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LA RELAZIONE FRA I COSTI DI SBILANCIAMENTO I PREZZI E LE QUANTITÀ DELL'ENERGIA ELETTRICA NEI MERCATI ELETTRICI ITALIANI

THE RELATIONSHIP BETWEEN IMBALANCE COSTS ELECTRICITY PRICES AND QUANTITIES IN THE ITALIAN ELECTRICITY MARKETS

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ABSTRACT

Il presente lavoro tratta della relazione fra costi di sbilanciamento, prezzi e quantità dell'energia elettrica nei mercati elettrici italiani. Dopo una breve panoramica sull'attuale configurazione del sistema elettrico nazionale, ci si concentra sull'analisi svolta al fine di individuare, se esistente, la suddetta relazione. Per farla è stato necessario raccogliere i dati sul sito del Gestore dei Mercati Energetici per il periodo di riferimento (Gennaio 2013 – Giugno 2015), e per i due diversi mercati: Mercato dei Servizi di Dispacciamento ex-ante (MSD ex-ante), e Mercato del Giorno Prima (MGP). I risultati ottenuti vengono interpretati in chiave economica, facendo riferimento ai livelli di concorrenza presenti nelle 6 zone del mercato elettrico italiano. Infine si accenna al possibile impatto delle Smart Grid sulla relazione studiata.

INTRODUCTION

The great increase of the Distributed Generation[1], especially in distribution networks for medium voltage and low voltage, calls for a rethink of the methods of protection, management and regulation of the networks, which have to go from a “passive” status to an “active” one. This sort of evolution is identified at an international level with the term Smart Grid, implying structures and operating methods strongly innovative that have to: maintain an high level of safety and reliability of the entire system, deal with some problems related to the management of the Distributed Generation, face the possibility of the load control, promote energy efficiency and the interaction of the final users, also in the electricity market.

This transformation, that regards the entire power system, does not have a well defined bound: satisfying the increasing electricity demand is not the only main objective of the grid, nowadays it is necessary to solve other problems through the development of innovative technologies (both at the central level, and at the peripheral one) that communicate with each other, also thanks to the use of ICT system.

At European level, the main causes at the base of this revolution are to be found in the development of Distributed Generation, that is the only way to hit the goals of increased production of electricity from renewable sources, and reducing pollutant emissions, objectives that are set in the strategic plan “20-20-20”. But, the European targets for 2020 also require the active involvement of end-users of electricity grids, which is the second cause of the revolution in progress, and that in recent years has led to the development of smart meters.

These, today, are the two main causes that lead to smart grids, so: it is necessary to connect distributed generation units to the grid, guaranteeing a real contribution (today in some ways very limited) to the safety of overall electricity system and the management and control of distribution networks; it is also necessary to introduce the possibility for end-users to act in the market through price/market signals (demand response).

At national level, Italy is doing well, thanks to investments made by utilities, such as the smart metering project “Telegestore”[2], designed by Enel and registered by the European JRC Report on Smart Grid (2012) as the most important smart meter European instalment; Italy is

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[1] Or decentralized energy generation of power plants with an output of less than 10 MW and connected normally, to the MV and LV networks.

[2] In 2002, the Italian “Telegestore” project allows for the installation of 32 million automated meters, which guarantee the Distributor remote access to residential consumption data: in this way, the distributor is able to immediately assess the energy demand of the single load and consequently regulate its service.

doing well also looking at the development and conception of the transmission grid, unified in the property of Terna Spa, and the laws made by policy maker. In Italy the main driver for the development of the Smart Grid consists in the massive contribution of Distributed Generation (especially because of the photovoltaic plants) to the distribution grid. Spread-scale smart metering, and modern transmission grid (and partially also distribution grid) are the two major divergences in the Italian case from the European context.

In this dynamic context, in recent years, in Italy (as in Europe) many initiatives related to smart grid have been promoted, almost all, however, in research, or applied research. Currently, however, is widely believed that real progress in the direction of Smart Grid can be achieved only through initiatives and investments involving real networks, with end users and active users (loads and generators), so that it is possible to try in real life what has been studied. This is why Europe decides to finance what are defined as Projects of Common Interest in the energy field.

The dynamics of investment in recent years shows the strong interest of markets to the industry of the smart technologies for the production and distribution of electricity. The investments in this sector are strongly influenced by public policy, as the political goals and economic incentives for the development of renewable plants create a favourable framework for the investments, ensuring stability of the regulatory system and a lower degree of financial risk (such as the incentives schemes “Conto Energia” issued by Italian government).

The aim of this work is to, after describing the current Italian electricity system, define the relationship between imbalances costs and electricity prices and quantities describing how they have evolved in recent years and their correlation. We will also try to understand how the implementation of smart grids will benefit this possible relationship.

In particular the Italian electricity system is described in the first chapter, looking at the phases of production, transmission, distribution and consumption, trying to note in particular the role played by renewable energy sources. At the end of the chapter we will focus on what is the current management of electricity flow (dispatching), and the Italian electricity market.

The second chapter introduces the market structure of the two electricity markets considered for the analysis. We will identify the characteristics of the six areas in which the Italian electricity system is divided. After that it is described the structure of Day-Ahead Market and Ancillary Services Market in Italy, with a particular attention to the ASM ex ante, and prices and quantities of the wholesale market, useful in order to better understand the analysis.

In the third chapter we will focus on the analysis of imbalance costs, the energy prices and the quantity of energy supplied in Italy, in order to identify, if any, the relationship between imbalance costs and wholesale market outcomes (price and quantity). The collected data are analyzed in the light of the characteristics of the DAM, ASM and areas, highlighting the correlation between imbalances costs, price and quantity (in different areas), and their trends. This study required the collection and selection of useful data on GME's website, as well as a statistical analysis to better understand data collection. The period of analysis goes from January 2013 until June 2015, taking into account any time of day for each of the 6 physical zones in which Italy is divided.

The chapter concludes with a brief paragraph on the Smart Grid theme, starting from distributed generation, since the small electrical units of self-production play an important role in the intelligent management of the power grid. After that there will be a brief presentation of a cost benefit analysis on the GREEN-ME project, a project between Italy and France that regard the implementation of Smart Grid. We want to understand the impact of the possible benefits on the relationship between ASM ex ante (imbalance costs) and MGP market (prices and quantities of electricity), after the adoption of Smart Grid. If Smart Grid will reduce imbalances costs (as the study of Green-me proves) with a reduced demand for dispatching services, then this should also has an effect on the price and the amount of energy delivered.

1. THE ITALIAN ELECTRIC SYSTEM: THE CURRENT SITUATION

Before talking about the relationship between the Italian electricity markets, it is important to identify the context in which the power grid operates. So we start focusing on the Italian electric system.

The electric system consists of three phases: generation, transmission, and distribution of electricity (Terna, 2015). Electricity does not exist as a natural resource and it is therefore necessary to generate it. Generating energy means transforming into electricity the power gained from primary sources. To do this power plants are needed. Then energy has to be transmitted. Transmitting electricity means transferring the power produced in the plants to consumer areas through high voltage system. The last phase of the electricity generation process is represented by distribution, that is the delivery of medium and low voltage electricity to users. It is important to note that electricity is not a storable commodity. So it is necessary to produce exactly the requested quantity and distribute it through the system in such a way as to ensure that electricity supply and demand are always balanced, thus guaranteeing continuity to the system. This activity is known as Dispatching.

The main actors involved in the Italian electricity system are: the producers, Terna, distributors, consumers, GSE, and AEEGSI.

Terna is an independent grid operator in electricity transmission grid; it safely manages the national transmission grid with over 63,500 km of high voltage lines (HV), and it has responsibility for supplying the entire country's electricity needs, not directly but via those companies that distribute and sell electricity to end-consumers. Terna is responsible for the dispatching activity.

Gestore dei Servizi Energetici (GSE) is an Italian company owned by the Ministry of Economics and Finance that gives economic incentives for the renewable energy production and promotes a responsible use of energy.

Autorità per l'energia elettrica il gas e il sistema idrico (AEEGSI) is an independent body established in 1995 to regulate and control the electricity and gas sectors; the task is to pursue two main objectives: guaranteeing the promotion of competition and efficiency while ensuring adequate service quality standards in electricity and gas sectors.

Today the electricity market is liberalized. The process starts in 1999 with the Bersani law that liberalized activities of production, importation, exportation, purchase and sale of electric energy. The decree established the Italian Power Exchange (IPEX) that enables producers, consumers and wholesale customers to enter into hourly electricity purchase and sale contracts, and the Gestore del Mercato Elettrico (GME) which has to organize and economically manage the electricity market, under principles of neutrality, transparency, objectivity and competition between or among producers. The creation of an electricity market responds to two specific requirements: encouraging competition in the potentially competitive activities of electricity generation and sale, through the creation of a marketplace; favouring maximum efficiency in the management of electricity dispatching, through the creation of a market for the purchase of resources for the dispatching service.

1.1 PHASES

1.1.1 PRODUCTION

Electric energy production activity is carried out by producers and by auto-producers, where auto-producers are defined as a natural or legal person who generates electricity and consumes at least 70% of that electricity on a yearly basis (Terna, 2015). In 2014, electricity demand came to 310,5 billion of kWh, a fall of 2,5% over the previous year. This drops follows the decrease (-3,0%) already recorded in 2013. In summary, after the sharp drop in demand (-5,7%) recorded in 2009, the following two years saw a partial recovery followed by another drop in the three years (2012-2014) that brought the level of electricity demand to that of 2002. In 2014, 85,9% of electricity demand was met by national production, equivalent to 266.800 GWh (-3,4% compared to 2013), net of the consumption of ancillary services and energy pumping. The remaining part of this demand (14,1%) was covered by net imports from other countries, amounting to 43.700 GWh, up 3,7% over the previous year.[3]
According to Terna, the total Italian electric production amounted to 279.828,5 GWh in 2014: 60.256,3 GWh generated by hydro power plants, 182.087,5 GWh generated by thermoelectric power plants (of whom 5.916,3 from geothermal plants), 15.178,3 GWh generated by wind farms, and 22.306,4 GWh generated by photovoltaic power plants.

[3] Statistical Data on Electricity in Italy – Synthesis, Terna for SISTAN 2014.

	2013					2014				
GWh	Hydro	Thermal	Wind	Phot.	Total	Hydro	Thermal	Wind	Phot.	Total
Producers	54.044,70	183.202,80	14.897	21.588,60	273.733,10	59.518,10	167.083,70	15.178,30	22.306,40	264.086,50
of which geothermal	-	5.659,20	-	-	5.659,20	-	5.916,30	-	-	5916,3
Autoproducers	627	15.443	-	-	16.070	738,2	15.003,90	-	-	15.742,10
Total - ITALY	**54.671,70**	**198.646**	**14.897**	**21.588,60**	**289.803,20**	**60.256,30**	**182.087,50**	**15.178,30**	**22.306,40**	**279.828,50**

Table 1 - Gross electric generation in Italy, divided by source (Author's elaboration on data from Terna, 2015).

Thermoelectric generation represents the biggest quota, with natural gas as the most used fuel, but between 2013 and 2014 it is the only energy source that decreased its production, both in absolute terms (from 198.646 GWh to 182.087,50 GWh) and in percentage over the total production (from 68,5% to 65,1%), while other sources increased their contribution.

	2013	2014
Hydro	18,90%	21,50%
Thermo	68,50%	65,10%
Wind	5,10%	5,40%
Photo.	7,40%	8,00%

Table 2 Gross electric generation in Italy (%), divided by source (Author's elaboration on data from Terna, 2015).

In 2014, hydroelectric production represents more than 20% of overall production, wind farm contributed for 5,4%, and photovoltaic power plants for 8%.
Total production decreased by 3,5% between 2013 and 2014: the hydroelectric production increased by 11%, wind production by 1,9%, and photovoltaic production by 3,3%, while thermoelectric production complexly decreases by 8,9%.
Finally, considering the auto-producers, in 2014 they represented the 9% in the thermoelectric sector, about 1,2% of the hydroelectric sector, while there were no auto-producers in wind and solar generation. This can be explained with high incentives dedicated to the renewable production, that make more convenient to sell energy to the grid rather than auto-consume it.

The increase of renewable sources in the production of energy during these years has led to some issues; so, it is interesting to analyse some aspects about them.
Renewable sources play an important role for Italy, especially considering the lack of sources for producing electricity. The number of plants that produce renewable energy has grown continually, and nowadays it has exceeded 600.000 units, especially thanks to photovoltaic

plants. Renewable sources produced 120.678,9 GWh in 2014, up 7,7% over the previous year (112.008,3 GWh in 2013)[4].

Hydropower represents the major share of electric energy production: looking at the GWh production between 2007 and 2014, it is clear that the hydro source is the major renewable contributor to energy supply.

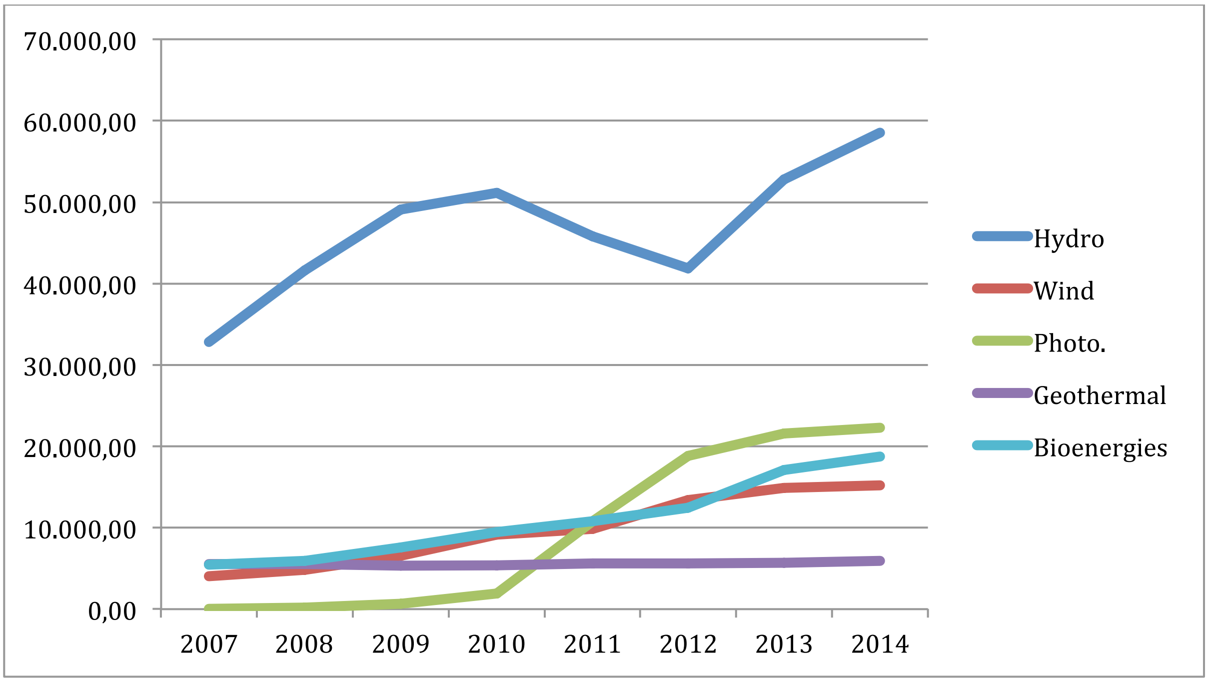

Figure 1 Renewable energy production, 2007-2014 (Author's elaboration on data from Terna, 2015).

However, as you can see from the Figure 1 it is the photovoltaic production that has grown more during these years. The reason is linked to the fact that this renewable source has strongly reacted to incentives schemes "Conto Energia" issued by Italian government, reaching in 2012 the second position of renewable sources under the hydro source. Conto Energia is a policy mechanism designed to accelerate investment in photovoltaic technology. The incentive consists of a financial contribution per kWh of energy produced for a certain period of time (up to 20 years), variable depending on the size or type of plant and up to a defined maximum level. National decrees for the execution of the first Conto Energia were issued between 2005 and 2006, after the European Directive 77/2001 (which started the promotion of renewable energy production in member states), and it started the development of photovoltaic investment in Italy; the second Conto Energia started in 2007, and this was particularly successful especially in its last phase, when it is possible to recognize a huge increase in photovoltaic energy production. The subsequent decrees had shorter duration and

[4] Rapporto Statistico Energia da fonti rinnovabili, GSE 2014.

started the decrease of the incentives. The fifth (and the last) Conto Energia ended in July 2013 without the starting of a new incentive plan on the energy produced; however it has been replaced by tax relief on the cost of the plant installation[5].

The increase of the renewable sources as sources of production has brought many advantages; but it has caused also a sort of shock to the grid, especially due to the great increase of photovoltaic and wind production. The Figure 2 represents the percentage increase of photovoltaic and wind production, with respect to the preceding years, between 2008 and 2014.

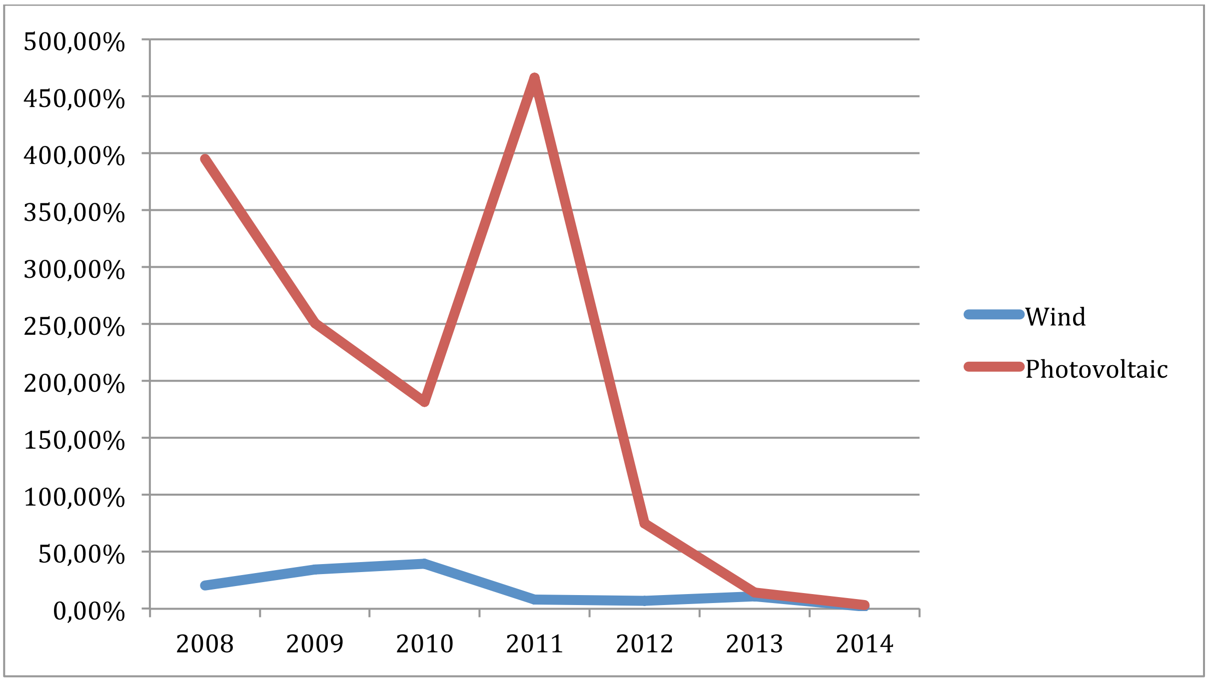

Figure 2 Wind and solar production, percentage increase between 2008 and 2014 (Author's elaboration on data from Terna, 2015).

We consider wind and solar sources, since their productions are unpredictable and highly fluctuating: as a consequence, their impact on managing the grid and on the instantaneous balancing between production and loads is much higher with respect to other productions, but we will talk about dispatching in the last paragraph of this chapter. Smart grids could have a solution to this problem.

Photovoltaic production, in particular, is affected by weather conditions and it suffers not only from seasonality, but also from an hourly variation that can be really large in presence of clouds or other temporary obstacle to solar radiations.

[5] Info taken from www.gse.it

As you can see from the Figure 2 wind production remains quite stable; on the contrary solar production shows great variability: between 2010 and 2011 (2nd Conto Energia) you can see an increase by 466% in photovoltaic production, from 1.906 GWh to 10.796 GWh.

The presence of intermittent and unpredictable production, like the one that comes from solar and wind, is a challenge for the system, because it influences the protection system of the electric grid, and it influences the provision of energy for dispatching service, increasing the costs of the balancing activity carried out by the operator, as we will see in the third chapter.[6]

1.1.2 TRANSMISSION

Transmission is the second phase of the electric system. Electric power transmission is the transfer of electricity from generating power plants to electrical substation located near demand centers, through the interconnected high and extra-high voltage grid.

This activity is carried out by the Transmission System Operator (TSO), in a condition of natural monopoly, because the grid is unique on the national territory. So TSO is an entity entrusted with transporting energy in the form of electrical power on a national level using fixed infrastructure (European Commission).

In Italy the TSO is Terna. It has been an industrial reality providing services to the country for years. Terna was established within the Enel Group by implementing Italian Legislative Decree No. 79/99 ('Bersani Decree') as part of the deregulation of the Italian electricity sector; this marked the separation between the ownership and management of the national transmission grid. At the beginning of its history, Terna was endowed with the operations and management activities related to the transmission infrastructure. In 2004, following the Prime Minister's Decree, Terna was put on sale with an IPO on Borsa Italiana. In 2005 Terna acquired the property of infrastructures for electric transmission and changed its name in Terna – rete elettrica nazionale S.p.a.. Nowadays the major shareholder is Cassa Depositi e Prestiti (owned by the Italian Ministry of Economy and Finance).Terna is responsible for the greatest efficiency of its infrastructures and for their maintenance; it is also responsible for planning and developing the National Transmission Grid. However the major activity is managing energy flows along the grid so that offer and demand are always balanced, guaranteeing in this way the continuity and safety of the service provided; this activity is known as dispatching. Electricity is not a storable commodity. Hence it is necessary to

[6] AEEGSI, PAS 21/2011

produce the requested quantity and distribute it through the system in such a way as to ensure that electricity supply and demand are always evenly balanced, thus guaranteeing continuity in supply of the service. The balance is gained by coordinating energy inflows from different production plants spread on the national territory, borders connections, transmission and auxiliary services; thinking about renewable sources, high levels of unpredictability and intermittency make the balancing activity challenging for the operator.

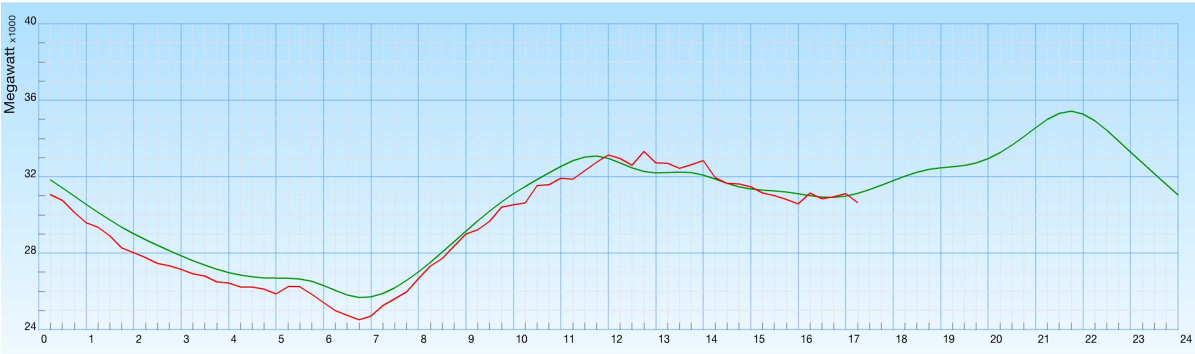

Figure 3 Real time data and forecast data for national demand of electricity, August 4th (Terna, 2015).

1.1.3 DISTRIBUTION

Distribution represents the final stage in the delivery of electric power. Electricity is delivered to consumers at medium and low voltage. Primary distribution lines carry medium voltage power to distribution transformers located near the customer's premise. Distribution transformers again lower the voltage to the utilization voltage of household appliances and typically feed several customers through secondary distribution lines at low voltage. Customers that demand a much larger amount of power may be connected directly to the medium voltage level.

In Italy, electricity distribution to final customers is a liberalized activity, allowing more operators to act in the market. The distribution service is carried out by Distribution System Operators (DSOs), which operate in a regime of local monopoly. DSOs in Italy have 3 important functions[7]:

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[7] Sandoy P., "The Role of Distribution System Operators (DSOs) as Information hubs", EURELECTRIC Networks Committee paper, 2010.

- distribution of electricity
- connection between plants and grids
- measurements and data management

Looking at data given by Terna, there are 137 DSOs (Terna, 2013) whose activity is subjected to license. However, only 10 DSOs serve more than 100.000 end users, covering almost the 97% of all customers[8]. Enel Distribuzione is the biggest operator and distributes almost the 86% of the electricity (ENEL Distribuzione, 2014). There are other big operators, such as Acea, A2A, IREN, HERA, but they concentrate their services on specific geographic areas. Here there is a list of the major DSOs in Italy[9].

Year 2012 - Main DSOs (Societies)

	Withdrawals (n.)	Withdrawals (GWh)
ENEL	31.689.259	239.733
Acea	1.623.209	9.158
A2A	1.117.898	10.971
IREN	692.359	3.881
Dolomiti Energia	300.642	1.979
HERA	259.730	2.216
AGSM VERONA	164.658	1.760
Acegas-Aps	141.749	761
Azienda Energetica - Etschwerke Bolzano	137.891	962
Compagnia Valdostana delle Acque	136.321	912
	36.263.716	**272.333**

Table 3 Main DSOs in Italy, 2012 (impresedistributrici.terna.it).

Looking at the process of liberalization of energy market in the European Union, the Commission imposed to big operators (with more than 100.000 customers) in the energy sectors the "unbundling". Unbundling is the separation of energy supply and generation from the operation of transmission networks. If a single company operates a transmission network and generates or sells energy at the same time, it may have an incentive to obstruct

[8] impresedistributrici.terna.it

[9] Unfortunately the list is about 2012, and it is the most recent list that you can find on impresedistributici.terna.it, the site of Terna that regards distributors.

competitors' access to infrastructure. This prevents fair competition in the market and can lead to higher prices for consumers[10].

In Italy the unbundling law has been issued by the Authority in 2007 with the decree 11/07, regarding the separation of administration and accountability duties for the firm that operate in electricity and gas sectors. The Authority underlines the willingness to strictly monitor the application of the rule, and it is reasonable to expect a great attention to the bigger operators, especially because of the monopoly that characterised the energy Italian market in the past, that brought to the current situation.

Two of the main functions of the DSOs are the measurement and management of data, so DSOs seem to be good candidates for an important role in improving grid efficiency and developing smart grids.

1.1.4 CONSUMPTION

Usually, after the three phases of production, transmission and distribution, consumption is discussed. Here it is considered the load composition and its trend over time for Italy.

In 2014, total electricity consumption fell to 291.083 GWh (-2,1%). Grid losses were down 8,2%, with an impact on demand of 6,3%, equal to 18.300 GWh (6,7% in 2013). Total internal net production, as already mentioned, was about 266.800 GWh, that implied a deficit of 43.700 GWh that were imported: about 80% of imported energy proceeds from France and Switzerland (Terna 2015).

In 2014, in accordance with existing regulations, the final electricity consumption market was again divided into: free market (including the "protection service"), captive market, and self-consumption. In 2014, consumption within the free market were 208.000 GWh, stable with respect to the previous year (+0,1%), while consumption in the captive market decreased to 58.100 GWh (-9,8%). Also self-consumption was stable at 25.000 GWh, with a little variation of +0,1% with respect to the previous year.

The distribution of electricity consumption by economic sector showed a further significant decline in consumption equal to -1,9%. With a consumption of 122.500 GWh, the industrial sector accounted for 42,1% of total Italian electricity consumption in 2014 (42% in 2013). Consumption in the tertiary sector decreased to 99.000 GWh in 2014 (-0,8% with respect to

[10] ec.europa.eu, Energy Market Legislation.

2013). Domestic consumption also decreased to 64.300 GWh (-4,1%), and agriculture recorded a decline in consumption as well, reaching 5.400 GWh (-5,4%)[11].

