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Master of Science in Energy Engineering for an Environmentally Sustainable World

ANALYSIS OF RES SUPPORT MECHANISMS AND TECHNICAL IMPACTS TOWARDS GRID PARITY IN GERMANY, ITALY AND SPAIN

Master Graduation Thesis
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Abstract

Support schemes have been put into force to enhance the electricity production from renewable energy sources (RES), under the lines of the EU Directive 2009/28/EC. The countries studied in this Thesis, where the highest deployment has been achieved during the last years, and the most promising developments are expected, were Germany, Italy and Spain. Throughout the issuance of the National Renewable Energy Action Plans, each of the stated Member States has set the local policy instruments to promote the development of RES generation along their territories, with mechanisms as *feed-in tariffs*, *quota obligation*, *net metering* and many others, in order to fulfill the EU 2020 targets, and with the main objective of supporting the technologies throughout the development stage until reaching the competitiveness in the market, which is known as *grid parity*. Accordingly, the grid parity of photovoltaics (PV) would be reached first in Italy around 2013, thanks to the higher irradiance factors and higher electricity prices and then, spread to Spain and Germany before 2020. The analysis, focused on the technical and economical effects of the high penetration of RES at local and regional level, pointed out the considerable amount of growth of RES fed Dispersed Generation (DG),in contrast to the distribution network development. This case is observed in Italy due to the unexpected installation of a huge quantity of PV power in year 2011, due to the previous incentive scheme (IV Conto Energia), instead of the planned schedule. The Thesis was concluded with a sharp analysis of the sensible market parameters affecting the grid parity and the effects of overcoming the present barriers on a possible future balanced scenario. Italian PV market was the reference for this sensitivity analysis, considering that it is the market where grid parity could be reached sooner.

Key Words: renewable energy sources (RES), photovoltaics (PV), wind energy, support schemes, incentive mechanisms, Germany, Italy, Spain, European Union (EU), feed-in tariffs, grid curtailment, grid parity

I meccanismi di sostegno sono stati messi in vigore per aumentare la produzione di energia elettrica da fonti energie rinnovabili (FER), sotto le linee guida della direttiva UE 2009/28/CE. I paesi studiati in questa Tesi, dove il maggiore sviluppo è stato realizzato nel corso degli ultimi anni, e le prospettive future sono promettenti, sono stati la Germania, Italia e Spagna. Durante l'emissione dei Piani di Azione Nazionali delle Energie Rinnovabili, ciascuno degli Stati membri indicati ha emesso gli strumenti di policy locali per promuovere lo sviluppo della produzione di FER sul proprio territorio, con meccanismi come *feed-in tariff*, *quota obligation*, *scambio sul posto* e molti altri , al fine di raggiungere gli obiettivi del 2020, e con l'obiettivo principale di sostenere le tecnologie fino a raggiungere la competitività sul mercato, anche nota come *grid parity*. Di conseguenza, la grid parity del fotovoltaico (FV) sarebbe stata raggiunta prima in Italia intorno al 2013, grazie ai fattori di irraggiamento superiori, e ai prezzi dell'energia elettrica, e poi, diffusa in Spagna e in Germania prima del 2020. L'analisi, concentrata sugli effetti tecnici ed economici della penetrazione delle FER a livello locale e regionale, ha sottolineato la notevole quantità di crescita di FER alimentati da Generazione Dispersa (GD), in contrasto con lo sviluppo della rete di distribuzione. Questo caso si osserva in Italia, a causa dell' installazione di una quantità enorme di energia fotovoltaica nel 2011, in conseguenza del regime d'incentivo precedente (IV Conto Energia), ben altro il programma previsto. La tesi si conclude con un' analisi dei parametri sensibili di mercato che interessano la grid paritye gli effetti di superare le barriere presenti su un possibile scenario di futuro. Il mercato italiano del fotovoltaico è stato il riferimento per questa analisi di sensitività, visto che è il mercato in cui la grid parity potrebbe essere raggiunto prima.

Parole chiave: fonti energie rinnovabili (FER), fotovoltaico(PV), energia eolica, regimi di sostegno, meccanismi d'incentivo, Germania, Italia, Spagna, Unione Europea (UE), Conto Energia, mancata produzione eolica, grid parity

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List of Abbreviations

AEEG	Electric Energy and Gas Authority (Autorita per l'energia elettrica e il gas, Italia)
BAU	Business as usual
BDI	Federal Association of German Industry (Bundesverband der Deutschen Industrie e.V)
BEE	The German Renewable Energy Federation (Bundesverbandes Erneuerbare Energien)
BioKraftQuG	Biofuels Quota Act
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit)
BMWA	Federal Ministry of Economics and Labour (Bundesministerium für Wirtschaft und Arbeit)
BNetzA	Federal Network Agency (Bundesnetzagentur)
BOE	Official State Bulletin (not official journal)
BWE	The German Wind Energy Association (Bundesverband WindEnergie e.V)
CAPEX	Capital Expenditures
CCP	Consideration for the correct prevision (Corrispettivo per la corretta previsione)
CECRE	Central Control for Renewable Energy
CEI	Italian Electrotechnical Commission
CHP	Combined Heat and Power
CNE	National Commission of Energy
CSP	Concentrated Solar Power
DG	Dispersed Generation/Generators
DN	Distribution Network
DSO	Distribution System Operator
DTCR	Dynamic Thermal Circuit Ratings
EC	European Commission
EEG	The Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz)
EEWarmeG	The Renewable Energies Heat Act (Das Erneuerbare-Energien-Wärmegesetz)
EEX	European Energy Exchange
EnEV	Energy Saving Ordinance (Energieeinsparverordnung)
EnWG	The German Energy Industry Act (Energiewirtschaftsgesetz)
EPC	Engineering, Procurement and Construction
EPEX	European Power Exchange
EPIA	European Photovoltaic Industry Association
EU	European Union
EWEA	European Wind Energy Association
FIT	Feed-in Tariff
FRT	Fault Ride Through
GC	Green Certificate
GCC	General Coordination Center
GDP	Gross Domestic Product
GFEC	Gross Final Energy Consumption
GH	Greenhouse
GME	Gestore dei Mercati Energetici
GSE	Gestore Servizi Energetici
HV	High Voltage
ICT	Information and Communication Technologies
IPR	Interface protection Relay
IWES	Fraunhofer Institute for Wind Energy and Energy System Technologys
KraftNAV	Power Plant Connection Decree (Kraftwerks-Netzanschlussverordnung)
KWKG	Combined Heat and Power Act (Kraft-Wärme-Kopplungsgesetz)
LCOE	Levelised Cost of Electricity
LTL	Line Thermal Limit
LV	Low Voltage

LVFRT	Low Voltage Fault Ride Through
MD	Ministerial Decree
MGP	Day-ahead market (Italy)
MiSE	Economic Development Minister (Ministero dello Sviluppo Economico)
MIBEL	Iberian Electricity Market
MIET	Minister of Industry, Energy and Tourism
MPE	Mancata Produzione Eolica (Wind Curtailment in Italy)
MSD	Ancilliary Sevices market (Italy)
MV	Medium Voltage
NABEG	Grid Expansion Acceleration Act (Netzausbaubeschleunigungsgesetz)
NPV	Net Present Value
NREAP	National Renewable Energy Action Plan
O&M	Operation and maintenance
OPEX	Operating Expenditures
OTC	Over-the-counter
PREFO	Register of reassignment payment for photovoltaic technology
PS	Primary Station
PUN	Unique National Price (Prezzo Unico Nazionale)
PV	Photovoltaics
R&D	Research and development
RD	Royal Decree (Spain)
RE	Special Regime (Régimen Especial)
REE	Spanish Electrical Network
REP	Plan of Renewable Energy
RES	Renewable Energy Sources
RES-E	RES-Electricity
RES-H	RES-Heating
RES-T	RES-Transportation
RIPRE	Administrative remuneration pre-assignment register
RVC	Rapid Voltage Change
SCADA	Supervisory Control And Data Acquisition
STMD	Soluzione Tecnica Minima di Dettaglio
StrEG	Electricity Feed Act (Stromeinspeisungsgesetz)
SVV	Supply Voltage Variation
TICA	Integrated text for active connections (Italy)
TN	Transmission Network
TO	Tariffa Omnicomprensiva
TSO	Transmission System Operator
QO	Quota Obligation
UCTE	Union for the Coordination of Transmission of Electricity
VDN	Association of German Network Operators (Verband der Netzbetreiber)

CHAPTER 1

INTRODUCTION

1. INTRODUCTION

Energy is considered to be the primary necessity for society, as crucial as food and water. This is the reason why the well-being of the people depends on a safe, secure, sustainable and especially, from a customer point of view, an affordable energy supply. While providing this necessity, another important challenge is to come up with practical solutions for global warming by decreasing the energy related to green house emissions. Following these facts, the energy challenge is one of the greatest concerns in Europe today. From competitivenesspoint of view, for the energy market and energy security of Europe, crucial decisions and corresponding actions are required to be taken in order to tackle the rising energy prices and to reduce the dependence on energy imports. It is obvious that the time needed to reach a full sustainable and competitive energy system, takes decades. However, in this way, the decisions should be set immediately in order to enable the process within the energy market. Postponing these decisions would bring concerning consequences for the society, in terms of higher costs and security.

There are many options in the European energy mix and many of them can be target sources, when the future energy supply is planned. Among these sources that are present in Europe, and depending mostly on the geographical locations, RES have the priority given by the authorities, due to its clean and sustainable way of energy production. This preference on going through the development of renewable energy has been done and regulated in the EU by the energy policy framework. Their aim to foster the improvements for renewable energy technologies and to increase their share in the primary energy mix are the most significant and promising solutions for fighting against the global warming and reaching the competitiveness. Regarding sustainability, there would be other options such as developing the non conventional fossils sources, like the promising shale gas, which is the future of fossil fuels, or investing more on nuclear power. But the lacks of fossil reserves or nuclear capacity are not the reasons for the action taken in favor of renewable energies. On the contrary, in spite of developing the high potential of shale gas in Europe and being able to apply the best technology for nuclear power plants, Europe has chosen the path through the RES.

Regarding the mechanisms and the framework to reach the RES development, this study will start with an overview on European Directive 2009/28/EC in which the energy targets for 2020 and the responsibilities of the countries were clearly defined. After the publication of the directive, all the countries have published their action plans with the objective of fulfilling the requirements stated in the European Directive. In the present report, the target countries (Italy, Germany and Spain), that are going to be analyzed in terms of RES support schemes, are determined based on the RES penetration level and the achievements in terms of the acceptance into the existing systems. These three countries are going to be analyzed separately by studying the market maturity and the actions taken for supporting the deployment of renewable energy.

For the purpose of integrating renewable energy systems, one of the areas that require improvements is the current energy market. When a high penetration of the RES into the system is being witnessed, security of supply and fair competition are laid on the line of the market functioning. With the aim of integrating this new business, the priority will be focused on a market reform. In the current paper, some concerns and issues will be addressed with the aim of understanding the possible regulations for driving this market adequacy and foster a higher RES integration. By applying new policies at European level, the purpose would be to ensure that consumers are treated as a priority, in a society where people can enjoy of their rights and can be provided with the highest level of energy quality, safety and security.

As being non-competitive technologies, the renewable energy plants and the investments are not able to survive financially without necessary support mechanisms. By extension, all the countries have regulated their support schemes in order to foster each renewable technology to reach the technical and market maturity, which will lead them to be self-sustainable. In this content, the support schemes differ from each other depending on the country and the type of sources. Today, the most advanced support schemes are observed in Germany and many of the other European countries have implemented the German model in order to incentivize the RES growth. The significant key idea of the incentives should be allowing each technology to a progressive improvement towards the competitiveness or so-called *grid parity*. At the same time of focusing on the improvements to reach *grid parity*, the implemented policies have also to be given the same importance. Today, many of the world's most advanced renewable energy companies are located in Europe. This fact allows Europe to be in the world leadership market position, providing its members an economical growth and strength that is desired to be kept by the governments.

Regarding the effects of RES integration, this study describes the possible technical impacts and inappropriate results that the target countries can face due to the high RES penetration into bothTN and DN. Among the technical problems, the present work points out the consequences of the support mechanisms which may cause unbalanced high penetration from renewable producers to the grid in certain locations. Throughout this analysis, many questions arise due to the criticism of the existing grid codes (designed for conventional plants) and the adequacy of such codes to the RES presence into the network, remarking if they are required to be adjusted accordingly or kept as they are.

After presenting all the features related to RES about the electricity market, policy regulations, support mechanisms, access to the grid and corresponding technical impacts, the purpose of the work is to combine the stated features and comment on possible barriers stemming from the implementations and their effects towards reaching the competitiveness. By studying the sensitivity of those barriers, in a quantitatively assimilation into a competitiveness feasibility model, it will be investigated if *grid parity* can be delayed or accelerated. Accordingly, the significant key factors to be implemented are determined after the sensitivity analysis. These key factors are already considered in the action plans of the regulators and are known as the successive implementations needed for the network development. While in some countries they are already implemented, in the others they are still waiting for the related policy regulation.

CHAPTER 2

2020 EU ENERGY POLICY AND NREAPs

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2.1. THE EU ENERGY POLICY

When economic growth is considered to be supported on one key industry, energy emerges as the first option. The entire development and sustainability of a region depends on a safe and secure supply of energy.

In the EU, many energy policies have been put in force in order to guarantee a common objective for the entire region: the assurance of a continuous supply of energy services and products on the market, being affordable for all consumers from all sectors and keeping in mind the global warming issue.

But the central objectives of the last energy policy are focused on three main topics: *security of supply, competitiveness and sustainability*. These were the goals laid down in the Lisbon Treaty[1].

Although it is considered that some progress towards the meeting of these objectives has been achieved, energy systems in Europe are adapting very slowly and with many barriers, producing new challenges in an unfavorable economic context for the region.

For the upcoming 10 years, in order to face this challenges and changing energy requirements, to diversify the existing sources and replace infrastructure, it is considered that investments are going to be of the order of €1 trillion for the entire region. The main challenge for the EU is to reduce the fossil oil dependence, and for the electrical sector, the called "age" problem, which has been determined since the last boom for construction of conventional and nuclear power plants in the 80s, when many gas-fired and coal facilities have started to be built up.

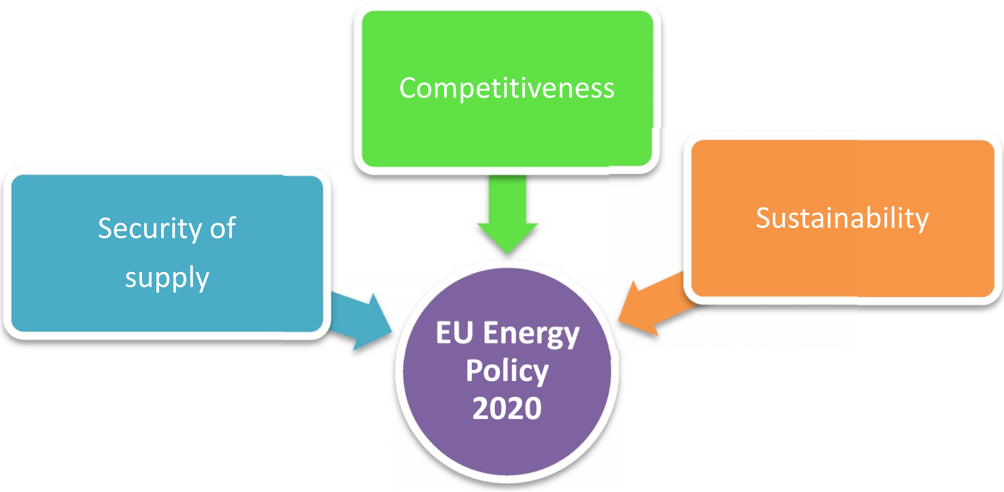


Figure 1 – EU Energy Policy objectives laid down in the Lisbon Treaty, Art. 194 of the TFUE.

[1] Lisbon Treaty of 13 December 2007, and entered into force on 1 December 2009. Article 194 of the Treaty on the functioning of the European Union (TFUE).

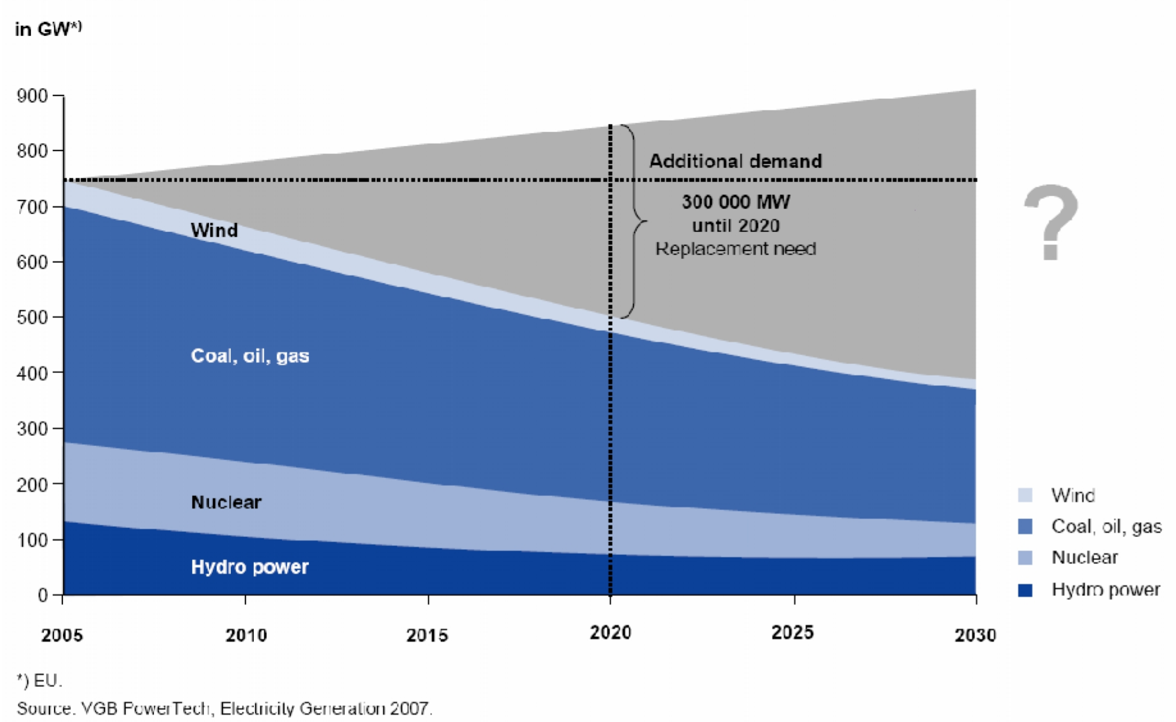


Figure 2 - Development of EU power generation mix towards 2020

EU policy efforts are in context with the scenario described in the figure 2, for the case of the electrical energy sector. Not only a demand in constant growth, but as well, a need of diversification of the generation mix (towards the use of RES and reducing the fossil oil imports dependence) and the replacement of the obsolete facilities. Thus, in this particular case, the sector demands a policy framework that supports decisions aiming to direct a sustainable growth for the same.

