.00	3.38%
COPEL	4.92	3.33%
HPP Jirau	3.37	2.28%
Total capacity	147.75	100%

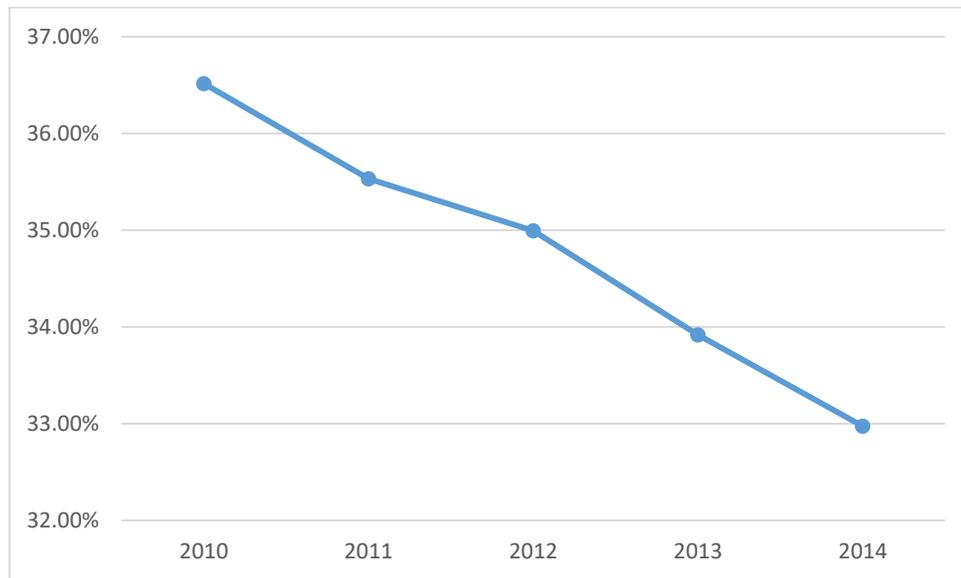
\*Owned by the Eletrobras Group

Source: ANEEL (2015b)

As for the group as a whole, its market share has decreased slightly and consistently in recent years, but it remains above 30%, higher than ENEL’s most recent values. Currently, Eletrobras has over 44GW of installed capacity, compared to Brazil’s 134GW. This capacity is divided among the groups 29 hydro plants, 20 thermal ones, 6 wind farms, 2 nuclear plants and

1 solar plant (taken from the Eletrobras website). Figure 5.4 illustrates this decrease in market share.

Figure 5. 4. Eletrobras' market share over time (as % of total installed capacity)

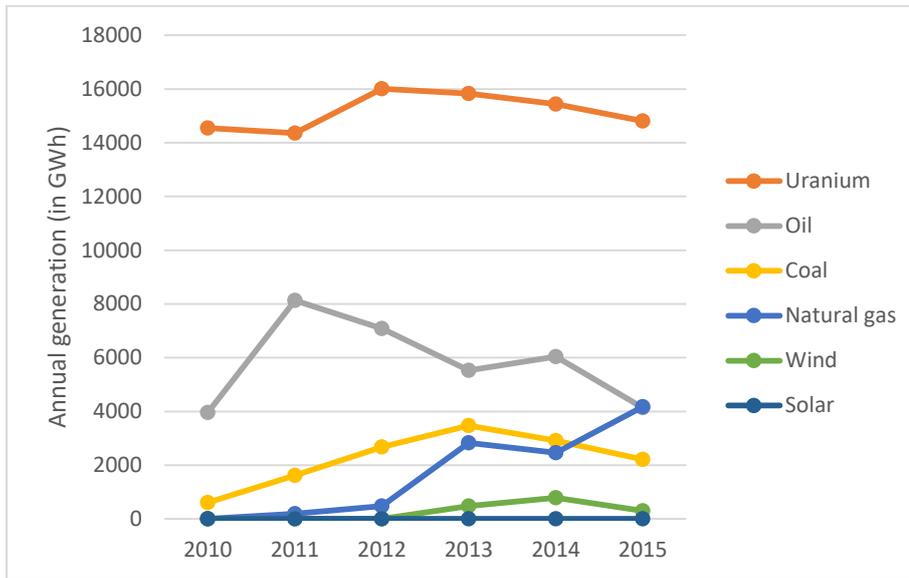


Source: Eletrobras' Annual Sustainability Report (2015)

#### 5.2.4. Energy Mix

Unlike its Italian counterpart, Eletrobras' energy mix does not exactly mimics that of its country. For example, the dominance of hydro energy seems to be even more extreme, at around 85% of total installed capacity. Eliminating this source, which has remained fairly constant (with a slight decrease), we obtain Figure 5.5, which represents total annual generation from owned plants. It shows that uranium is an important source of energy, mainly because all of Brazil's nuclear energy operations are concentrated in Eletronuclear, a subsidiary of Eletrobras. In addition, Oil seems to be more used than natural gas, although the situation seems to be in the process of reversing itself.