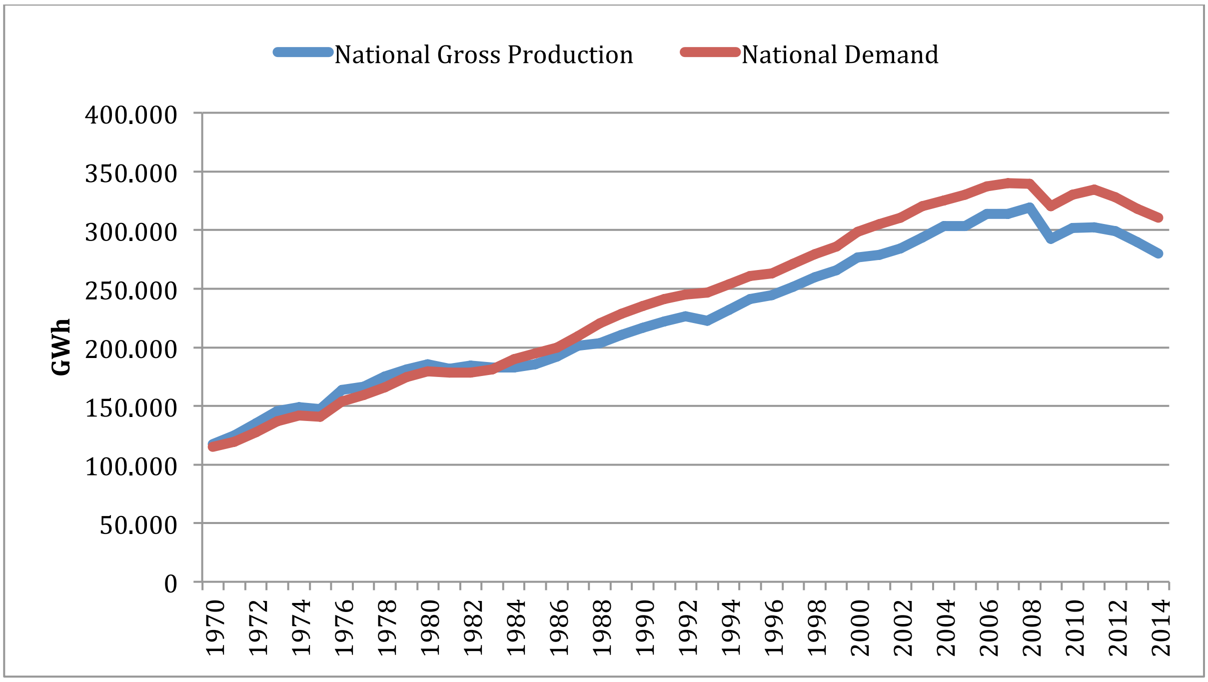

Figure 4 Energy gross production and consumption, historical data (Author's elaboration on data from Terna, 2015).

Thanks to the "Conto Energia" photovoltaic energy production and consumption are increased in these years, as we saw in the previous paragraphs. Managing the production of electricity from renewable sources that are not programmable has some implications on the dispatching activity. One possible solution that is linked to a smart managing of the electricity system could be acting on the load curve through signals that can modify the behaviour of the consumer. This is linked to the introduction of smart metering that can bring information to the consumer allowing him to better manage his consumption. Figure 5 below shows that private behaviour could be a resource for the grid.

[11] Statistical Data on Electricity in Italy – Synthesis, Terna for SISTAN 2014.

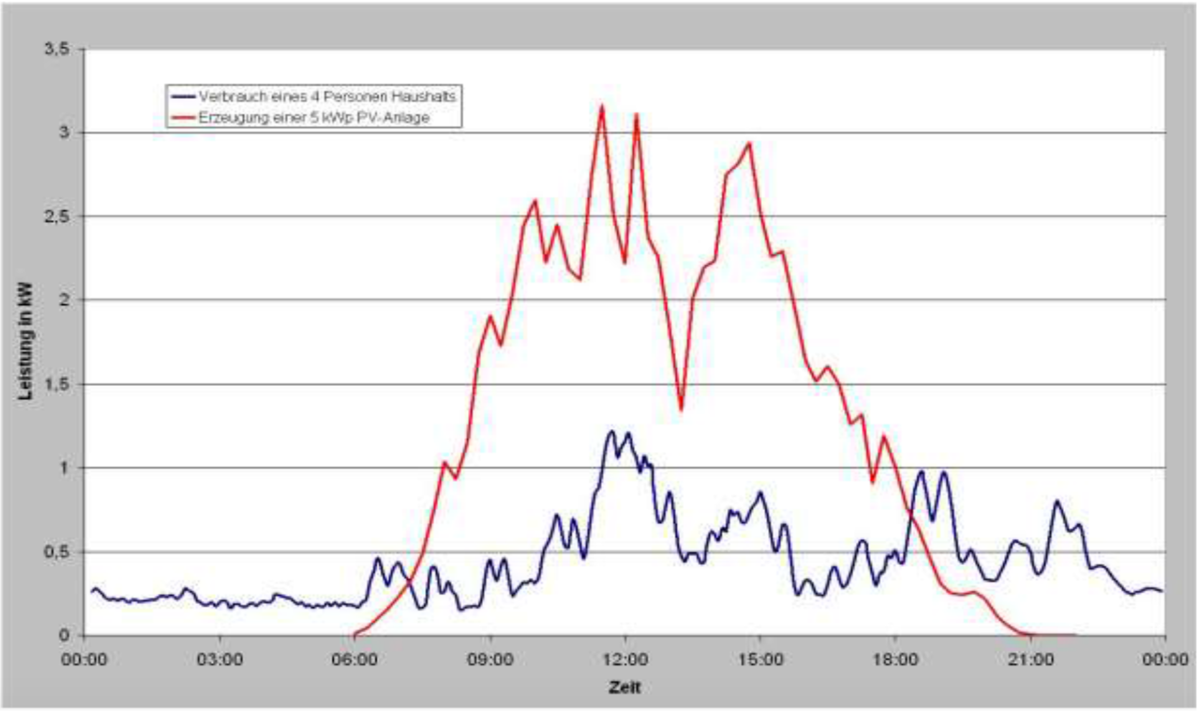

Figure 5 Average consumption for a four-member family in a typical summer day VS photovoltaic power generated by a 5kWp plant (from www.sma-italia.com).

Figure 5 shows an example of residential load for a four-member family in a summer day, while photovoltaic production is active: photovoltaic power is higher than requested load during all the daylight time slot. Changing plant power and looking at different season and weather conditions we will surely find considerable differences in production pattern (and consumption pattern too), but what is important is that, at yearly level, investing in smart load management tools to take advantage of photovoltaic production can be valuable. This private behaviour could be a resource for the grid too, if properly regulated to respond to system needs: private production and private consumption could be, jointly, a new energy resource for the system.

1.2 MANAGING ENERGY: DISPATCHING

Dispatching is managing energy flows along the grid so that offer and demand are always balanced, guaranteeing in this way the continuity and safety of the service provided (Terna, 2015).

As we know, electricity is not a storable commodity. So it is necessary to produce exactly the requested quantity and distribute it through the system in such a way as to ensure that electricity supply and demand are always balanced, thus guaranteeing continuity to the system.

In Italy, this activity is performed by Terna, and it requires monitoring of electricity flows and the application of what is necessary for the coordination of the system components, that are production plants, transmission grid and the auxiliary services. The real time management of the Italian electricity system, interconnected with the European system, is performed through a control system that is the National Control Centre. This is a bunker with over 100 control screens and a 40 sq. meters wallscreen that monitor 293 lines, among which 9 interconnections with foreign countries, 3 submarine cables and 281 national 380 kV lines[12].

It is the National Control Centre's duty to ensure that the electricity system works under conditions of maximum safety, in order to guarantee service continuity and quality. The control system acquires, minute by minute, all the data relating to the state of the electricity system and, in accordance with the requirements of the moment, implements the appropriate corrective measures. The essential functions of the National Control Centre are related to:

- the planning phase, with the drawing up of the operation plans developed on the basis of the forecasts for electricity and power demand at national level, and the availability of the means of production. The short term weekly and daily forecasts, developed on the basis of medium-term forecasts, allow the determination of the production levels, the configuration of grid functioning and power reserve.
- the real time control phase; analysing the state of the electricity system, the National Control Centre intervenes in the production of active and reactive power and on the grid structure; at the same time it works to achieve optimisation of the service, recovery in the event outage, control of any emergencies and coordination of works-related procedures.
- the operation analysis phase; in addition to processing the statistics relating to all the operating data, it analyses the functioning of the production and transmission system, so as to gather useful indications for optimisation of system operation.

The National Control Centre performs its duty through eight distribution centres which, for their own territorial area of competence, decide on plant intervention in both planning and real time control phases.

The figure below shows the electricity balance by regional area and at a total level for 2014, considering the eight centres. These are data that have to be considered for the dispatching activity.

[12] www.terna.it

	TURIN	MILAN	VENICE	FLORENCE	ROME	NAPLES	PALERMO	CAGLIARI	Total 2014	Total 2013	Total %Var.
Hydro production	11,687	13,326	21,007	2,328	5,930	2,886	455	448	58,067	54,068	7.4
Thermal production	18,740	24,422	16,859	21,121	19,487	38,434	16,417	10,204	165,684	183,404	- 9.7
Geothermal production	0	0	0	5,541	0	0	0	0	5,541	5,319	4.2
Wind production	23	0	0	229	1,096	9,043	2,934	1,641	14,966	14,812	1.0
Photovoltaic production	1,691	2,218	2,817	3,260	4,676	5,742	1,921	974	23,299	21,229	9.8
Total net production	**32,141**	**39,966**	**40,683**	**32,479**	**31,189**	**56,105**	**21,727**	**13,267**	**267,557**	**278,832**	**- 4.0**
Electricity consumed by pumping	491	498	35	35	74	563	421	137	2,254	2,495	- 9.7
Net production allocated for consumption	**31,650**	**39,468**	**40,648**	**32,444**	**31,115**	**55,542**	**21,306**	**13,130**	**265,303**	**276,337**	**- 4.0**
Import	*17,580*	*22,341*	*6,697*	*0*	*0*	*106*	*0*	*0*	*46,724*	*44,338*	*5.4*
Export	*787*	*131*	*139*	*207*	*0*	*1,337*	*0*	*420*	*3,021*	*2,200*	*37.3*
Net import/export balance	**16,793**	**22,210**	**6,558**	**- 207**	**0**	**- 1,231**	**0**	**- 420**	**43,703**	**42,138**	**3.7**
Balance of physical exchanges between regional areas	- 17,018	2,201	- 1,288	17,626	12,481	- 9,053	- 1,498	- 3,451			
Electricity supplied	**31,425**	**63,879**	**45,918**	**49,863**	**43,596**	**45,258**	**19,808**	**9,259**	**309,006**	**318,475**	**- 3.0**
Year 2013	32,865	68,226	46,245	49,841	44,965	46,514	20,509	9,310			
% variation	**- 4.4**	**- 6.4**	**- 0.7**	**0.0**	**- 3.0**	**- 2.7**	**- 3.4**	**- 0.5**			

N.B. Net import/export balance excluding the Republic of San Marino and the Vatican City.

Figure 6 Electricity balance by regional area (Provisional data report, Terna 2014).

As you can see, and as we have already seen in the production phase above, the electricity demand reached 309 billion kWh, a decrease of 3% compared to 2013. The net domestic production allocated for consumption registered a 4% decrease. The variation in the balance of physical exchanges of electricity with overseas was positive compared to the previous year (+3,7%). Specifically, there was an increase in production from geothermal (4,2%), wind power (1%), and photovoltaic (9,8%). Hydroelectric production registered an increase (+7,4%), while thermoelectric production dropped (-9,7%). Imports of electricity from overseas increased by 5,4%, with an even greater increase in exports (+37,3%).

Other important data that are the result of the dispatching activity are the weekly maximum values of energy.

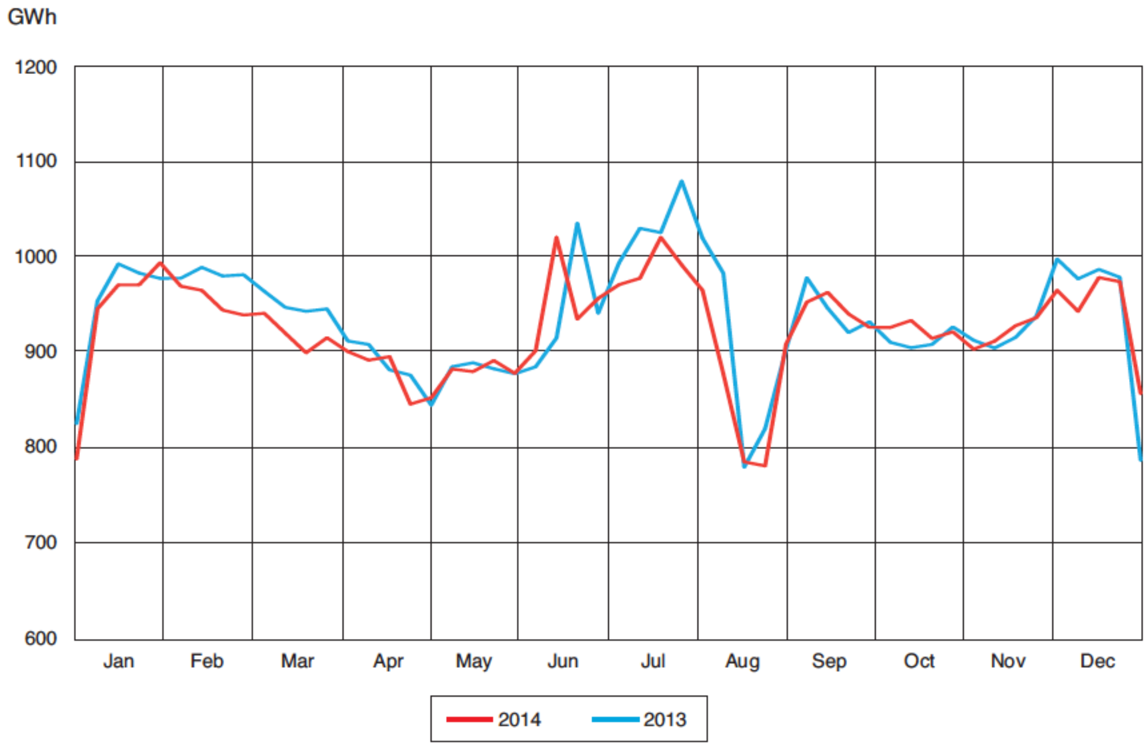

Figure 7, Weekly maximum values of energy (Provisional data report, Terna 2014).

The curve in Figure 7 shows the maximum values of energy demanded recorded on the Italian grid in each of the 52 weeks of 2014, compared with 2013. The diagrams clearly show low demand values during the Easter holidays, August and year-end holidays. Data collected can be used for better forecasts for the following year, helping the TSO in the dispatching activity.

The figure below shows the balance of physical exchanges of electricity in 2014. You can see the energy flows among the various areas of the Italian power system. It is interesting to note the high flow that goes from Lombardy towards central Italy. Moreover it is important to underline that electricity exports from Sicily to the mainland through the 380 kV connection, provide for the safe of the system in the south of Italy.

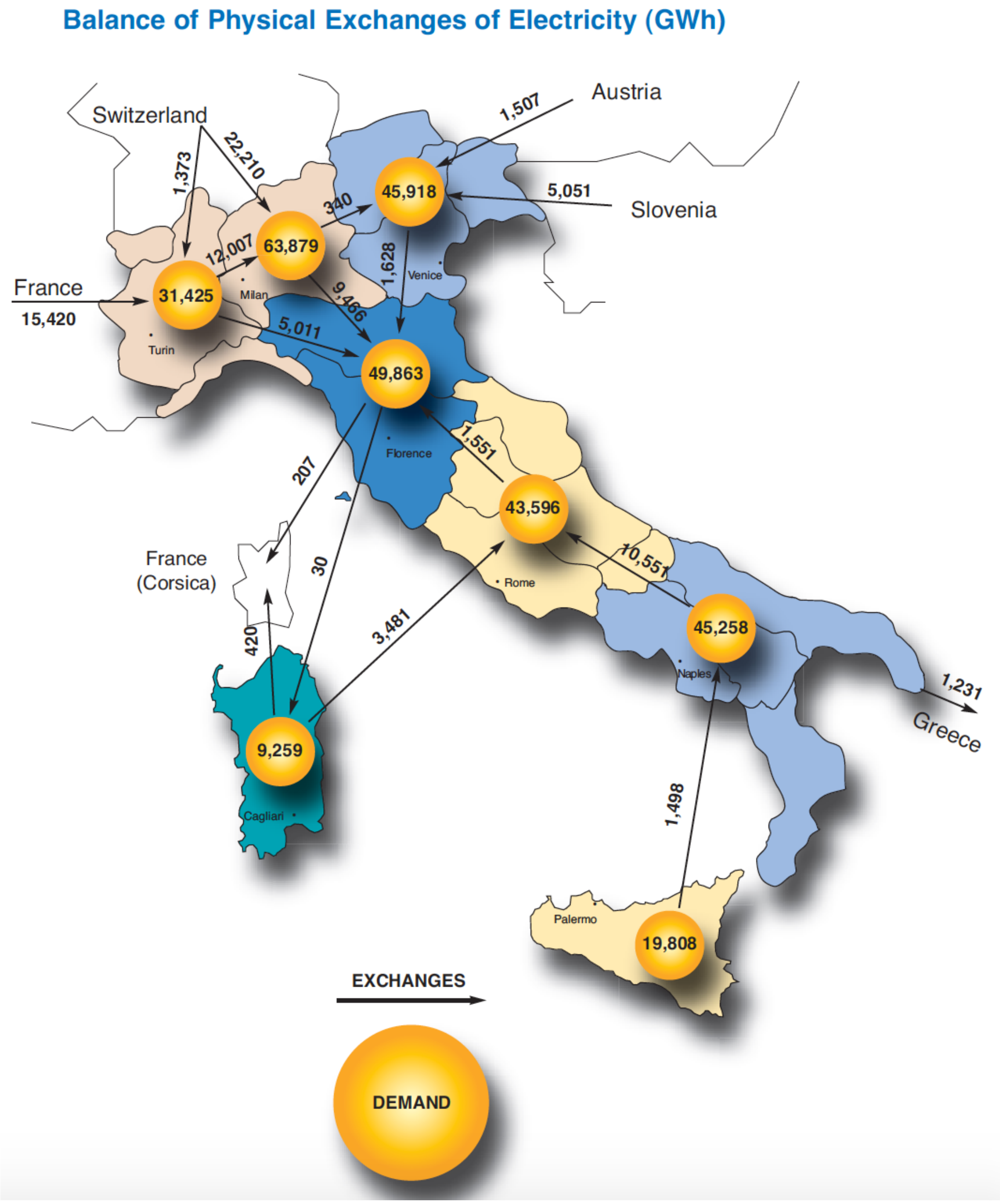

Figure 8 Balance of physical exchanges of electricity (GWh) (Provisional data report, Terna 2014).

Since the penetration of renewable sources in the Italian electricity system has become considerable, the authorities have started talking about dispatching priority. Dispatching priority for renewables is planned at European level. In fact the European directive 2009/28/CE provides that: “[…] members States have to ensure that, considering dispatching of power plants, transmission system operators have to give priority to those plants that produce renewables energy, to the extent that allows a safety management of the national power system, and in a transparent and non-discriminatory method."[13]

In the Italian electricity system when there are some bids characterized by the same price, this is the priority order:

- bids of the units that are essential for the safety of the system;
- bids of the production units that use non-programmable renewable sources (sun, wind, biogas, landfill gas, geothermal energy, waves);
- bids of the production units that use renewable sources that are different from the those written in the previous point;
- bids of the cogeneration production units;
- bids of the CIP6/92 production units;
- bids of the production plants that use national sources of fossil fuels;
- other bids.

These points indicate that plants powered by renewable sources (programmable and non-programmable) have to be dispatched first with respect to the others, but only for the same bid price and if the safety of the system is granted. The main criterion by which the dispatching priority is determined is therefore the price. So firstly it is dispatched energy that costs less, and secondly the energy that costs more, until the demand is satisfied. Hypothetically, a bid of a MWh produced by a wind plant if costs more than a bid of MWh produced by a traditional plant it will not dispatch, even if the plants powered by renewable sources have to be dispatched first with respect to the others. However, renewable energy has incentives, and does not compete on the market with the energy produced by traditional sources, and then basically it does not compete on equal terms with the energy produced by fossil fuels. Moreover the variable production cost of energy of a renewable plant is very low.

[13] 2009/28/CE.

As a consequence of the dispatching priority of the renewable energy, when the electricity production from renewable sources is high, and at the same time the demand is very low (for example during the public holidays), traditional plants that participate to the formation of the equilibrium price are less, thus causing a low energy price per hour, sometimes even null. See for example in the graph below the price schedules formed for the day April 5, 2015 (Easter): in the middle of the day (when the photovoltaic production is very high) prices are lower than 10€/MWh.

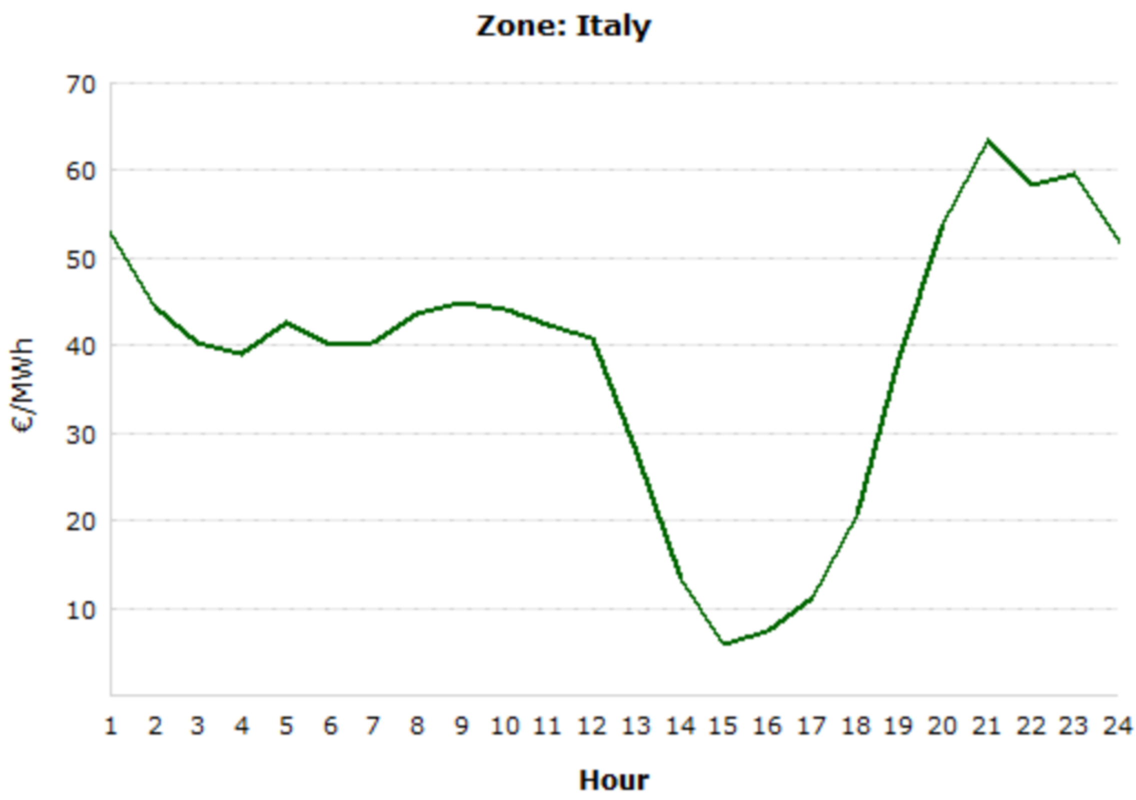

Figure 9 Energy prices per hour (GME, 2015).

The possibility that dispatching priority for renewable sources will be removed is unfounded. Instead, the problem could be that, because of the drop in electricity demand of these years, also because of the economic crisis, plants that use renewable sources will force traditional plants to stop, going out of the market, even those power plants that are maybe necessary for providing ancillary services or granting a safe supply during the winter time or when the sun does not shine. In fact, these plants could be substituted by intermittent plants that are not able to provide an absolute safety service, at least nowadays. This is a problem that could be solved with the future implementation of the smart grid, especially thanks to the introduction of accumulators that will allow to store energy produced by renewable sources, and thanks to the smart meters. We will talk about this at the end of the third chapter.

1.3 THE ITALIAN ELECTRICITY MARKET

In 1999, the decree n.79 launched the electricity market in Italy, transposing the EU directive on “common rules for the internal energy market” (96/92/EC). This decree, named “Bersani”, set out the process of liberalization of the energy sector which would led to the current market organization structure (of course after some years and applications of new rules). The legislator’s aim was the creation and the regulation of an effective market for generation and sale of electricity, based on the principles of competition, transparency and neutrality. The sector changed from a monopoly to a complex mechanism, with a plurality of parties competing to offer services and products to customers rather than users. Currently the parts involved in the market are: production companies, one transmission operator (Terna Spa), distribution companies, and market operators active in energy trading and supply delivery.

The structure of the market has been defined following the roles of different actors (producers, customers, managers, regulators, controllers) as well as defining the different trading venues of different products and services. In particular the following companies have been created: the Electricity Services Operator (GSE), the Manager Energy Markets (GME) entrusted with the organization and the management of the electricity market, and the Single Buyer (AU) which is given the role of guarantor for the supply of electricity to households and small businesses. The physical process of power generation and supply to cover consumption is of course at the basis of this complex system, while an Authority (The Authority for Electricity and Gas AEEGSI) oversees the entire market. The prospect of generating value on the energy sector attracted more investments, allowing a significant technological modernization, improved services and the range of services and products choice.

The Italian electricity Market, called Italian Power Exchange (IPEX), enables producers, consumers, and wholesale customers to enter into hourly electricity purchase and sale contracts. Market participants can connect to an electronic platform through internet and enter into on-line contracts under secure access procedures based on digital certificates.

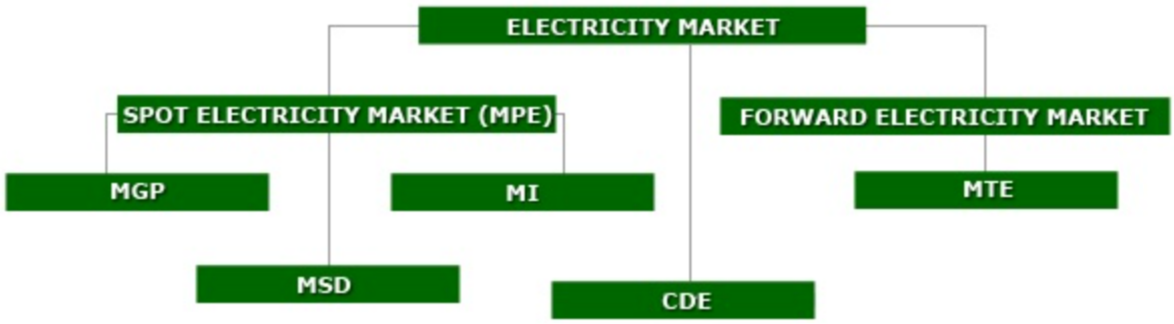

Figure 10 Italian Electricity Market (GME, 2015).

As we know, GME (Gestore dei Mercati Energetici Spa) is the company which was set up by GSE with the mission of organising and economically managing the Electricity Market, under principles of neutrality, transparency, objectivity and competition between producers, as well as of economically managing an adequate availability of reserve capacity.

As you can see from the figure 10, the Electricity Market consist of[14]:

- the Spot Electricity Market (Italian acronym MPE, Mercato Elettrico a Pronti), including:
    a. the Day-Ahead Market (DAM, Italian acronym MGP, Mercato del Giorno Prima), where producers, wholesalers, and eligible final customers may sell/purchase electricity for the next day; GME is the central counterparty in the transaction concluded in the DAM.
    b. the Intra-Day Market (IM, Italian acronym MI, Mercato Infragriornaliero), where producers, wholesalers, and final customers may modify the injection/withdrawal schedules that they have defined in the DAM; GME is the central counterparty in the transactions concluded in the IM.
    c. the Ancillary Services Market (ASM, Italian acronym MSD, Mercato dei Servizi di Dispacciamento), where Terna Spa provides the dispatching services needed to manage, operate, monitor and control the power system. The ASM consists of the scheduling stage (ex-ante ASM), and of the Balancing Market (BM). Terna is the central counterparty in the transaction concluded in the ASM.
- the Forward Electricity Market that is the place where forward electricity contracts with delivery and withdrawal obligation are traded (FEM, Italian acronym MTE,

[14] www.gme.it

Mercato Elettrico a Termine). GME is the central counterparty in the transactions concluded in the FEM.