2.2. THE 20-20-20 ENERGY AND CLIMATE PACKAGE

In response to the real energy challenges described above (both in regards to sustainability and emissions of greenhouse gases, security of supply and dependence on their imports, and the competitiveness and full completion of the internal energy market), the EU has defined an energy policy as a common framework for all Member of State.

Throughout this new energy policy, the EU aims to develop the energy industry at the same compass of the economical growth, under a strategy for "smart, sustainable and inclusive growth, in support of a strong, diversified and competitive industrial base[2]", thus, in this way, reaching a high competitiveness for all the stages of the industry value chain. For this purpose, the new policy focuses on five priorities:

2.2.1. Priority 1: Reducing the emissions of greenhouse gases

The energy consumption causes 80% of emissions of greenhouse gases in the EU. Determined to fight climate change, the EU has committed to reduce their domestic emissions by at least 20% by the year 2020. In addition, it was considered that in a previous international agreement, the developed countries had committed to reduce their emissions by 30% of

[2] EC's communication "Energy 2020 — A strategy for competitive, sustainable and secure energy".COM (2010) 639 final of 10 November 2010.

greenhouse gases by 2020. In that agreement, the EU would set a new goal of reducing its own emissions by 30% over 1990. These objectives are the cornerstone of the Community strategy to limit climate change. Reducing emissions of greenhouse gases means to use less energy and using more clean energy. This priority would be carried on by policies frameworks focused on three strategic indexes of the energy sector:

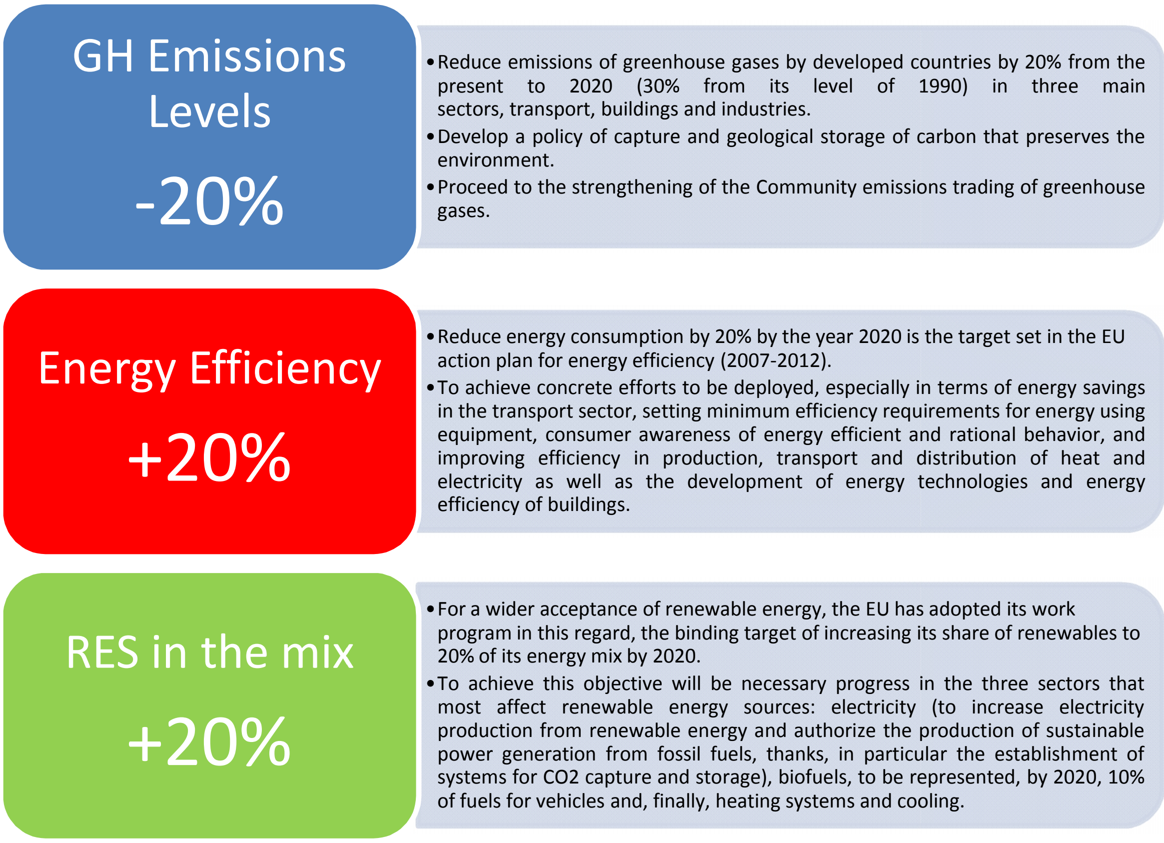


Figure 3 – Greenhouse emissions reduction policy for the 20-20-20 Energy and Climate package.

The use of renewable energies (wind, solar and photovoltaic, biomass and biofuels, geothermal heat) undoubtedly contributes to limit climate change. Moreover, also promotes energy security and growth and job creation in Europe, thanks to increased production and consumption of local power. The RES remain marginal in the European energy mix, as their cost continues to be higher than traditional energy sources. Thus, the EU policy supports the national development of the RES industry throughout special action plans, in order to promote the technologies until reaching the competitiveness and market maturity in what is called the "grid parity".

2.2.2. Priority 2: Building a truly pan-European integrated energy market

The internal energy market depends crucially on the reality of cross-border energy trade, often complicated by differing national technical standards and an uneven meshing of networks. An EU-wide effective regulation is needed, in particular, to harmonize the powers and independence of energy regulators, to strengthen their cooperation, to force them to consider the EU objective of completing the internal market for energy and to define at Community level and technical regulatory aspects as well as common security standards necessary for cross-border.

To realize the European energy network, the priority interconnection plan stresses the importance of political and financial support for the implementation of infrastructure that are considered essential, as well as the appointment of European coordinators to follow the most problematic priority projects.

2.2.3. Priority 3: Achieving the highest level of safety and security of supply

A priority is to limit the vulnerability of the EU on imports, interruptions in supply, potential energy crises or the uncertainty about future supplies. This uncertainty is more problematic for those Member States that depend on a single gas supplier. Thus, the new energy policy emphasizes the importance of mechanisms to ensure solidarity between Member States and the diversification of supply sources and routes.

Mechanisms will strengthen strategic oil reserves and explore the possibilities of improving the security of gas supply ensuring greater security of electricity supply, which remains essential.

2.2.4. Priority 4: Extending Europe's leadership in energy technology and innovation

Energy technologies will play a key role in reconciling competitiveness and sustainability of energy, at the same time reinforcing security of supply. They are also essential for achieving the other objectives on energy.

World leader today in the renewable energy sector, the EU intends to consolidate that position and also impose on the growing market of energy technologies of low carbon. Thus, the EU should develop energy-efficient technologies existing and new technologies, especially those aimed at energy efficiency and renewable energy. Although the EU carries out a considerable diversification of its energy mix, it will continue to rely largely on oil and coal, so that it will continue to watch for fossil fuel technologies that produce low carbon and in particular, technology of carbon capture and storage.

Investments in these technologies will contribute directly to the EU strategy for growth and employment. The Commission proposes an outline for a strategic European Energy Technology covering the whole innovation process from basic research to commercialization.

2.2.5. Priority 5: Applying a common international energy policy

The EU cannot achieve by itself the goal of energy secure, competitive and sustainable. This should ensure the participation and cooperation of developed and developing countries, consumers and energy producers and transit countries. For the sake of greater efficiency and consistency, it is essential that Member States and the EU speak with one voice on international energy issues.

2.3. THE DIRECTIVE 2009/28/EC AND THE RENEWABLE ENERGY NATIONAL ACTION PLANS

Following the line of the EU energy policy previously described, and continuing with the already supported development and deployment of RES technologies, the EU has approved the 2009 Renewable Energy Directive (2009/28/EC[3]), which with the same logic, establishes a 20% of renewable energy as a target for 2020 in the EU. The directive assures that each Member State has set a target for the share of energy from renewable sources in gross final energy consumption by 2020, in line with the overall objective "20-20-20" of the European Community, and being carried out by a specific national policy to be put in force in each of the MS.

Therefore, each Member State has established a *National Renewable Energy Action Plan* (NREAP) for 2020 to determine the share of energy from renewable sources consumed (see table 1) in **transport** (RES-T), **electricity** (RES-E) and **heat production** (RES-H). These action plans have taken into account the effects of other measures relating to energy efficiency in final energy consumption. These plans have also established methods to improve the policy regulations, incentive tariffs and access to electricity networks in benefit of the energy generated from renewable sources.

Table 1 - Total contribution from RES for all 27 EU Member States. This table has been compiled based on the aggregate RES values as specified in the NREAPs (Source: ECN – Additional energy efficiency scenario).

	Energy				Share[4]	Average Annual Growth		
	2005	2010	2015	2020	2020	2005-2010	2010-2015	2015-2020
	[Mtoe]	[Mtoe]	[Mtoe]	[Mtoe]	[%]	[%/year]	[%/year]	[%/year]
RES-E	41.1	55.0	76.3	103.1	**34**	6.0	6.8	6.2
RES-H/C	54.7	67.9	84.8	111.6	**21.4**	4.4	4.5	5.7
RES-T	3.9	15.1	21.4	32.1	**11.3**	31.2	7.2	8.5
Total RESc	98.7	137.0	181.0	244.6	**20.7**	6.8	5.7	6.2

According to the submitted NREAPs by each of the members to the EC in 2010, the targets have been taken under serious responsibility and were estimated under "positive" circumstances, although the financial crisis is affecting all the sectors and mainly the industry one. While the present economic situation in the European context (and also global) requires urgent revision of the national energy policies, in order to achieve in a large extent the objectives already set, for the present study, the original targets of the respective NREAPs have been considered. Regarding the scope of the work, it will focus the goals towards the development of renewable energy in the electricity sector (RES-E).

[3] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. *http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32009L0028:EN:NOT*

[4] The share %s refer to the values in '[ktoe]' and express the share of the renewable technology in the sector over total of the final gross energy consumption ('Additional energy efficiency scenario' only).

2.3.1. The electricity sector in the National Renewable Energy Action Plans of the EU-27

According to the NREAPs RES targets (in the three sectors), the EU members would succeed and moreover exceed their original objective of reaching 20% of its gross final energy consumption from renewable sources by 2020 (actually, it would reach 20.7%). From the current 27 members of the EU, five plan to exceed its target (Bulgaria at +2.8% above its target, Spain +2.7%, Greece +2.2%, Hungary +1.7 and Germany +1.6%), other ten would meet their target, and just two Member States, Luxembourg with -2.1% and Italy with -0.9%, have officially communicated the EC that they would draw on the cooperation mechanisms to meet their national targets.

From the compilation of all the member's NREAPs, the overall 2020 EU for the EU-27 objectives can be summarized as follows:

Table 2 - RES target capacity, energy consumption and share for EU-27 in 2020 by sources according to NREAPs (Source: EWEA)

Source	Capacity [GWh]	Energy [TWh]	Share
Wind	213	494,7	14,00%
Hydro	136	370,3	10,50%
Biomass	43	232	6,70%
Solar PV	84	83,3	2,40%
CSP	7	20	0,50%
Geothermal	1.6	10,7	0,30%
Tidal, wave and ocean	2	5,8	0,20%

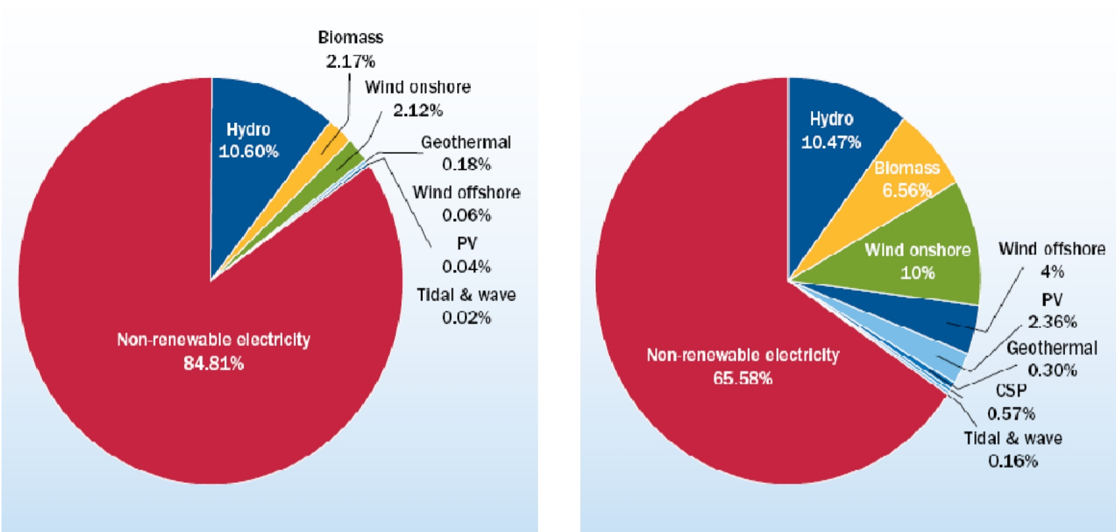


Figure 4 – Total share of electricity mix in 2005 (left) with 3270,3 TWh and in 2020 (right) with 3537,3 TWh (EU-27 in 2020 according to NREAPs). (Source: EWEA)

The technologies leading the share by 2020 are wind energy (off-shore and on-shore) with a total capacity of 213 GWh, covering 494.7 TWh of energy consumed from this source. Northern countries (strong integration of off-shore technologies), Spain, Portugal and Greece are expected to exceed the EU-27 wind energy target (14%). In the second share they are positioned hydroelectric sources, the one with more history, with a total capacity of 136 GWh and energy feed-in of 370.3 TWh, being Austria, Sweden and Slovenia the leaders in this technology. In third place, biomass technologies are with a total capacity of 43 GWh and total covered demand of 232 TWh. Leading this technology are Denmark, Finland, Netherland and Latvia. And last remarkable share is solar PV with installed capacity of 84 GWh and 83.3 TWh of energy consumed from this sources. Leading this sector, Germany, Greece, Spain, Italy and Cyprus are exceeding the EU-27 target of 2.4%. Regarding the rest of the technologies: CSP (Concentrated solar power), geothermal and tidal/wave/ocean, it is expected a further integration in the following years to 2020, in line with the 2050 Roadmap[5] EU energy policy.

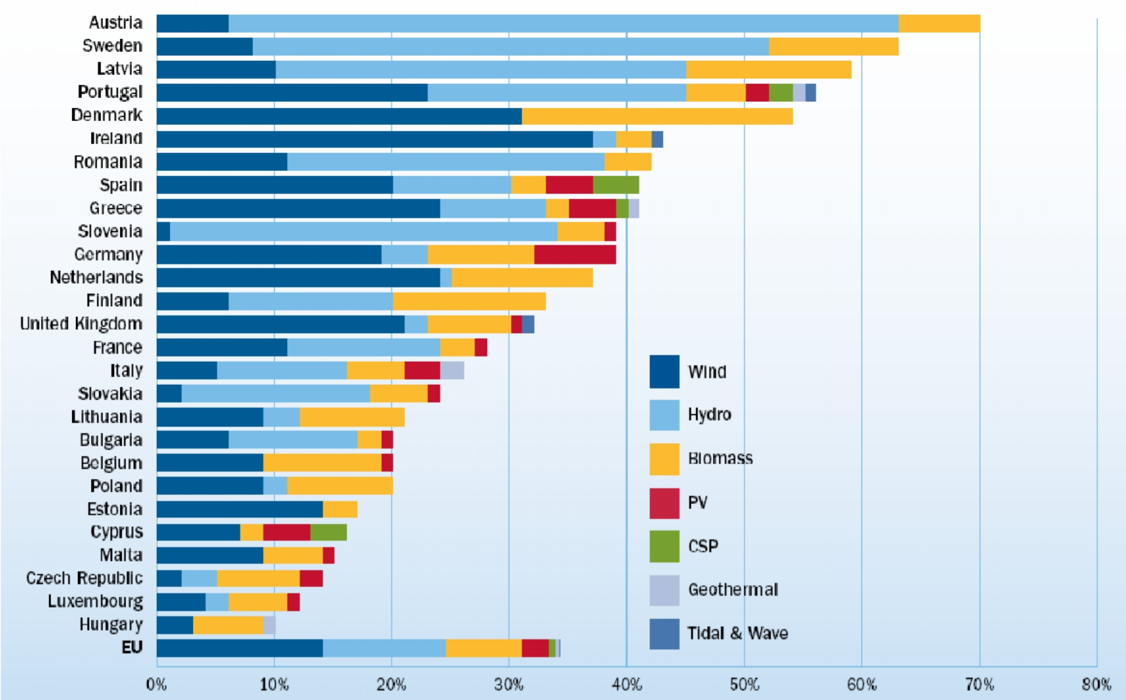


Figure 5 – RES share of electricity consumption per Member State (%) in 2020 according to the NREAPs (Source: EWEA)

Regarding the RES-E growth in the EU region from 2010 to 2020, it is expected to be reached the total of 1199 TWh of energy final gross energy consumed produced from RES (34%). The RES yearly consumed growth rate is expected to be of around 50 TWh/year in the first 5 years and increasing to above 60 TWh/year for the last 5 years until 2020, meaning a percentage growth rate of around 5%/year with respect to the previous annual estimation.