Figure 5. 5. Eletrobras' sources of energy generation (2010 – 2015)



Data Source: Eletrobras' Annual Sustainability Report (2015)

Much like ENEL, Eletrobras bring a lot of attention to its devotion to nuclear energy. Its annual sustainability report derives its name from the fact that the Group aims to provide clean, renewable energy. Nevertheless, wind and solar energy generation are quite clearly behind other sources and have shown very little improvement in the past half-decade. This fact refers back to the company's plants in operation, which include 29 hydro and 20 thermal ones, compared to 6 wind farms and a single solar plant.

## 6. THE MONOPOLISTS' SITUATIONS POST-REFORM

### 6.1. ENEL

ENEL is currently under private control and, while the government does still have a stake in the company, it represents less than 30% of ordinary shares. Therefore, ENEL's main goal is to generate profit to its investors via generation (and distribution) activities. In theory, the company should charge whichever prices it predicts will lead to highest profits. In fact, Perekhodtsev et al (2004) calculate ENEL's average price differential in comparison to its competitors. By bringing these prices in line with competition, they find excess pricing of 18% to 27%, due to the group's abuse of market power. As explained in section 4.3, this market power comes from a situation of effective monopoly over the Italian market at the time. Table 6.1 details these findings.

Table 6. 1. ENEL's Market Power In line with Competitors' (2004)

Month	Original Price	Counterfactual Price	Excess price due to market power (%)
April	€ 66.50	€ 55.80	19.18%
May	€ 65.47	€ 52.63	24.40%
June	€ 93.00	€ 73.06	27.29%
July	€ 95.68	€ 77.29	23.79%
August	€ 70.47	€ 59.55	18.34%

Source: Perekhodtsev and Baselice (2010)

However, more recent studies show that ENEL does not fully utilize its market power. When attempting to plot a marginal cost curve for the company, Bosco et al (2012) find that the assumption of profit-maximizing behavior does not fit the data. The study shows that the resulting curve, under this assumption, would be decreasing with quantity produced, which is inconsistent with thermal plants' physical characteristics. Boffa et al (2009) encounter a similar issue when analyzing bid data for ENEL. Both articles reach the conclusion that ENEL's behavior must include an aspect of public welfare maximization in order to achieve consistency.

This curious behavior can be explained by a variety of reasons. Wolak (2001) shows that engagement in long-term contracts and vertical integration can reduce a firm's incentive to maximize price levels. The former is a result of a company's previous commitment of resources at a set price and the latter due to a distribution branch reliance on low price levels. But in addition to that, influence from partial State-ownership, fear of new entrants (caused by attractive profit margins) and fear of stronger regulation and intervention by the Italian Competition Authority may also cause ENEL to bid in this manner. Indeed, the authority has already intervened more than once, stripping ENEL of some of its capacity, so the company's fears are well-founded.

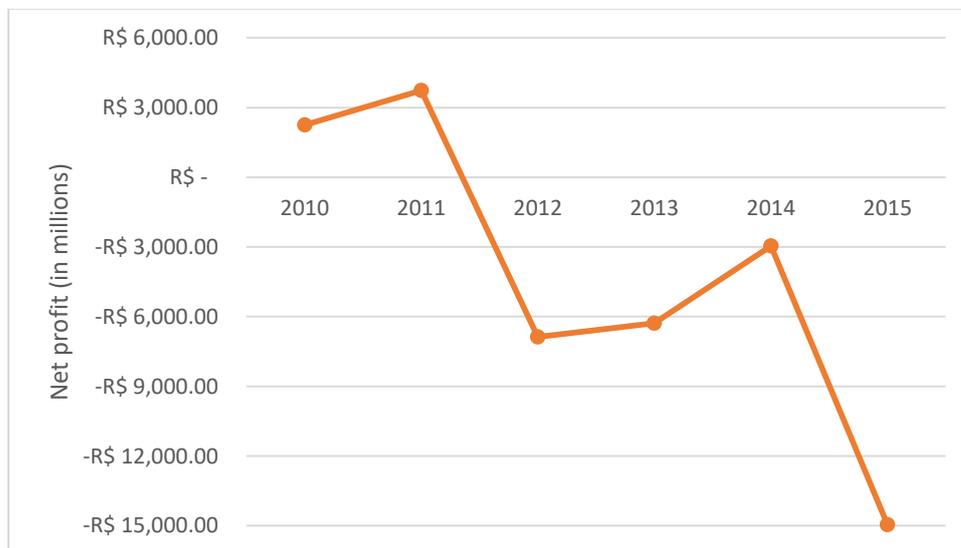
## 6.2. Eletrobras

Brazil's government, unlike Italy's, still owns a majority share in its major generation company: Around 55% of ordinary shares, according to Eletrobras' 2015 Annual Sustainability Report. As a result, the company plays a much more complex role in the Brazilian energy market than its Italian counterpart. More specifically, the group performs three main functions