- the platform for physical delivery of financial contracts is the IDEX (CDE, Consegna Derivati Energia). IDEX is the segment of the financial derivatives market of Borsa Italiana Spa, where financial electricity derivatives are traded. The contracts executed on the CDE are those for which the participant has requested to exercise the option of physical delivery in the Electricity Market. GME is the central counterparty of the delivered contracts.

1.3.1 ELECTRICITY MARKET AND PRICES

Electricity is not like common commodities, because it is not a good that is stocked in a store. In the Electricity Market is sold the "promise" to produce a certain amount of energy on any given day at a given time. Italian Electricity Market is divided into 6 zones, North, North Central, South Central, Sardinia, Sicily, and South, and for each hour of the day in every zone producers offer at a certain price packets of energy that sellers or wholesalers buy.

The equilibrium price for the hour is established after the intersection of the demand and supply curves. The criterion by which the price is established is the System Marginal Price. According to this SMP, all suppliers receive the same market-clearing price, set at the offer price of the most (or nearly most) expensive resource chosen to provide supply.

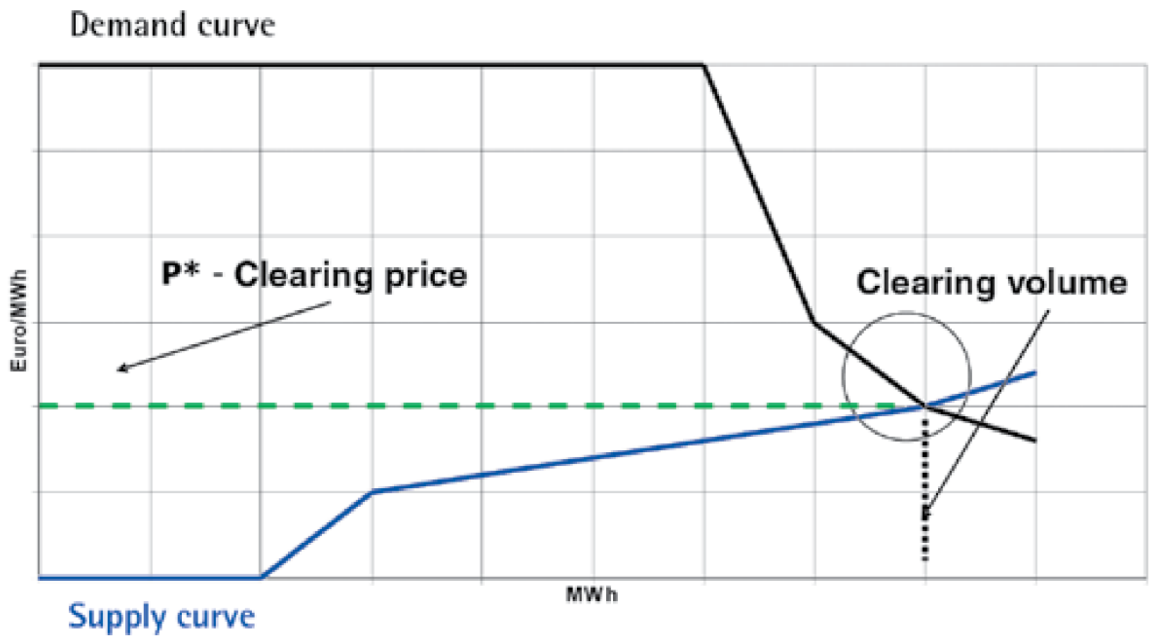

Figure 11 Equilibrium price with system marginal price.

There is another system that is in contrast with the SMP, and it is the Pay as Bid criterion: prices paid to winning suppliers are based on their actual bids, rather than the bid of the highest priced supplier.[15]

In Italy, the national price for electric energy is known as PUN (Prezzo Unico Nazionale). It is calculated as the mean of the different prices originated at the zonal level, weighted by the volume of effective exchanges, net of purchases for pumping and from foreign regions. According to the GME, the mean value of the PUN in 2014 was 52€/MWh.

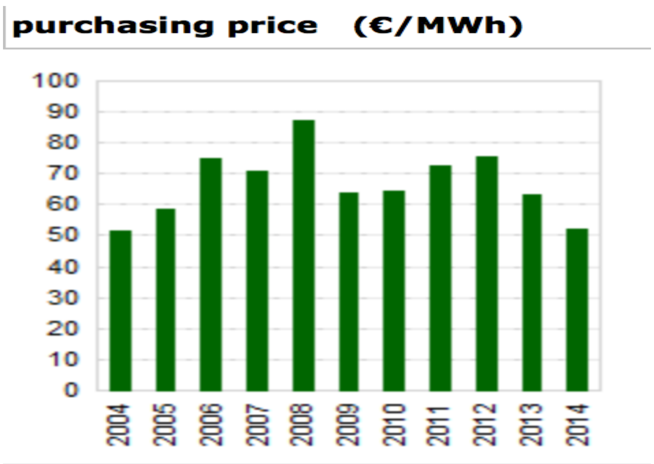

Figure 12 PUN evolution (GME, 2015).

[15] Steven Stoft, Power System Economics - Designing Markets for Electricity, Wiley-Interscience, 2002, p. 65.

Looking at the Figure 12, it is possible to see that in the last few years the PUN has registered a negative trend. This is probably because of the drop in energy demand due to the economic crisis, and the contemporaneous availability of higher distributed energy generation (for example photovoltaic power plants on the roofs of many houses); however, further future observations are needed to confirm this trend.

Finally, we have to underline that the PUN is not the final price of energy for the end consumers, because they face an higher price level due to the presence of grid costs, general costs and taxes, but this is not detailed in the paper.

2. ITALIAN ELECTRICITY MARKETS CONSIDERED FOR THE ANALYSIS: DAY-AHEAD MARKET AND ANCILLARY SERVICES MARKET

In order to do the analysis on a possible correlation between imbalance costs and electricity prices and quantities, information has been taken from the GME site, where all data that regard the electricity market are uploaded day by day. The study period goes from January 1th, 2013 to June 2015, and regards specifically two markets: the Day-Ahead Market (MGP, Mercato del Giorno Prima) and the ex ante Ancillary Services Market (ex ante MSD, Mercato dei Servizi di Dispacciamento). On the Day-Ahead Market we have collected data on prices and quantities of electricity, while on the Ancillary Services Market we have collected data that have been used for the calculation of the imbalance costs.

For both markets the website of GME shows the values of price (or quantity, in the case of the MGP market that concerns the amount of energy) for every hour of the day and for each of the six market zones.

MGP and ex ante MSD are the two markets that were been taken into account because:

- on the MGP market we can find data that regard prices and quantities of electricity that every day is exchanged in the market;
- on the ex ante MSD we can find data that regard the selling and the buying prices, for every hour and in every zone, of the ancillary services that Terna has to acquire in order to guarantee the safety of the system. Through these data, as it will be explained, we have obtained a measure of the imbalance costs.

The Italian Ancillary Services Market, as it will be detailed after, consists of two parts: ex ante MSD, that is the scheduling stage, and the Balancing Market. For the analysis we excluded the Balancing Market, because only the ex ante MSD market has the same structure of the MGP market (both have the same availability of data for hours, days, zones) and so can be compared for an analysis. We know that this can limit the study (all the considerations are explained at the beginning of the third chapter where data are presented) but it is the best choice, taking into account the Italian regulation for the electricity market.

An analysis of the correlation between these markets is useful because many variations have been occurred in these markets during recent years, especially because of the increased impact of renewable energy. Moreover, there are some works that prove that the future Smart Grid can bring some benefits to the Ancillary Services Market in term of cost reduction; so it is useful to understand if this could have a positive effect also on the Day-Ahead Market.

As we know, the electricity market was created in Italy as a result of the approval of legislative decree 79/99. This decree, which marked the beginning of the structural reform of the Italian electricity sector, responded to the following needs:

- promoting competition in the activities of electricity generation and wholesale through the creation of a "marketplace";
- maximising transparency and efficiency in the naturally monopolistic activity of dispatching.

The electricity market is an electronic venue for the trading of wholesale electricity, where the electricity price corresponds to the clearing price resulting from the intersection between the volumes of electricity demanded and offered by its participants.

It is a real physical market, where the schedules of injection[16] and withdrawal[17] of electricity into and from the grid are defined under the economic merit-order criterion[18]. The Italian Power Exchange (IPEX) is a voluntary market: purchase and sale contracts may also be concluded off the exchange platform, i.e. bilaterally or over the counter (OTC).

Before of the analysis it is useful understand the technical constraints of the power system, also to better understand when we will briefly talk about MGP, ex ante MSD, and interconnections between zones.

In the national power grid system, the activities of transmission and dispatching are subject to very strict technical constraints, such as:

- the need for instantaneously and continuously balancing the volumes of electricity injected into the grid and those withdrawn from the grid, taking into account transmission and distribution losses;
- the need for keeping electricity frequency and voltage on the grid within a very narrow range, so as to protect the security of installations;
- the need for ensuring that the power flows on each line do not exceed the maximum admissible transmission capacity (transmission or transit limits) of the same line.

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[16] The hourly injection schedule is the hourly diagram which defines, for an offer point and for each relevant period, the volume of electricity to which the dispatching rules are applied.

[17] The hourly withdrawal schedule is the hourly diagram which defines, for an offer point and for each relevant period, the volume of electricity to which the dispatching rules are applied.

[18] As we have said in the first chapter, the economic merit-order criterion means that supply offers are ranked in increasing price order and demand bids are ranked in decreasing price. order.

Even minimum deviation from any of the above parameters for more than a few seconds may rapidly trigger critical conditions in the power system. Satisfying these constraints is further complicated by the characteristics of the technologies and procedures through which electricity is generated, transmitted and consumed.
In particular, the difficulties arise from three factors:

- non-rationable, inelastic and variable demand: demand on the grid has high variability in the short term (on hourly basis) and in the medium term (on a weekly and seasonal basis);
- no storage of electricity and dynamic constraints on the real-time adjustment of supply: electricity can be stored in significant amounts only indirectly and, considering the hydro power plants, through the amount of water contained in the reservoirs;
- grid externalities: after being injected into the grid, electricity flows through all the available lines, like in a system of communicating vessels, under complex physical laws that depend on the equilibrium between injections and withdrawals; hence, the path of electricity is not traceable and, if a local imbalance is not promptly redressed, it will propagate to the overall grid inducing voltage and frequency variations.[19]

The high complexity of the power system and the co-ordination needed to guarantee its operation make it imperative to identify a central co-ordinating entity, that is Terna for Italy.

This chapter makes a description of the six Italian zones and their interconnections, of the Day-Ahead Market, and of the Ancillary Services Market.

2.1 MARKET ZONES

The power system is divided into portions of transmission grids (zones) where, for reasons of power system security, there are physical limits for the transmission of electricity to/from the corresponding neighbouring zones. These transmission limits are determined through a computational model that is based on the balance between electricity generation and consumption. The Italian power system thus consists of market zones, groups of geographical and virtual zones, each with a zonal electricity price.

[19] Steven Stoft, "Power System Economics - Designing Markets for Electricity", Wiley-Interscience, 2002.

Terna divides the network into zones on the basis of these criteria:

- transport capacity between the zones has to be adequate to the implementation of the programs of injection and withdrawal corresponding to situations of operation that are considered most frequent, on the basis of the forecasts made on the market;
- the programs execution of injection and withdrawal does not have to cause congestions within each zone considering the predictable operating situations;
- the location of injections and withdrawals, including the potential ones, within each zone does not have to have a significant influence on the transport capacity between areas.

The zones of the so-called "rete rilevante" (relevant grid) may correspond to physical geographical areas, to virtual areas (that are not directly corresponding physical areas) and to constrained zones or points of limited production (that are virtual zones whose generation is subject to constraints aimed at maintaining the security of the power system).

The national transmission grid is interconnected with neighbouring countries via 22 lines: 4 with France, 12 with Switzerland, 1 with Austria, 2 with Slovenia, 1 direct-current submarine cable with Greece, in addition to the SACOI direct-current cable linking Sardinia to mainland Italy through Corsica, an additional alternating-current cable between Sardinia and Corsica, and the SAPEI direct-current link between Sardinia and mainland Italy.[20]

The configuration of these zones depends on how Terna manages the flows along the peninsula. The zone may be summarised as follows:

- 6 geographical zones (North, North Central, South Central, South, Sardinia and Sicily);
- 8 neighbouring Countries' virtual zones (France, Switzerland, Austria, Slovenia, BSP[21], Corsica, Corsica AC and Greece);
- 4 national virtual zones representing constrained zones, that are zones consisting only of generating units, whose interconnection capacity with the grid is lower than their installed capacity (Rossano, Brindisi, Priolo and Foggia).

To identify and remove any congestion that may be caused by scheduled injection or withdrawal, GME uses a simplified map of the real grid. The map only shows the most

[20] www.terna.it

[21] Zone representing the interconnection dedicated to market coupling between Italy and Slovenia.

significant transmission limits that are those between national geographical zones, neighbouring countries' or foreign zones and constrained zones.

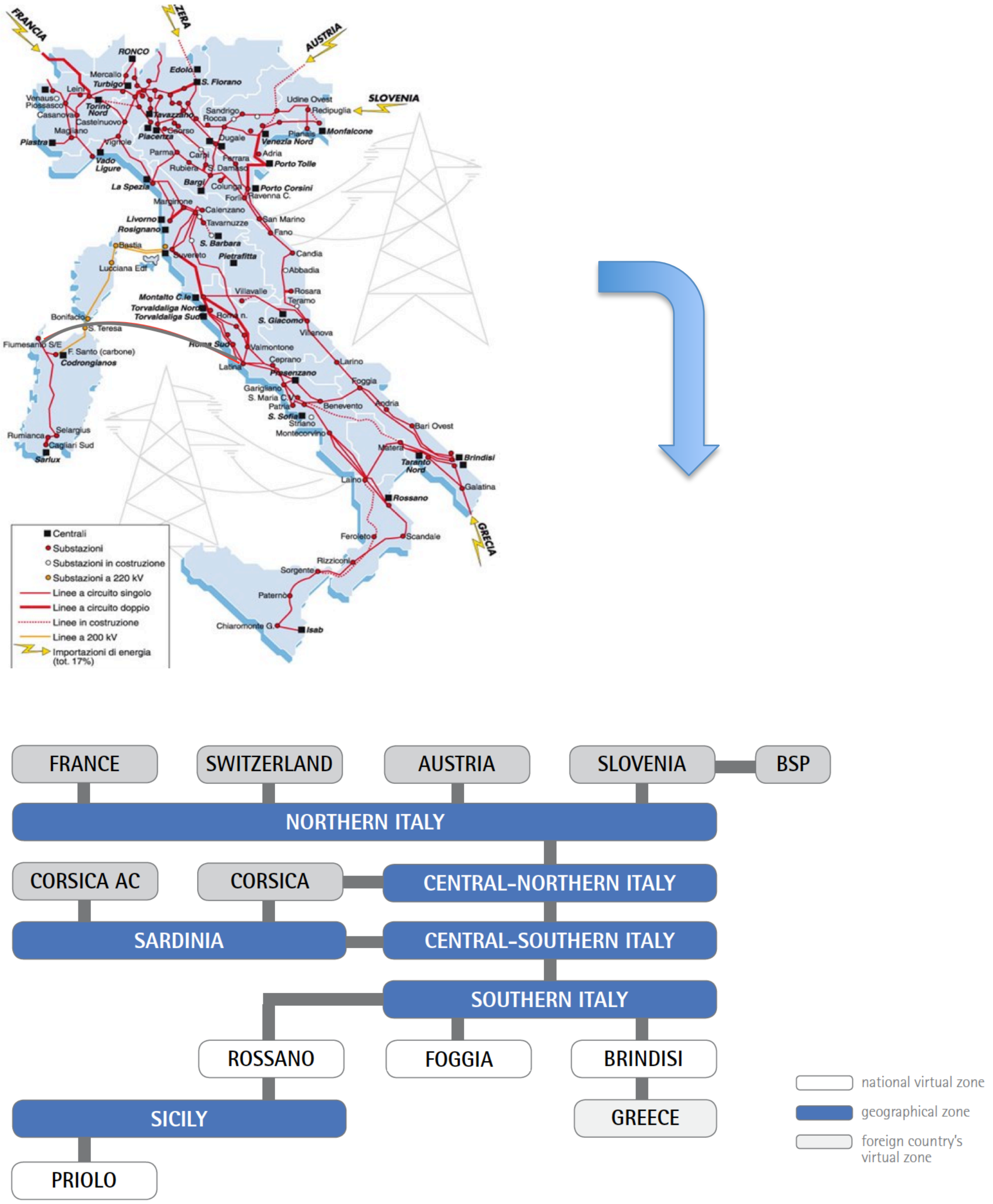

Figure 13 From real transmission grid to virtual and geographical zones representation.

A zonal market allows for Terna's costs reduction in the MSD to supply the necessary resources, to ensure the compatibility of energy flows programmed, and the safety of the system in general with the actual system constraints. This is an important element, especially if we consider the critical conditions of competition in MSD. Without a division of the market the national uniform price might align to the values of the expected price in the area with higher prices, with consequent negative impact on prices paid by final consumers.

Interconnections between zones are really important especially for efficiency. This is why it is very important to develop them constantly. The realization of new electricity grids or the upgrading of the existing ones aims to speed up the connection of the new facilities and to increase the transport capacity between zones, in order to solve congestion. The need to develop the existing network in order to make possible that all the electricity produced by power plants, especially renewable ones, can flow through the grid seems to be quite urgent, especially in some areas of the Country characterized by high potential for generating and by poor local load (south Italy). Today, in fact, there are some saturated power grids (for example some Apennine ridges characterized by the presence of numerous plants, mostly wind, and little or no load) and, therefore, they are not able to convey all the electricity production into the grid.

The Authority is trying to promote the realization of new power grids in the most critical zones. In addition, to improve existing networks, it has begun with demonstration projects to evaluate the key technologies identified as "smart". The results of these experiments should allow the Authority to have more information on the potential of new technologies and the various ways of managing networks. Thus it will be able to start a process of re-engineering of the current regulatory system in order to promote the development and implementation of a smart system, calibrated both on technological solutions that have to be promoted, both on the benefits achievable.

2.2 ITALIAN DAY-AHEAD MARKET

Looking at the Italian electricity market, the scheme below could be a good representation for the temporal sequence of the markets (according to the actual Italian regulation). Of course the best situation is the real time market, but actually this is not possible as we saw in the previous paragraph.

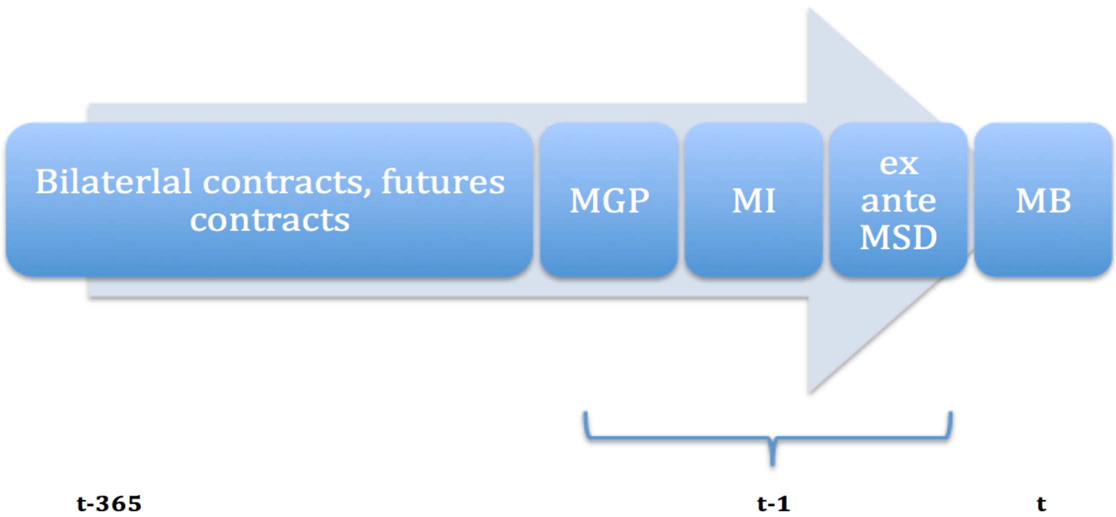

Figure 14 Wholesale electricity market. Temporal sequence of markets. (Author's elaboration).

As we shown in the paragraph 1.3, the Day-Ahead Market (MGP) is a part of the spot electricity market. The MGP hosts most of the electricity sale and purchase transactions. In this market, hourly energy blocks are traded for the next day.

The MGP sitting opens at 8 a.m. of the ninth day before the day of delivery and closes at 12 p.m. of the day before the day of delivery. The results of the MGP are made known within 12.55 p.m. of the day before the day of delivery. All parties that have acquired the status of "Electricity Market participants" may trade in the MGP. We want to remember that GME acts as a central counterparty to purchase and sale transactions in the MGP.

When the sitting of the Day-Ahead Market is open, participants submit offers/bids where they specify the quantity and the minimum/maximum price at which they are willing to sell/purchase. Supply offers and demand bids must be consistent with the injection or withdrawal capabilities of the offer points[22] to which they refer and, above all, they must correspond to the real willingness to inject or withdraw the related volumes of electricity.

At the end of the session for the bid/offer submission, the GME activates the market resolution process. For each hour of the following day, the market algorithm will accept bids/offers in such a way that maximise the value of transactions, concerning the maximum transmission limits between zones.

[22] Offer points are the minimum units of electricity in respect of which hourly injection and withdrawal schedules have to be defined.

The acceptance process may be summarised as follows: firstly, all valid and adequate supply offers that have been received are ranked in increasing price order on an aggregate supply curve, while all valid and adequate demand bids that have been received are ranked in decreasing price order on an aggregate demand curve. The intersection of the two curves (as you can see from Figure 11 in paragraph 1.3.1) gives: the overall traded volume, the clearing price, the accepted bids/offers and the injection and withdrawal schedules obtained as the sum of accepted offers related, in a same time, to the same offer point.
After that, if the flows on the grid resulting from the schedules don not violate any transmission limit, the clearing price is the same for all the zones, and it is equal to P*. Accepted bids/offers are those that have a selling price not higher than P*, and a purchasing price not lower than P*.
If at least one limit is violated, the market is separated into two market zones, one exporting zone including all the zones that are upstream of the constraint, and one importing zone including all the zones that are downstream of the constraint. In each zone, the algorithm repeats the intersection process mentioned above and, for each market zone, it builds a supply curve (including all the supply offers submitted in the same zone, as well as the maximum imported volume) and a demand curve (including all the demand bids submitted in the same zone, as well as a volume equal to the maximum exported volume). The result is a zonal clearing price (Pz), which is different in the two market zones. In particular, Pz is higher in the importing market zone and lower in the exporting one. If, as a result of this solution, additional transmission limits within each market zone are violated, the market splitting process is repeated also within this zone until a result that is consistent with the grid constraints is obtained.
Finally, with regard to the price of electricity for consumption, GME implemented an appropriate algorithm. In case of prices differentiated by zone, the algorithm applies a national single purchasing price (PUN), which is equal to the average of zonal selling prices weighted for zonal consumption.

2.3 ITALIAN ANCILLARY SERVICES MARKET

The Ancillary Services Market (MSD) is the market where Terna, as Transmission System Operator, procures the resources needed to manage, operate, monitor and control the power system (relief of intra-zonal congestions, creation of energy reserve, real-time balancing). In

the MSD, Terna acts as a central counterparty and accepted offers are remunerated at the price offered (Pay as Bid).
The MSD consists of a scheduling substage (ex-ante MSD) and Balancing Market (MB). The ex-ante MSD and MB take place in multiple sessions, as provided in the dispatching rules.

The ex-ante MSD consists of four scheduling substages: MSD1, MSD2, MSD3 and MSD4. The sitting for bid/offer submission into the ex-ante MSD is a single one. It opens at 12.55 p.m. of the day before the day of delivery and closes at 5.30 p.m. of the same day. In the ex-ante MSD, Terna accepts energy demand bids and supply offers in order to relieve residual congestions and to create reserve margins.[23]

There are three types of reserves, and here they are presented, according to Terna, in a decreasing order of flexibility:

- Secondary Reserve: the secondary reserve has the purpose of offset the gap between demand and production of the national system, thus bringing the power exchange at the national border to the correct values, and contributing, as a result, to the reestablishment of the European frequency. The secondary reserve is considered as the most valuable resource, because it is automatically activated in a few second.
- Tertiary Fast Reserve: the tertiary fast reserve has the purpose to maintain the balance of the system in case of rapid changes in demand. It is the increase (decrease) of production that can be injected (taken) in (from) the network within 15 minutes from the request of the Manager.
- Tertiary Replacement Reserve: the tertiary replacement reserve has the purpose to reconstitute the tertiary fast reserve after deviations of the requirements, the increasing use of non-programmable renewable energy, failures of few hours in the production groups. It is the increase (decrease) of production that can be injected (taken) in (from) the network within 120 minutes from the request of the Manager.

The MB takes place in different sessions, during which Terna selects bids/offers in respect of groups of hours of the same day on which the related MB session takes place. At present, the MB consists of 5 sessions. The first session of the MB takes into consideration the valid bid/offers that participants have submitted in the previous ex-ante MSD session. For the other sessions of the MB, all the sittings for bid/offer submission open at 10.30 p.m. of the day

[23] www.gme.it

before the day of delivery (and anyway not before the results of the previous session of the ex-ante MSD are made known) and close 1 hour and a half before the first hour which may be negotiated in each session. In the MB, Terna accepts energy demand bids and supply offers in order to provide its service of secondary control and to balance energy injections and withdrawals into/from the grid in real time.[24] Some of the services provided in this market are frequency and voltage control, black start (the process of restoring an electric power station or a part of an electric grid to operation without relying on the external transmission network), remote tripping (automatic disconnection of the power plant from the network), load shedding.

The Italian Ancillary Services Market, if compared with the other European markets, presents some peculiarities that many players of the sector could define as problems. The majority of operators think that the architecture of MSD is still insufficient to represent the costs associated with the different services required by Terna. This is because:

- for some services, any form of remuneration (implicit or explicit) is not provided, regardless of the underlying costs;
- the services provided are very heterogeneous, and they have a different cost structure that is not represented in the data given by the GME.

This is true especially for the Balancing Market, and this is one of the main reason for which we decided to exclude it from the calculation of the imbalance costs. So, as we said at the beginning of the chapter, the analysis for the imbalance costs is focused only on the ex ante MSD (that has the same structure of the MGP market, both have the same availability of data for hours, days, zones), even if it is only a subset of the total imbalance costs.[25]

[24] www.gme.it

[25] The Authority through the document 163/2015/R/EEL has proposed some changes for a better definition of the imbalance costs. The document is available for consultation.

3. ANALYSIS OF THE CORRELATION BETWEEN IMBALANCE COSTS AND WHOLESALE MARKET OUTCOMES: PRICES AND QUANTITIES

The analysis that is presented comes from data taken on the GME website. The study period goes from January 1th, 2013 to June 2015. As we said at the beginning of the chapter we take into account the Day-Ahead Market (MGP) and the ex-ante Ancillary Services Market (ex-ante MSD). Key figures that are listed in this section have been obtained after a statistical analysis (data are reported into the attachment at the end of this work), and they refer to the months and years taken into consideration.

We know that the imbalance costs that result from the ex-ante MSD do not represent the entire cost of imbalance. In the ex-ante MSD, Terna accepts energy demand bids and supply offers in order to relieve residual congestions and to create reserve margins; so data show only a part of the imbalance costs, and we do not even know what of this part comes from congestion resolution or from constitution of reserves. Also prices that come from the balancing market would have to be part of the imbalance costs, but for these data there is not the possibility to find a correlation with the MGP market, because they are the expression of many services that are mixed up, they are not divided per hours and for the Italian market zones, and looking at the GME site the available data stop to 2009.