[5]On 15 December 2011, the EC adopted the Communication "Energy Roadmap 2050". The EU is committed to reducing greenhouse gas emissions to 80-95% below 1990 levels by 2050 in the context of necessary reductions by developed countries as a group. In the Energy Roadmap 2050 the Commission explores the challenges posed by delivering the EU's decarbonisation objective while at the same time ensuring security of energy supply and competitiveness. The Energy Roadmap 2050 is the basis for developing a long-term European framework together with all stakeholders.
(Source: http://ec.europa.eu/energy/energy2020/roadmap/index_en.htm)

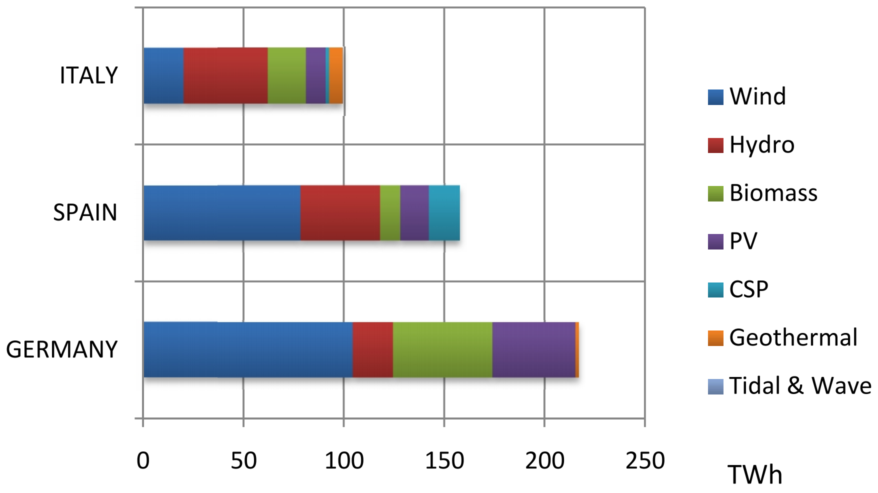


Figure 6 - RES share of electricity consumption for 3 selected countries in 2020

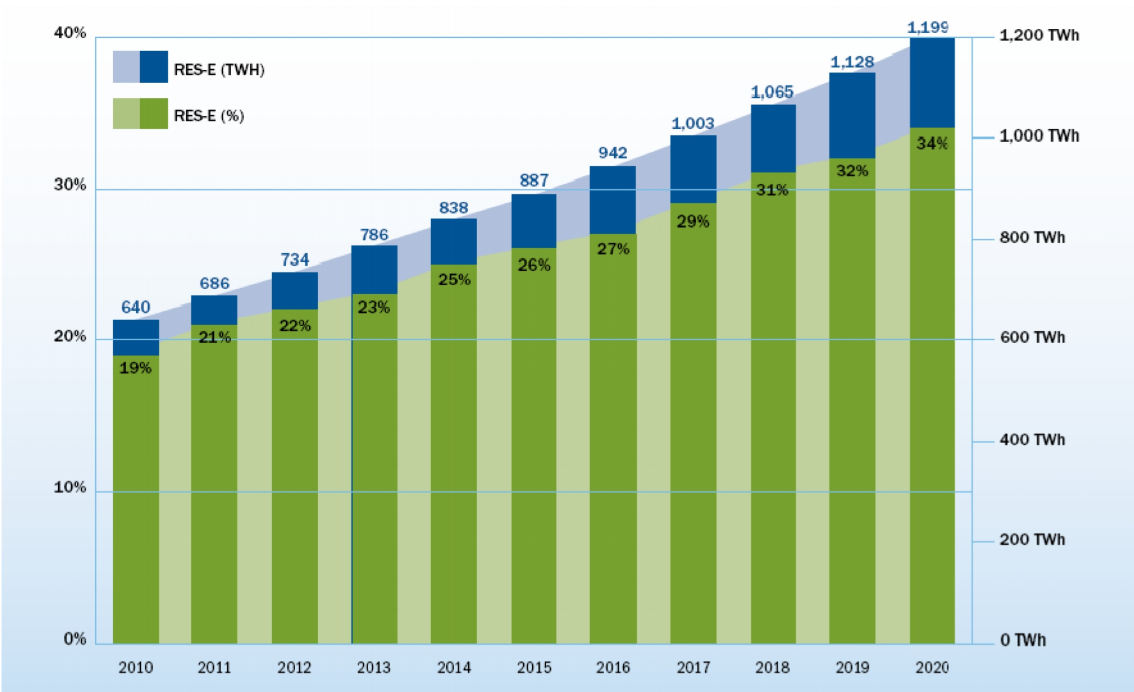


Figure 7 - Electricity production evolution from RES according to the NREAPs (EU-27) (Source: EWEA)

For the purpose of understanding the growth magnitude in terms of energy to be produced from RES in the electrical sector, by each of the Member States of the EU-27, in order to contribute to the achievement of the European targets, from the previous figure 6, it is observed that the six countries with highest energy production from RES for 2020 are Germany, in first place with (216.9 TWh), Spain in the second with 157.6 TWh, and following France, UK, Italy (99 TWh) and Sweden in respective order.

For the purpose of this work, as the Member States in scope are Germany, Spain and Italy, the three RES technologies which are going to be considered as the most important in terms of production, integration and competitiveness evolution are wind energy, biomass and solar (as shown above, PV is of importance mainly for Spain). Regarding the Hydro technologies, as they are considered to have reached technical and market maturity (this means being self-sustainable, not needing incentives or support schemes for having a profitable internal rate of return for the investors), are not going to be considered as key RES technologies to be supported towards *grid parity*.

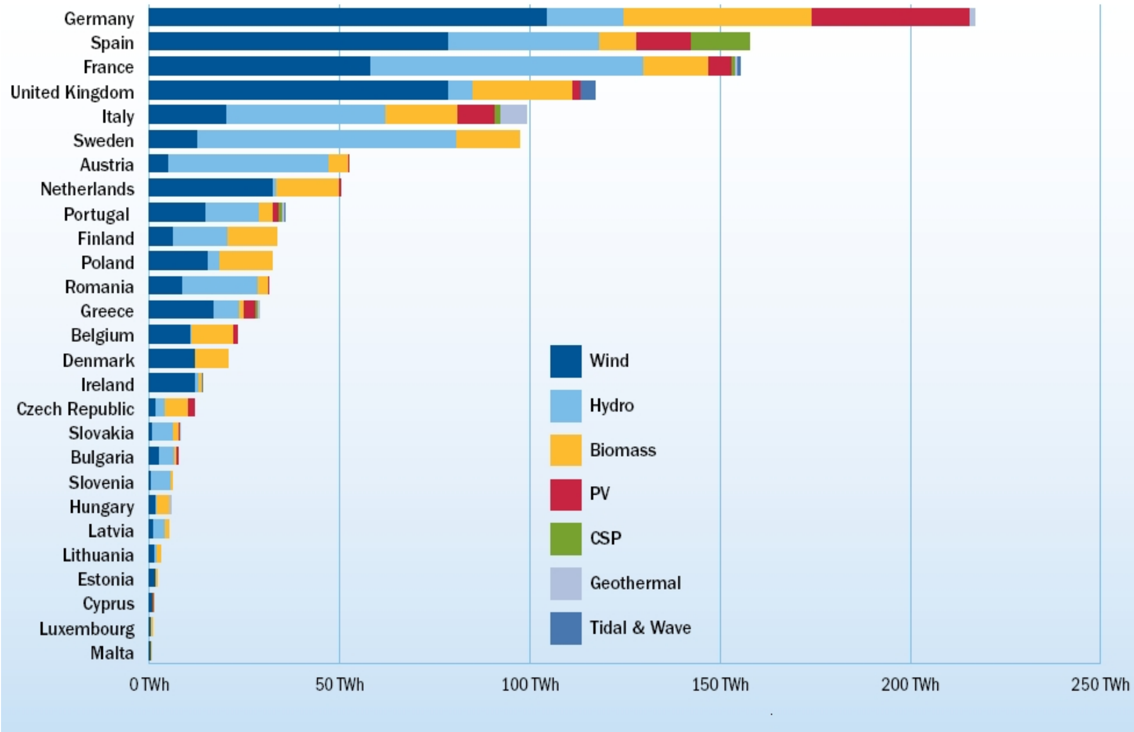


Figure 8 - RES-E total production per Member State in 2020 (according to NREAPs). (Source: EWEA)

2.4. REFERENCES

1. Lisbon Treaty of 13 December 2007, Article 194 on the functioning of the European Union (TFUE).

2. European Commission's communication "*Energy 2020 — A strategy for competitive, sustainable and secure energy*". November, 2010.

3. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.

4. http://ec.europa.eu/energy/energy2020/roadmap/index_en.htm

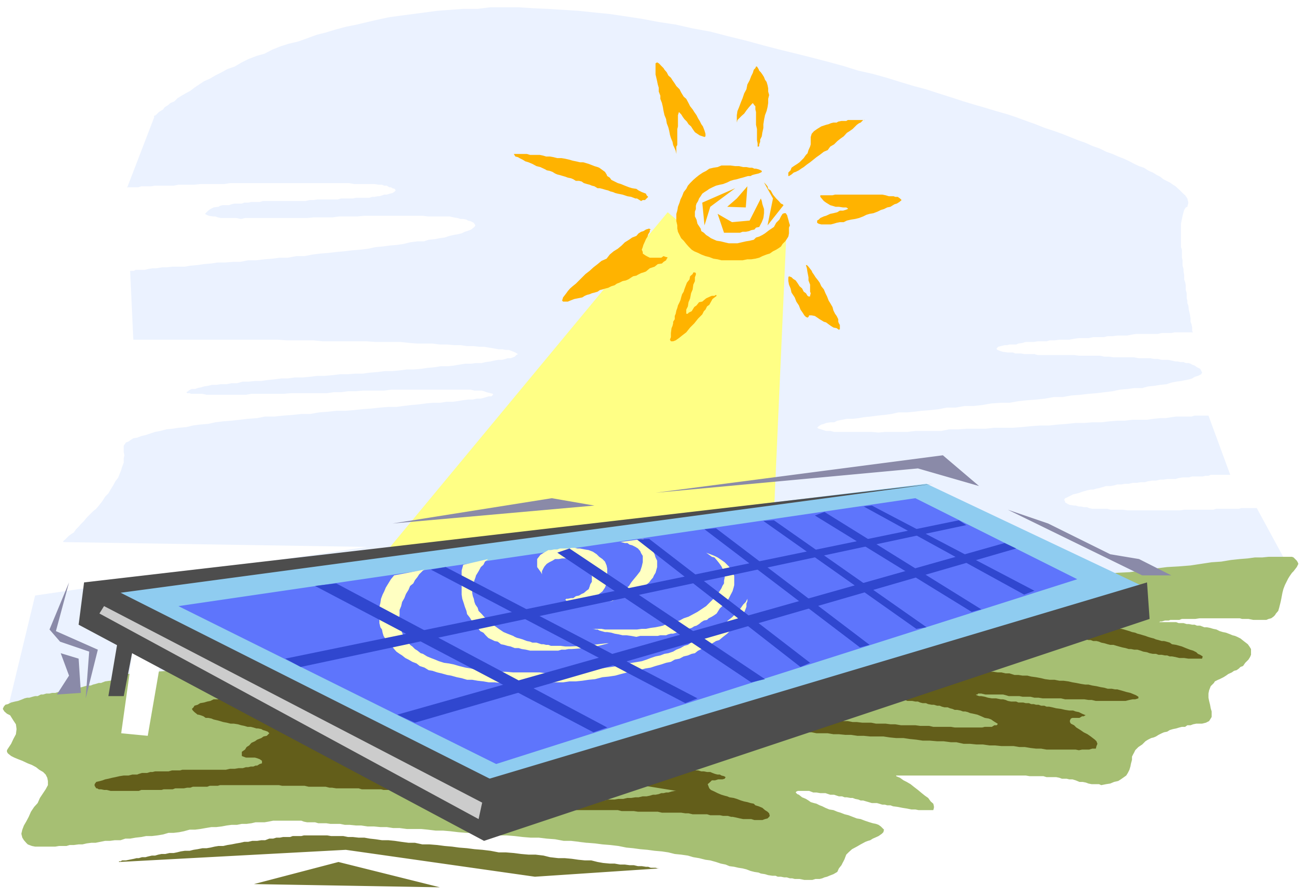
5. EWEA, "*EU Energy policy to 2050, achieving 80-95% emissions reductions*". March, 2011.

6. EWEA, "*Wind in Power, 2011 European Statistics*". February 2012.

CHAPTER 3

RES SUPPORT SCHEMES

AND ACCESS TO THE GRID



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"On 31 January 2011, the European Commission (EC) presented its Communication showing that the 2020 renewable energy policy goals are likely to be met and exceeded if Member States fully implement their NREAPs and if financing instruments are improved. It also stresses the need for further cooperation between Member States and a better integration of renewable energy into the single European market. Estimates indicate that such measures could lead to 10 billions Euros savings each year."[6]

3.1. GERMAN ENERGY POLICY REGULATION

In its Cabinet decisions of 6 June 2011 on the basis of the Energy Concept, the German government decided a comprehensive reconfiguration of its energy policy. The main concerns of this thorough reorientation are to perform an immediate phase-out of nuclear energy and, at the same time, move into the age of renewable energy.

In that way, the confirmed cornerstones are:

- Decommissioning the nuclear power plants until the end of 2022,
- Dynamic expansion of RES in all sectors,
- Rapid expansion and modernization of electricity grids,
- Improvements in energy efficiency (use of modern technologies to minimize electricity consumption)

Regarding the phase-out of nuclear energy, the Fukushima disaster led the German government to reconsider the risks of nuclear power and directed them to the side of non-nuclear production. Thus, the regulatory institution came up with a step-by-step plan with an amendment to the Atomic Energy Act. According to the plan, as it is stated before, the last nuclear power plant is planned to be disconnected from the grid by the end of 2022.

One of the most significant counter acts with respect to the decommissioning of the nuclear power plants, and resulting capacity loss on the system, is the expansion of RES, which are thought to become the main part of the future energy supply. In order to let this development, the Renewable Energy Sources Act (EEG) has been revising its version according to the situation and thus enabling electricity generation from RES to continue to rise steadily and improve the integration of RES into the market and the energy system. The latest version was published and came into force on 1.1.2012. That amendment is going to be analyzed in more detail on the following parts while mentioning about incentives. The goals of the German government in the hot topic of renewable energies are shown on the table given below.

[6]http://ec.europa.eu/energy/renewables/targets_en.htm

Table 3 - Goals of the German government (Renewables share).

	RE share in electricity	RE share in gross final energy consumption (GFEC)
Until the end of	(%)	(%)
2020	at least 35	18
2030	at least 50	30
2040	at least 65	45
2050	at least 60	60

These targets are not only for contributing to the energy supply, but also for lowering the greenhouse emissions in Germany (40 % by 2020 and by 80 to 95 % by 2050 compared to 1990).

Due to the financial support that is required in the process of the renewable development, political figures become important key agents. On the administrative level, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety [BMU][7], which are the main actors in the support of the renewables. Two other significant roles are performed by the Federal Ministry of Economics and Labour [BMWA], dealing with energy policy in general, and the Federal Ministry of Agriculture, dealing specifically with the support of the different forms of biomass. One state-related actor is the German Bank of Reconstruction and Development – KfW, which provides loans at reduced rates for investment in RES and environmental issues. The significant expansion in RES has led to the establishment of sector associations which promote RES in general such as Bundesverbandes Erneuerbare Energie [BEE], or single technologies such as the German Wind Energy Association [BWE]. Apart from that, because of the rise in the number of jobs in the RES-related industry, trade unions are also becoming involved in the policy arena.

Grid operators are responsible for the grid connection and the physical and financial coordination of the integration of RES into the system. They are represented by the Association of German Network Operators [VDN]. On the contrary, the consumers are represented by the Federal Association of German Industry [BDI], which is an important player in the political debate.