as a government agent: providing affordable electrical energy to consumers, contributing to expansion projects and absorbing underperforming generation and distribution companies.

In all these activities, its role as a political entity can be shown. For its first function, Eletrobras has agreed to much lower prices than its competitors in recent years. This explains the case discussed in section 4, where Eletrobras' subsidiaries were responsible for 65% of the electricity contracted in the December/2004 auction, despite only owning 48% of installed capacity. Many generators claim that the group accepts lower prices than what is commercially viable, hindering effective competition. More recently, in 2012, President Dilma Rousseff aimed to reduce consumers' electricity tariffs. For this purpose, the government offered to preemptively renew many power plant concession contracts which ended in 2015. In return the companies holding those contracts had to agree to supply their energy at a pre-established price, set by the government. Every company involved refused the agreement due to excessively low prices, except for Eletrobras. The result of these actions is evident in the group's profit, seen in figure 6.1. The graph shows consistent losses experienced by the Eletrobras Group since 2012 and worsened drastically in 2015. As a result, the government has again begun to consider privatizing the company and its subsidiaries.

Figure 6. 1. Eletrobras' net profit (2010 – 2015)



Source: Eletrobras' Annual Sustainability Report (2010 – 2015)

Eletrobras also has an important role in capacity expansion. According to its 2015 annual report, the group is supposed to have over 54GW of capacity connected to the national transmission system by 2020. This represents an almost 9GW increase from 2015. Furthermore,

EPE's 10-year expansion plan predicts around 35GW of new capacity in the same period, for the entire country, which means that the Eletrobras Group would be responsible for over 25% of new generation in Brazil.

Finally, the company acts as a last resort for failing, but important generation and distribution companies in Brazil. In fact, seven of its subsidiaries are generators and distributors acting in the North and Northeast region. These companies were bought by Eletrobras in 1997 and 1998 when experiencing financial troubles. In addition to that, many other small thermal plants in these regions have been absorbed by the group in recent years, in order to ensure sufficient generating capacity for locations with more difficult access to the national transmission system.

### **6.3. Comparisons**

The differences between ENEL and Eletrobras are mainly due to how their role in the new, liberalized markets was handled. While Italy decided to privatize its former monopolist and only remain as a minority shareholder, Brazil's government opted to remain in control of the Eletrobras Group. Consequently, ENEL operates similarly to other competitors in the country, aside from its greater influence over the market. Although the company does not fully maximize its profits, which can be seen as a remnant of governmental influence, it does use its market power in order to charge higher prices in the country's auctions.

Eletrobras behaves in an opposite way. Instead of using its size to overcharge consumers, the group's subsidiaries accept low energy prices in order to keep consumer tariffs low. Furthermore, the company invests in new projects, although this also relates closely to Brazil's economic context. It can be easily seen that, unlike ENEL, Eletrobras acts as a government service much more than it does as an electricity generation business.

Nonetheless, the two companies do show similarities. Both of them inherited a large influence over the market, due to their former status as monopolists and both use this size in order to hinder competition and achieve their goals. Both governments also aim to reduce dependence on these companies over time. The Italian government enacts market power-limiting policies, such as price caps and virtual power plants, while the Brazilian one simply tries to attract as much private investment as it can into the country's capacity expansion activities. Finally, both ENEL and Eletrobras have started to diversify their activities and expand internationally, although ENEL has done it to a much greater extent.

## 7. CONCLUSION

### 7.1. Overall comparisons

The Brazilian and Italian cases are clear examples of how two liberalization reforms can greatly differ, despite happening in the same industry and at similar times. These differences can be caused by a variety of reasons: from political goals to economics, geographical and demographical contexts. Italy is a relatively small and developed country, with mature infrastructures and few renewable energy sources. Brazil, on the other hand, is large (in both area and population) and experiencing rapid economic growth (again, despite the recent recession). The country also possesses ample potential for hydro and wind energy, with only the first being sufficiently explored. All these circumstances have shaped each country's liberalization reforms, as well as the eventual role assumed by their former monopolists.