However we think that this analysis is still valid because ex-ante MSD measures a great part of the imbalance costs. In fact, a balanced grid would need less reserves, and these are taken into account in the ex-ante MSD. Moreover when the system has less need for reserves also it means that there is efficiency between areas, and that the network structures (interconnections) are such as not to cause congestion. For these reasons, the ex-ante MSD can be taken into account for a good approximation of the imbalance costs.

An analysis of the correlation between MGP and ex-ante MSD is useful because many variations have been occurred in these markets during recent years, especially because of the increased impact of non-programmable renewable energy. Moreover, there are some works that prove that the future Smart Grid can bring some benefits to the Ancillary Services Market in term of cost reduction; so it is useful to understand if this could have a positive effect also on the Day-Ahead Market, and so on prices and quantities of energy.

Now, we will present results starting from the analysis made on the Day-Ahead Market; after that, we will take into account data that come from the ex-ante Ancillary Services Market; finally, we will make some considerations about the correlation found between the two markets.

3.1 RESULTS FROM THE DAY-AHEAD MARKET

For the Day-Ahead Market we took into account prices and quantities for every zone, from January 1[th], 2013 to June 2015.

Starting from the prices, it is here presented the summary graph (Figure 15).

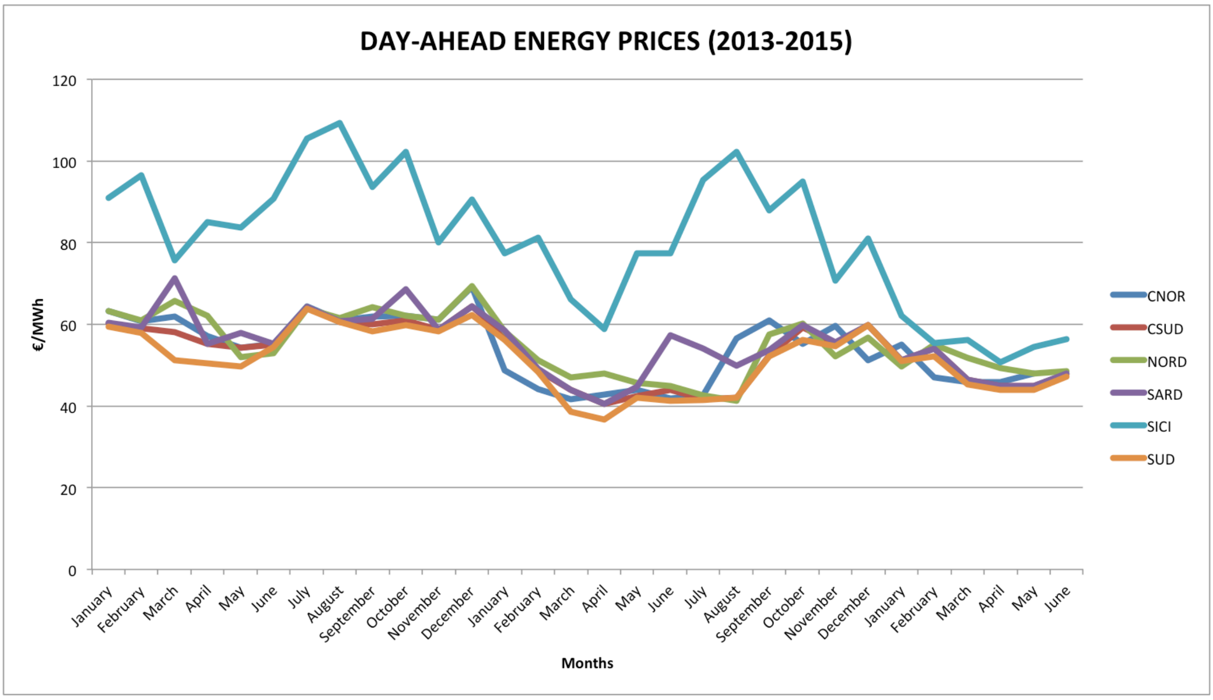

Figure 15 Energy prices for the Day-Ahead Market; the period goes from January 1th, 2013 to June 30th, 2015. (Author's elaboration on data taken from GME website).

These are the electricity prices (€/MWh) for every zone taking into account the studied period:

	CNOR	CSUD	NORD	SARD	SICI	SUD
2013	61,0313	59,2372	61,5695	61,4583	91,9908	57,2034
2014	49,6680	48,9392	50,4637	52,2444	80,8732	47,4563
2015	48,8509	48,2292	50,3671	48,2633	55,8571	47,2256
Average	53,1834	52,1352	54,1334	53,9886	76,2403	50,6284

Table 4 Electricity prices for every zone of the Italian markets.

The first consideration that has to be done regards the fact that Sicily has the higher price with respect to the other zones. However we have to register the decrease of Sicily's price in 2015; in fact as you can see all day-ahead prices stay between 40 €/MWh and 60 €/MWh. Looking at the details (see Attachment) you can see a general decline in prices, which fell on the mainland and in Sardinia at around 47-50 €/MWh, with declines of between 15% and 18%. In

Sicily, the price has decreased but not as in the other zones, falling back at the 81 €/MWh in 2014 (-12% with respect to 2013), and at 56 €/MWh in June 2015. Following this general decline of the zonal prices, we can notice a difference in prices between the north (North and Central North) and the south (South, Central South, Sardinia, Sicily) that goes from the 4,36 €/MWh in 2013 to 2,97 €/MWh; probably at the end of 2015 this difference will be even thinner. Looking to the islands, in 2014 the differential between Sicily and the mainland is confirmed at around 30 € / MWh, reaching € 34 / MWh if the comparison is made with the cheapest South area. This difference seems to reduce during 2015. With regard to Sardinia, in 2014 the average price reached 52 €/MWh, with a difference of only 2 €/MWh with respect to the North price. This trend is confirmed in the first half of 2015.

Differences in zonal prices are determined by differences on transmission capacity, consumer's behaviour (Gianfreda and Grossi, 2009) and different distributed production patterns, that have increased their importance in the latest years: it can be assumed that zonal prices give a measure of the local congestion of the grid in every time of the day. Moreover, we have to consider the different characteristics of the market zones. In the north of Italy there are more players than in the south (more demand because of the greater level of industry, and many firms that supply and distribute energy); so, the north market, and especially the North zone, is more competitive, and you can see a lower trend in price with respect to the south market (Sicily in particular), where the market is smaller (there are less players) with efficiency problems linked to the interconnections.

Difficulties in managing grid connections with the islands are a well-known issue for the Italian system. A part of the problems was been solved with the realization of the SA.PE.I cable (see Figure 16) between Sardinia and the mainland in 2011 that leaded to a convergence with the prices of the most competitive zones. Before 2011 the island lived a situation of isolation. In fact, the old interconnection cable was not able to ensure the safety of electricity transmission from the mainland. This is the reason why imbalance costs, as well as the electricity price, were very high; 80% of consumption came from reserve. Another important

Figure 16 SA.PE.I cable between Sardinia and mainland.

aspect that has to be taken into account regards the duopoly situation that Sardinia market lived before the realization of SA.PE.I cable. Endesa in the north and Enel in the south, producing 90% of the electricity demanded, prevented the emergence of a true free energy market. But, after the realization of the new cable, the maximum interconnection capacity between Sardinia-Continent and Continent-Sardinia goes respectively to 1,000 MW and 870 MW. This increase in capacity and in competition has leaded to a convergence of Sardinia average prices with those of the mainland.

Sicily represents the other part of difficulties in managing grid connections with the islands. Systematically higher prices in Sicily are due to the obsolescence and the inefficiency of the local production system, and to the difficulties in the connections with the rest of the Italian territory; moreover, as you can see from the Figure 15, at the half of 2013 this problem was stressed by some speculative actions that caused a substantial increase in price differentials between Sicily and the rest of the nation. A small isolated market with few players has brought to a grey situation of low competition. Lacks in connections for Sicily should be managed through the building of a new line between Sorgente and Rizziconi, that was scheduled by Terna in 2011, and whose works, after a stop because of law problems, are now going on; the end of the works is scheduled for early 2016. Terna's calculations in the "Sorgente-Rizziconi" economic evaluation reported that the Sicilian congestion causes, on average, higher electricity bills for about 800 million euro every year. However, as you can see from Figure 15, the situation appears to be improving.

There are two reasons that can explain the decrease of the electricity price in Sicily: first of all we have to consider the effect of the competitiveness decree 91/2014 ("Taglia Bollette"). Through an amendment Sicily has become, even if for a limited period, an administered market. In fact, until the entry into operation of the power line "Sorgente-Rizziconi", the production units located in Sicily, with the exception of the non-programmable renewable ones, of power greater than 50 MW (almost all power plants in Sicily) have to be considered essential for the safety of the electrical system, and they have to offer on the Day-Ahead Market. So, through this amendment, whatever the market prices zone are, the energy produced by these plants will always be remunerated with a fixed fee, which is established by the AEEGSI for each plant so that costs can be covered. This has avoided what happened for the last three years, when Sicilian power plants applied high prices (140 €/MWh) during the night, in order to balance the lost profit of the day because of the electricity produced by the renewable power plants (photovoltaic and wind plants that have priority of dispatch), causing an high increase of the local price. In fact, while ten years ago the highest prices were formed during the day, when demand for electricity reached the peak, currently the highest prices are

formed in the evening (17-21), or in the hours when the photovoltaic production gradually ceases.
The second reason that explain the reduction of Sicilian price is linked to the diffusion of electricity generated by renewable power plants, both wind plants (Sicily has the largest installed capacity in Italy) and photovoltaic plants (about 1400 MW in 2014)[26]. The photovoltaic power plants have caused a reduction of operating hours of conventional power plants, generating electricity during daytime peak demand. The approximately 130 MW of photovoltaic power plants installed in 2014[27], despite the end of the incentives of “Conto Energia”, have helped to change the structure of the historical price of electricity in Sicily. In fact, the first three months of 2014 show a difference of 22 €/MWh between zonal price in Sicily and PUN, while the first three months of 2015 show a difference of 6 €/MWh.
Sicilian price reduction has been possible through a mix of government act and renewable power plants. We hope that after the complete implementation of the new power line, the decreasing trend will continue.

For the Day-Ahead Market we took into account also quantities for every zone, from January 1th, 2013 to June 2015. It is here presented the summary graph (Figure 17).

[26] “Rapporto Statistico Energia da fonti rinnovabili”, GSE, 2014.

[27] “Rapporto Statistico Energia da fonti rinnovabili”, GSE, 2014.

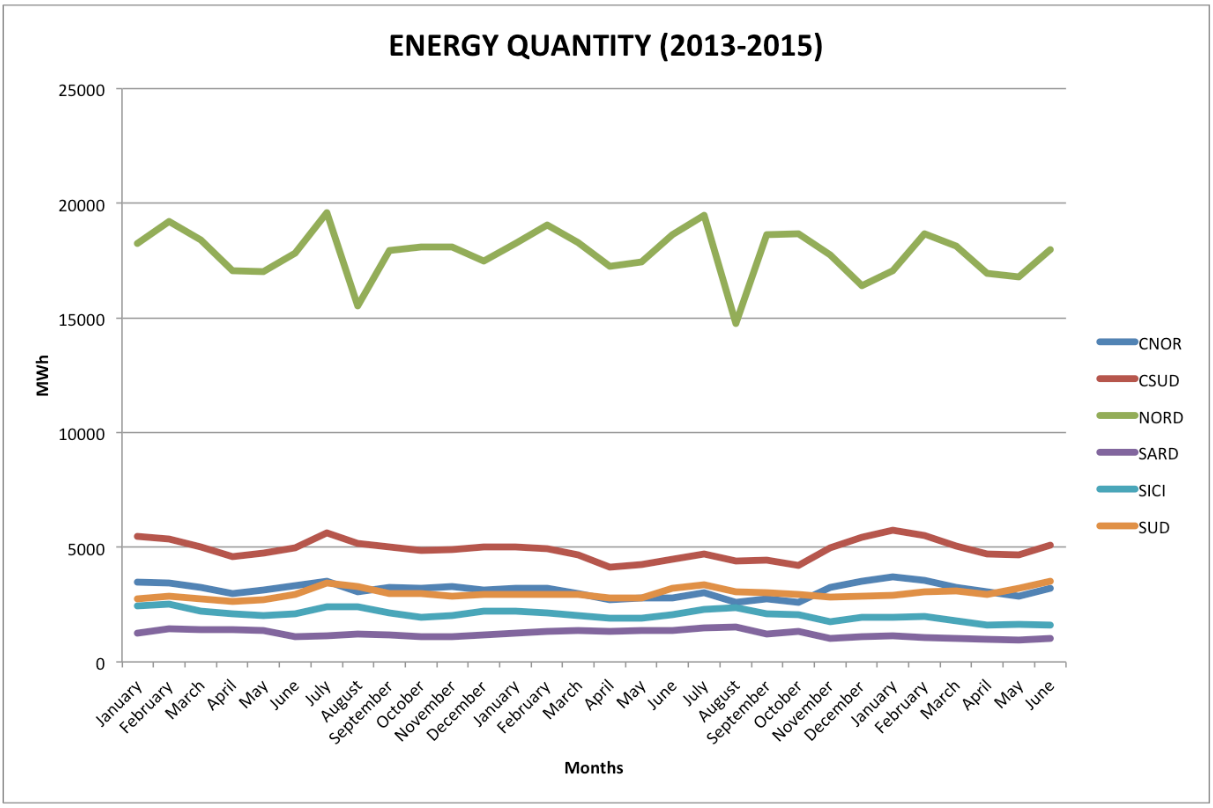

Figure 17 Electricity quantities for the Day-Ahead Market; the period goes from January 1th, 2013 to June 30th, 2015. (Author's elaboration on data taken from GME website).

These are the electricity quantities (MWh) for every zone taking into account the studied period:

	CNOR	CSUD	NORD	SARD	SICI	SUD
2013	3256,5444	5062,7493	17878,695	1244,9233	2207,2784	2932,5836
2014	2955,0819	4641,2670	17882,378	1302,6086	2060,1340	2965,0025
2015	3274,3396	5127,0978	17591,315	1030,7289	1760,8292	3114,0450
Average	3161,9886	4943,7047	17784,129	1192,7536	2012.6472	3003,8770

Table 5 Electricity quantities for every zone of the Italian electricity markets.

As you can see from the graph (Figure 17) the North zone uses higher quantity of electricity with respect to all the other zones. This is an obvious result, especially if we consider that four of the most industrialized regions (Piemonte, Lombardy, Veneto, Emilia-Romagna) are inside the North zone. Of course this zone is also the most populated, and this, combined with the industrial needs, explain the high level of energy demanded.

In 2014 the amount of electricity purchased in Italy amounted to 282 TWh, a decrease of 2.5% if compared to 2013 (289.2 TWh), thus extending the downward trend that began in 2010. From the analysis of data (see Attachment) this decrease seems to be confirmed especially in three zones: the Central North went from 3.256 MWh in 2013 to 2.955 MWh in

2014 (-9,3%), the Central South went from 5.062 MWh to 4.641 MWh (-8,3%), and Sicily went from 2.207 MWh to 2060 MWh (-6,6%). North and South remained stable (17.800 MWh the first and 2.940 MWh the second) while Sardinia showed a small increase, going from 1.244 MWh in 2013 to 1.302 MWh in 2014 (+4,6%). Looking at 2015, Central North, Central South, and South seem to slightly increase the required amount of electricity, while the other zones seem to remain stable.

This data give us the size of the six different markets. This will have some implication when we will talk about correlation between the Day-Ahead market and the ex-ante Ancillary Services market. A big market like the North one, with a low concentration of distributors and many consumers, favors the development of a competitive environment, while a market like Sicily that is small, nowadays isolated, and with few producers and distributors (Enel, Erg, Edipower) favors the development of an environment that is far from being competitive. This, as we will see in the next paragraph, has implications also on the Ancillary Services Market.
But looking at the quantity of electricity produced and demanded, another important consideration has to be done again on interconnections. The Italian power system is experiencing a rapid development of renewable sources in the form of wind and solar capacity. This development concerns largely southern Italy (South, Sicily and Sardinia), where the demand for electricity is lower with respect to the North. So the interconnections between zones (especially between Sicily and mainland, and between South and Central South zone) have to be improve, in order to avoid that limited interconnection capacity available between these zones makes them particularly vulnerable to power oversupply or shortage.

3.2 RESULTS FROM THE EX-ANTE ANCILLARY SERVICES MARKET

As we said the ex-ante MSD measures a great part of the imbalance costs. In fact, a balanced grid would need less reserves, and these are taken into account in the ex-ante MSD. Moreover when the system has less need for reserves also it means that there is efficiency between areas, and that the network structures (interconnections) are such as not to cause congestion. For these reasons, the ex-ante MSD can be taken into account for a good approximation of the imbalance costs.
But, how we got imbalance costs from the information given by the GME on its website?

For the ex-ante MSD, GME gives data about the selling price of the services provided by power plants to Terna, when Terna has to buy reserve because according to forecasts there is the necessity of more electricity than the one bought on the Day-Ahead Market. GME gives also data about the purchase price of the balancing services purchased by power plants when, for example, Terna has to cut the load for safety reasons.

These prices are given for every hour of the day and for every zone of the Italian electricity market. So, in order to find the imbalance costs we made the difference between the sale price and the purchase price. The imbalance cost is the cost paid for the forecast error of the electricity quantity. If Terna were a public operator, the difference between the selling price and the purchase price would be the social cost for users, in order to have the balancing service. This cost is higher than the electricity price on the MGP market, because balancing services are supplied by a small number of subjects.

This is the summary graph of the results that we found on the ex-ante Ancillary Services Market.

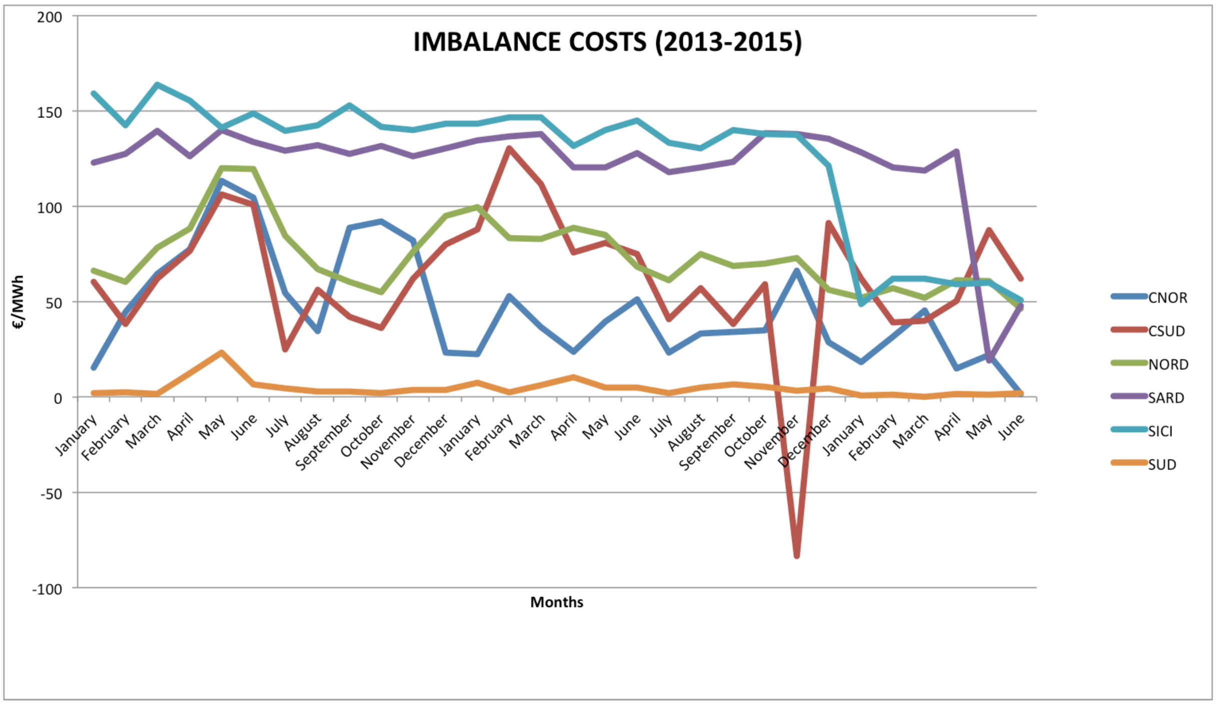

Figure 18 Imbalance costs obtained from the ex ante MSD; the period goes from January 1th, 2013 to June 30th, 2015. (Author's elaboration on data taken from GME website).

As you can see from the Figure 18, on average the imbalance costs are higher with respect to electricity price on the MGP.

These are the imbalance costs (€/MWh) for every zone taking into account the studied period:

	CNOR	CSUD	NORD	SARD	SICI	SUD
2013	66,0911	61,9892	80,7760	130,456	147,341	5,57214
2014	37,1553	63,6119	75,8724	129,103	137,643	5,15969
2015	22,1215	56,7135	54,7495	93,7060	56,9972	1,13642
Average	41,7893	44,1025	69,1326	117,755	113,993	3,95615

Table 6 Imbalances cost for every zone of the Italian electricity markets.

One of the aspects that we have to take into account is the great drop of the red line (Central South) that goes below zero. This is a peculiarity that ex-ante MSD has, and that we cannot find on the Day-Ahead Market because of regulative reasons that put a price floor at zero. On the MSD we can find negative price. In this case in November 2014, in the Central South zone we registered an imbalance cost of -83,5 €/MWh; this means that for that month, on average, Terna had to stop the injections into the grid, and the power plants that would had to put a certain quantity of electricity scheduled on the ex-ante MSD, had to re-buy the extra amount of energy at the end. Because of the fact that on the ex-ante MSD reserves and congestion relief are mixed together, we don not know what is the specific cause of that negative price; this is a limit of the actual Ancillary Services Market regulation.

As we said before on the Day-Ahead Market there cannot be negative prices, and this has to be taken into account when we will talk about the correlation between MGP and ex-ante MSD.

There are two other important aspects that we have to consider looking at Figure 19: the significant drop of the imbalances costs in Sicily and Sardinia.

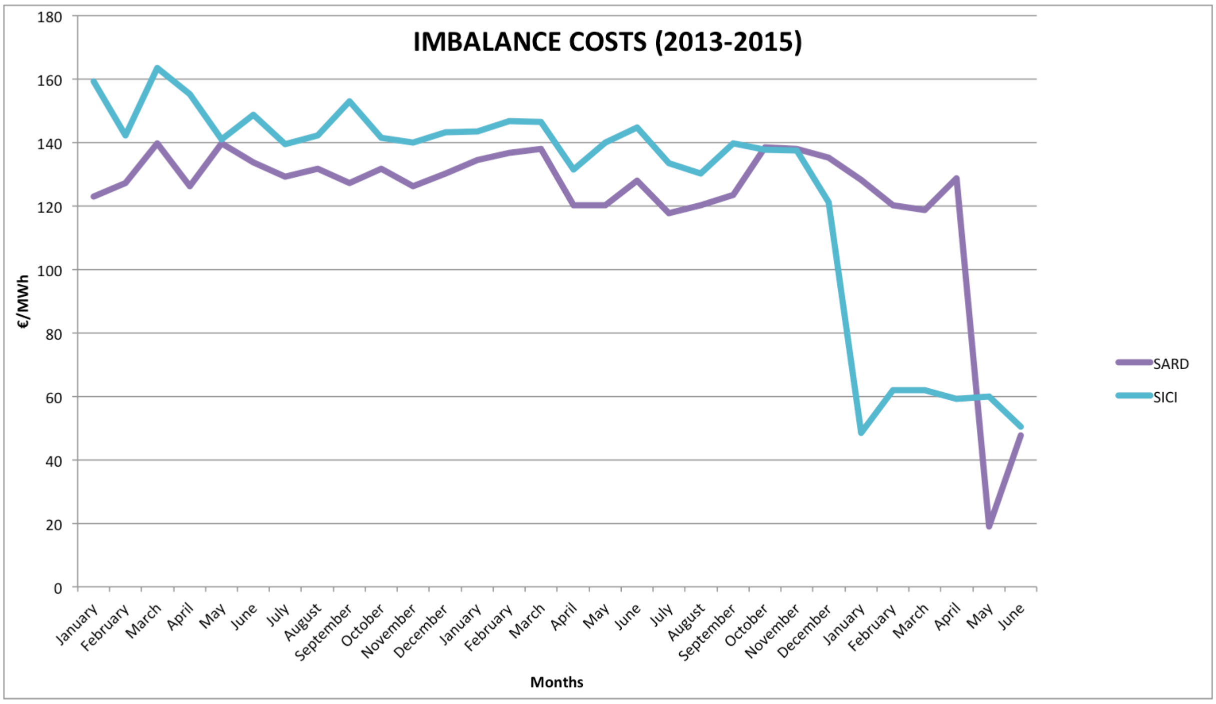

Figure 19 Imbalance costs for Sicily and Sardinia obtained from the ex-ante MSD; the period goes from January 1th, 2013 to June 30th, 2015. (Author's elaboration on data taken from GME website).

Starting from Sicily, the drop could be explained with the introduction of the decree 91/2014 ("Taglia Bollette"). As we said in the previous paragraph, through an amendment Sicily has become, even if for a limited period, an administered market. Because of this amendment, whatever the market prices zone are, the energy produced by the Sicilian power plants will always be remunerated with a fixed fee established by the Authority. When this decree was issued, it received a lot of criticism, especially from some groups, most notably Assoelettrica. There were two main raisons that the association underlined: first of all the decree, allowing for administered market, would have the effect of eliminating the competitive dynamics in Sicily, betraying the path of liberalization and market opening in the electricity sector; moreover, the measure would be financed by an increase in expenses of dispatching, which would then lead to an increase in imbalance costs.

Looking at the Figure 19 this is not seems to happen. Of course the decree has influenced a lot the competitive dynamics in a zone like Sicily, where competitiveness is always been hard to reach, but we have to remember that this is only a temporary measure; in fact when the new power line "Sorgente-Rizziconi" will be completed, Sicily should no longer be an administered market. Taking into account the imbalance costs, we can see that they have decreased a lot during the first half of 2015, despite the implementation of the decree. This could be due to the fact that, having to use thermoelectric power plants, the Day-Ahead Market did not have to "suffer" from the unpredictability of non-programmable renewable power plants. Consequently, the prices on the ex-ante MSD declined. Another possibility could relate to the end of possible strategic games that were made in order to use the more expensive thermoelectric plants in the MSD, to ensure the safety of the system in the case where the abundant electrical energy produced in Sicily from renewable sources would not have been dispatch.

However this is only a temporary situation. Another analysis will have to be done when the new power line will be completed.

Taking into account the drop in Sardinia it is different from the one that we have already seen for Sicily. In fact the drop regards only the month of May, and it does not seem to be structural. There is not a resolution of the Authority that informs for a specific action on the Sardinia zone, neither a decree of the government. Looking at the data that we analysed we can see that in the month of May Terna has bought few MWh in order to constitute reserve margins and to relief congestions. Of course, a small amount of energy required on the ex-ante MSD caused a lower price with respect to the previous months (19 €/MWh with respect to the 120 €/MWh of April). The trend seems to return at the usual level, because looking at June the imbalance cost reached 50 €/MWh, and in July went to 90 €/MWh.

We do not know for sure the reason of this “month drop”. Maybe it can be due to the favourable climatic conditions, that allowed for a better forecast of the electricity that non-programmable renewable power plants have produced. In this case Terna could have bought few MWh on the ex-ante MSD in order to ensure the safety of the system. However this is just a guess. We do not know if there may have been errors on the data provided by GME. It would be useful to do further analysis.

Finally there is another important aspect that we have to take into account. Looking at the previous graphs you can notice that variability of the imbalance costs decreases over the years. In fact, standard deviation decreases in all zones (Central North from 74 to 65, North from 54 to 49, Sardinia from 23 to 17, Sicily from 41 to 28, South from 25 to 23) with the exception of the Central South zone.