Through the way of the accelerated energy revolution, the German government has established a special "Energy and Climate Fund" in order to have a financial support. This resource will be used to fund research and development on energies and storage technologies. From 2012, the revenues coming from the auctioning of emission allowances will be paid in the fund which will have 3 billion EUR per annum at its disposal from 2013 onwards.[8]

[7] The following units are established within BMU to support the development of RES: General aspects of RES; Biomass, Geothermal, Solar Energy; Hydro and Wind Power; International Affairs of RES; RES Research and Development; Legal Aspects of RES.
[8] Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), "Renewable Energy Sources in Figures, National and International Development", July 2011

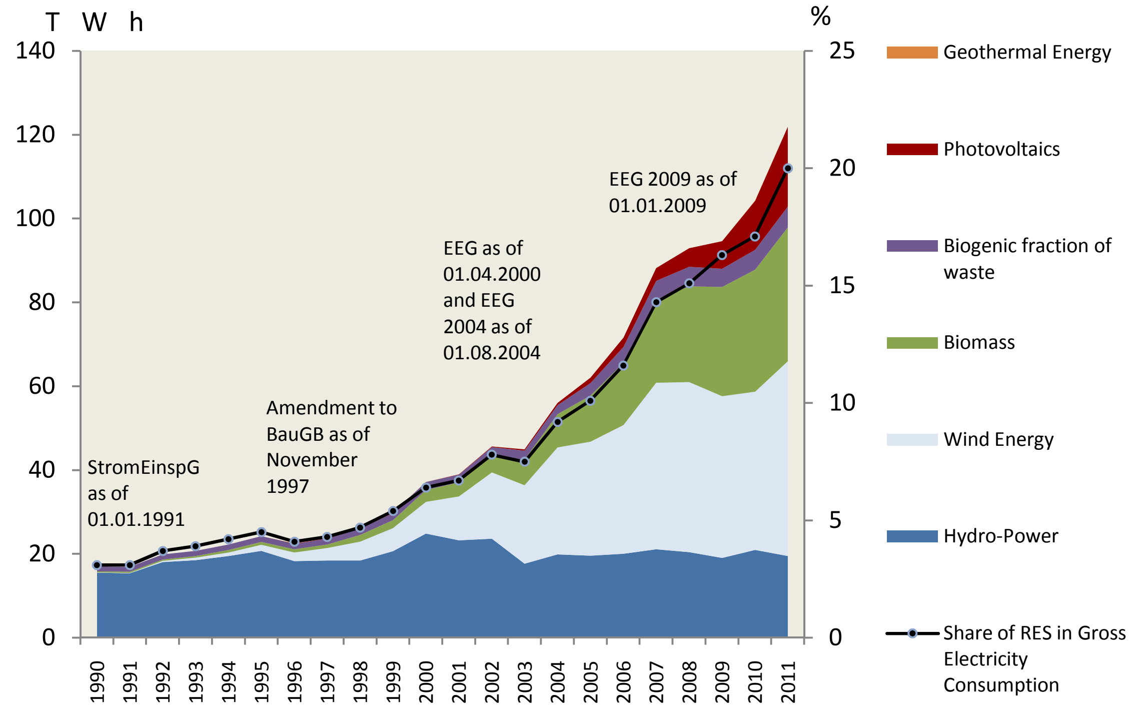

Figure 9 - Development of electricity generation from renewable energies in Germany since 1990 [9]

On the figure stated above, the renewable energy shares and their development from 1990 to 2011 is shown. These improvements on the RES are accelerated by means of the European Directive and the renewable action plan of the country. All the targets given in the beginning of this topic are derived according to the directive and the action plans for Germany as all the other member states.

3.1.1.The German National Renewable Energy Action Plan

The Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy renewable sources, which came into force in 25 June 2009, set challenging targets. After the Directive, all the member states approved NREAP. The Federal Cabinet of Germany approved the NREAP Germany on 4 August 2010. Through its extensive and detailed character, NREAP is a key document that supports its policy objectives of security of supply, climate protection, competitiveness, promotion of technology and innovation, as well as of securing and expanding employment in Germany. Due to the obligation of publishing the progress reports in every 4 years, the first progress report of 2011 was published and showed that Germany had maintained the expected development at the initial years through the way to 2020.

In this plan, the government estimates the share of RES in gross final energy consumption to be 19.6 % (the Directive's binding target is 18 %) in 2020 and the shares of RES in the electricity sector will be 38.6 %.In the light of this data, the required measures and instruments to reach the national target of 18 % have already been established.

[9] Sources : BMU on basis of AGEE-Stat

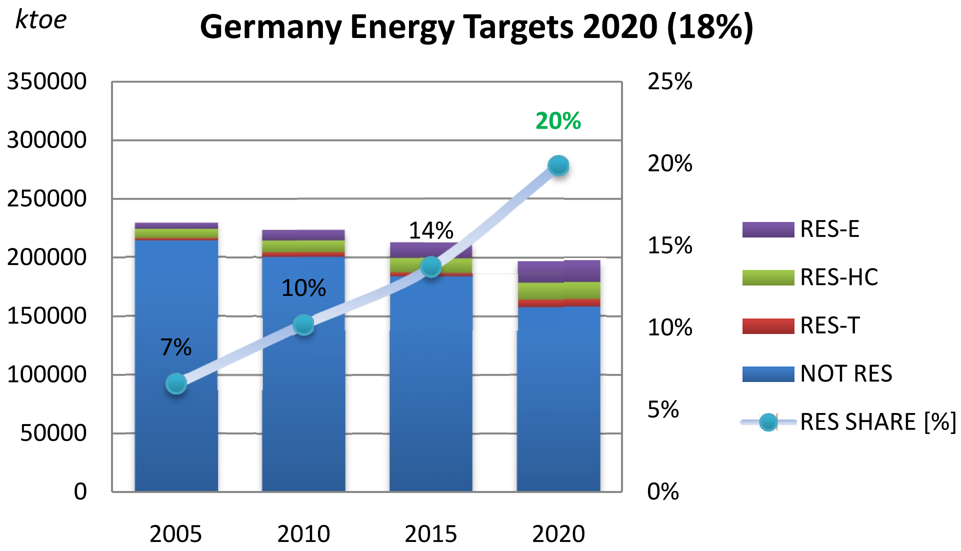

Figure 10 - German energy targets from NREAP to 2020

The table given above also shows the corresponding decrease in the gross final consumption of energy from 229092 ktoe to 197178 ktoe.[10] This is also a result of the increase in the energy efficiency which was included in the Directive's targets.

3.1.2.The RES-E towards 2020

Taking the estimated GFEC and RES share by 2020 into consideration, the estimated value for energy from renewable is going to be 35492 ktoe. The renewable sources in the sectors are categorized as heating and cooling, electricity and transport. The Federal Government has priority to satisfy the targets of the Directive, the overall national target of 18 % and the minimum target of 10 % in the transport sector.

Specifically for electricity; the share from RES in gross final consumption of energy will enhance from 2005 to 2020 from 10.2 % to 38.6 %.[11]

With regards to the regulation, in order to promote the use of renewable energy, specifically on this purpose, policies and measures were published. These policies and measures are divided into parts according to the targeted sector. For instance, EEG is aimed to increase RES in electricity while Renewable Energies Heat Act (EEWarmeG) has purpose on the heating of the buildings by RES. These policies can differ both from the targeted part of the population and activity or from type of the measure such as legislative or financial.

10 The numerical estimates are evaluated according to the scenario with additional energy efficiency (EEF Scenario) measures from the two scenarios (the other scenario is the Reference scenario).
11 Federal Republic of Germany, "National Renewable Energy Action Plan", in accordance with Directive 2009/28/EC on the promotion of the use of energy from renewable sources, p 15.

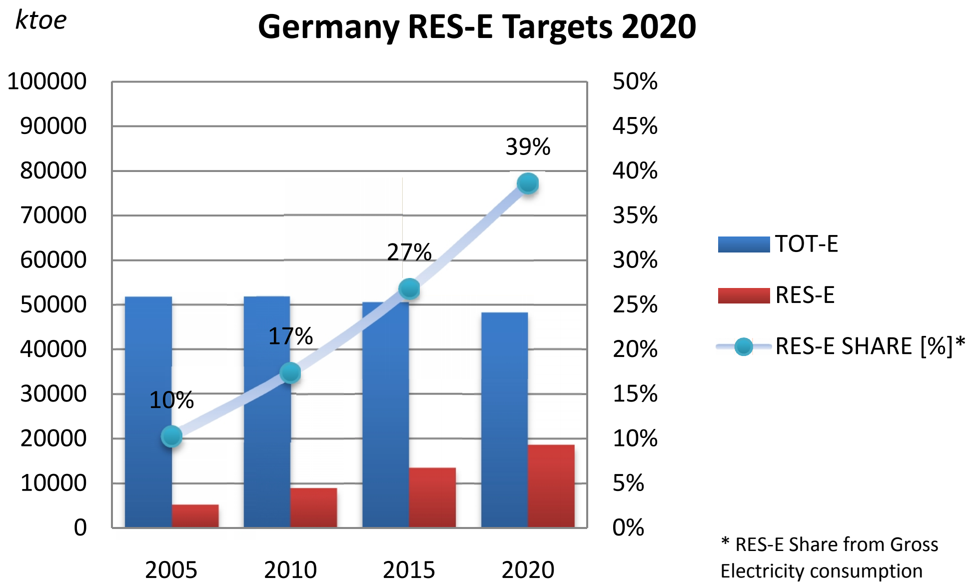

Figure 11 - German renewable energy (electricity) targets for 2020

Table 4 - Overview of all policies and measures in Germany

Name of the Measure	Type	Expected Result	Targeted group or activity	Date of start and end of the measure
Renewable Energy Act (EEG)	Legislative	Increase of RES share in electricity	Investors, private households	Start: April 2000; amendments 2004 2009, 2011, 2012. (not limited in time)
Renewable Energies Heat Act (EEWarmeG)	Legislative	Increase of RES share in heating of buildings (focus on new buildings)	Building owners	Start: Jan 2009; first revision 2011
Market Incentive Program (MAP)	Financial	Investments in RES in heating	Investors, private households	Start: 1999 financed from funds established in EEWarmeG; until 2012
KfW-funding-programs (e.g. CO2 renovation program)	Financial	Energy efficiency measures and investments in RES in buildings	Investors, private households, building owners, municipalities	Start: 1996 End of measures 2011
Combined Heat and Power Act (KWKG)	Legislative	New construction, modernization and operation of CHP plants	Power plant operators, energy suppliers, investors	Start: April 2002, amendment in Jan 2009
Energy Saving Ordinance (EnEV)	Legislative	Compliance with min. standards for energy efficiency in buildings and heating cooling systems	Building owners	Start: October 2007, current version dated 01.10.2009
Biofuels Quota Act (BioKraftQuG)	Legislative	Min. share of biofuels of total fuel put into circulation and tax incentive for certain biofuels	Companies that bring fuels on the market	Start: Jan. 2007 Duration: beyond 2020/ tax incentive for certain bioguels until the end of 2015

Among these policies, (EEG) the legislative measure related to electricity generation deals with the incentives which are assigned to certain renewable energy technologies and sources. The RES sources that are utilized to generate electricity are paid for under the EEG. Starting from 01 April 2000, the EEG electricity has become a significant part in the whole share. Due to the current need for RES (and the need to be increased until its saturation point), the EEG average fee has been enhancing during last years.

3.2. GERMAN ENERGY INCENTIVES

Through the expansion of the RES in Germany, one of the most significant figures has been the EEG which was launched in 2000 and amended successively in August 2004, January 2009, and most recently, in January 2012. This Renewable Energy Act is successor to the 1991 Electricity Feed Act (Stromeinspeisungsgesetz, StrEG), which was mainly focused on wind power.

The purpose of the EEG is to accelerate certain technologies from the renewable energy point of view and make them become self sustainable without any incentives. In this period, they are incentivized in order to attract the investors. The core element of the legislation is the duty of the grid operators to give priority to electricity generation from RES in terms of connection of the installations, purchase and transmission. General support is performed by feed-in tariff (FIT) systems for wind power, solar radiation, biomass, geothermal, hydropower and mine gas by differentiated amounts according to the market situation and the adaptation to market developments.

The FIT paid for the electricity depends on the energy source and the size of the installation. Additionally, the date of commissioning also decides the amount of the fee that the later the installation is established, the lower tariff is received.

The duration of the payment for incentives is generally 20 years which is guaranteed for all the renewables, except hydropower (15 or 30 years). The amount paid from the year of decommissioning remains constant with the exception of the situation for wind energy plants. With regard to the wind energy, special regulations are laid down. Normally the incentive is paid with two different rates: starting fee for couple of years and a lower fee at the remaining period.

Apart from the features stated, the EEG set a degression rate for the incentives which can also be seen as annual percentage of rate reduction in the fees. This degression makes the industry to improve innovative solutions in order to decrease the cost of installations.

3.2.1.Development of PV

From the 2004 law amending the EEG, PVs have been increasing significantly in the share of overall electricity consumption. The minimum fee paid for solar electricity was 37.96 ct/kWh (year of start-up) according to the 2004 amendment. The majority of the current active plants were started up in the years between 2004 and 2007 thus still they are paid accordingly. One of the most important features of the amendment in 2004 was the location-specific remuneration for the first time. The main diversification on the PVs is done according to the placement such as roof-top or on-ground installed.

In order to distinguish the difference between a roof-top and a regular layout of the PV plants on the ground, the condition in the EEG 2012 Section 33 states that buildings shall mean roofed for building structures which can be independently used and entered by humans and are primarily designed for the purpose of protecting humans, animal or objects. In this context, investors have been utilizing this bullet of the amendment by converting the parking lot buildings, barns into the green buildings, which are compatible with the statement.

Table 5 - Incentive differentiation and decrease from 2004 to 2007 (Source: EEG)

PVs	**Remuneration in ct/kWh**				
Start-up year	*2004*	*2005*	*2006*	*2007*	*1.1.2012 (last amendment)*
Installed on buildings					
Less than 30 kW	57.4	54.53	51.8	49.21	28.74
30kW to 100 kW	54.6	51.87	49.28	46.82	27.33
Over 100 kW	54	51.3	48.74	46.3	25.86
Building surface bonus	5	5	5	5	(21.56 for over 1 MW)
Not installed on buildings					
Minimum tariff	45.7	43.42	40.6	37.96	21.11

The current situation of the fees presented in the last amendment shows that the maturity for PV technology has been establishing with the successful regulation schemes since 2000.

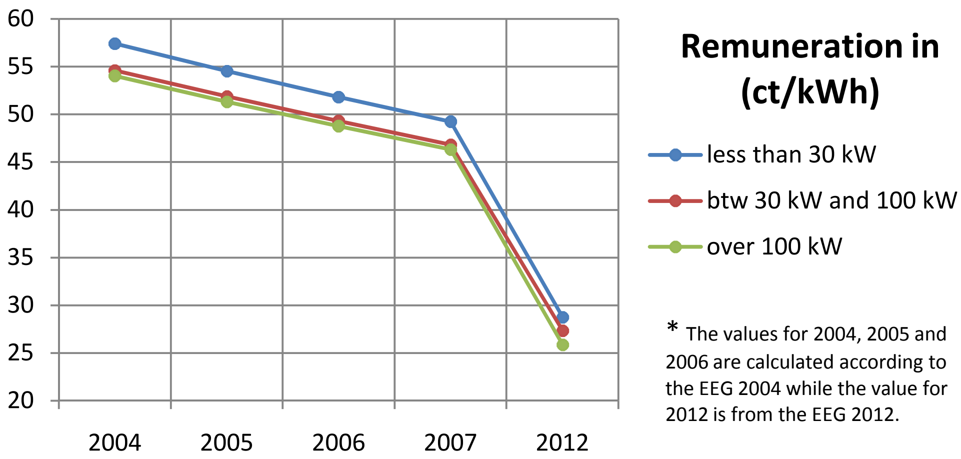

Figure 12 - Remuneration of PVs differentiated acc. to the capacity of the installations (Comparison of the first and the last amendments on the EEG)

The table figure is calculated according to 5 % of degression rate. However, it shows differences nowadays (within the EEG 2012) when the trend is compared with the 2004.

The degression rate for electricity from solar installations is adjusted on the basis of the new capacity installed each year in Germany. In the last amendment of January 2012, the basic rate for degression is given as 9 %. The determination of the degression rate which is going to be launched for the following year is done by contributing the new installed capacity within the twelve months before 30th September. The main range is between 2500 and 3500 MW which results in keeping the degression rate at the same value of 9 %. Otherwise, if this range is violated (exceeded or not fulfilled) the degression rate is increased or decreased. Through the process of the determination, by 31st October of each year, the Federal Network Agency (BNetzA) announces in the Federal Gazette the registered installed capacity, the resulting degression percentage rate and the tariffs for the following year. For instance, the BnetzA announced that the new installation capacity registered within 1st October 2010 and 30th September 2011 was about 5200 MW. Hence the degression rate will be 15 % as at the amendment of January 2012.

The incentives are given to the producer also for own consumption of electricity. The condition for this application is to use the electricity in the immediate vicinity of the installation by transmitting it via self-constructed structure but not via the public grid. To be eligible to apply the provisions on own consumption under the new EEG 2012, the installation must also satisfy the following conditions:

- It must be built between 1 January 2012 and 31 December 2013 and be attached to or on top of a building,
- The installed capacity must be less than or equal to 500 kW,
- The installation must be connected to the grid.

As the general properties of tariffs, the fee is decided by the installation's size and also the amount of own consumption. However, the value of the tariff is not comparable with the incentives for the grid usage. (16.38 ct/kWh for the share of electricity self-consumed that does not exceed 30 % and 12 ct/kWh otherwise)[12].

The following figure shows the results of the successful regulation and PV integration from 2004 until today, experienced by Germany. This increase is related to the applied policy for the renewable within EEG.