Italy's reforms followed closely those of its European neighbors, focusing on hourly auctions that determine energy prices, with the option of bilateral contracting. It also happened relatively smoothly. Only small adjustments were necessary, mostly to encourage competition and alternative energy sources. Nonetheless, problems remain due to market power abuse, the country's reliance on natural gas and other fossil fuels, and a problematic transmission infrastructure and physical dispatching system.

Brazil attempted to follow a similar structure to that of European Union members, but its vastly different situation resulted in an array of problems that required a significant "reform of the reform". This second process attempted to adapt the European model to Brazil's context, by reinforcing longer-lasting regulated contracts and stimulating investment in new energy concessions. Even after these corrections, Brazil still faces challenges when attempting to simultaneously attract private capital and supply affordable electricity to consumers.

These decisions are also reflected in how the ENEL and Eletrobras cases were handled. The former was effectively privatized, with the goal of entering it into the competitive generation market. Italy's expectation was that free competition would ensure that ENEL and its competitors performed their roles as electricity providers, generating and selling their electricity at competitive prices. Brazil, however, decided not to completely privatize Eletrobras and retained a majority share in the group. The country aimed to use the group in order to achieve its political goals: electricity supply at affordable prices and security of supply through capacity expansion. Both entities, however, have proven too large for the market where they participate. ENEL uses its size to increase prices beyond competitive levels, damaging consumers and

hindering competition. Eletrobras also hinders competition by accepting low prices and the losses that follow, preventing competition from private companies with a duty to generate profit for their investors.

## **7.2. Next steps**

Both countries have room for improvement in their market model. Italy's main opportunities lie in promoting competition, diversifying its generation mix and improving its transmission infrastructure. The former can be at least partly achieved by promoting the last two. Brazil, in turn, needs to reduce its dependence on Eletrobras, diversify its mix and attract private investments into capacity expansion projects. Both countries' diversification challenges would require significant government investment. This is because the thermal plants in Italy are currently much more efficient than its renewable alternatives, while hydro plants in Brazil are even more so. As a result, government investment, be it direct or in the form of subsidies, is necessary in order to stimulate the growth of these alternative sources. However, studies have already shown a great potential for wind energy in Brazil and both ENEL and the Italian government are dedicating resources towards green energy expansion. Succeeding in this task could prove greatly beneficial to Italy, by reducing its marginal cost curve and, consequently, prices. Brazil would significantly reduce its hydrological risks and, if it does so by investing in green rather than fossil fuel sources, could keep both its carbon emissions and marginal cost levels low.

In order to improve its transmission infrastructure, the Italian government requires investment into the sector. The lack of new transmission lines is apparent in sections 3 and 4, as well as its consequences on congestion and price levels. However, it could also take a lesson from the Brazilian physical dispatching model, with a greater separation between physical and commercial energy transactions. By taking greater control over this process, Terna could optimize electricity flows, increasing energy efficiency and, most importantly, reducing stress on the transmission system. By ensuring greater connection between its different zones, Italy could also reduce market power by its larger, local players, advancing its goal of free competition.

Brazil can also learn from its European counterpart. Italy's virtual power plants have proven significantly helpful in reducing ENEL's market power without severely distorting competition. Brazil could apply this system to Eletrobras, in two different contexts. First, it could opt to privatize the group, then apply this measure in order to prevent market power abuse, much like the Italian government has done. This would create more effective competition among market

players and reduce private generators' worries that Eletrobras distorts competition and market prices. But it could also opt to keep the company as a public service. In this case, Eletrobras' virtual power plants would sell electricity to other generators at below market prices. This could be used to guarantee affordable tariffs while also encouraging investments in electricity generation, since generators (and not distributors or consumers) would receive the primary benefits from these low prices. It could also be used to achieve greater security of supply, by selling this electricity to owners of thermal plants, so that they can keep consistent returns during periods when thermal energy is not needed.

These steps and measures, if conducted appropriately, could benefit both countries by promoting a healthier energy source mix and greater competition among market participants. In Italy's case, this should lead to lower consumer tariffs and carbon emission levels. In Brazil's, it could mean a more attractive environment for private investors and lower exposure to hydrological risks. Overall, it is apparent that, even though both countries have had vastly different liberalization processes, these have led to solutions to more universal problems. By learning from each other's experiences and adopting some common measures, the Italian and Brazilian electricity supply industries can become better both for its participants and its final consumers. Further studies could more carefully consider the impact of physical dispatching separation in the Italian market (which would necessitate measures such as a liquidation price for differences) and the consequences of an Eletrobras privatization in the Brazilian market (whether the company's size could be used to increase prices even further and, if so, what steps could be taken to avoid it).

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