However this is in contrast with the common belief that, because of the increasing number of renewable power plants, the imbalances costs would have to increase. In fact, the non-programmability, and the randomness of these sources usually cause an increase of the forecast error of the residual load that has to be balanced in real time. Moreover most renewable energy production, reducing the load portion satisfied by thermoelectric production units with a capacity of adjustment, makes even more complex the constitution of the reserve margins that are necessary to ensure the real-time balancing of the electricity grid. In addition you have to consider that these critical issues are even more stressed due to the lack of infrastructure network in zones where non-programmable sources are available (Sicily and south in general). This would lead not only to an increase of imbalance costs, but also to an higher price volatility, if compared to the past; but as we have already seen, this does not seem to be the case.

Document 277/2014/I/EFR of the Authority on the state of the services gives a possible explanation of this issue. First of all hydroelectric power is perfect to solve a part of the problem; this because hydro power plants can be ready and vary the production very quickly. After that you have to consider that tools for the forecasts have improved significantly in recent years. Moreover high voltage renewable power plants are monitored by Terna, that has the possibility to manage them in order to ensure the stability of the system. Finally large wind power plants participate to the dispatching services, reducing the total cost.

However, there is still much to do; the Authority open to possible changes in the Ancillary Services Market, especially to take into account the high potential and the contribution that renewable energy and distributed generation can give. Finally it is important to emphasize the need for an improvement in infrastructure, particularly in areas most in need of updates, such as islands and south Italy.

3.3 THE CORRELATION BETWEEN IMBALANCE COSTS AND WHOLESALE MARKET OUTCOMES

Now we present the results on the correlation between imbalance costs and wholesale prices and quantities. An analysis of the correlation between MGP and ex-ante MSD is useful because many variations have been occurred in these markets during recent years, especially because of the increased impact of non-programmable renewable energy. Moreover a correlation between two markets means that actions on one of the markets have also an impact on the other one. This can be useful if the Authority aims to an improvement in the efficiency, or to specific actions on prices and quantities of electricity.

If there is correlation between imbalance costs and wholesale prices, this means that firms can act strategically, for example offering less electricity or losing profits on the Day-Ahead Market deliberately, in order to cause an increase of imbalance prices. The correlation can have also important consequences if we consider the impact of the renewable sources, especially in zones such as Sicily, Sardinia and South. In fact, sometimes, if wholesale prices

decrease thanks to the electricity produced through non-programmable renewable power plants, imbalance costs can increase because of the major need of ancillary services.
If there is correlation between imbalance costs and wholesale quantities, this can give an explanation about the changes in quantity volatility on the Day-Ahead Market, and the changes of imbalance costs because of different need of ancillary services on the ex-ante MSD market.

Before looking the analysis in details, we have to make some considerations. As we have already said the imbalance costs that result from the ex-ante MSD do not represent the entire cost of imbalance. In the ex-ante MSD, Terna accepts energy demand bids and supply offers in order to relieve residual congestions and to create reserve margins; so data show only a part of the imbalance costs. However we think that the analysis is still valid because ex-ante MSD measures a great part of the imbalance costs. In fact, a balanced grid would need less reserves, and when the system has less need for reserves also it means that there is efficiency between areas, and that the network structures (interconnections) are such as not to cause congestion.
Another important consideration regards the negative prices on the ex-ante MSD. As we saw from the analysis of the ex-ante Ancillary Services Market (Figure 18), prices can be negative. When Terna has to stop the injections into the grid, power plants, that would had to put a certain quantity of electricity scheduled on the ex-ante MSD, have to re-buy the extra amount of energy; so, because of this, prices can be negative. Because of the fact that on the ex-ante MSD reserves and congestion relief are mixed together, we do not know what is the specific cause of that negative price, and, as we said, this is a limit of the actual Ancillary Services Market regulation. But prices on the Day-Ahead Market cannot be negative, because of regulative reasons that put a price floor at zero, so this can bring some errors in the analysis of the correlation between two markets, and it has to be taken into account.

All the results were obtained using the Pearosn Correlation index. It is a measure of the linear correlation between two variables X and Y, giving a value between +1 and −1 inclusive, where 1 is total positive correlation, 0 is no correlation, and −1 is total negative correlation.

Starting from the possible correlation between imbalance costs and electricity prices on the Day-Ahead Market, the analysis suggests that there are different situations taking into account the different Italian market zones. In fact, there are some zones where there is not correlation (or it is very little), and there are zones where we can find a strong correlation.[28]

Taking into account the Pearson correlation index these are the results for every zone:

	CNOR	CSUD	NORD	SARD	SICI	SUD
2013	-0,72262	-0,65211	-0,58165	0,32943	-0,48801	-0,63304
2014	0,04765	-0,20771	0,02592	0,39711	-0,23612	-0,16178
2015	0,17100	-0,42447	0,05187	0,41015	-0,65207	0,06758
Average	0,29585	-0,19649	0,07762	0,40300	0,71099	-0,11098

Table 7 Pearson correlation indexes between imbalance costs and day-ahead prices for every zone of the Italian electricity markets.

The North zone is the one that has the lower correlation with respect to the others (0,077 Pearson index). This is reasonable, because the North zone is the most competitive, with a high demand of energy (according to Terna's last report 2014, load is higher in the north of Italy) and a high supply. In fact there are many firms that operate both in the Day-Ahead Market and in the Ancillary Services Market. This, as we have seen in the two previous paragraphs, causes a lower price for electricity on the MGP and a lower imbalance cost on the ex-ante MSD, but it is also the reason why the two markets can be considered as distinct markets. Thus, the firms' strategies are distinct in the two markets. This is the reason why we can assert that there is no correlation between the Day-Ahead Market and the ex-ante Ancillary Services Market in a zone with these characteristics. Probably the volatility observed in the markets is due to external factors such as climate, the period of year, the holidays, and the hours of day.

The considerations that we have done for the North zone are valid also for Central North (0,295), Central South (-0,196), and South (-0,110). In fact the correlation is very little even if these are zones that are less competitive with respect to the North one. However the interconnections among them are enough to bring efficiency to the system. We think that this is the reason why the correlation is low, and so we can consider the two electricity markets as distinct markets. Central South zone and South zone have a negative index. The reason may be due to the major presence of non-programmable renewable power plants that, as we know, have the dispatching priority and play an important role on the Day-Ahead Market, lowering electricity prices. Even if the correlation is low, when the day ahead price goes down because of renewable energy, imbalance costs rise as a signal of the fact that there is a more need for ancillary services in order to ensure the safety of the system. However this is only a possible

[28] Looking to the Attachment for the statistic analysis.

explanation of the negative sign. The most important consideration remains the very little correlation between the two markets.

Sicily and Sardinia, in contrast, show a high positive correlation (0,711 for Sicily and 0,403 for Sardinia). Two islands represent small and relatively isolated markets (especially Sicily). The demand is lower with respect to the other zones, and there are few firms and few power plants that operate on the Day-Ahead Market and on the Ancillary Services Market. So there is a low level of competitiveness; in fact as we have seen electricity prices and imbalance costs before the government act were higher with respect to the mainland, and they are still today, even if in a lower measure. The companies have market power and, depending on developments on the Day-Ahead Market, they can act strategically. In fact they can offer less electricity on the MGP market, and supply ancillary services for a higher price on the ex-ante MSD. This happened for true in Sardinia in 2012; in 2013 the Authority has certified, with the resolution 197/2013/E/EEL, the presence of speculative behaviours, and instructed Terna to resolve the situation through a new price calculation of imbalance prices, in order to avoid strategic behaviours.

Another important consideration that has to be done in order to justify the correlation between imbalance costs and day-ahead prices, takes into account the role of non-programmable renewable energy. The two islands have many wind and photovoltaic power plants; in 2014, Sicily produced 26,4% of the total Italian production of photovoltaic and wind electricity, while Sardinia accounts for 21,5%[29]. Their interconnections, especially for Sicily, are not so efficient. In this situation, firms can make low profit on the Day-Ahead Market (especially taking into account the dispatching priority of renewable electricity); so they try to make more profit on the Ancillary Services Markets.

Taking into account the possible correlation between imbalance costs and electricity quantities on the MGP market (instead of day-ahead prices),

	CNOR	CSUD	NORD	SARD	SICI	SUD
2013	-0,23857	-0,57156	-0,19975	0,24400	0,09430	-0,36711
2014	0,15833	-0,01113	0,00919	-0,55922	0,04756	-0,43776
2015	0,13360	-0,36144	-0,45071	0,61004	0,00856	0,59148
Average	0,10003	-0,16961	-0,04535	0,38051	0,65965	-0,07113

Table 8 Pearson correlation indexes between imbalance costs and day-ahead quantities for every zone of the Italian electricity markets.

[29] "Rapporto Statistico Energia da fonti rinnovabili", GSE 2014.

So, after the analysis we found almost the same values for the indexes: 0,100 for Central North, -0,169 for Central South, -0,045 for the North, 0,380 for Sardinia, 0,659 for Sicily, and -0,071 for South. Data on electricity quantities give information about the liquidity of the six Italian zones. All the considerations that we have done about the competitiveness of the zones are confirmed by these results. North, Central North and Central South show higher levels of electricity quantities; great quantities mean that there are more firms that supply electricity, so an higher level of competitiveness. Sicily and Sardinia have a high positive correlation also because, being small markets, it is easier to forecast the electricity quantity needed on the MGP market and on the ex-ante MSD market. However, the relationship that might exist between imbalance cost and electricity quantities is an indirect relation. Of course the relation between imbalance costs and day-ahead electricity prices is more relevant.

Italian electricity market is an interesting study case because, as you can see from the analysis, there are some zones that are competitive and have a high level of interconnections that brings efficiency, and there are other zones that are small and not so competitive, also because of the lack of interconnections. Moreover there are zones that have many non-programmable renewable power plants, and other zones that have less photovoltaic and wind power plants. Also because of this heterogeneity it is interesting and useful to monitor the correlation between imbalance costs and the wholesale market outcomes.

3.4 HOW THE FUTURE SMART GRID COULD BRING SOME BENEFITS, CONSIDERING THE CORRELATION BETWEEN MARKETS

In this chapter we have seen that, especially in some zones, a correlation between the Ancillary Services Market (ex-ante MSD) and the Day-Ahead Market (MGP) exists. So it is reasonable to think that actions on one market may cause some consequences to the other. This could be very important if we consider the impact of the future power grid, the so-called Smart Grid. In particular there is a study (a cost/benefit analysis for the European project of common interest GREEN-ME) that has calculated the possible benefits that the system might have as a result of the introduction of smart grids. In fact there could be benefits in terms of greater efficiency for the Ancillary Services Market, and so, as a consequence, also benefits on the Day-Ahead Market. The study on the GREEN-ME project will be presented in this paragraph, after a brief presentation of the main themes that regard the Smart Grid

Most of the European power systems are crossing a new phase: the aim is to transform the grid, changing its role, from a passive to an active one. This sort of revolution is identified with the term “Smart Grid”, implying structures and operating methods strongly innovative that have to: maintain an high level of safety and reliability of the entire system, deal with some problems related to the management of the Distributed Generation, face the possibility of the load control, promote energy efficiency and the interaction of the final users also in the electricity market. There are many definitions of Smart Grid, and each of them highlights particular aspects (e.g. the ICT role, the evolution of network components, the role of the market, the need to ensure an adequate supply of energy in the respect of the environment, the integration of renewables energies). For the purpose of this work we have decided to adopt the CEER[30] definition: “Smart Grid is an electricity network that can cost efficiently integrate the behaviour and actions of all users connected to it, generators, consumers and those that do both, in order to ensure economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety.” This definition emphasizes the fact that the investment in the Smart Grid should be designed to:

- meet the needs of the electrical energy system in the medium and long term;
- bring value to the end user;
- bring direct benefits to all network users.

According to the European Commission, one of the most important benefits connected to the evolution of the Smart Grid is the increase and the development of renewable sources connected to the network. In other words the Smart Grid are essential to enable the placing or rather, the real integration, of Renewable Energy Sources (RES) in the electricity supply chain. At a national level, recent regulatory measures have confirmed this relationship: in Italy Smart Grid will be developed in close relation with the Distributed Generation[31].

[30] The Council of European Energy Regulators (CEER) is the voice of Europe's national regulators of electricity and gas at EU and international level. Through CEER, a non-for-profit association, the national regulators cooperate and exchange best practice. A key objective of the CEER is to facilitate the creation of a single, competitive, efficient and sustainable EU internal energy market that works in the public interest.

[31] Delfanti Maurizio, Silvestri Andrea, Smart Grid. Le reti elettriche di domani, GieEdizioni, Roma 2011.

Another important theme linked to the development of the Smart Grid is the active involvement of the end users of energy networks ("prosumers"): it is useful to introduce more opportunities for the final customers to join the market through price/market signals (demand response), for example through the implementation of smart meters.
Smart Grid will modify also the distribution system. Emerging smart grid technologies are accelerating the transformation of the distribution system into the smart distribution system of the future. New operating techniques and design practices will be developed to continue improving the reliability of the distribution system. Engineers will develop tools and applications to be integrated with today's technologies so as to ensure the resilience of the distribution system and to achieve a self-healing grid.
Smart Grids are an important element for the European 20-20-20 strategic energy plan, and they are even more important for the European energy future, if we want to reach an higher independency from the suppliers that nowadays sell the major part of sources that Europe need to have for its system.

3.4.1 A NEW ROLE FOR CONSUMERS

In a "Smart Grid vision" it is necessary to involve agents on the consumption side. When we talk about electric energy consumers we consider industrial, commercial and residential consumers: all of them can play a big role in balancing the grid, in optimizing the overall consume, and in a more efficient use of energy. They can do this by shaping and shifting usage patterns, following the energy variable availability of intermittent energy sources. This service could have a significant role, reducing the need for overall power capacity and, as a consequence, its cost. Load could be driven by prices and contracts that optimize grid performances, and through real time pricing.
Looking at the types of consumers, industrial customers, especially the most energy intensive ones, could have a great impact on the consumption optimization, because some of them could change their loads pattern by programming industrial processes with different timing; moreover, some of them, have the possibility to offer availability for disconnections in case of necessities (ARG/elt 212/10). Other firms of course do not have this possibility because they have a constant need for energy. Residential customers, on the other hand, do not usually have a relevant role in determining the demand, if taken as individual loads, while they do matter if taken as a whole.

Consumers' side seems to be particularly interesting, since customers, by directly reacting to energy instantaneous prices, may gain advantages from energy savings and smoothing demand peaks (Alcott, 2009; Gans, Alberini and Longo, 2011; Ito 2012). The interaction could be realized by trying to empower customers with information on electricity prices, so that they could decide to adapt their electric consumption depending on price signals obtained from the grid.
Another important aspect of the active role, played by the consumer, regards the possibility for the end user to become an electricity producer. For this reason we talk about of the "prosumer" (that is the result of the joint condition of "producer" and "consumer"). The energy prosumer embodies the new paradigm of the Smart Grid system, which moves from a centralized management and control to a more wide and participated system. Building a "participated" system for energy management means that different agents connected to the grid could be called to act in favor of it, shaping loads patterns depending on grid necessities, providing ancillary services and, in general, reacting to grid requests.
However to do all these stuff that regard the new role of the consumer, it is necessary to implement one of the most important aspects of the "Smart Grid revolution", represented by the high information flow required for its functioning. For this reason smart meters are a fundamental tool that has to be developed and integrated into the power grid, in order to make more possible the gradual change toward a smart power grid.

3.4.2 SMART DISTRIBUTION SYSTEM

Recent technological advances are reshaping today's electricity markets. While changes of electricity market architecture in the past are generally related to wholesale markets, today, new advancing technologies are expected to radically change local electricity markets at the distribution level. As we know, more mature technologies for local renewable generation, decreased investment costs, and ambitious national support schemes for low-carbon generation led to a significant market penetration of distributed generation in many EU Member States. At the same time, as we have already seen, innovation in metering and appliances could allow consumers to react to local and upstream generation patterns and prices. Consequently, traditional top-down power flows from centralized generation sources connected to the transmission grid to consumers are challenged by local distributed generation and local means of electricity trade. Moreover, existing decades-old distribution infrastructure may need significant renewals soon in many systems. So, in order to allow for further market penetration of advanced local generation and consumption technologies and an efficient operation of distribution grids, the renewal and expansion of existing networks should go hand in hand with a modernization of distribution systems.

The progressive development towards smart distribution systems can be described in few steps. Firstly, the traditional passive distribution networks have been developed based on a "fit-and-forget" approach (nowadays most of European power systems have these distribution networks). Under this regime, Distributed Generation is not visible to the system so, while it can replace the energy produced by centralized units, it lacks the conditions required to provide system supports and security activities. So centralized generation capacities must be retained to perform this function. With growing pressure to increase Distributed Generation penetration, this passive approach will lead to raising the costs of investment and operation of the system and ultimately impact on the rhythm of DG adoption.

But, with an increasing penetration of distributed energy resources, also the "smartness" of the system should increase. An approach used already today in some countries with a high share of DG, therefore, is a reactive network integration, or "operation only" approach.[32] Congestion and other grid problems are solved at the operation stage by restricting load and generation; this means that DSOs solve problems once they occur.

An active system management would allow DSOs to become "real system operators". The existing hosting capacity of the distribution network can be used more efficiently if an optimal use of distributed energy resources is considered. Eurelectric[33] (2013) proposes that DSOs should have the possibility to buy flexibility on so-called "flexibility platforms" to optimize network availability in the most economic manner and to solve grid constraints. This could be defined a proper smart distribution system. So the network reinforcement then could be deferred until it becomes more cost-effective than procuring services from distributed energy resources. However, in-depth analyses going beyond the current more conceptual discussion are required to propose suitable concrete architectures and responsibilities,

[32] Sandoy p., "The Role of Distribution System Operators (DSOs) as Information hubs", EURELECTRIC Networks Committee paper, 2010.

[33] The Union of the Electricity Industry (EURELECTRIC) is the association that represents the common interests of the electricity industry at pan-European level, plus its affiliates and associates on several other continents. EURELECTRIC covers all major issues affecting the sector, from generation and markets to distribution networks and customer issues.

including an answer to the question on who should set-up and coordinate such a flexibility platform.

3.4.3 THE COST/BENEFIT ASSESSMENT ON THE GREEN-ME PROJECT

In this chapter we saw that, especially for market zones like Sicily and Sardinia, there is a correlation between the imbalance costs and electricity prices and quantities, and so a relation between the Ancillary Services Market (ex-ante MSD) and the Day-Ahead Market (MGP). A correlation between two markets means that actions on one of the markets have also an impact on the other one. This is particularly interesting especially if we take into account the possible benefits that the implementation of a Smart Grid could bring in the future, in terms of a better manage and safety of the system.
In fact there is a recent work that confirms the existence of benefits, especially in the Ancillary Services Market, if the Smart Grid were implemented.
In 2014, the Italian Regulatory Authority for Electricity Gas and Water (AEEGSI), with the support of experts from ACER (Agency for the Cooperation of Energy Regulators) and ISGAN (International Smart Grid Action Network), was involved in a real case of cost benefit assessment for a large scale smart grid project, "Grid integration of REnewables Energy sources in the North- MEditerranean" (GREEN-ME). GREEN-ME covers a large area between the North of Italy and the South of France; it has been conceived and proposed by a consortium involving two transmission system operators (TSOs: Terna in Italy, RTE in France) and two distribution system operators (DSOs: ENEL Distribuzione in Italy, ERDF in France). Expected results of GREEN-ME are a "deeper integration of Renewable Energy Sources (RES) distributed generation thanks to improved predictability and control of distributed resources, as well as to enhanced automation and control of medium voltage grids according to an integrated approach already tested in pilot projects in Italy under the regulator's oversight and financing"[34]. The two Italian promoters of GREEN-ME submitted to the AEEGSI a joint request for an assessment of significant positive externalities of the Italian part of the project. The result is a paper that regards the cost/benefit analysis for the Italian

[34] www.eneldistribuzione.it

part of the project[35]. We want to briefly present the project and the major results that can be very interesting, looking at the analysis done in this work on the relation between imbalance costs and electricity prices and quantities.

GREEN-ME would go towards a smarter management of the distribution and transmission grids, becoming an important key facilitator for European low-carbon energy future. The aim of the project is to implement innovative solutions for the management of Distribution Generation, mainly, but not only, from Renewables Energies Sources (RES). To do this the project aims to implement several innovative functionalities, distributed in different technical areas, mainly: enhanced cross-border interconnection management; power system observability and controllability; transmission and distribution grid automation; emergency actions on generation and loads.

The CBA took into account the RES forecast scenarios according to the whole area of the project, and the calculation of benefits is based on the implementation of the functionalities mentioned above, assuming a period of 15 years.

The CBA analysis identifies three types of benefits:

- Dispatching-related benefits: GREEN-ME could provide the technical infrastructure enabling the increase of the amount of controllable resources able to provide the ancillary services (in particular, the downward tertiary reserve and the downward balancing). RES contribution to the downward tertiary reserve and to the downward balancing could: 1) Decrease the costs of the grid services procured on the Ancillary Services Market, because it is possible to redispatch less thermal generation. In fact, during the hours with scarcity of reserve, it is necessary to move upward some conventional power units and to move downward other conventional power units, in order to create the desired reserve margins. Instead, if RES generation is allowed to provide part of the tertiary system reserve (with a new regulatory framework), the Ancillary Services Market will redispatch less resources; 2) Reduce the Over Generation[36] and hence the RES curtailment, since the system requires less thermal generation in service for creating the desired reserve margins.

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[35] Lo Schiavo L., Larzeni S., Vailati R., Stromsather J., Rinaldi R., Delfanti M., Elia E., Sommantico G., "Cost/benefit assessment for large-scale smart grids projects: the case of Project of Common Interest for smart grid GREEN-ME", CIRED paper 1658, Lyon, 2015.

[36] A condition that occurs when total demand is less that or equal to the sum of regulatory must-take generation, regulatory must-run generation, and reliability must-run generation.

- Network-related benefits: A smart integration of Distributed Generation can enable a reduction of the need for network reinforcements, and therefore allow a deferral of traditional investments.
- Environmental benefits: some functionalities, allow an increase of the RES contribution, and consequently a reduction of the share of conventional energy sources.

Of course the most interesting benefits for the correlation analysis that we did in this work are the dispatching related benefits. Although some uncertainty inherent in any exercise of benefits and cost estimates, the result of the CBA are the following findings[37]:

	Range (M€)
Dispatching-related benefits	85/95
Network-related benefits	50/60
Environmental benefits	32/42
Total benefits (Italy only)	167/197
Of which: externalities	117/137
Of which: internalized benefits	50/60
Total costs (Italy only)	105/127
Ratio total benefits/cost (best estimates)	1,57

Table 9 Results from the CBA on the project "GREEN-ME", Italy only (Author's elaboration on data taken from CIRED paper 1658).

As you can see dispatching-related benefits account for almost half of the total benefits. From a societal point of view, the benefits outweigh the costs incurred by the project, demonstrating that the project is economically sustainable when all benefits (both internalized in the regulation and externalities) are taken into consideration.

GREEN-ME will bring benefits to the Italian electric system since it allows to actively manage resources, especially photovoltaic (PV), connected to distribution grids. The project,

[37] For an accurate description of the methodology used see Lo Schiavo L., Larzeni S., Vailati R., Stromsather J., Rinaldi R., Delfanti M., Elia E., Sommantico G., "Cost/benefit assessment for large-scale smart grids projects: the case of Project of Common Interest for smart grid GREEN-ME", CIRED paper 1658, Lyon, 2015.

indeed, makes controllable a certain amount of resources that normally are non-controllable at all. Therefore, with a proper evolution of the regulatory framework, the RES production units connected at distribution level could provide significant dispatching services (namely, the downward tertiary reserve and the downward balancing services), ensuring benefits to the whole power system.

This is particularly interesting taking into account the correlation analysis that we did in this work. In fact with a total benefit on the Ancillary Services Market of 85/95 M€ (for Italy only, and in particular for the area of the GREEN-ME project), we may expect other benefits on the Day-Ahead Market, so in terms of electricity prices and quantities.

CONCLUSIONS

We know that energy in all its forms plays an important role in many fields. So its management is critical not only for efficiency reasons, but also to guarantee continuity and safeness of most of the human activities.

Facing new challenges of energy supply forced the governments and the market agents to look new ways to produce, manage and consume it.

In particular, electric energy management states some peculiar criticalities given by the fact that supply and demand need to be balanced in real time, while respecting technical parameters. It is difficult and costly to store electric energy, and many agents are involved in the grid. All this generates problems, but also a great role for forecasts and information.

In this work we try to give an overview of the Italian electric system, looking at all the phases and the actors involved in them. We know that the dispatching activity is fundamental in order to balance demand and supply so that the continuity and the safety of the service are guaranteed. In Italy, this activity is performed by Terna, and it requires monitoring of electricity flows and the application of what is necessary for the coordination of the system components, that are production plants, transmission grid and the auxiliary services. Plants powered by renewable sources (programmable and non-programmable) have to be dispatched first with respect to the others.

After the decree n.79 launched in 1999 (named “Bersani”) the place where actors can buy and sell electricity is the market. This decree set out the process of liberalization of the energy sector which would led to the current market organization structure. The Italian electricity Market, called Italian Power Exchange (IPEX), enables producers, consumers, and wholesale customers to enter into hourly electricity purchase and sale contracts. The equilibrium price for the hour is established after the intersection of the demand and supply curves. The criterion by which the price is established is the System marginal price. According to this SMP, all suppliers receive the same market-clearing price, set at the offer price of the most (or nearly most) expensive resource chosen to provide supply.

Of course the most interesting part of this work regards the analysis done on the relationship between imbalance costs electricity prices and quantities. In order to do this study we focus on the Italian Day-Ahead Market and the Italian ex-ante Ancillary Services Market. On the MGP market we can find data that regard prices and quantities of electricity that every day is exchanged in the market. On the ex-ante MSD we can find data that regard the selling and the buying prices, for every hour and in every zone, of the ancillary services that Terna has to acquire in order to guarantee the safety of the system. Information has been taken from the GME site, where all data that regard the electricity market are uploaded day by day, for each zone, and for the two markets considered. The study period goes from January 1th, 2013 to June 2015.

We have underlined the importance of the links between zones. Interconnections are really important especially for efficiency. This is why it is fundamental to develop them constantly. The realization of new electricity grids or the upgrading of the existing ones aims to speed up the connection of the new facilities and to increase the transport capacity between zones, in order to solve congestion. The need to develop the existing network in order to make possible that all the electricity produced by power plants, especially renewable ones, can flow through the grid seems to be quite urgent, especially in some areas of the Country characterized by high potential for generating and by poor local load (south Italy). Today, in fact, there are some saturated power grids (for example some Apennine ridges characterized by the presence of numerous plants, mostly wind, and little or no load) and, therefore, they are not able to convey all the electricity production into the grid.

An analysis of the correlation between MGP and ex-ante MSD is useful because many variations have been occurred in these markets during recent years, especially because of the increased impact of non-programmable renewable energy. Moreover, there are some works that prove that the future Smart Grid can bring some benefits to the Ancillary Services Market in term of cost reduction; so it is useful to understand if this could have a positive effect also on the Day-Ahead Market, and so on prices and quantities of energy.

From the analysis of the Day-Ahead Market we point out:

- the characteristics of the six zones that influence the competitiveness level; big zones with many players, such as North, Central North, Central South show an higher level of competitiveness (so lower prices) with respect to Sardinia and Sicily, that can be considered as smaller markets, with few players that can also act strategically on the MGP and on ex-ante MSD.
- the importance of the interconnections; differences in zonal prices are determined by differences on transmission capacity, consumer's behaviour and different distributed production patterns, that have increased their importance in the latest years: it can be assumed that zonal prices give a measure of the local congestion of the grid in every time of the day. Difficulties in managing grid connections with the islands are a well-

known issue for the Italian system, and this is another important reason that explain the higher prices registered, especially in the previous years, in Sicily and Sardinia.

- the convergence of the prices that we have seen from the analysis of the graphs; this phenomenon regard especially the islands. We have tried to identify the reasons of this convergence with the other zones of Italy, looking at the new interconnections realized, and the regulated actions on the Sicilian market.
- the quantity demanded in every zones; in 2014 the amount of electricity purchased in Italy amounted to 282 TWh, a decrease of 2.5% if compared to 2013 (289.2 TWh). We have registered a decrease in CNOR (-9,3%), CSUD (-8,3%), SICI (-6,6%), and an increase in SARD (+4,6%), while North and South remain stable during the studied period.