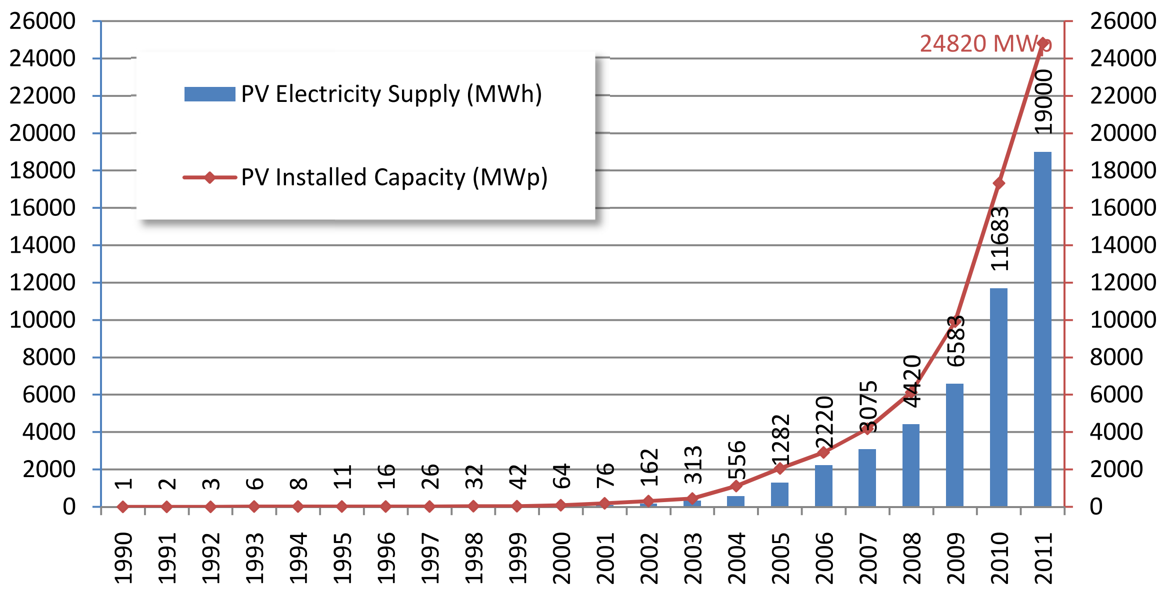

Figure 13 - Photovoltaics Development in Germany

3.2.2.Development of Wind Power

The expansion of the wind turbines was highly accelerated through the Electricity Feed Act and the EEG. More than 7 % of total feed-in of Germany is supplied from wind energy, which is a significant number and corresponds to total energy consumption of many countries in the world.

[12] Section 33-2, Act on granting priority to renewable energy sources (EEG), Gesetz für den Vorrang Erneuerbarer Energien ("Erneuerbare-Energien-Gesetz" – EEG), Consolidated (non-binding) version of the Act in the version applicable as at 1 January 2012.

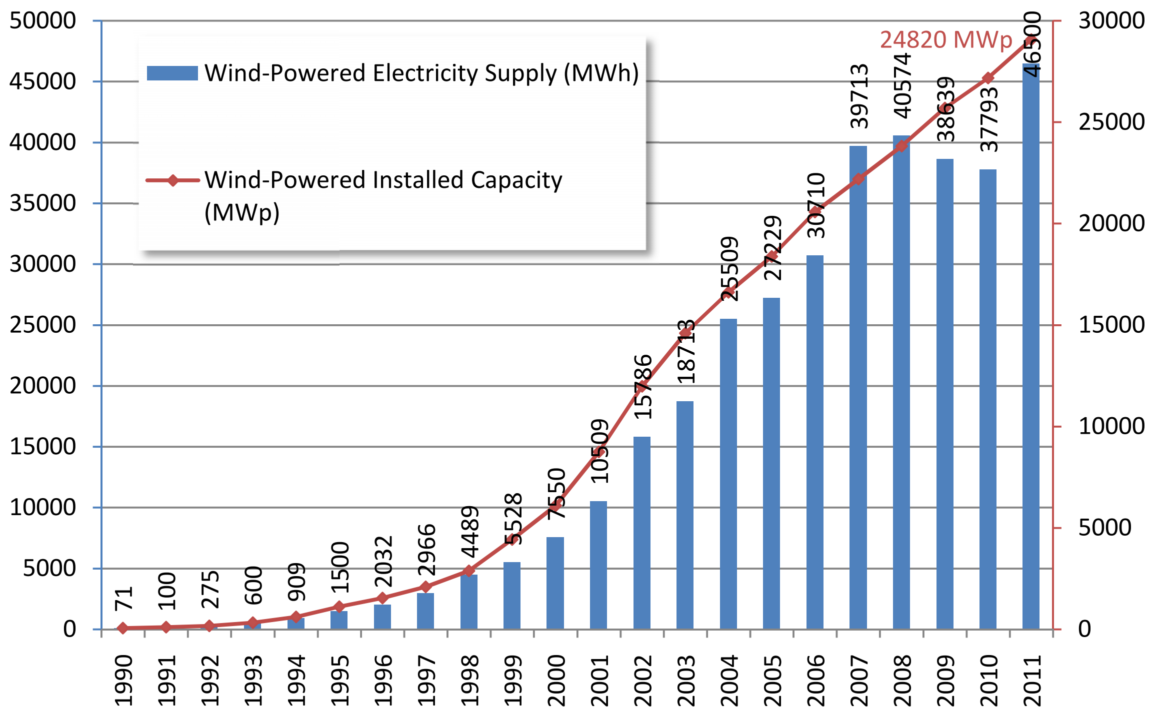

Figure 14 - Wind-Power Development in Germany

In the figure 14 above, the development of the wind-powered electricity generation can be seen in terms of the capacity increase and the annual feed-in into the grid. The deviations observed in the amount fed-in for the last years are due to the decrease in the wind potential for that specific year.

Generally, the tendency of the demands being placed on wind turbines is for the good locations in terms of wind occurrence, due to the fact that the regulated incentives are organized as location-dependent to prevent this tendency. As a result of this act, the plants in less windy areas receive the higher fee for longer than those in windy coastal locations. The most popular region, in terms of the wind turbines density, is Lower Saxony region with 7039 MW of wind power capacity in 2011. The wind power capacity distribution, among the regions, and the new installed capacity in 2011 are given in the following figure 15.

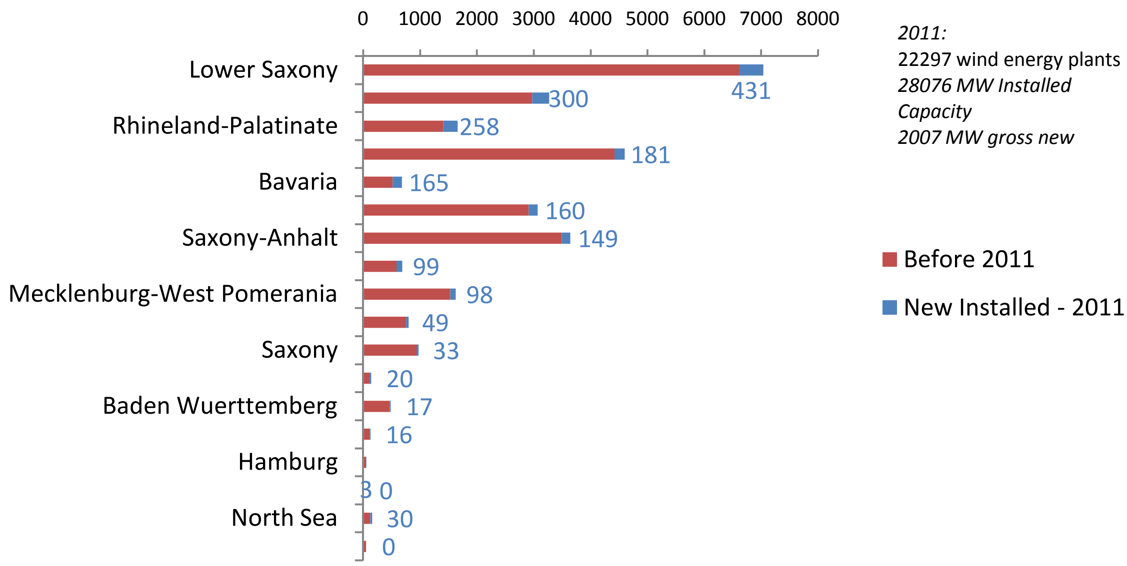

Figure 15 - Regional Distribution of installed wind energy capacity (MW) in Germany 2011

The last amendment of the EEG (1.1.2012) gives the basic tariff paid for electricity from wind-powered installations as 4.87 ct/kWh[13], which is decreased from 5.17 ct/kWh compared to the 2004 law amending the EEG. The incentive payment for wind energy in Germany is handled through two periodical amounts. The payment begins with the initial payment for 5 years, starting from the commissioning dates, and then continues with the basic tariff.

In the EEG-2012, the initial tariff is 8.93 ct/kWh (8.19 ct/kWh in amendment of 2004). In order to provide advantages to the investor, the duration of the availability of this initial tariff is extended by two months for each 0.75 % of the reference yield, by which the yield of the installation falls short of 150 % of the reference yield. Additionally, for the installations commissioned prior to 1.1.2015, the initial tariff shall increase by 0.48 ct/kWh (system services bonus) if the installation operator fulfills the requirements for the system services ordinance.

The further expansion of wind power on land is to be achieved in Germany through repowering. Existing installations are replaced by new ones which provide higher energy output for the same region. In this purpose, the EEG encourages repowering by introducing the incentive of paying the increased initial tariff for a longer period (0.5 ct/kWh increase to the initial tariff). One of the criteria for this replacement is that the installations that are going to be replaced should be commissioned prior to 1.1.2002. The last amendment also limits this application with an increase on the existing capacity at least three-fold.

An important difference made in the amendment of 2012 (compared to the one in 2004 about wind-powered installations) is performed mostly on offshore wind turbine installations. Off-shore wind turbine installations have a more important role for current trends due to the reached maturity in the on-shore wind turbines in Germany. That is why the last amendment includes more detailed and carefully calculated amounts of fees for the remuneration of the wind offshore. The basic concern for the offshore installations is to encourage the investors to construct as far as possible from the coast; therefore the distance and the mileage are criteria to gain additional incentives.

In the amendment of 2004, offshore power plants were supposed to be paid the initial fee of 9.1 ct/kWh for the first 12 years. However, the current amendment states that number as 15

[13] EEG 1.1.2012, Section 29-(1).

ct/kWh for the first 12 years, which shows that the expected growth in 8 years of period, between the two amendments, were not fulfilled. In addition to the initial tariff of 15 ct/kWh, the installation operator has an option to choose another scheme which offers 19 ct/kWh for the first 8 years. In the following years that complete the duration to 20 years, the tariff is reduced to basic tariff of 3.5 ct/kWh. On the table below, the differences in the fees can be seen.

Table 6 - Incentive differentiation from 2004 to 2012 (Source: EEG)

* without any bonuses and additional increase on the fees	**Wind Onshore**		**Wind Offshore**	
The EEG Amendment	Basic Tariff [ct/kWh]	Initial Tariff (5 years) [ct/kWh]	Basic Tariff [ct/kWh]	Initial Tariff (12 years) [ct/kWh]
01.08.2004	5.17	8.37	6.19	9.1
01.01.2012	4.87	8.93	3.5	15 (or 19)

The initial tariff is the attractive point in the remuneration for the investors of the wind-powered electricity generation: it is always desired to extend the duration of receiving this amount as an incentive. In this respect, the EEG 2012 offers to the installation operators additional time to receive the initial tariff depending on the distance from the coast line and the depth of water where the installation is located.

According to the EEG 2012 - Section 31 (2), the additional time after 12 years is calculated as:

$$\textbf{ADD. TIME PERIOD} = 0.5 * (\textbf{DISTANCE} - 12) + 1.7 * (\textbf{DEPTH} - 20) \quad [months]$$

where,

DISTANCE is in miles and the DEPTH is in meters.

3.2.3.Development of Biomass

Through the rural areas in Germany, the biomass installations are predominantly seen. These RES provide a significant opportunity for farmers to increase their incomes. The farmers run an energy farm from liquid manure or sustainable raw materials. When the potential is considered, the electricity and heating supply from biomass is high and the share among the other sources in the annual electricity production has an essential amount. The feed-in in 2011 was 31.92 TWh from biomass-total which includes solid biomass, liquid biomass, biogas, sewage gas, landfill gas and biogenic share of waste.

Among these, the total share of all the solid biomass and liquid biomass in the total final energy from RES is 10.4%. The following figure 16 shows the distribution of the electricity generation amount produced and given to the grid in 2011 from different biomass-based technologies.

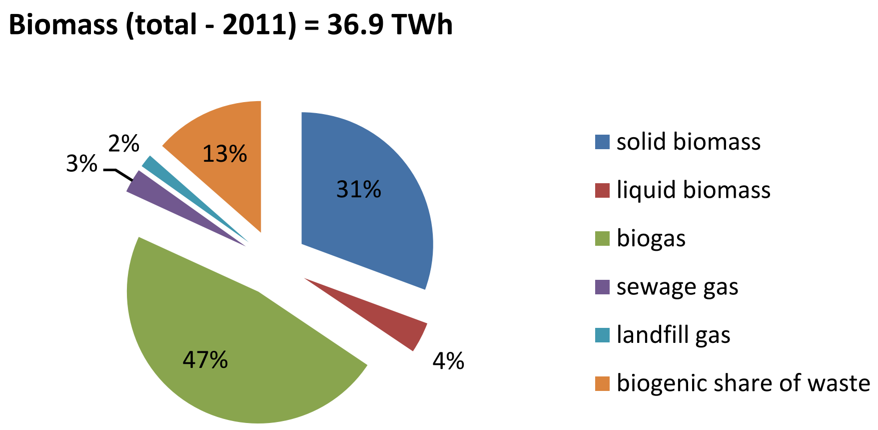

Figure 16 - Structure of biomass-based electricity supply in Germany 2011

In the last amendment of the EEG 2012, the biomass is differentiated into two subsections which differ from the main resource of reaction: as fermentation of biowaste and fermentation of manure. Both of them are anaerobic fermentation processes, defined according to the Biomass Ordinance (Bioabfallverordnung).

The basic tariff for biomass electricity is 14.3 ct/kWh for an installation with a capacity of up to a maximum of 150 kW; 12.3 ct/kWh up to 500 kW; 11 ct/kWh up to 5 MW and 6 cents per kilowatt-hour for the rated average annual capacity, between 5 and 20 MW (EEG 2012).

Apart from the given tariffs and the definition of the biomass, there are some obligations and criteria that all the installation operators have to fulfill in order to take advantage of the incentives. There are two main obligations stated in the EEG 2012 amendment: Obligation to employ CHP technology and Obligation to keep a record of substances.

Regarding the obligation to employ CHP technology, in order to take advantage of the full tariff proposed in the EEG, a certain amount of the electricity (generally 60 %) is required to be generated from CHP (§ 27 par. 4 no. 1, Annex 2 EEG). Otherwise the tariff is going to be decreased to the market price.

With regard to the obligation to keep a record of substances, the installation operator needs to prove the type of biomass used by presenting a copy of a record of the substances and provide evidence that no other substances are used (§ 27 par. 5 EEG). As the previous, the opposite case will be a reduction of the tariff to the market price.[14]

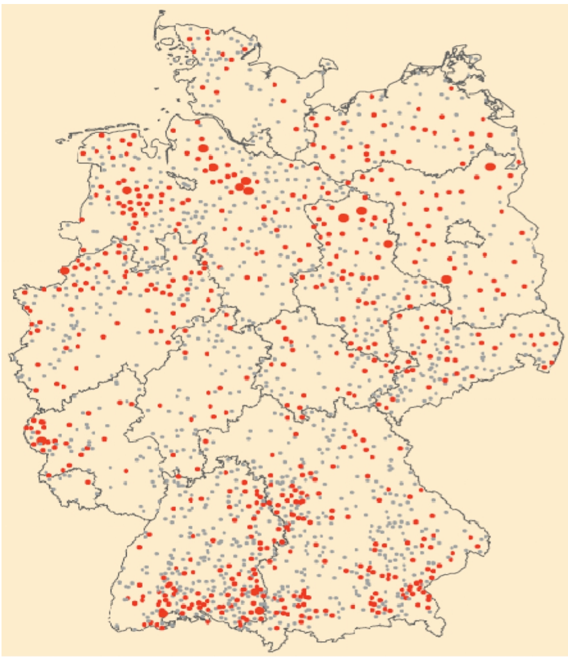

Figure 17 - Map distribution of biomass plants along Germany

Taking everything about the FIT of the EEG 2012 into consideration, apart from the

[14] EEG 1.1.2012, Section27.

sketched regulation for all the renewables, there is another way that the installation operator can choose in order to sell its electricity directly.

Biogas Plant Distribution in Germany is given on the right in the map. While the small agricultural biogas plants tend to be located in the south of Germany, most of the large plants are located in the north (Source: IE Leipzig).

3.2.4.Direct Selling

This optional service stated and regulated in EEG provides operators the possibility to sell generated electricity to third parties, which are defined as a buyer for direct selling, unless they are located in the immediate vicinity of the energy installation.

Likewise the general trend in the regulation, the direct selling also contains some obligations for the installation operators to utilize the system. For instance, the installation operators may only directly sell electricity if the installation has been equipped with a technical facility to reduce the output in case of a fault and provide the security, or to provide metering and control. The metering system should measure the electricity feed-in and it should be accounted for at quarter-hourly intervals.

Taking all these into consideration, instead of receiving the FIT for RES electricity, an installation operator has right to go through the direct selling by a supply agreement or at the stock market and, therefore, can claim the market premium from the grid operator. The amount of the market premium is decided each month. The calculation done according to the difference between the FITs for that technology, as set out in the EEG, and the average stock market price, which is calculated every month ex post. However, that choice will bring features which are totally different with the ones that are determined for the FITs in Section 16. The period of receiving the premium is consistent with the FIT period. As it is stated in the beginning of the direct selling functions, the operators are free to choose between the FIT and the market premium for direct selling. Exceptions are the large biogas plants that are commissioned after 31.12.2013, which are not going to be eligible for a FIT.