From the analysis of the ex-ante Ancillary Services Market we point out:

- a great drop in imbalance costs for Central South zone in the month of November 2014, when the price went below zero. This is a peculiarity that ex-ante MSD has, and that we cannot find on the Day-Ahead Market because of regulative reasons that put a price floor at zero.
- the significant drop of the imbalance costs for Sicily thanks to the decree 91/2014 (named "Taglia Bollette"), that makes this market a regulated market. We hope that this situation, that is distortive for competition, will change at the beginning of 2016 with the realization of the new line "Sorgente-Rizziconi".
- the decrease of the imbalance costs variability over the years. In fact, standard deviation decreases in all zones (Central North from 74 to 65, North from 54 to 49, Sardinia from 23 to 17, Sicily from 41 to 28, South from 25 to 23) with the exception of the Central South zone. This could be due to the improvement of the tools for the forecasts, to the increased ability of Terna in monitoring the high voltage renewable power plants, and to participation of wind power plants to the dispatching services, reducing the total cost.

Finally from the analysis of the correlation index between imbalance costs electricity prices and quantities, we point out that there are different situations taking into account the different Italian market zones. In fact, there are some zones such as North, Central North, Central South, South, where there is little correlation, and there are zones where we can find a strong correlation, such as Sicily, Sardinia.

The correlation is low in zones with a high demand and supply of energy, and a great interconnection infrastructure. In these zones there are many firms that operate both in the Day-Ahead Market and in the Ancillary Services Market. This causes a lower price for electricity on the MGP and a lower imbalance cost on the ex-ante MSD, but it is also the reason why the two markets can be considered as distinct markets. Thus, the firms' strategies are distinct in the two markets. Probably the volatility observed in the markets is due to external factors such as climate, the period of year, the holidays, and the hours of day.
The correlation is high in zones that are small and relatively isolated markets, like Sicily and Sardinia. The demand is lower with respect to the other zones, and there are few firms and few power plants that operate on the Day-Ahead Market and on the Ancillary Services Market. So there is a low level of competitiveness. The companies have market power and, depending on developments and on the role of non-programmable renewable energy on the Day-Ahead Market, they can act strategically. Taking into account the dispatching-related benefits that will come from the future implementation of the Smart Grid, markets like Sicily and Sardinia with high imbalance costs would be good places to test the potential of the innovative grid.

We know that this analysis can be object of some critics.
The Italian Ancillary Services Market, as we have explained, consists of two parts: ex-ante MSD, that is the scheduling stage, and the Balancing Market. For the analysis we excluded the Balancing Market, because only the ex-ante MSD market has the same structure of the MGP market (both have the same availability of data for hours, days, zones) and so can be compared for an analysis. In the ex-ante MSD, Terna accepts energy demand bids and supply offers in order to relieve residual congestions and to create reserve margins. In order to find a measure that could represent imbalance costs we made the difference between the sale price and the purchase price of the ancillary services. So in this sense the imbalance cost is the cost paid for the forecast error of the electricity quantity. If Terna were a public operator, the difference between the selling price and the purchase price would be the social cost for users, in order to have the balancing service. But we know that this is not properly the imbalance cost. Data on the ex-ante MSD show only a part of the imbalance costs, and we do not even know what of this part comes from congestion resolution or from constitution of reserves. This is because of the structure of the Italian Ancillary Services Market that mixes together balancing services (to relieve residual congestion), and reserves. However we think that this analysis is still valid because ex-ante MSD measures a great part of the imbalance costs. In fact, a balanced grid would need less reserves, and these are taken into account in the ex-ante

MSD. Moreover when the system has less need for reserves also it means that there is efficiency between areas, and that the network structures (interconnections) are such as not to cause congestion. For these reasons, the ex-ante MSD can be taken into account for a good approximation of the imbalance costs.

As we have already said, we think that Italian electricity market is an interesting study case. As you have seen from the analysis, there are some zones that are competitive and have a high level of interconnections that brings efficiency, and there are other zones that are small and not so competitive, also because of the lack of interconnections. Moreover there are zones that have many non-programmable renewable power plants, and other zones that have less photovoltaic and wind power plants. Also because of this heterogeneity it is interesting and useful to monitor the correlation between imbalance costs and the wholesale market outcomes.

We think that the Italian power market presents some peculiarities that, if compared with the other European markets, could be defined as problems, especially considering the current trend to harmonize the European electricity markets. Recently the European Commission has stressed the importance to improve the functioning of the internal electricity market in order to allow electricity to move freely to where and when it is most needed, reap maximum benefits for society from cross-border competition and provide the right signals and incentives to drive the right investments, while fully integrating increasing shares of renewable energies. In this sense the wholesale and retail markets should provide the basis for investment decisions, and boost the development of new services by innovative companies. Moreover in a network industry like electricity, an effective market design needs effective regulatory oversight, in particular of distribution and transmission system operators.

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ATTACHMENTS

A) We present here the tables with the results of the statistical analysis.

These are the results of the statistical analysis on the imbalance costs, variance and standard deviation on average, for every month, for the ex-ante Ancillary Services Market.

	ex-ante MSD																	
	CNOR			CSUD			NORD			SARD			SICI			SUD		
	Imbalance costs	Variance	St. dev.	Imbalance costs	Variance	St. dev.	Imbalance costs	Variance	St. dev.	Imbalance costs	Variance	St. dev.	Imbalance costs	Variance	St. dev.	Imbalance costs	Variance	St. dev.
2013	66,09111069	5669,347424	73,96997336	61,9892817	7362,626233	84,49161525	80,77602125	3006,573814	53,8651239	130,4566856	570,0161944	22,9329126	147,341102	1956,071957	41,31521658	5,572149423	760,4871644	25,33682548
January	15,43832152	2159,858953	46,4742827	60,0695318	9684,734375	98,41104803	66,17735144	3255,144079	57,05386997	122,8184058	395,1663893	19,87879245	159,1056262	2092,488426	45,74372553	1,849636295	288,0683688	16,97257696
February	44,49016751	4041,613167	63,57368297	38,20911368	6288,120101	79,29766769	60,2426052	5407,753464	73,537429	127,1734097	343,6948266	18,53900824	142,1900764	4029,294146	63,47672129	2,188428724	494,1689376	22,22991088
March	64,27475178	5183,780142	71,99847319	61,9419958	6457,78363	80,36033618	78,30627725	2664,266459	51,6165328	139,570413	1833,371738	42,8178904	163,4762006	1866,342201	43,20118287	1,329612904	469,7416016	21,67352306
April	77,19584635	6704,380538	81,88028174	76,42732793	8151,922466	90,28799735	88,06372351	2364,990892	48,63117202	126,2620335	393,266944	19,83095923	155,2036933	1398,491699	37,39641292	12,24992875	1222,509476	34,96440298
May	113,0996487	6980,651582	83,55029372	105,9212204	10638,72373	103,144189	119,7512588	1610,728049	40,13387658	139,7157778	776,3537408	27,86312511	140,9704772	4267,452673	65,3257428	23,40143852	3320,400536	57,62291676
June	104,5359545	5361,962128	73,22541996	100,6163611	12812,91221	113,194135	119,3644207	1320,600747	36,34007081	133,7411857	682,7074872	26,12867175	148,5288324	1730,006567	41,59334763	6,55842807	876,5155719	29,60600567
July	54,53006381	6452,036895	80,32457218	24,75344276	3368,916874	58,04237137	84,40170748	2274,110583	47,68763554	129,093733	361,8377938	19,02203443	139,3203887	3384,78328	58,17889033	4,445871699	455,9623057	21,35327389
August	34,38393002	5197,886093	72,09636671	56,04645802	6063,494715	77,86844493	67,08957318	3738,015902	61,13931552	131,7479328	363,1915375	19,05758478	142,2578234	2065,515641	45,4479443	2,67660445	374,4380429	19,35040162
September	88,60954932	4902,562191	70,01829897	41,88818983	8330,826564	91,27336175	60,22242284	2605,855967	51,04758532	127,1789337	422,0983242	20,54503162	152,8964943	711,7083227	26,67786203	2,893160803	389,1880827	19,72785043
October	91,74086133	5060,560351	71,13761559	36,03893477	4224,567311	64,99667154	54,91997231	3411,726025	58,40998224	131,6672452	385,3196314	19,62956014	141,3436294	1381,868896	37,17349723	2,146962122	301,720601	17,37010653
November	81,79254037	11791,50359	108,58869	61,97686207	6034,492921	77,68199869	76,10024065	2734,182361	52,28940965	126,266131	514,8731227	22,69081582	139,7827802	119,9736402	10,95324793	3,52872865	500,9345896	22,38156808
December	23,00169306	4195,373457	64,77170259	79,98194226	6295,0199	79,34116145	94,67270164	4691,511242	68,4946074	130,2450259	368,3127968	19,19147719	143,0172017	424,9379918	20,61402415	3,596992081	432,1978593	20,7893689
2014	37,15535661	4360,13494	64,61032067	63,61192356	8789,142072	88,85783125	75,87248905	2681,233571	49,19814618	129,1033286	304,4068173	16,76507209	137,6433776	849,5694936	27,64226775	5,159696215	709,2985752	25,84328291
January	22,241655	3298,477871	57,43237651	87,63359009	9043,737631	95,09856798	99,57123738	6258,242008	79,10905136	134,4435539	308,5467749	17,56549956	143,308556	1320,138329	36,33370789	7,512738346	742,6418402	27,25145575
February	52,73345917	5202,368811	72,12744839	130,3404938	15677,72239	125,210712	83,32426755	6846,676021	82,74464346	136,5562027	493,1501749	22,20698482	146,573903	270,5169451	16,44739934	2,562557007	280,6051553	16,75127324
March	36,32369915	6328,108576	79,54940965	111,5559068	19686,01979	140,3068772	82,67986144	3131,075458	55,9560136	137,7919894	172,9025059	13,14923974	146,3224968	232,2134712	15,23855214	5,941655245	858,5039621	29,30023826
April	23,61222168	2897,539466	53,82879774	75,59929529	10855,42288	104,1893607	88,54788757	1637,279425	40,46330962	120,0961903	860,3852535	29,33232438	131,4425404	710,284837	26,65116952	10,14618367	1619,71171	40,24564212
May	39,5051357	9691,719279	98,44653005	80,72143032	7195,159722	84,82428734	84,64738336	2250,939146	47,44406334	120,0694927	109,5695322	10,46754662	139,9326394	382,2916225	19,55227921	4,690765646	667,4354394	25,83477191
June	51,08675343	5471,246604	73,96787549	74,86489978	6933,572078	83,26807358	67,97952854	1329,191264	36,45807543	127,839756	270,2368606	16,43888258	144,7516844	253,0688427	15,90813763	4,680246526	487,033276	22,06883042
July	23,28925046	3434,200394	58,60205111	40,84690014	3759,987706	61,31873862	61,19976343	3263,880036	57,13037752	117,6749496	282,7872328	16,8162788	133,2939105	1026,599383	32,04058962	1,972358823	201,0099439	14,17779757
August	32,99556842	2422,650203	49,22042466	56,96490573	3331,11785	57,71583708	75,02727963	767,569272	27,70504055	120,0700587	176,1927719	13,27376254	130,1446922	1667,033602	40,82932282	4,980278218	646,7665186	25,43160472
September	34,16816302	2610,845966	51,0964379	38,19899895	2325,015521	48,21841475	68,75490861	1882,396113	43,38658909	123,2874827	197,6511869	14,05884728	139,688808	623,6596721	24,97317905	6,532501288	578,4606235	24,05120836
October	35,04313736	3137,004712	56,00896992	58,8889961	2681,973389	51,78777258	69,8199367	1783,842422	42,23555874	138,3020368	224,1734725	14,97242374	137,6678826	1056,09007	32,49753944	5,226331328	914,1592627	30,23506677
November	66,08798576	4186,478669	64,70300355	-83,48603097	16797,16966	129,6038952	72,62961861	1580,666352	39,7575949	137,8778042	185,2667895	13,61127435	137,3924673	784,6570342	28,0117303	3,064451244	606,1556784	24,62022905
December	28,7772502	3640,978725	60,34052307	91,21369668	7182,806251	84,75143805	56,28819575	1443,045331	37,98743649	135,2304262	372,0192526	19,28780062	121,2009501	1868,280115	43,22360599	4,606287227	909,0994924	30,1512768
2015	22,12151939	3049,878266	53,94816746	56,71350193	7347,710889	80,34557438	54,74958977	1470,987189	37,82997975	93,70603157	846,6197491	26,53538282	56,99729399	1073,199424	32,74317751	1,136427753	163,5941436	11,48803339
January	18,13751524	2627,910906	51,2631535	62,10280683	4469,603387	66,85509245	51,91080841	2495,68965	49,95687791	128,2410051	329,1296507	18,14193073	48,48150772	1153,620593	33,96499069	0,860380623	94,97727479	9,745628496
February	31,41549874	3803,488581	61,67242967	39,09446108	2593,367229	50,92511394	56,95940529	1559,727733	39,49338847	120,237994	398,280592	19,95696851	62,01407467	988,3522877	31,43807067	1,269958451	208,4894328	14,43916316
March	45,13406766	5721,152447	75,63830013	39,69327851	2495,00048	49,94997978	51,77082829	1325,668853	36,4097357	118,5294633	1445,39033	38,01828941	62,0157035	1046,245424	32,34571724	0	0	0
April	14,77510605	2109,15967	45,9255884	50,20096608	5240,503409	72,39132137	60,98365727	834,8661216	28,89404993	128,5861993	60,61775338	7,785740388	59,05746705	1034,729249	32,16720767	1,340281693	161,2136846	12,6969951
May	21,75476135	2507,988214	50,07981843	87,36978595	13929,81945	118,0246561	60,64219811	1238,675759	35,19482574	19,00066179	1250,186568	35,35797743	59,86999272	1037,41445	32,2089188	1,196050751	216,6701443	14,71971957
June	1,512167305	1529,569778	39,10971463	61,81971311	15357,97138	123,9272826	46,23064123	1371,295016	37,03100074	47,64086602	1596,113601	39,95139048	50,54501828	1178,834542	34,33415998	2,151895002	300,2143253	17,32669401

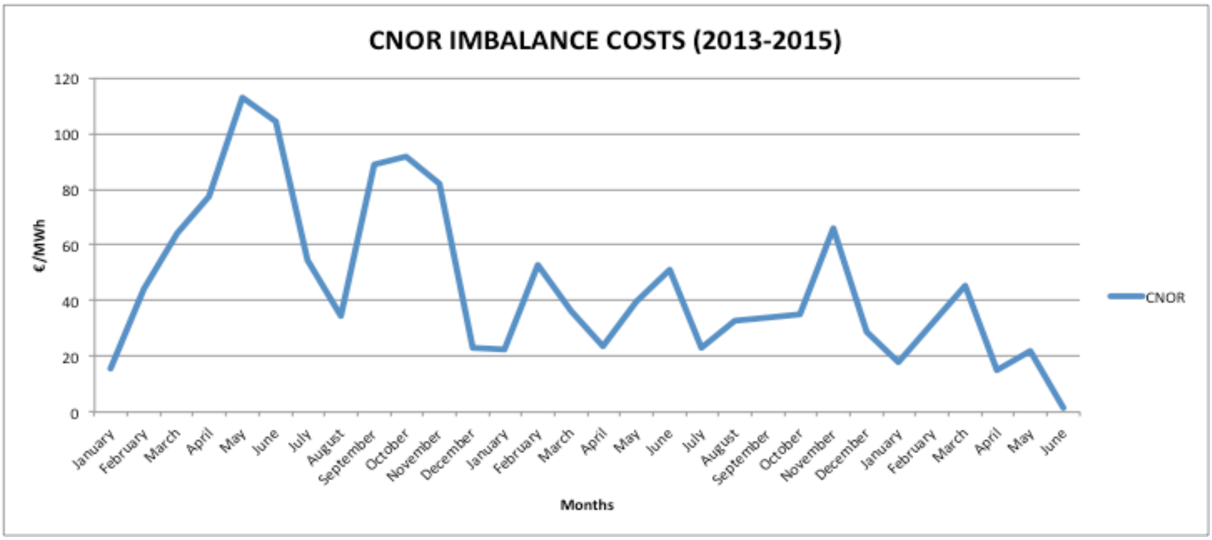
These are the results of the statistical analysis on day-ahead prices, variance and standard deviation on average, for every month, for the Day-Ahead Market.

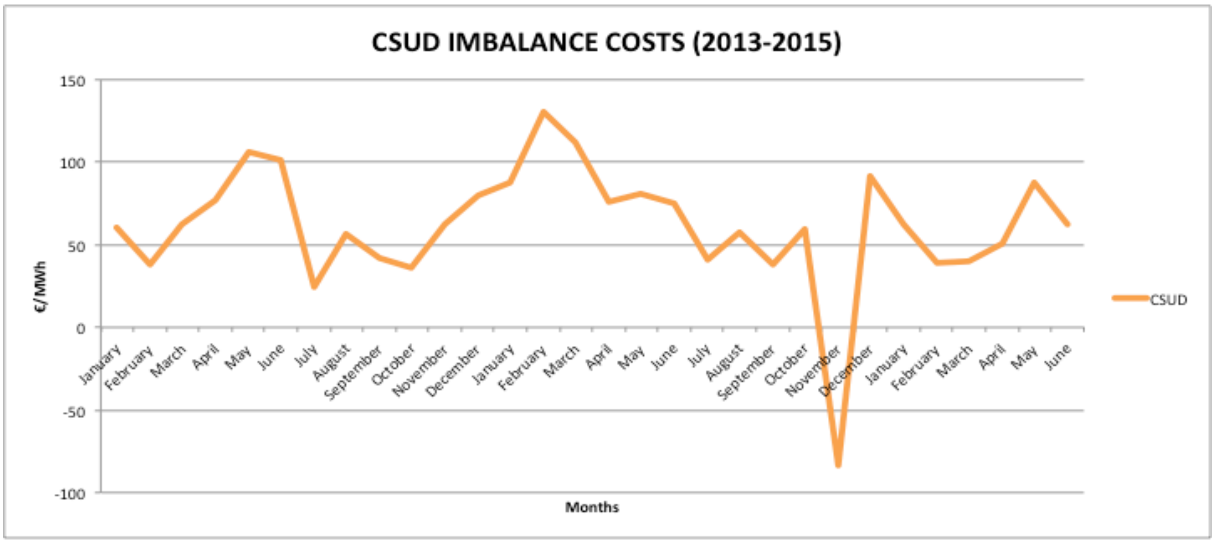
	MGP																	
	CNOR			CSUD			NORD			SARD			SICI			SUD		
	Day-ahead p.	Variance	St. dev.	Day-ahead p.	Variance	St. dev.	Day-ahead p.	Variance	St. dev.	Day-ahead p.	Variance	St. dev.	Day-ahead p.	Variance	St. dev.	Day-ahead p.	Variance	St. dev.
2013	61,03131016	341,6595286	17,89703392	59,23722337	408,1851403	19,65139595	61,569595	280,1639736	16,2873483	61,45834571	745,9853218	24,99531119	91,99082466	1341,993118	36,37682842	57,20343883	423,5092987	19,9959942
January	63,25907031	217,6621013	14,75337593	60,10460471	276,7007461	16,63432434	63,28283056	209,7176768	14,48163239	60,46955095	336,6460716	18,34791736	90,87687972	1282,019008	35,80529302	59,52293287	274,9774396	16,58244372
February	60,77600303	181,2248605	13,46197833	59,08293187	231,4064811	15,21205052	60,93849653	169,6977394	13,02680849	59,2103833	235,1102515	15,3333053	96,55560174	1070,072088	32,71195634	57,81229837	223,7866636	14,95950078
March	61,92545077	315,5917519	17,76490225	58,06750757	387,5692519	19,68677861	65,65090058	276,0414128	16,61449406	71,32400183	2778,984098	52,71607059	75,67900869	1418,754793	37,66636156	51,16513078	455,2528064	21,33665406
April	57,06371891	554,9344411	23,55704653	55,1727531	577,7202946	24,03581275	62,18420472	534,4706477	23,11862123	55,25278088	580,5856525	24,09534504	85,12210787	1621,008759	40,26175305	50,40490211	599,1201709	24,4769314
May	54,33605541	740,492078	27,21198409	54,34964571	773,3491408	27,8091557	51,91527184	477,9952952	21,86310351	57,99086702	1103,906759	33,22509231	83,67954738	1874,231384	43,29239406	49,75366589	847,3203479	29,10876754
June	55,26919266	632,5397261	25,15034246	55,04087321	641,6724744	25,33125489	52,84529276	448,1800934	21,17026437	55,21373433	662,6687998	25,7423542	90,68450279	1271,30053	35,65530157	54,46179095	633,2494924	25,16444898
July	64,31078692	214,0173114	14,62933052	64,22080173	212,5502387	14,57910281	63,85786458	134,768345	11,60897691	64,22080173	212,5502387	14,57910281	105,4568267	929,0214171	30,47985264	63,81398516	216,1813745	14,70310765
August	60,97906093	158,4292714	12,58686901	60,67132823	168,7577542	12,99067951	61,59326181	141,5105221	11,89581952	60,68772608	169,0760139	13,00292328	109,3848917	915,8409262	30,26286381	60,66958092	168,7473262	12,99027814
September	61,93733803	198,0066984	14,0714853	60,09918334	239,646229	15,48051126	64,19510217	137,2388141	11,7148971	61,36261631	362,1304378	19,02972511	93,57632978	1106,929735	33,27055356	58,30725407	272,4782466	16,50691511
October	62,14822553	305,9837695	17,49239176	60,92540133	338,3180256	18,39342343	62,02748827	264,7785111	16,2720162	68,64079459	1459,3522	38,20146856	102,1763291	1915,665823	43,76831985	59,83699052	348,4590584	18,66705811
November	61,18173854	281,2154763	16,7694805	58,64366178	616,2854444	24,82509707	61,07004953	269,7880118	16,42522486	58,64366178	616,2854444	24,82509707	80,03412747	1506,509652	38,81378173	58,3082278	619,933864	24,89847112
December	69,18908091	299,8168573	17,31522039	64,46798785	434,2456031	20,83856049	69,27437661	297,7806134	17,25632097	64,48322978	434,5278936	20,84533266	90,66374297	1192,563298	34,53350979	62,38450654	422,6047934	20,55735375
2014	49,66804618	235,92549	14,86052743	48,93922113	240,7042824	15,04693295	50,46371104	183,5484517	13,18178125	52,24442844	476,7136271	21,08996306	80,87325046	1149,493642	33,62910681	47,45633161	261,563476	15,64253845
January	57,79939599	200,2140824	14,14970256	57,25394102	221,3679353	14,8784386	58,31178735	191,3921507	13,8344552	58,49194113	282,6703573	16,81280337	77,30285481	1757,162256	41,91851925	56,18120312	226,0179222	15,03389245
February	48,80792159	271,3306167	16,47211634	48,68253855	272,6780317	16,51296556	51,29945423	208,3904217	14,43573419	49,02173608	345,4072482	18,58513514	81,28707012	1402,04083	37,44383567	48,28210247	280,7757242	16,75636369
March	44,09571475	400,7652761	20,01912276	43,91873894	408,8212298	20,21932813	46,99369259	333,7034029	18,26755055	43,91880614	408,8207042	20,21931513	66,06887337	1556,804789	39,45636563	38,62973809	515,7926159	22,71106814
April	41,56870413	283,7592829	16,84515607	40,52744609	293,1031771	17,12025634	47,90196246	236,4404755	15,37662107	40,52744609	293,1031771	17,12025634	58,77866363	1140,762691	33,77517862	36,62624746	357,7153359	18,91336395
May	42,87911936	244,4233013	15,63404302	42,34272909	252,7438042	15,89791823	45,61110171	168,4922521	12,98045654	44,66102097	364,1046806	19,08152721	77,3600395	1206,46197	34,73416142	42,13158757	263,4731137	16,23185491
June	43,99815437	122,8226419	11,0825377	43,99034882	122,9076989	11,08637447	44,82704297	115,1354933	10,73012084	57,34433484	1278,5872	35,75733771	77,43272756	1154,781953	33,98208282	41,23779827	168,7024926	12,98855237
July	41,92861703	38,20415992	6,180951377	41,5795822	43,21512429	6,573821133	42,59558311	35,49116995	5,957446597	54,16442232	944,3753784	30,73069115	95,41560653	749,7935581	27,38235852	41,5303353	42,81955393	6,543665176
August	42,58852017	99,16816453	9,958321371	42,03207823	102,441731	10,12135025	41,275211	84,11330689	9,171330704	49,83499839	421,0126369	20,51859247	102,1490815	724,2896616	26,91263015	42,01297571	102,5530341	10,12684719
September	56,48131784	191,3182944	13,83178565	52,36289552	207,7457927	14,41338936	57,5664855	194,0641589	13,93069126	53,78522885	363,754057	19,07233748	87,86932471	865,9795447	29,42753039	52,21276871	207,0438059	14,38901685
October	60,91965746	354,3203058	18,82339783	59,28757125	340,5969976	18,45527018	60,22628997	241,7522159	15,54838306	59,86158928	395,7861331	19,89437441	95,02318113	1034,896586	32,16980861	56,24144745	353,4518291	18,8003146
November	55,2369553	333,3470278	18,25779362	55,49395015	326,1035422	18,05833719	52,21097945	231,2869855	15,20812235	55,52278348	326,2156287	18,06144038	70,74972166	1099,777829	33,16289838	54,62049786	324,9353445	18,02596307
December	59,71247622	291,4327262	17,07140083	59,79883375	296,7263238	17,22574596	56,74494211	162,3193866	12,74046257	59,79883375	296,7263238	17,22574596	81,04186097	1101,172035	33,18391229	59,7692773	295,4809397	17,18955903
2015	48,8509744	148,4235232	12,01790176	48,22920058	150,9281443	12,12725946	50,36713593	103,7696584	10,11603099	48,26333733	153,2703352	12,23813812	55,85712416	245,5481427	15,32324095	47,22562264	151,8996281	12,13583745
January	51,25172171	142,3501675	11,93105894	51,25172171	142,3501675	11,93105894	49,64593972	96,07001209	9,80153111	51,28579173	143,2820478	11,97004794	62,0670745	135,7205682	11,64991709	50,99082617	139,3494845	11,80463826
February	55,13045729	110,4649628	10,51023134	54,12489599	116,3239754	10,78535931	55,04172143	106,4046028	10,31526067	54,12489599	116,3239754	10,78535931	55,40431882	290,2409303	17,03645885	52,12296477	113,6031369	10,65847723
March	46,94578742	177,3719758	13,31810706	46,53270577	182,9619905	13,52634431	51,71736933	124,1595553	11,14269067	46,45185899	188,5228135	13,73036101	56,11393676	279,5647174	16,72018892	45,32412656	177,0186151	13,30483428
April	45,88987224	222,9105971	14,93019079	44,90257926	219,148271	14,80365735	49,321986	101,3752095	10,06852569	44,90257926	219,148271	14,80365735	50,71026215	370,3016561	19,24322364	43,86169403	234,7533049	15,3216613
May	45,95027704	161,7760082	12,71911979	44,85274269	168,37784	12,97604871	47,99611395	133,6561824	11,56097671	44,85274269	168,37784	12,97604871	54,54102832	295,4034806	17,1873058	43,86656776	173,5322596	13,17316437
June	47,93773071	75,66742761	8,698702639	47,71055808	76,40662149	8,741088118	48,47968513	60,95238848	7,807201066	47,96215531	83,96706331	9,16335437	56,30612439	102,0575038	10,1023514	47,18755657	73,14096759	8,552249271

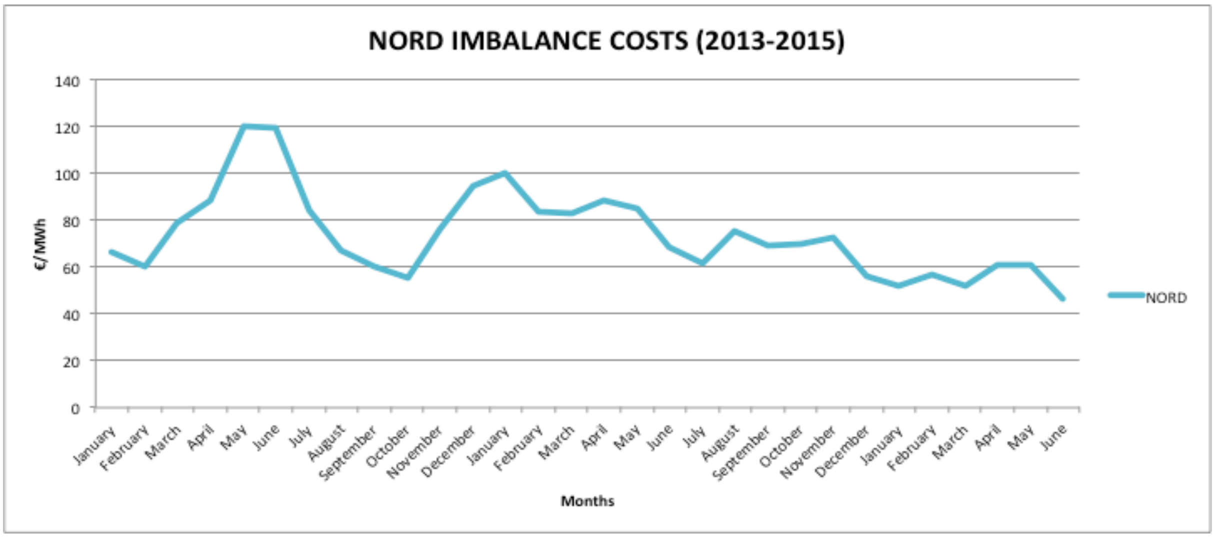
These are the results of the statistical analysis on day-ahead quantities, variance and standard deviation on average, for every month, for the Day-Ahead Market.

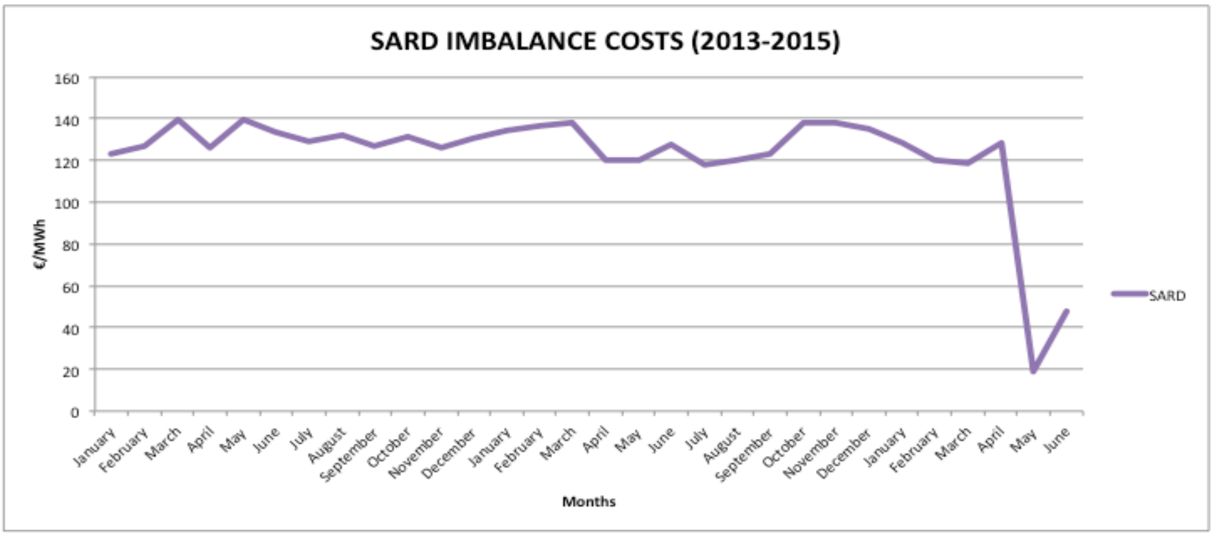
	MGP																	
	CNOR			CSUD			NORD			SARD			SICI			SUD		
	Day-ahead q.	Variance	St. dev.	Day-ahead q.	Variance	St. dev.	Day-ahead q.	Variance	St. dev.	Day-ahead q.	Variance	St. dev.	Day-ahead q.	Variance	St. dev.	Day-ahead q.	Variance	St. dev.
2013	3256,544468	545248,1418	733,8612721	5062,749336	1139301,235	1058,2562	17878,69595	15883902,1	3972,781279	1244,923331	28611,81748	166,3365156	2207,278476	121779,5543	344,4502178	2932,583687	261880,1677	507,6130856
January	3492,373981	732753,7016	856,0103397	5491,234444	1745285,737	1321,09263	18266,14013	19355394,52	4399,476619	1238,484359	36258,88922	190,4176704	2446,415294	199741,1679	446,9241187	2763,059438	373810,7808	611,4006712
February	3447,530299	642946,2391	801,8392851	5369,430302	1615774,672	1271,131257	19205,24499	16004253,35	4000,531634	1450,724234	35490,58473	188,3894496	2524,40901	195111,8502	441,7146706	2855,649394	379755,0253	616,2426676
March	3247,962871	550191,2956	741,7488089	5001,885176	1207244,036	1098,746575	18397,19039	16880052,06	4108,534052	1419,511365	23385,11437	152,9219225	2226,052823	120185,1371	346,6772809	2760,444327	288206,33	536,8485168
April	2991,942125	434110,2237	658,8704149	4591,64151	861238,1978	928,0292009	17051,55065	14510634,49	3809,282674	1423,706636	17779,93622	133,3414273	2080,473854	79531,63472	282,0135364	2635,98799	211774,9726	460,1901483
May	3135,123054	449155,9241	670,1909609	4744,544844	834913,3014	913,7359035	17035,1783	13124029,83	3622,710288	1377,788161	15502,89726	124,5106311	2032,715101	73589,38148	271,2736284	2713,049266	193583,5815	439,9813423
June	3314,197789	486390,7673	697,4172118	4971,637093	966173,3906	982,9411939	17835,38476	15133125,26	3890,131779	1109,359158	14461,83596	120,2573738	2103,503231	102745,9761	320,5401319	2951,416175	229514,6557	479,0768787
July	3534,963741	520725,3611	721,6130273	5614,857544	1091806,041	1044,89523	19581,53856	17130477,62	4138,898117	1128,707444	30094,75816	173,4784083	2390,782027	113031,8138	336,2020432	3459,272423	220368,7217	469,4344701
August	3038,695163	364195,6128	603,4862159	5162,298415	833220,197	912,8089597	15527,61304	10721624,16	3274,389127	1232,975582	44572,65074	211,1223596	2387,240566	98864,63088	314,4274652	3274,663618	257866,0267	507,805107
September	3257,657201	453752,3505	673,611424	5021,501122	896796,5374	946,9934199	17955,74637	15087607,16	3884,276916	1161,827893	45768,37598	213,9354482	2127,687624	96868,22865	311,236612	2996,078018	192910,7733	439,2160896
October	3195,26143	471615,6327	686,7427704	4851,872297	909645,1147	953,7531728	18111,99814	15133058,41	3890,123187	1114,671122	23297,52062	152,6352535	1933,552668	99151,94291	314,884015	2965,201406	197298,9101	444,1834194
November	3290,758499	681459,7299	825,5057419	4904,777246	1218907,125	1104,04127	18091,99576	17122541,5	4137,939282	1091,392265	22526,64336	150,0887849	2031,951575	111610,2402	334,081188	2860,203803	235766,6226	485,5580528
December	3132,067466	755680,8631	869,2990643	5027,312038	1490610,466	1220,905593	17484,77032	20404026,82	4517,08167	1189,931758	34202,60314	184,9394581	2202,557934	170922,6477	413,4279233	2955,978382	361705,612	601,4196638
2014	2955,081979	470470,9523	674,7892515	4641,267031	958684,8903	960,2430457	17882,37827	15622353,67	3937,464974	1302,608603	28349,57671	166,0588595	2060,13401	99146,23934	310,8640348	2965,002512	281548,8272	525,0501577
January	3209,169573	732444,1633	855,8295177	5027,837188	1580906,626	1257,341094	18256,5425	20423929,75	4519,284207	1237,850026	38091,73622	195,1710435	2193,914731	166069,0242	407,5156735	2929,518122	414587,607	643,8847778
February	3223,331125	675047,7744	821,6129103	4950,561253	1373478,796	1171,955117	19047,52965	15792681,55	3974,000699	1322,650749	25972,49989	161,1598582	2143,491891	151362,0565	389,0527682	2959,852162	338435,7325	581,7522948
March	2997,036327	586183,9642	765,6265174	4672,226997	1147054,753	1071,006421	18276,81388	14047264,32	3747,968025	1374,632489	22976,60465	151,5803571	2014,12521	118762,2461	344,6189868	2924,095164	267074,2661	516,7922852
April	2727,950676	459759,9645	678,0560187	4131,094736	746179,9506	863,8170817	17259,56363	14175814,52	3765,078288	1315,092476	16091,09699	126,8506878	1902,730831	78280,76631	279,7870017	2772,771915	242585,3508	492,5295431
May	2778,487827	372547,885	610,3670084	4254,635647	650775,3582	806,7064882	17452,27551	13894182,93	3727,490165	1375,325961	16367,69926	127,9363094	1908,83579	65685,40785	256,2916461	2787,280022	152271,8872	390,220306
June	2803,432099	310689,8149	557,3955641	4483,573957	628918,8466	793,0440382	18624,18016	17457588,5	4178,227914	1362,056496	31661,0369	177,9354852	2063,596213	86418,72988	293,9706276	3200,328753	258141,1745	508,0759534
July	3000,157546	330497,0331	574,8887137	4724,085808	615971,7107	784,8386526	19461,89592	15278800,36	3908,810607	1472,249313	32944,74057	181,5068609	2287,672206	80814,10725	284,2782216	3352,644218	197797,5663	444,7443831
August	2593,432664	227728,0425	477,2085943	4402,568993	497296,056	705,1922121	14751,52445	9439700,33	3072,409532	1524,203429	40286,94848	200,7160892	2362,065019	85277,38953	292,0229264	3037,787173	199766,1657	446,9520844
September	2759,814193	341775,3188	584,6155307	4455,579951	707348,0395	841,0398561	18614,95231	15950437,43	3993,799874	1218,0116	16616,9089	128,9065898	2089,237031	65269,00486	255,4779929	3032,8808	231096,7958	480,725281
October	2592,56262	323933,7468	569,1517783	4194,868161	712279,7451	843,966673	18678,62282	15533678,68	3941,278812	1325,965338	43749,60062	209,1640519	2049,545158	66066,8987	257,03482	2926,698575	307348,1983	554,3899334
November	3250,339306	612756,0958	782,7873886	4966,450263	1341872,834	1158,392349	17767,66515	16993454,64	4122,311808	1007,502057	23041,22337	151,7933575	1770,225154	97252,50243	311,8533348	2808,682346	381063,0206	617,3030217
December	3525,269788	672287,6246	819,9314755	5431,721414	1502135,967	1225,616566	16396,97332	18480711,07	4298,919756	1095,7633	32394,82463	179,9856234	1936,168884	128496,7386	358,4644175	2847,49089	388418,1617	623,2320288
2015	3274,339693	504058,9689	703,5135253	5127,097813	1167360,649	1067,076192	17591,3157	17685507,57	4199,244952	1030,728996	23022,206	149,8489073	1760,82929	104927,0774	318,1315084	3114,045011	345128,2142	585,3873082
January	3722,667144	699184,026	836,1722466	5738,58844	1670936,219	1292,646982	17060,77053	21066131,36	4589,785546	1135,126085	32092,29332	179,1432201	1944,284747	158814,3916	398,5152339	2902,604698	383207,3393	619,0374296
February	3544,020519	624171,8677	790,0454846	5525,283393	1587620,659	1260,008198	18654,62644	18525145,82	4304,084783	1067,441263	31285,38339	176,8767463	1981,269049	148703,0497	385,6203439	3056,826951	412830,89	642,5191748
March	3239,182725	566207,1749	752,4673912	5048,581481	1263040,631	1123,850805	18123,16031	15989758,23	3998,719573	1037,108921	24420,70589	156,2712574	1803,205952	117784,2343	343,1970779	3076,781504	402202,7106	634,1945368
April	3055,788797	425133,8202	652,0228678	4694,096424	923728,4469	961,1079268	16926,39728	15546353,62	3942,886458	978,5375972	15484,73516	124,4376758	1610,901813	79394,55438	281,770393	2930,953761	287424,4751	536,1198328
May	2879,624484	326125,9934	571,0744202	4650,554427	731052,9027	855,0163172	16790,00006	16297145,47	4036,972314	953,0274422	13566,68875	116,4761295	1619,780117	60731,83637	246,4383013	3209,386859	321287,3351	566,8221371
June	3204,754492	383530,9313	619,2987415	5105,482715	827785,0322	909,8269243	17992,93957	18688510,91	4323,02104	1013,132669	21283,42948	145,8884145	1605,53406	64134,39785	253,2477006	3507,716294	263816,5348	513,6307378

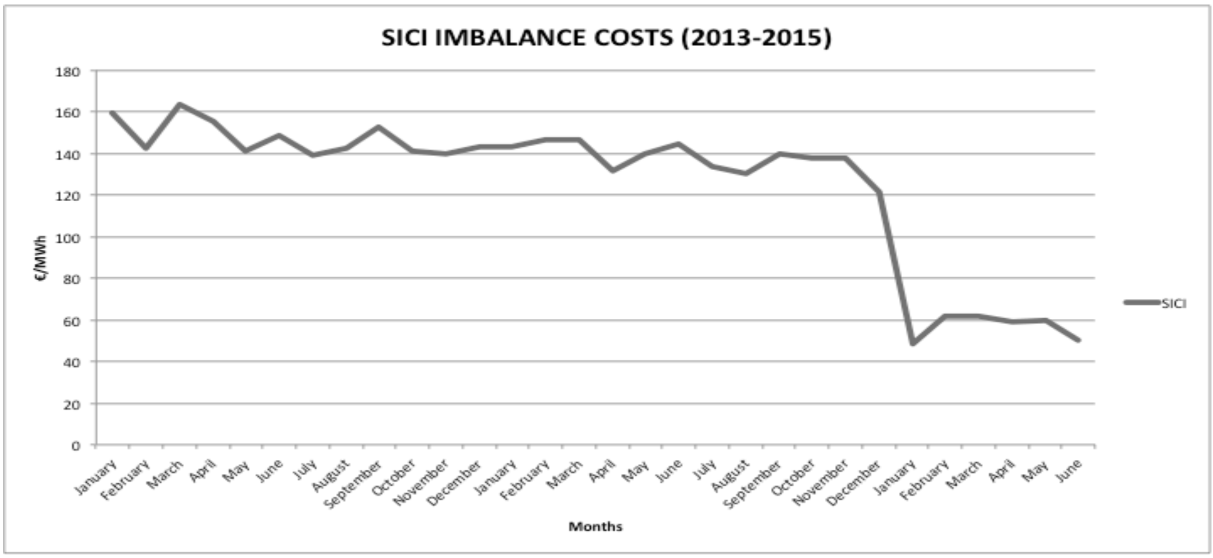
B) These are the graphs of the imbalance costs for every zone of the Italian power market.

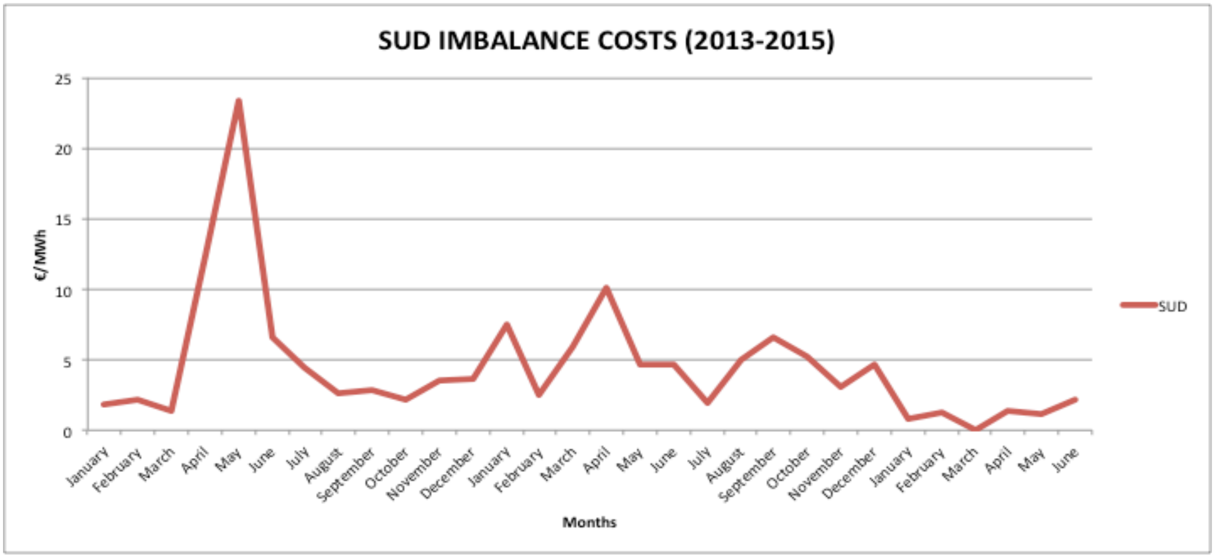




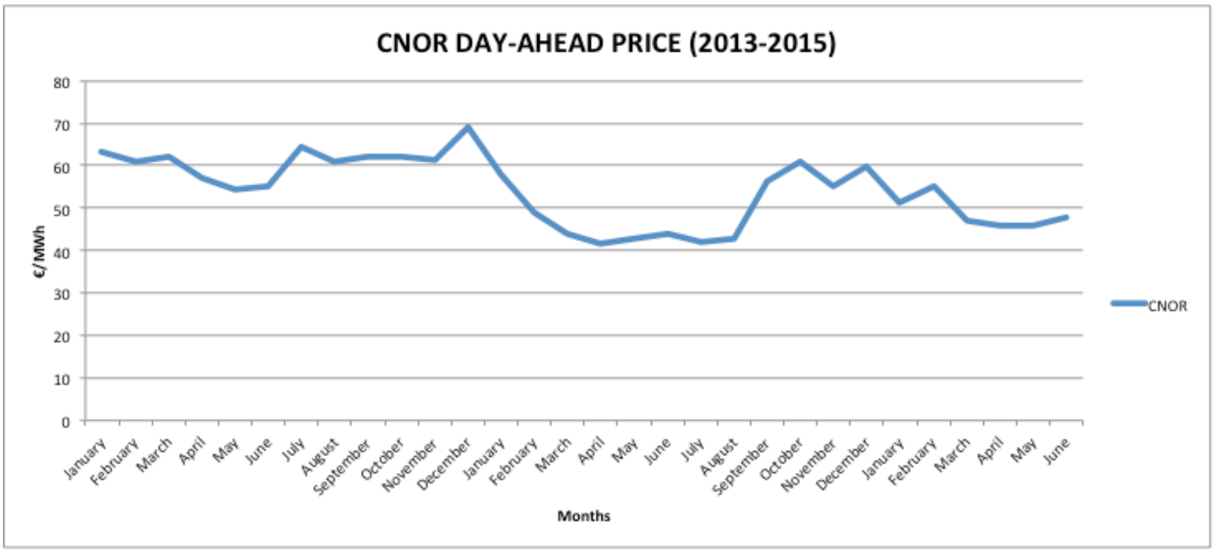


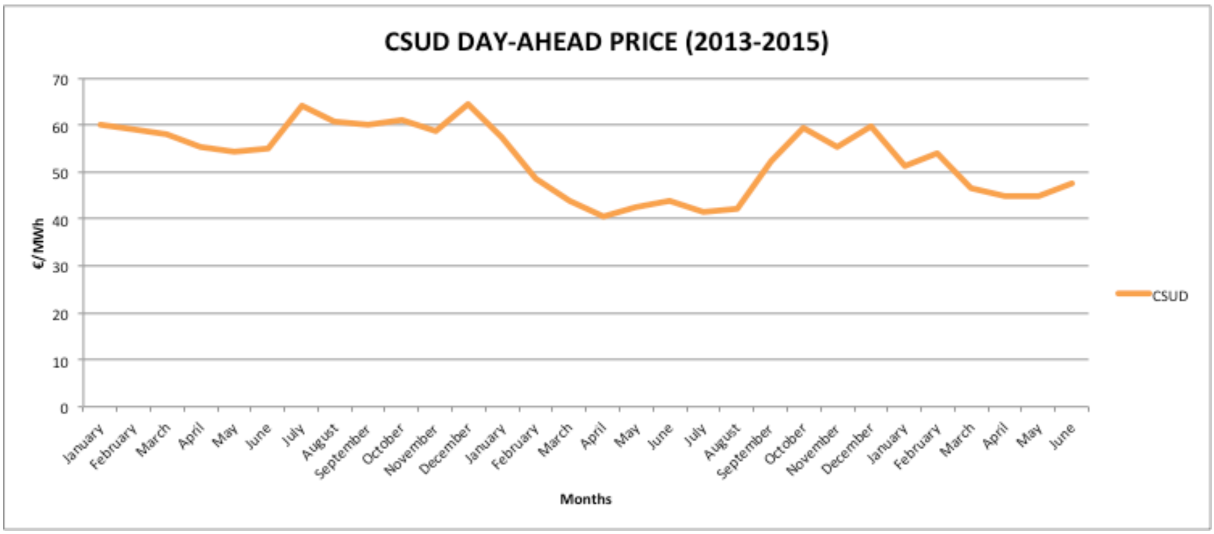

SARD IMBALANCE COSTS (2013-2015)
€/MWh
160
140
120
100
80
60
40
20
0
January February March April May June July August September October November December January February March April May June July August September October November December January February March April May June
Months
SARD

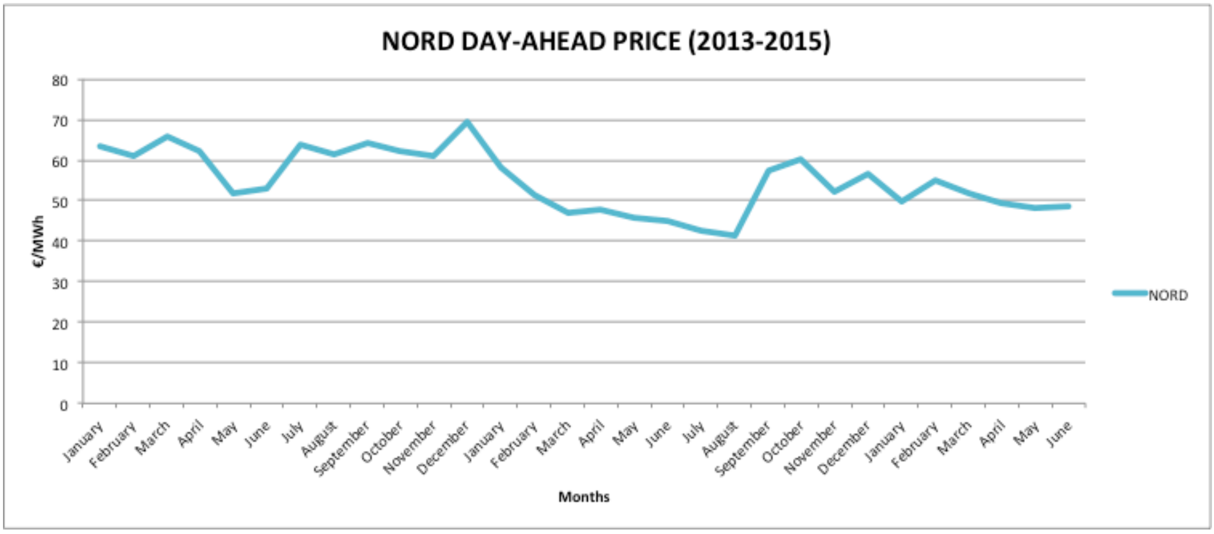

SICI IMBALANCE COSTS (2013-2015)
€/MWh
180
160
140
120
100
80
60
40
20
0
January February March April May June July August September October November December January February March April May June July August September October November December January February March April May June
Months
SICI

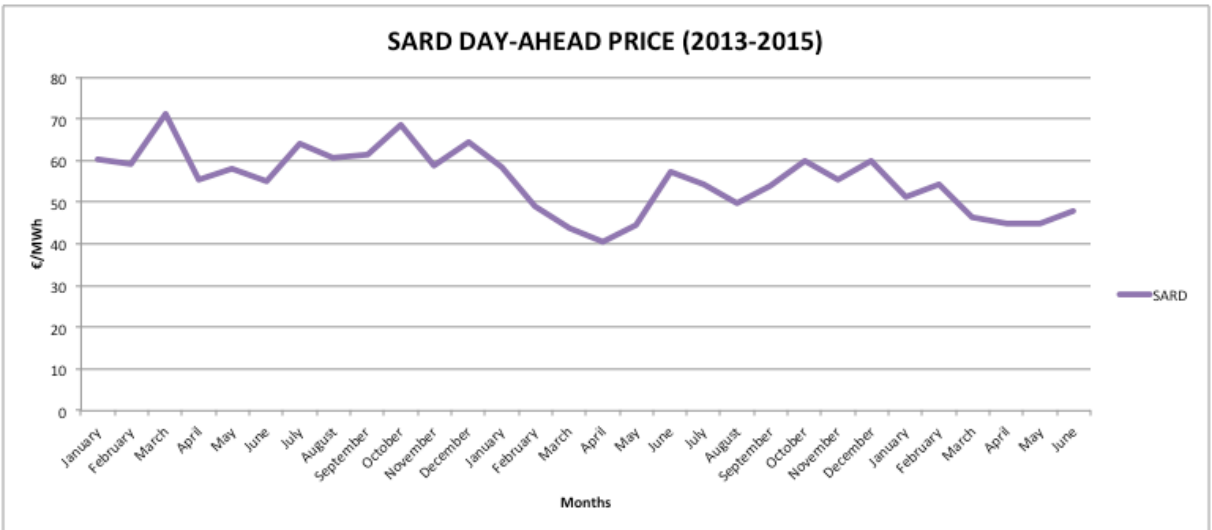

SUD IMBALANCE COSTS (2013-2015)
€/MWh
25
20
15
10
5
0
January February March April May June July August September October November December January February March April May June July August September October November December January February March April May June
Months
SUD

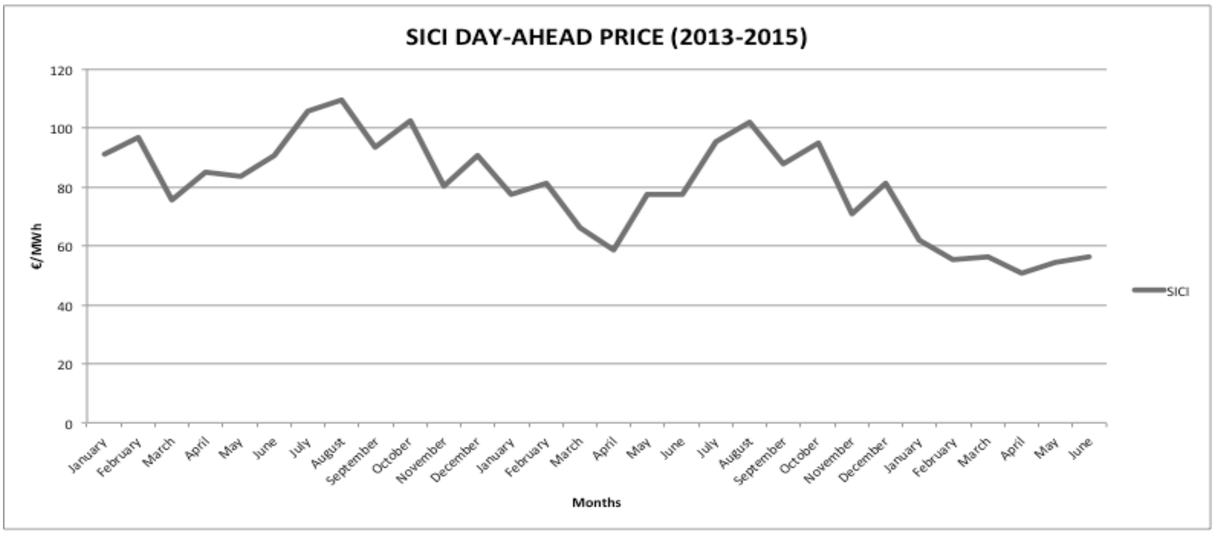
C) These are the graphs of the day-ahead prices for every zone of the Italian power market.