Additionally to the market premium, there exists another premium that the biogas operators can claim from the grid operator, which is called *flexibility premium*. The optional flexibility premium is meant to promote investments in targeted fashion to improve the ability to generate power from biogas facilities, in a market-based fashion. This additional premium provides additional revenue for the extra installed capacity to generate electricity on a demand basis. The amount of the flexibility premium is calculated each calendar year, but not like the market premium for which the period is monthly. Similar to market premium, also for flexibility premium, the installation operator must notify the grid system operator in advance of the first claim.

All these definitions and the statements done for the direct selling were comprehensively analyzed in the last amendment of the EEG in order to follow the targets. The reform aims to improve market and system integration for RES. The primary goal behind these provisions is the requirement of the demand-based generation of power from RES, as the share of the renewables, in overall energy production, has been enhancing. This requirement can only be fulfilled if the generation from RES is determined by the market price. In this respect, the importance of the direct selling of power has been increasing. Hence, in order to improve system integration, feed-in management should be developed and extended until competitiveness is reached.

3.3. GERMAN ACCESS TO THE GRID MECHANISM

The grid connection for the producers of electricity from RES has priority against the conventional electricity generators in the majority of the countries, according to the regulation. This has been stated in part of the German regulation for RES under the title of “principle of priority”.

The grid operator has an obligation to fulfill the connection requests coming from the RES producers in any case except from the cases which are not economically reasonable. Grid operator has to expand the network technical structure in case of necessity and should supply the required infrastructure to the installation’s operator in the closest time period which is limited in the regulation.

With regards to the relevant legal sources for the grid connection, the framework is mainly defined by the EEG. On the other hand, the general Energy Law (EnWG) and the decrees based on these laws, such as the Power Plant Connection Decree (KraftNAV), have importance in the determination of the details about the access to the grid. Moreover, the grid operators have their own grid codes that define technical requirements for generation in more detail.

The procedures that should be followed by both, the installation’s operators and the grid operators, are specifically determined in the EEG Act in order to provide the most efficient connection for the operators and the development of the existing network system.

3.3.1.Procedure

It is divided into two subsections, according to the technical feasibilities of the system: as connection for the low and medium voltage grids and connection for HV grid.

3.3.1.1. Low and Medium Voltage

The law set out only specific elements of the process for connection to low-voltage and high-voltage grids. Every grid operator has a chance to decide an individual connection process. Generally, the procedure and the required application forms are published on the grid operator’s website. However, the technical reasons need some rules and processes that must be followed by those interested in feeding in electricity.[15]

1. Grid system connection request.
2. Grid operator has to provide a precise timetable that contains the procedure steps for performing the connection requests and a list of all information required by the grid operator to decide the grid connection points or to see if the expansion of the grid is needed or not (without delay).
3. The necessary information for the grid system operator has to be given by everyone interested in feeding in electricity (installation’s operators).
4. The grid operator (without delay and within 8 weeks after receiving the first information requested) has to submit a timetable for establishing the grid connection and the data required to test the grid connection point. Apart from these, if it is requested by the installation’s operator, grid operator should provide a detailed and thorough analysis of the costs that will incur for the establishment of grid connection and the grid system data to test grid compatibility.
5. The grid operator assigns a connection point.
6. The grid operator comes up with a connection offer.

[15] § 3,4 par. 5 KraftNAV

7. An optional agreement can be done between the installation and the grid system operators.
8. The system is connected and electricity is given to the grid.

3.3.1.2. High Voltage

HV grids comprise the systems with a capacity of at least 100 MW with a voltage of at least 100 kV.

1. Grid system connection request.
2. The grid operator has to inform the installation operator on the required audits and the expected costs after two weeks and request additional information within one week.
3. The installation operator has to pay 25 % of the expected costs.
4. The grid operator announces the results for the grid stability test, and has to provide the connection within three months after advance payment stated in bullet 3.
5. An optional agreement can be done between the installation and the grid system operators.
6. An agreement on an implementation roadmap is done between the two sides.
7. The system is connected and electricity is given to the grid.

Regarding the grid stability test, the EEG has no specifications about the deadlines by which the grid operator needs to complete the test. The time for the test can take three weeks to three months, depending on the number of the staff.

The grid operator has obligations, prior to the connection procedure, as publishing the following information on its website (§ 3 par. 1 KraftNAV):

- Information that is requested from those interested in feeding in electricity to the grid in order to start the application process and to estimate the available grid capacity.
- Standardized requirements for the conclusion of a connection agreement.
- A diagram of the grid network and a load diagram for the entire network.

Apart from these published data, informing the installation operator about the required tests and the expected costs is another obligation that has to be done by the grid operator after the connection request is received.

3.3.2.Costs of grid connection

The type of connection charges is “shallow cost”, meaning that the installation operator bears the costs of the connection to the system from the closest or technically and economically most feasible connection point. Besides that, the plant operator also bears the costs of the measuring devices required to record the electricity received and transmitted. On the other hand, the grid operator bears the costs for optimizing, strengthening and expanding the grid. Moreover, the grid operator bears the incremental costs in case of a necessity that result in another connection point solution proposed by the grid operator, which is not the closest one.

However, the case of offshore wind differs from the general connection procedure and general division of the costs. In this case, the grid operator bears the full costs for the expansion of the grid, which also includes the connection costs itself, starting at the offshore substation.

No matter how much is the final cost borne by the grid operator, finally all the costs are going to be reflected on the calculation of the grid usage fees and passed on to the final consumer.

3.3.3.Use of the grid

The claim for purchase and transmission arises when the system is connected to the grid, which obliges the grid operator to purchase and transmit the electricity. In this sense, there are only three specifications that let the grid operator deny commercialization of electricity generated: feed-in management, agreement and grid safety.

3.3.3.1. Feed-in Management

According to the EEG 2012, Section 11(1), although their obligation for RES electricity purchase, the grid system operators can intervene to the connection in order to handle the technical control over installations and to avoid grid shortage in the respective grid area.

Regarding the reliability of the grid system, the installations other than RES must stay connected to the supply system in order to have guarantee for the protection.

Before the control operation, the grid system operator is required to notify the installation operators (no later than the day before of the expected date) about the actual dates, the reasons for the operation and the duration of the technical control.

There are strict obligations on the grid operator related to this issue, which protects the system operator's rights. He may inform to the system operator just once a year (by 31st January of the following year) about all the control measures, only if the total duration of these measures did not exceed 15 hours per system. The installation operators have right to request for compensation of the losses for the period when they were not able to feed-in electricity. While the compensated amount is generally 95 % of the lost tariffs and revenues, less the expenses saved, if the lost income exceeds %1 of annual income, then all the lost amount can be requested from the grid system operator. The grid system operator is obliged to obey these rules and fulfill the needs regarding feed-in management, otherwise the installation operator may demand compensation for the damage incurred.

3.3.3.2. Agreement

The criteria for purchase and transmission of energy as a priority can be mitigated by a two-sided voluntary contract, which is done in order to sustain a better integration into the grid. For instance, this application can be done to reduce the installation operator's electricity exports on a few days per year and then avoid a grid expansion (EEG 2012 Section 8).

3.3.3.3. Grid safety

This is the most trivial reason to avoid the priority. The safety and functionality of the grid come before the RES integration.

3.3.4.Cost Structure

The network usage prices are divided into components as costs of the network infrastructure, costs of the system services and costs of covering the transport losses.

The costs of the network infrastructure include the supply and maintenance of lines, switching stations and transformers. The system services are defined in the Transmission Code 2007 (Section 5). These are required for the transmission and distribution. Generally they deal with the functional efficiency and safety of the electricity supply, such as the primary control capacity and energy, the provision of secondary control capacity, reserve capacity and also the managing of the transmission system. Moreover, the transport losses are calculated in the covering by the electrical loss stemmed from the transportation of the current in the transmission system.

3.3.4.1. Determination of charges

The network usage charge is formed by an annual demand cost and a kWh rate. These two components change depending on the annual duration of use and the level of utilization of the network user (installation operator).

The calculation of the system charges is done in two steps. Before starting to explain the calculation process, it is required to introduce some variables and necessary data that are going to be involved in the process of determining the network charges.

- E (Energy) – the energy received during the period (year or month, according to the demand charge system selection) [kWh]
- P_{max} (Maximum Capacity) – maximum quarter-hourly capacity average during the period [kW]
- P_L (Demand Charge) – the annual basic price [EUR/kW] (depends on the individual duration of use)
- P_A (Kilowatthour rate) – the consumer price [ct/kWh] (depends on the individual duration of use)
- Utilization level – EHV network or transmission to HV
- P_{NRK} (Reported capacity level) – the reported network reserve capacity [kW]

The following scheme demonstrates the two steps throughout the calculation of the network charges:

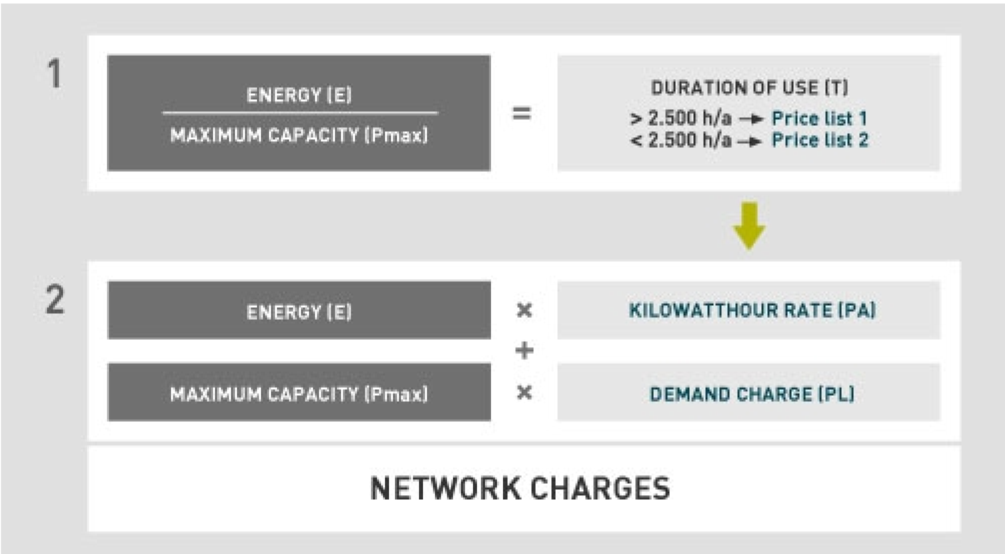

Figure 18 - Network charges calculation

As it is observed in Figure 1, the first step determines the annual duration of use T, which will direct the calculation to the corresponding price list to determine P_A and P_L factors, which both are necessary for the second step. The consultation is performed according to the T value and its amount with respect to 2500 h/a. Cases under longer durations, use Price list 1, while shorter durations use the second.

By using the kilowatt-hour rate and the demand charge obtained from price lists, the multiplications are done according to the way described in the figure, in order to find the final answer for the network charges.

Apart from the two cases of EHV and HV, customers with own production can also order a network reserve capacity, in case of facing a failure in their facilities, and need for the grid usage. The same process is applied in this case with different price list.

All the price lists mentioned above are presented as follows, and it should be stated that all price information contained in the price lists excludes taxes and surcharges:

Price list 1: prices for grid use in the case of load cycle count, T > 2,500 h/a

Point of use	Demand charge per year EUR / kWa	Kilowatthour rate ct / kWh
EHV network	20.74	0.034
Transformation to HV	23.18	0.030

Price list 2: prices for grid use with load cycle count, T < 2,500 h/a

Point of use	Demand charge per year EUR / kWa	Kilowatthour rate ct / kWh
EHV network	2.14	0.778
Transformation to HV	5.15	0.751

Price list 3: network reserve capacity with own production

Point of use	0 - 200 h/a EUR / kWa	200 - 400 h/a EUR / kWa	400 - 600 h/a EUR / kWa
EHV network	5.94	7.13	8.31
Transformation to HV	6.44	7.73	9.02

Table 7 - Price Lists for the network charge calculation according to the 3 cases[16]

3.4. GERMAN ELECTRICAL SYSTEM AND MARKET

In recent years, new challenges and problems are emerging in the regulatory models that were established at the beginning of the liberalization of European energy markets. Triggers are many, and largely country specific. Among the common include reduced demand for energy products, the difficulty of financing new infrastructure associated with the economic crisis, the rising price of fossil fuels and the introduction of measures against climate change. They can exert upward pressure on prices that consumers pay in respect of end use of energy facilities and / or acquisition of energy, depending on the regulatory and funding mechanisms chosen in each country.

The German electrical system has experienced a significant development since 2009 due to the crucial increase in the generation capacities, based on renewable sources of energy. In

[16]TransnetBW GmbH (TransnetBW), Adjusted structure according to the Ordinance on the Incentive Regulation of Energy Supply Networks § 4, Para. 3, Sentence 1, No. 1-2 ("Verordnung über die Anreizregulierung der Energieversorgungsnetze, ARegV ") dated October 29, 2007, last amended by the Ordinance of 03/09/2010 Art. 7 – Incentive Regulation Ordinance)

addition to this enhancement in the share of renewables in the electricity system, the decommissioning of eight nuclear power plants in early 2011 has also considerable effect on the change observed on the system. This loss of programmable generation capacities, along with the integration of the RES, came up with the requirements for the network expansion. As a consequence, the lawmakers figured out new paths with the network development plans in the Energy Act (EnWG) and new procedures and responsibilities in the Grid Expansion Acceleration Act (NABEG).

The decommissioning of the nuclear power in that amount brought out system security problems, therefore this reduction of nuclear power is planned to be compensated by new constructed programmable sources by 2014. However, according to the available Monitoring Data of 2011, the projects have stayed behind the schedule. Among the 149 expansion projects that were planned throughout 2014, 73 projects were behind the schedule or had postponed their commissioning dates at the end of the 2011. To maintain the system security, the first action should be to complete the power stations, which are already under construction on the right scheduled time.

Besides the network sector, these changes led positive developments in other areas of the energy market such as the integration of electricity markets in the EU, at the end of 2010 (an achievement to which the BNetzA[17] contributed significantly). Through the coupling of the electricity markets in north-western Europe (Benelux, Scandinavia, France and Germany), the national electricity spot markets of nine countries are now integrated at a wholesale level. This coupling gave a way to align the prices between the individual countries.

With regard to the German wholesale market for electricity, the wholesale volume in 2010 was seventeen times the actual electricity requirement in Germany. On the other hand, the over-the-counter (OTC) trade volume in 2010 was slightly more than fourteen times the one traded on the markets (EEX and EPEX Spot). In 2010, EEX and EPEX Spot performed an increase of 70 percent compared to the amount performed in 2009.

3.4.1.Generation

According to the data of 31 December 2010, 160.5 GW generating capacity was connected to the TSOs and DSOs grids in Germany. This amount refers an increase of 7.8 GW between 2009 and 2010 in which solar (7.1 GW) and wind power (1.7 GW) have significant role. Among the all renewable capacity which is evaluated as 54.2 GW, the amount, which is paid for in accordance with EEG[18] tariffs, is 50.7 GW. The effect of being a non-programmable energy source appears in the comparison between the generation capacity and the total energy fed-into the system in a year.

[17] The Federal Network Agency (German: Bundesnetzagentur, BNetzA) is the German regulatory office for electricity, gas, telecommunications, post and railway markets.
[18] The German Renewable Energy Act (in German: Erneuerbare-Energien-Gesetz, EEG) was designed to encourage cost reductions based on improved energy efficiency from economies of scaleover time. Consolidated version of the Act in the version applicable as at 1 January 2012.

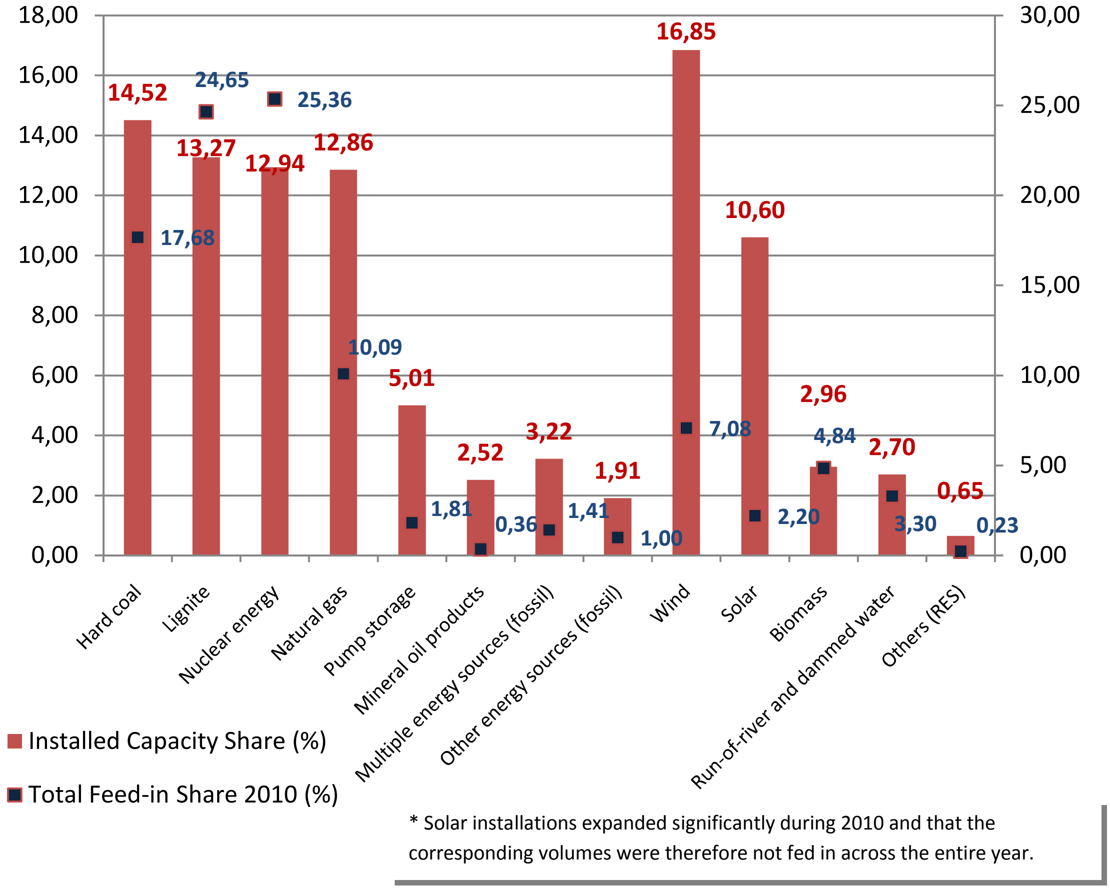

Figure 19 – Comparison of the shares of energy sources in terms of installed capacity and total feed-in (Source: Part 1 of the Report: "Elektrizitat, Erzeugung, Entwicklung nach EEG vergüteter Elektrizitatserzeugung")

Above on the graph, the most important parts that must be observed is the shares of the RES in which its feed-in volume is represented as 18 percent of the total feed-in, whereas the capacity of RES is 34 percent. This difference stems from the period of utilization of RES which is shorter than conventional sources. The related values of periods (in equivalent hours) are: wind installations (1391 h/a) and solar installations (686 h/a), which have short annual utilizations and on the other hand, biomass (5400 h/a) , hydroelectric power (4028 h/a), which have greater annual utilization periods.

Every year the Bundesnetzagentur collects data from the DSOs (approx. 900), the four TSOs and some electricity suppliers. The series of the data from EEG installations about the shares of renewables for each year and the growth is plotted on the following Figure 20. It is observed, as well on the graph, that there is a significant amount of solar installation penetration to the system between 2008 and 2010. Only in 2010, the solar installed capacity has increased 72 percent of the amount in the year before.

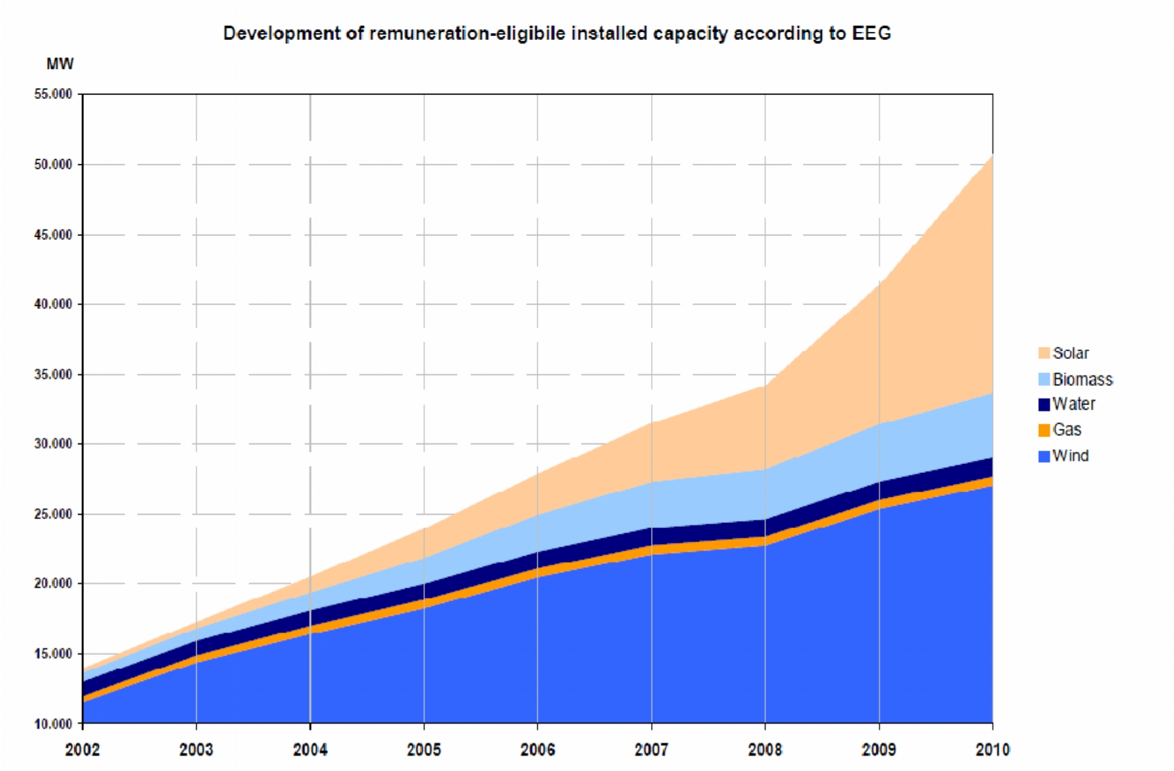

Figure 20 - Development of installed capacity of installations receiving payment in accordance with EEG from 2002 to 2010[19]

The EEG electricity generated from RES is remunerated at a tariff decided by law, according to the specifications to forms of generation. In 2010, 50.7 GW of the EEG installations were paid with an amount of 13182 million euro, overall remuneration.

Table 8 - Annual EEG energy feed-in and corresponding remuneration under the EEG for 2010 per energy source as absolute and percentage amounts (Values for 2009 in brackets)[20]

2010 *(2009)*	**FEED-IN (GWh)**	**FEED-IN (%)**	**Total Remuneration (million €)**	**Total Remuneration (%)**
Water	5050 *(4877)*	6 *(6)*	421 *(383)*	3 *(4)*
Solar	11682 *(6578)*	15 *(9)*	5090 *(3157)*	39 *(29)*
Wind	37635 *(38580)*	47 *(51)*	3342 *(3395)*	25 *(31)*
Biomass	25146 *(22980)*	31 *(31)*	4240 *(3700)*	32 *(34)*
Gas	1159 *(2019)*	1 *(3)*	83 *(143)*	1 *(1)*

One remarkable point from the data given on table is that the share of the solar power systems, among the renewable, is only 15 percent, while they consume the highest amount of the share of the EEG budget for remuneration payments. As in many countries, these

[19] Bundesnetzagentur für Elektrizität, Monitoring Benchmark Report published under section 63 (4) and (5) in conjunction with section 35 of the Energy Act

[20] The numerical data on the table are presented by the Annual Monitoring Report to EU (2011) and due to the low level, the values for "Geothermal energy" are not shown on the table.

payments are fixed at a certain amount which is going to be paid to the solar producers for 20 years.

Apart from the renewable power capacity, the electricity generation which is not paid under EEG, but forms the major part of the total, is mostly provided by four largest companies (E.ON, EnBW, RWE, Vattenfall). According to the data in 31.12.2010, from 107 GW of generating capacity (without EEG), 82.8 GW came from the four largest and this value resulted in 82.2 % of the feed-in share.

3.4.2.Wholesale

Electricity demand is subject to severe fluctuations depending on the time of day and the season, and the price elasticity is very little at short-term.

As in every country, also in Germany, electricity is generated by different types of power plants, which lead varying generation costs. In Germany, electricity is traded at wholesale level through exchanges such as in spot and futures markets of EEX (European Energy Exchange AG) and EPEX (European Power Exchange S.E.) or off-exchange in over-the-counter (OTC) transactions.

Regarding the structure of German electricity market, the following figure gives the first impression:

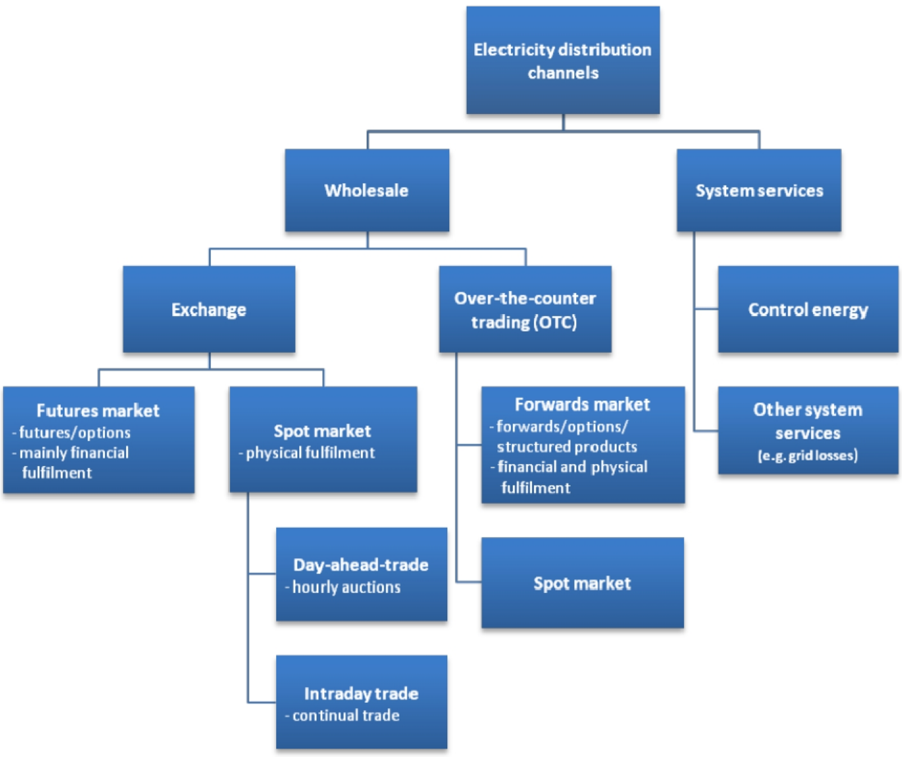

Figure 21 - Electricity Distribution Channels (Source: Bundeskartellamt)

Regarding the statistics of the previous years, about the shares among the structures, in 2010 more than half of the wholesale trading took place through broker platforms including OTC clearing (57 %). Moreover in the same year, the volume of the off-exchange trading which contains both, the broker platforms and bilateral contacts, were 14 times the volume of the on-exchange trading (EEX and EPEX spot markets).

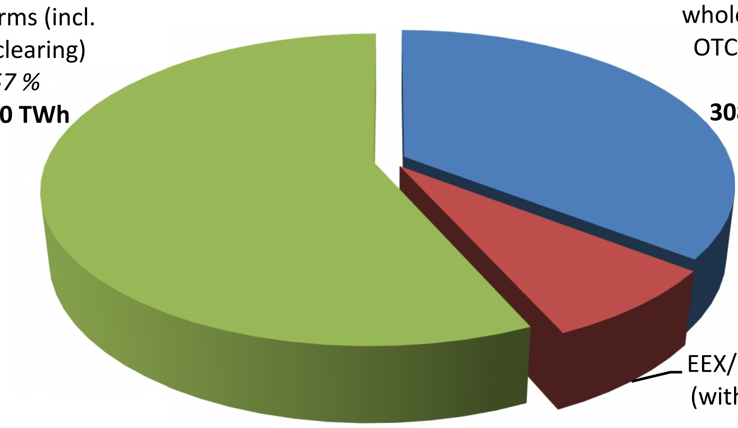

Figure 22 - Comparison of total electricity trade volumes for German at the EEX/ EPEX spot markets, broker platforms and in purely bilateral trade in 2010

However, in spite of the situation of the on-exchange trade, its volume performed a continuous increase thanks to the sales of EEG electricity through TSOs at the EPEX spot.

3.4.3.Price Development

Regarding the day-ahead trading, the base load wholesale price at the EPEX Spot was at 44.49 euro/MWh (Phelix[21]-Day-Base) and the peak load price was at 50.95 euro/MWh (Phelix-Day-Peak). The sale of EEG electricity at the EPEX Spot (began in early 2010) has had a dampening effect on prices which causes only a slight increase on the total.

However, in the futures market the bottlenecks in the energy generation, due to the decommissioning of the nuclear plants, resulted in an increase of the average price level of futures market for 2012 (increased to 56.39 euro/MWh for base load and 69.29 euro/MWh).

Another trend which can be observed on both the futures and spot market is the high decrease in price volatility that stems from the coupling of the German and the Nordic markets (since late 2009), sale of electricity under the EEG on the EPEX (since 01.01.2010).

[21]Physical Electricity Index. Calculated on a daily basis by EPEX SPOT, the Phelix is the average price for base load (Phelix Day Base) and peak load (Phelix Day Peak) electricity traded on the German/Austrian Auction. (EPEX Spot SE)

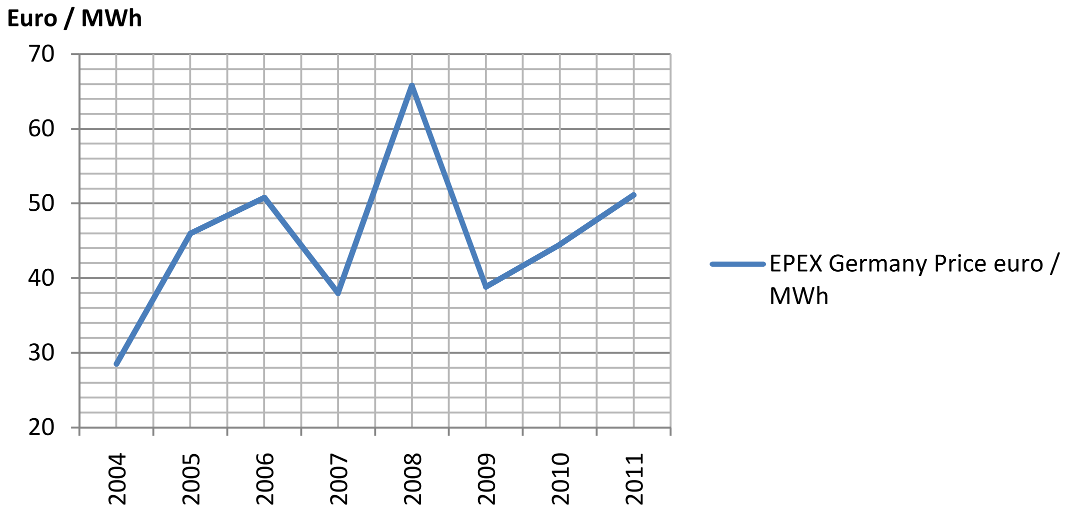

Figure 23 - Price development EEX Phelix-Base-Year for the consecutive year from 2004 to 2011

From the time of the introduction of the regulation, although the network incentive amounts have been decreasing gradually, there is no general decrease observed in the overall electricity prices for the household customers. The only advantage that regulation provides for the customer is the chance to change contract or the supplier, to arrange their contract according to their possible price reductions (what was called "market liberalization").

The important observation can be made on the household customer electricity price by specifying the segments of the price that are paid by customers. By analyzing the segmentation, the price components are understood clearer.

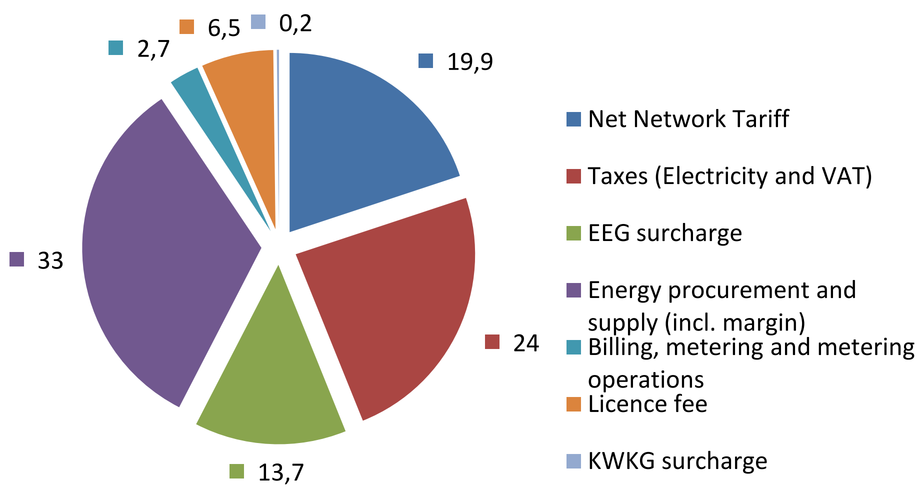

Figure 24 - Division of the retail price for household customers as of 1 April 2011

Regarding the development of the price portions, in 2011 the all network tariffs (Net network tariff and billing, metering operations) dropped by 2.2 %, compared to 2010, and the taxes in the price have fallen by 0.7 %. The largest portion of the customer price, the energy procurement and supply, was decreased by 1.6 % of its 2010 value. On the other hands, the corresponding surcharges coming from EEG and KWKG experienced a solid increase by 4.5 %. Resulting from these fluctuations in the components of the final price, the final price was affected with an 8.7 % (2.0 ct/kWh) increase between 2010 and 2011.