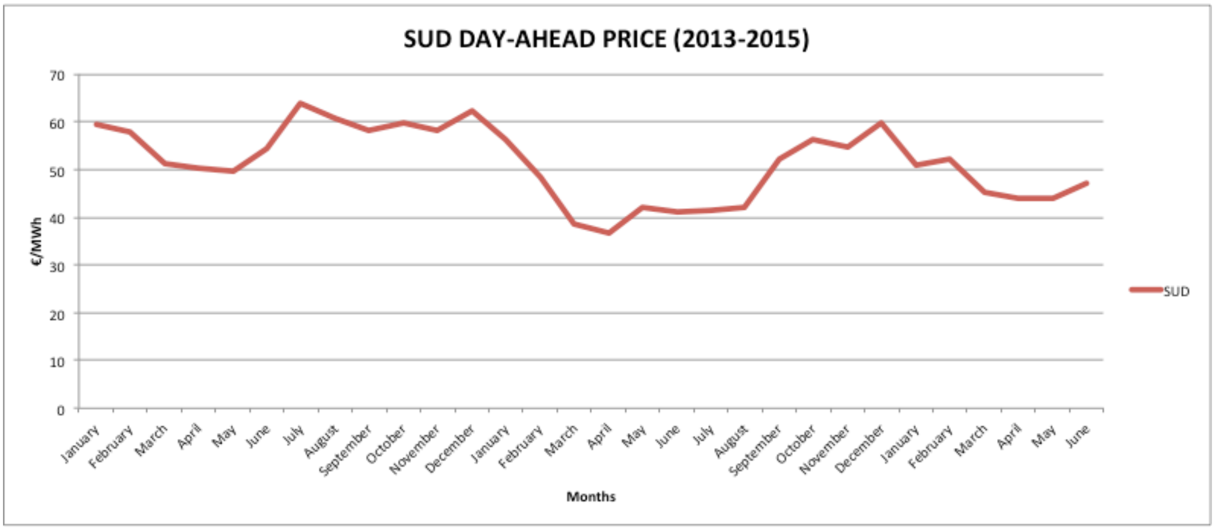




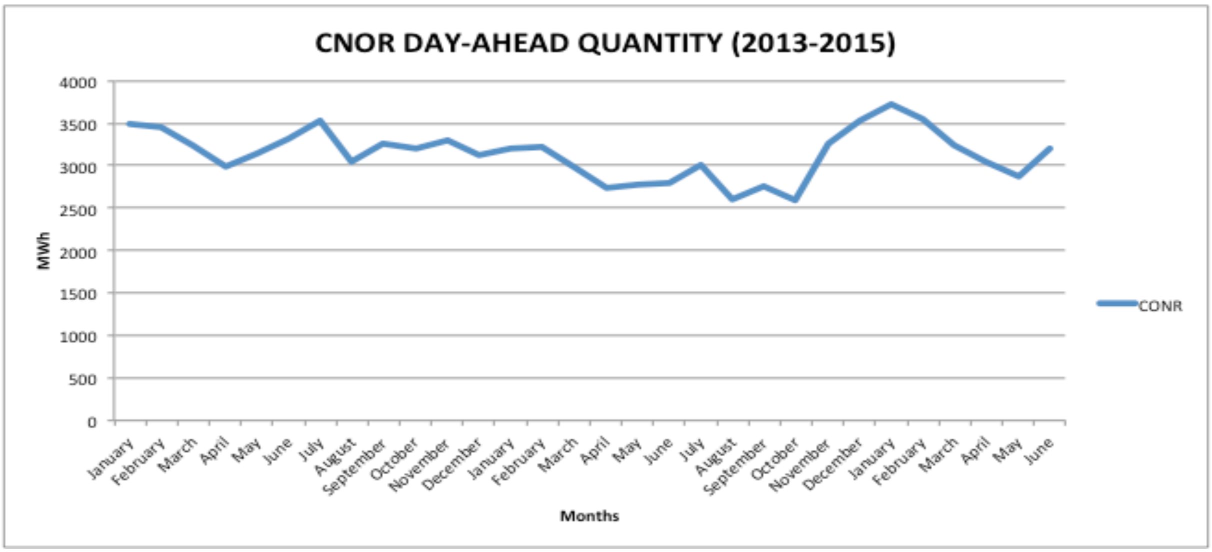


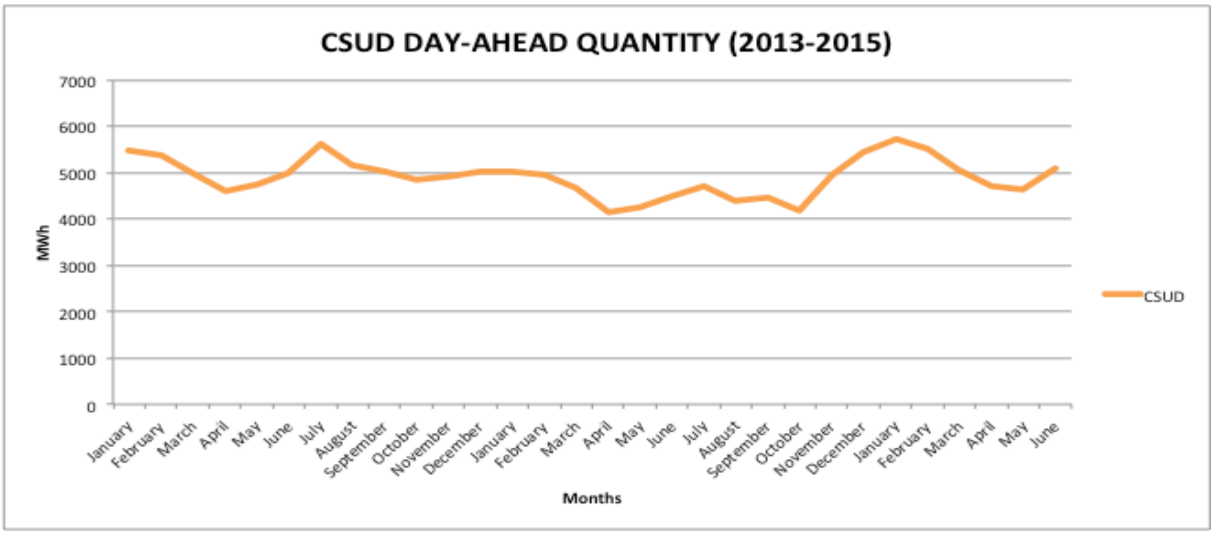

SARD DAY-AHEAD PRICE (2013-2015)
€/MWh
Months
SARD

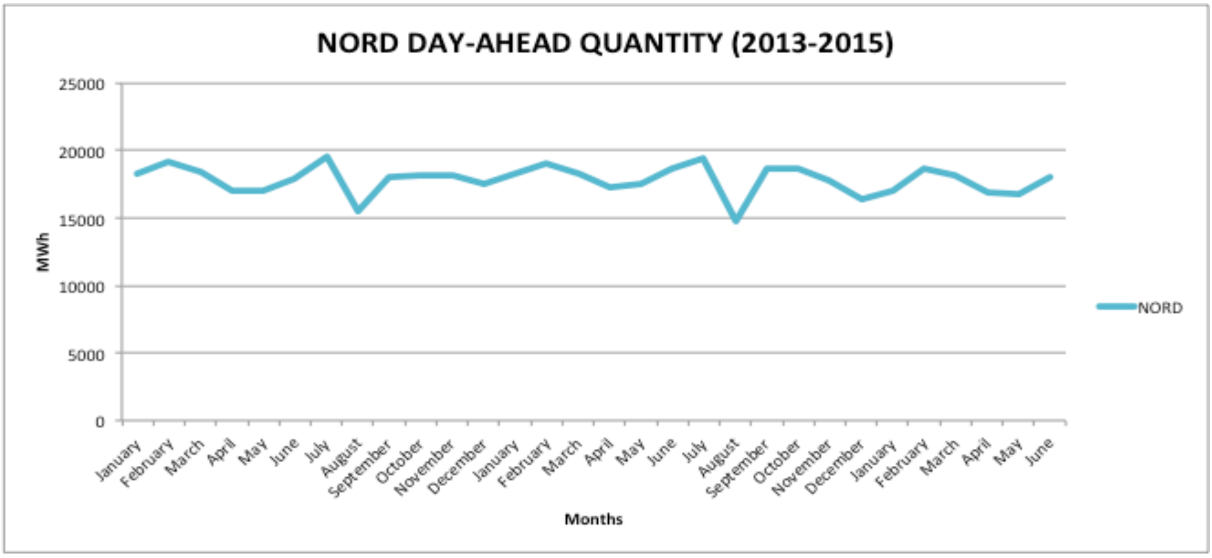

SICI DAY-AHEAD PRICE (2013-2015)
€/MWh
Months
SICI

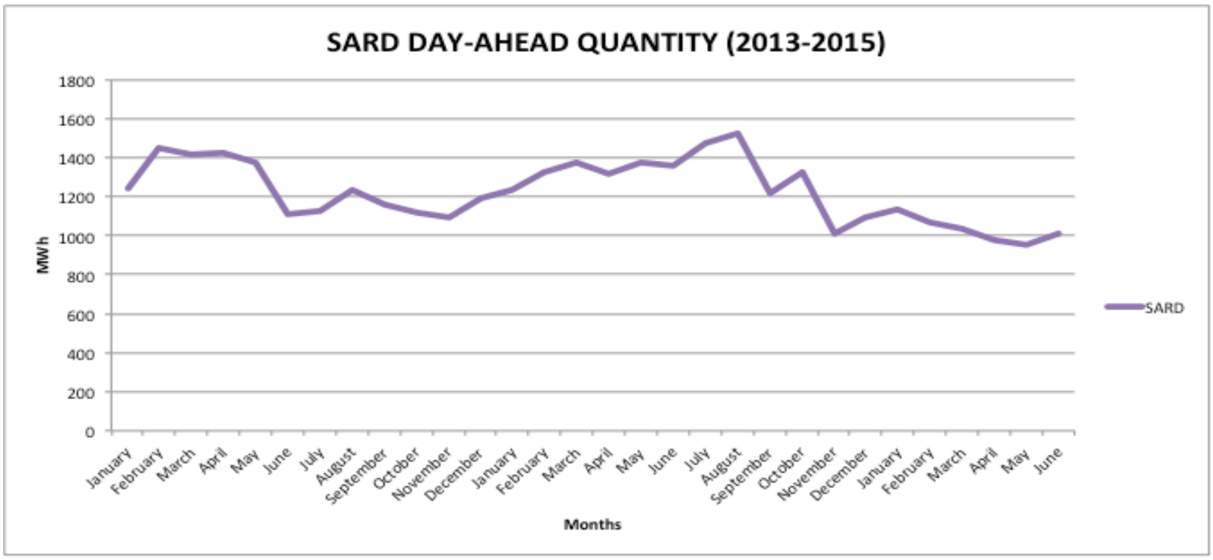

SUD DAY-AHEAD PRICE (2013-2015)
€/MWh
Months
SUD

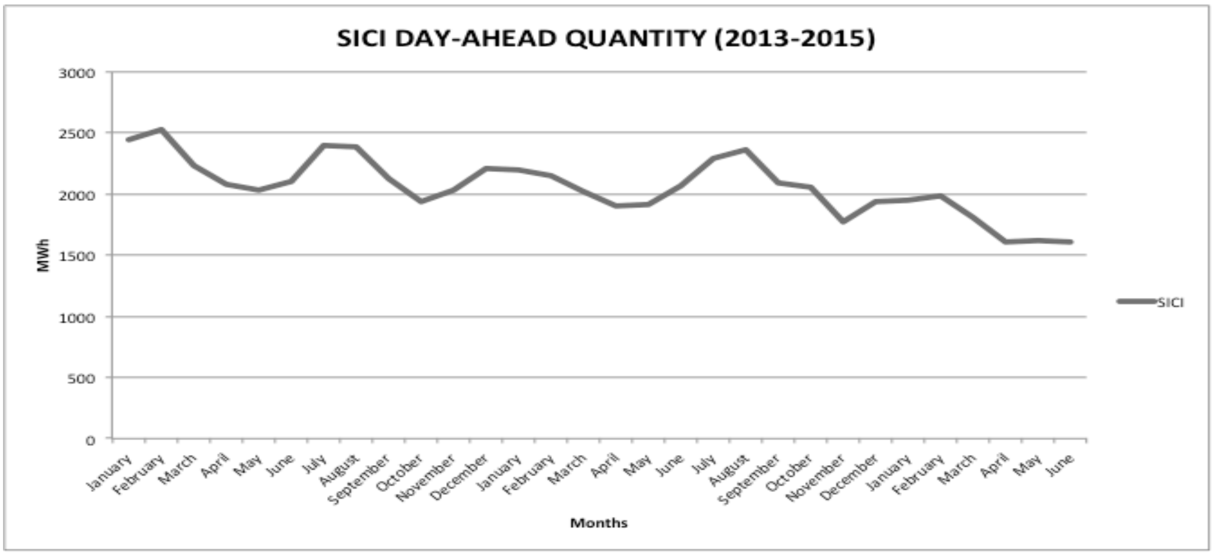
D) These are the graphs of the day-ahead quantities of every zone of the Italian power market.

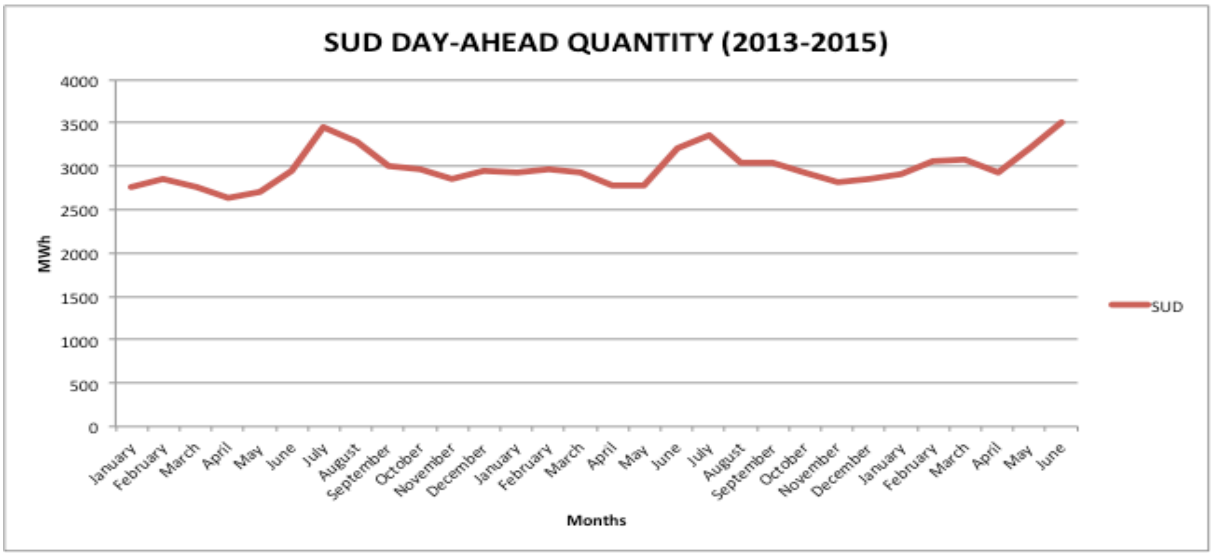







SARD DAY-AHEAD QUANTITY (2013-2015)
MWh
Months
SARD


SICI DAY-AHEAD QUANTITY (2013-2015)
MWh
Months
SICI


SUD DAY-AHEAD QUANTITY (2013-2015)
MWh
Months
SUD

E) These are the results of the statistical analysis on the correlation between imbalance costs and day-ahead prices.

	IMBALANCE COSTS - DAY-AHEAD PRICES																	
	CNOR			CSUD			NORD			SARD			SICI			SUD		
	Imbalance costs	Day-ahead p.	Correlation index	Imbalance costs	Day-ahead p.	Correlation index	Imbalance costs	Day-ahead p.	Correlation index	Imbalance costs	Day-ahead p.	Correlation index	Imbalance costs	Day-ahead p.	Correlation index	Imbalance costs	Day-ahead p.	Correlation index
Total			0,295859274			-0,196498697			0,077626214			0,403003584			0,710999295			-0,110987889
2013			-0,722628945			-0,652114041			-0,581659142			0,329431516			-0,488011573			-0,633040647
January	15,43832152	63,25907031		60,0695318	60,10460471		66,17735144	63,28283056		122,8184058	60,46955095		159,1056262	90,87687972		1,849636295	59,52293287	
February	44,49016751	60,77600303		38,20911368	59,08293187		60,2426052	60,93849653		127,1734097	59,2103833		142,1900764	96,55560174		2,188428724	57,81229837	
March	64,27475178	61,92545077		61,9419958	58,06750757		78,30627725	65,65090058		139,570413	71,32400183		163,4762006	75,67900869		1,329612904	51,16513078	
April	77,19584635	57,06371891		76,42732793	55,1727531		88,06372351	62,18420472		126,2620335	55,25278088		155,2036933	85,12210787		12,24992875	50,40490211	
May	113,0996487	54,33605541		105,9212204	54,34964571		119,7512588	51,91527184		139,7157778	57,99086702		140,9704772	83,67954738		23,40143852	49,75366589	
June	104,5359545	55,26919266		100,6163611	55,04087321		119,3644207	52,84529276		133,7411857	55,21373433		148,5288324	90,68450279		6,55842807	54,46179095	
July	54,53006381	64,31078692		24,75344276	64,22080173		84,40170748	63,85786458		129,093733	64,22080173		139,3203887	105,4568267		4,445871699	63,81398516	
August	34,38393002	60,97906093		56,04645802	60,67132823		67,08957318	61,59326181		131,7479328	60,68772608		142,2578234	109,3848917		2,67660445	60,66958092	
September	88,60954932	61,93733803		41,88818983	60,09918334		60,22242284	64,19510217		127,1789337	61,36261631		152,8964943	93,57632978		2,893160803	58,30725407	
October	91,74086133	62,14822553		36,03893477	60,92540133		54,91997231	62,02748827		131,6672452	68,64079459		141,3436294	102,1763291		2,146962122	59,83699052	
November	81,79254037	61,18173854		61,97686207	58,64366178		76,10024065	61,07004953		126,266131	58,64366178		139,7827802	80,03412747		3,52872865	58,3082278	
December	23,00169306	69,18908091		79,98194226	64,46798785		94,67270164	69,27437661		130,2450259	64,48322978		143,0172017	90,66374297		3,596992081	62,38450654	
2014			0,047658954			-0,207711662			0,025923785			0,397119455			-0,236124512			-0,161784321
January	22,241655	57,79939599		87,63359009	57,25394102		99,57123738	58,31178735		134,4435539	58,49194113		143,308556	77,30285481		7,512738346	56,18120312	
February	52,73345917	48,80792159		130,3404938	48,68253855		83,32426755	51,29945423		136,5562027	49,02173608		146,573903	81,28707012		2,562557007	48,28210247	
March	36,32369915	44,09571475		111,5559068	43,91873894		82,67986144	46,99369259		137,7919894	43,91880614		146,3224968	66,06887337		5,941655245	38,62973809	
April	23,61222168	41,56870413		75,59929529	40,52744609		88,54788757	47,90196246		120,0961903	40,52744609		131,4425404	58,77866363		10,14618367	36,62624746	
May	39,5051357	42,87911936		80,72143032	42,34272909		84,64738336	45,61110171		120,0694927	44,66102097		139,9326394	77,3600395		4,690765646	42,13158757	
June	51,08675343	43,99815437		74,86489978	43,99034882		67,97952854	44,82704297		127,839756	57,34433484		144,7516844	77,43272756		4,680246526	41,23779827	
July	23,28925046	41,92861703		40,84690014	41,5795822		61,19976343	42,59558311		117,6749496	54,16442232		133,2939105	95,41560653		1,972358823	41,5303353	
August	32,99556842	42,58852017		56,96490573	42,03207823		75,02727963	41,275211		120,0700587	49,83499839		130,1446922	102,1490815		4,980278218	42,01297571	
September	34,16816302	56,48131784		38,19899895	52,36289552		68,75490861	57,5664855		123,2874827	53,78522885		139,688808	87,86932471		6,532501288	52,21276871	
October	35,04313736	60,91965746		58,8889961	59,28757125		69,8199367	60,22628997		138,3020368	59,86158928		137,6678826	95,02318113		5,226331328	56,24144745	
November	66,08798576	55,2369553		-83,48603097	55,49395015		72,62961861	52,21097945		137,8778042	55,52278348		137,3924673	70,74972166		3,064451244	54,62049786	
December	28,7772502	59,71247622		91,21369668	59,79883375		56,28819575	56,74494211		135,2304262	59,79883375		121,2009501	81,04186097		4,606287227	59,7692773	
2015			0,171000437			-0,424478138			0,051874199			0,410158341			-0,652071573			0,067583098
January	18,13751524	51,25172171		62,10280683	51,25172171		51,91080841	49,64593972		128,2410051	51,28579173		48,48150772	62,0670745		0,860380623	50,99082617	
February	31,41549874	55,13045729		39,09446108	54,12489599		56,95940529	55,04172143		120,237994	54,12489599		62,01407467	55,40431882		1,269958451	52,12296477	
March	45,13406766	46,94578742		39,69327851	46,53270577		51,77082829	51,71736933		118,5294633	46,45185899		62,0157035	56,11393676		0	45,32412656	
April	14,77510605	45,88987224		50,20096608	44,90257926		60,98365727	49,321986		128,5861993	44,90257926		59,05746705	50,71026215		1,340281693	43,86169403	
May	21,75476135	45,95027704		87,36978595	44,85274269		60,64219811	47,99611395		19,00066179	44,85274269		59,86999272	54,54102832		1,196050751	43,86656776	
June	1,512167305	47,93773071		61,81971311	47,71055808		46,23064123	48,47968513		47,64086602	47,96215531		50,54501828	56,30612439		2,151895002	47,18755657	

These are the results of the statistical analysis on the correlation between imbalance costs and day-ahead quantities.

	IMBALANCES COSTS - DAY-AHEAD QUANTITY																	
	CNOR			CSUD			NORD			SARD			SICI			SUD		
	Imbalance costs	Day-ahead q.	Correlation index	Imbalance costs	Day-ahead q.	Correlation index	Imbalance costs	Day-ahead q.	Correlation index	Imbalance costs	Day-ahead q.	Correlation index	Imbalance costs	Day-ahead q.	Correlation index	Imbalance costs	Day-ahead q.	Correlation index
Total			0,10003782			-0,169616552			-0,045354577			0,380512535			0,659659097			-0,07113052
2013			-0,238570346			-0,571562338			-0,199752521			0,244006328			0,094307509			-0,36711725
January	15,43832152	3492,373981		60,0695318	5491,234444		66,17735144	18266,14013		122,8184058	1238,484359		159,1056262	2446,415294		1,849636295	2763,059438	
February	44,49016751	3447,530299		38,20911368	5369,430302		60,2426052	19205,24499		127,1734097	1450,724234		142,1900764	2524,40901		2,188428724	2855,649394	
March	64,27475178	3247,962871		61,9419958	5001,885176		78,30627725	18397,19039		139,570413	1419,511365		163,4762006	2226,052823		1,329612904	2760,444327	
April	77,19584635	2991,942125		76,42732793	4591,64151		88,06372351	17051,55065		126,2620335	1423,706636		155,2036933	2080,473854		12,24992875	2635,98799	
May	113,0996487	3135,123054		105,9212204	4744,544844		119,7512588	17035,1783		139,7157778	1377,788161		140,9704772	2032,715101		23,40143852	2713,049266	
June	104,5359545	3314,197789		100,6163611	4971,637093		119,3644207	17835,38476		133,7411857	1109,359158		148,5288324	2103,503231		6,55842807	2951,416175	
July	54,53006381	3534,963741		24,75344276	5614,857544		84,40170748	19581,53856		129,093733	1128,707444		139,3203887	2390,782027		4,445871699	3459,272423	
August	34,38393002	3038,695163		56,04645802	5162,298415		67,08957318	15527,61304		131,7479328	1232,975582		142,2578234	2387,240566		2,67660445	3274,663618	
September	88,60954932	3257,657201		41,88818983	5021,501122		60,22242284	17955,74637		127,1789337	1161,827893		152,8964943	2127,687624		2,893160803	2996,078018	
October	91,74086133	3195,26143		36,03893477	4851,872297		54,91997231	18111,99814		131,6672452	1114,671122		141,3436294	1933,552668		2,146962122	2965,201406	
November	81,79254037	3290,758499		61,97686207	4904,777246		76,10024065	18091,99576		126,266131	1091,392265		139,7827802	2031,951575		3,52872865	2860,203803	
December	23,00169306	3132,067466		79,98194226	5027,312038		94,67270164	17484,77032		130,2450259	1189,931758		143,0172017	2202,557934		3,596992081	2955,978382	
2014			0,158334347			-0,0111314			0,009198234			-0,559224055			0,047566893			-0,437764292
January	22,241655	3209,169573		87,63359009	5027,837188		99,57123738	18256,5425		134,4435539	1237,850026		143,308556	2193,914731		7,512738346	2929,518122	
February	52,73345917	3223,331125		130,3404938	4950,561253		83,32426755	19047,52965		136,5562027	1322,650749		146,573903	2143,491891		2,562557007	2959,852162	
March	36,32369915	2997,036327		111,5559068	4672,226997		82,67986144	18276,81388		137,7919894	1374,632489		146,3224968	2014,12521		5,941655245	2924,095164	
April	23,61222168	2727,950676		75,59929529	4131,094736		88,54788757	17259,56363		120,0961903	1315,092476		131,4425404	1902,730831		10,14618367	2772,771915	
May	39,5051357	2778,487827		80,72143032	4254,635647		84,64738336	17452,27551		120,0694927	1375,325961		139,9326394	1908,83579		4,690765646	2787,280022	
June	51,08675343	2803,432099		74,86489978	4483,573957		67,97952854	18624,18016		127,839756	1362,056496		144,7516844	2063,596213		4,680246526	3200,328753	
July	23,28925046	3000,157546		40,84690014	4724,085808		61,19976343	19461,89592		117,6749496	1472,249313		133,2939105	2287,672206		1,972358823	3352,644218	
August	32,99556842	2593,432664		56,96490573	4402,568993		75,02727963	14751,52445		120,0700587	1524,203429		130,1446922	2362,065019		4,980278218	3037,787173	
September	34,16816302	2759,814193		38,19899895	4455,579951		68,75490861	18614,95231		123,2874827	1218,0116		139,688808	2089,237031		6,532501288	3032,8808	
October	35,04313736	2592,56262		58,8889961	4194,868161		69,8199367	18678,62282		138,3020368	1325,965338		137,6678826	2049,545158		5,226331328	2926,698575	
November	66,08798576	3250,339306		-83,48603097	4966,450263		72,62961861	17767,66515		137,8778042	1007,502057		137,3924673	1770,225154		3,064451244	2808,682346	
December	28,7772502	3525,269788		91,21369668	5431,721414		56,28819575	16396,97332		135,2304262	1095,7633		121,2009501	1936,168884		4,606287227	2847,49089	
2015			0,133604029			-0,361442302			-0,450711624			0,6100443			0,008569261			0,591489983
January	18,13751524	3722,667144		62,10280683	5738,58844		51,91080841	17060,77053		128,2410051	1135,126085		48,48150772	1944,284747		0,860380623	2902,604698	
February	31,41549874	3544,020519		39,09446108	5525,283393		56,95940529	18654,62644		120,237994	1067,441263		62,01407467	1981,269049		1,269958451	3056,826951	
March	45,13406766	3239,182725		39,69327851	5048,581481		51,77082829	18123,16031		118,5294633	1037,108921		62,0157035	1803,205952		0	3076,781504	
April	14,77510605	3055,788797		50,20096608	4694,096424		60,98365727	16926,39728		128,5861993	978,5375972		59,05746705	1610,901813		1,340281693	2930,953761	
May	21,75476135	2879,624484		87,36978595	4650,554427		60,64219811	16790,00006		19,00066179	953,0274422		59,86999272	1619,780117		1,196050751	3209,386859	
June	1,512167305	3204,754492		61,81971311	5105,482715		46,23064123	17992,93957		47,64086602	1013,132669		50,54501828	1605,53406		2,151895002	3507,716294	