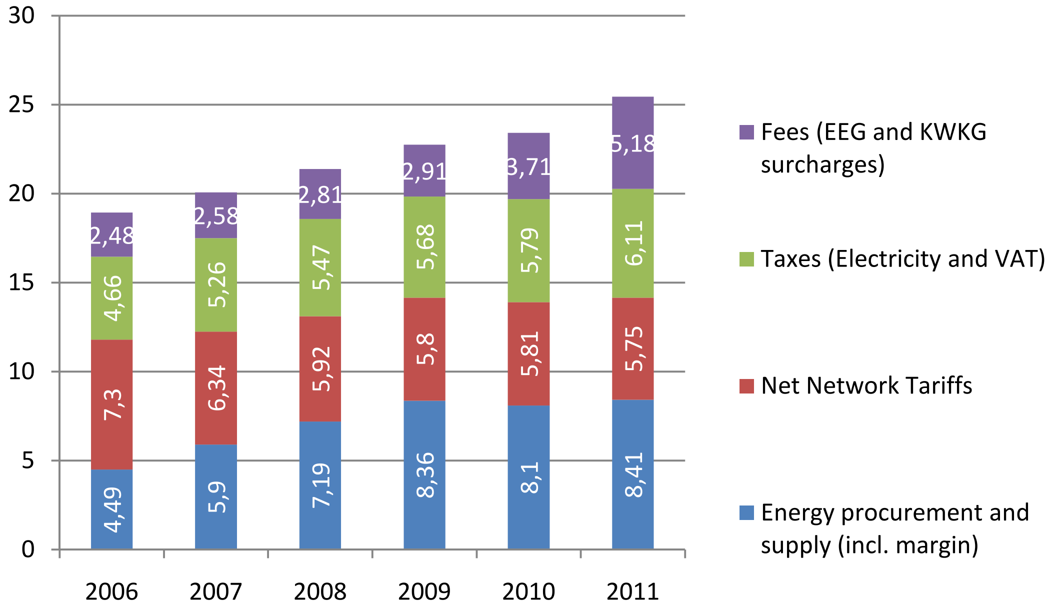

Figure 25 - Volume-weighted electricity prices across all price plans for household customers (2006 to 2011)

Regarding the reason and factors that caused this increase, from 2010 to 2011, fees (KWKG and EEG surcharges and concession fees) enhanced by 1.5 ct/kWh that mainly stems from the increase in EEG surcharges. The factors influencing the EEG surcharge were the increased total amount of remuneration payments to the installation operators. The statistical data shows that the forecast for the year 2010 was at 12.7 bn euro and in 2011, it was at 17.1 bn euro, in which approximately 8 billion were accounted for the solar power systems. Apart from the apparent increase in the amount, another factor to have a higher forecast for 2011 is the missing forecast of the EEG surcharge in 2010, with a deficit 1.1 bn euro (led to 0.3 ct/kWh increase for 2011).[22]

3.5. ITALIAN ENERGY POLICY REGULATION

For Italy as a Member State, with an important share of the energy consumption in the EU region, the renewable energy development has been, in a wide point of view, an important goal in the energy policy for the last seven years, but since 2009, it has renewed its commitment becoming the top priority (as the same time as the promotion of energy efficiency) for the ongoing future. Indeed, the government has been preparing the industry and the market aiming to pursue the new *Directive 2009/28/EC* challenge, which sets the target for the Italian RES consumption for the year 2020 in a share of *17% from the final gross energy consumption*.

3.5.1.The Italian National Renewable Energy Action Plan

Since the Italian NREAP was issued after the EC directive, the national policies in most of the EU states have had a substantial shift within the energy industries targets. This new efforts are focused in both, the tuning of the *energy efficiency* and the reducing of the *energy consumption*. But, although these have become the two most important goals, the path

[22] "Monitoring Benchmark Report 2011", Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen Monitoring, Marktbeobachtung – Energie, p 34.

towards the target fulfillment should never neglect the founding objectives of a national policy, which are: the supply security, the reduction of social costs, the technology innovation and mainly the environmental care, giving in this manner the sustainable growth for the developing region.

One of the principal issues of the Italian energy mix is the high dependency on imported fossil fuels. Thus, this premise would make the process of achieving the NREAP targets a tough work, if we consider, moreover, that the government has decided to stop the nuclear power development, after the Fukushima accident in the past March 11th, 2011.

Therefore, the Italian policy strategy, as described in the figure, will aim to reach the target of 17% by reducing the energy consumption, increasing the energy efficiency (under *Italian Law 99/2009*), and increasing the RES share in the three sectors of the energy industry: the electricity, heating-cooling and transportation. Thus, under this current scenario, the Italian gross energy final consumption would be reaching the 133 Mtoe by 2020[23], meaning that the 17% of RES final consumption would be covered by 22,6 Mtoe. But, according to this scenario, the total renewable consumption by 2020 would not be covered by the local industry, but by a minimum imported amount which would reach the 1,13 Mtoe. Hence, this last assumption would mean that the estimated evolution towards the goal would not allow achieving clearly the final target, suggesting that the efforts would be done with an extremely high commitment in all the involved sectors.

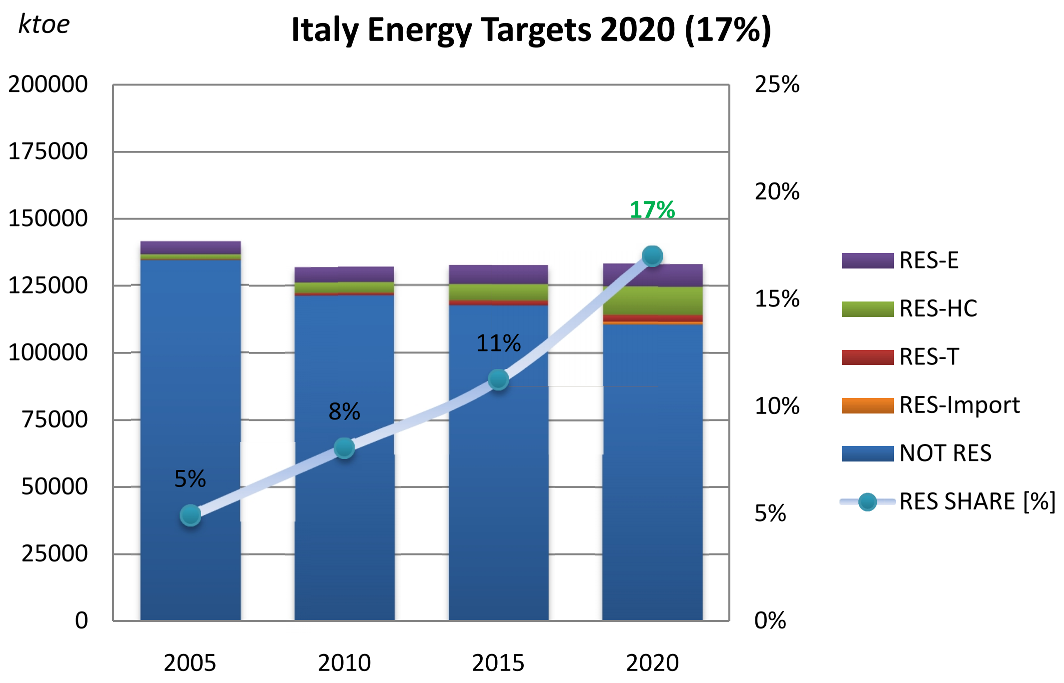

Figure 26 - Italian energy targets from NREAP to 2020 (Source: ECN24)

[23] All the energy consumption figures from the analyzed scenario were taken from the EC PRIMES model 2009 estimation, considering population growth, current financial crisis effects.
[24] ECN, L.W.M. Beurskens, M. Hekkenberg, P. Vethman, *Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States.* Nov, 2011.

3.5.2.The RES-E towards 2020

For the electricity sector, it is clear that Italy has a high competitive advantage in terms of resources, due to the geographical situation it is located. Although the efforts of promoting heating and cooling and transports should be focused mainly on the biofuels production, according to the Italian energy policy, most of the measures should be focused on the electricity generation and network management development. That is, commitment in terms not only of infrastructure and efficiency, but research, training, production and mainly fluidity in the authorization and administration procedures, in order to allow the installation and operation of the different mechanisms for the development of the network. Lastly, in terms of sustainability, the ideal would be to make efforts in developing the existing supply chain in order to meet a demand in growing assets and infrastructure.

During the development of the present study, the incentives policy has been witnessing a transition due to the strong impact of the first political measures and the current adaptation of new scenario. This is the reason why the participation of RES within the Italian demand, according to the old policy scenario, would reach by the 2020 year, a share of 26% of the GFEC. This means that if the total gross electricity consumption, for that year, reaches 32,2 Mtoe, the total amount of energy to be produced by renewable sources to cover the 26% of that amount would be 8,5 Mtoe.

Table 9 - Italian electrical consumption according to NREAP towards 2020 (Source: ECN)

	2010	***2015***	***2020***
TOT-E [Mtoe]	*30,7*	*31,5*	*32,2*
RES-E [Mtoe]	5,7	7,0	8,5
RES-E SHARE [%]	***18,7%***	***22,4%***	***26,4%***

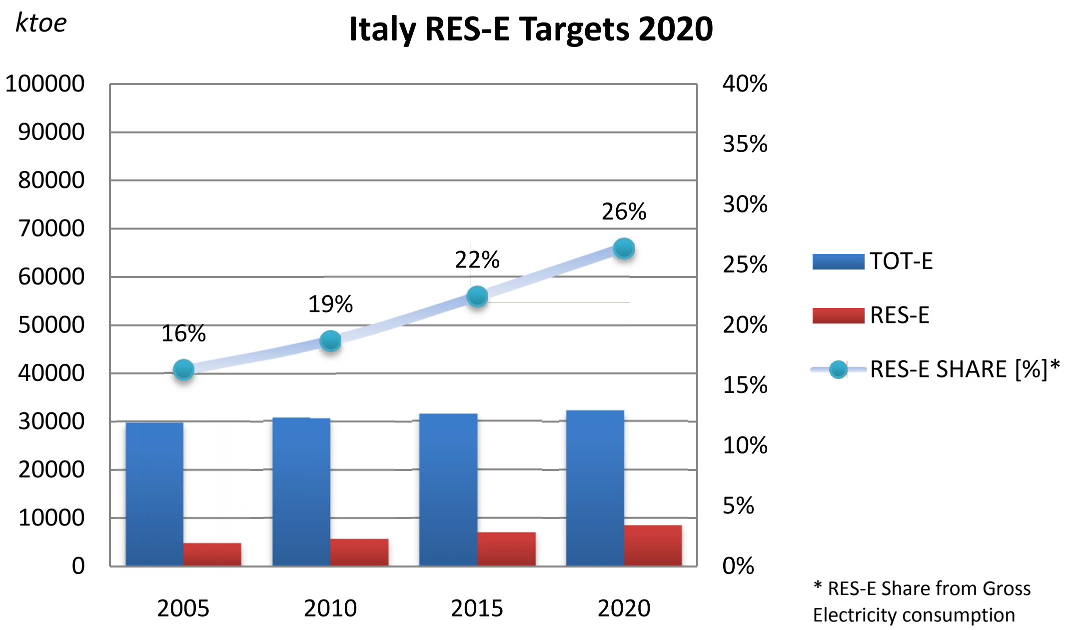

Figure 27 - Italian renewable energy (electricity) targets for 2020 (Source: ECN)

But the recent issued RES Ministerial Decree of 6th of July 2012, not yet put into force, will set the new target for 2020 of RES-E in 32% to 35%, in place of the 26% currently in force, according to the current development the sector has achieved due to the policies carried out during the last years.

Many cares must be taken into consideration at the moment of designing the support schemes to implement, in order to follow the current policies towards 2020 target. The most important fact that should be borne in mind is that the development of the system must be in a sustainable way, meaning that the growth that can be achieved by a suitable support mechanism must be balanced and synchronized with every sector of the industry. By stating this, it is not said that the system cannot evolve towards a criticality, inefficiency or contingency, but it is needed to consider that such a commitment implies high risks at the moment of implementing the eligible support mechanisms. For this reason, and considering mainly that the main constraint will be the financial availability originated in large part in the final consumers, every measure to support the energy policy must be implemented with a high grade of efficiency, flexibility and final effectiveness.

With regards to the RES-E contribution to the generation mix towards the year 2020, the following figure shows where the efforts are going to be focused. In first place, hydro capacity would remain invariable, in second place wind and biomass power generation are going to be developed in a similar rate (reaching almost the 20 TWh of energy consumed), solar in order to feed-in over 10 TWh, and finally, geothermal, with a slight increase below the 7 TWh.

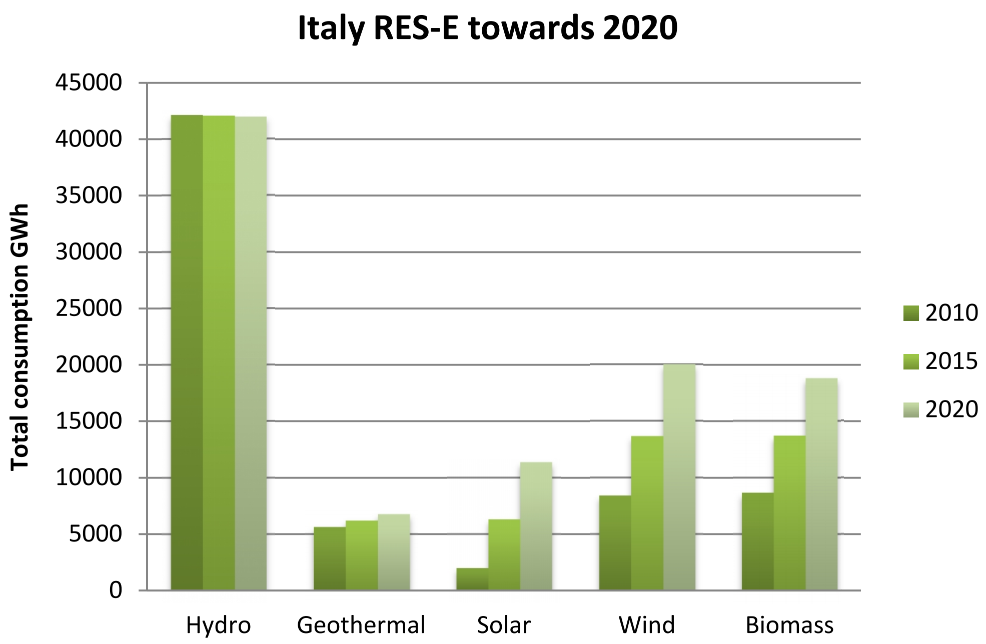

Figure 28 - Italian RES-E profile to be incentive towards 2020 (Source: ECN)

Therefore, in order to achieve the described RES participation into the generation mix, according to the NREAP, the support schemes that are being set into force are mainly:

Table 10 - RES-E support mechanisms in force to achieve targets in Italy

Name of the Measure	Type	Expected Result	Targeted group or activity	Date of start and end of the measure
Solar photovoltaic FIT (Conto Energia)	Financial	26000 MW by 2016 (according to V Conto Energia)	Investors / End users	Start: August 2005 – not given
Solar thermal FIT	Financial	2,000,000 m2 of panels installed by 2016	Investors	Start: May 2008
GCs	Legislative	Feeding electricity from renewable sources into the grid (except solar)	Investors	Start: April 1999
All-inclusive tariffs	Financial	Not Given	Investors, end users	Start: January 2008
Minimum quota for electrical capacity installed using renewable sources	Legislative	Not Given	End users who own newly-constructed buildings or buildings to be refurbished.	Start: January 2011

Of course, it has to be considered the fact that the energy policy to be enforced should encourage harmonized development, not only for RES, but for a sustainable network growth and adaptability.

3.6. ITALIAN ENERGY INCENTIVES

The production of electricity from renewable sources has covered, in 2011, 29% (84 TWh) of total GFEC, with an outstanding increase compared to previous years. During the last year, there has been a further marked increase, with particular reference to the generation of electricity from solar PV power plants, which in a single year, has increased abruptly from 1,9 TWh up to 10,7 TWh, during 2010.

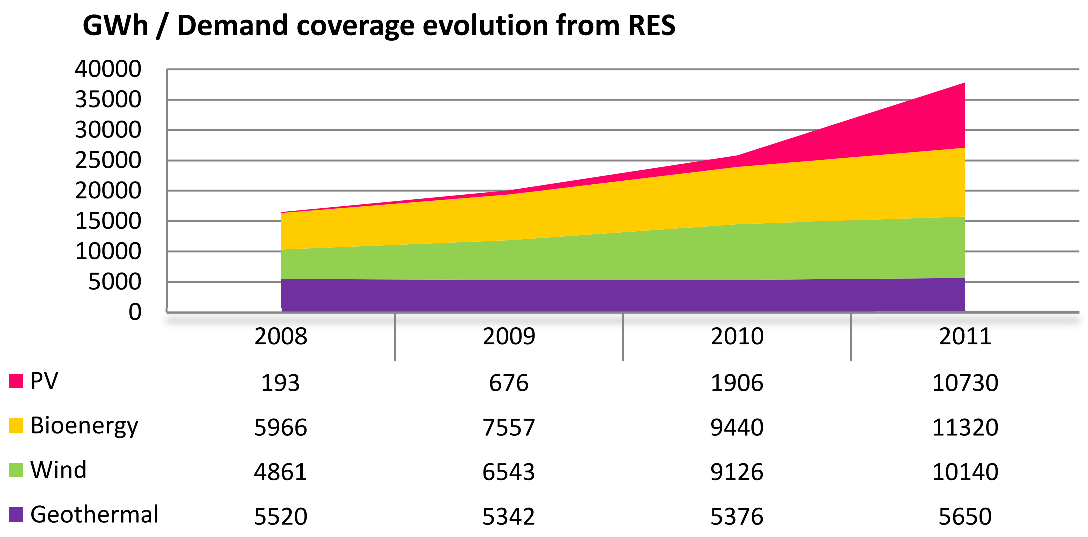

Figure 29 - Demand coverage evolution from RES (Source: Terna)

From the above figure, the first effects of the current RES support schemes for the electricity sector can be observed. It has been witnessed that the current growth has been produced by mainly three technologies, *wind, bioenergy and photovoltaic* power generation. In general, in Italy, all technologies used in renewable electricity generation are promoted; however, they are eligible for different incentives.

In Italy, GSE[25] is the public company in charge of promoting the renewable energy by conceding incentives and offering services for the RES producers. They are empowered to implement the support schemes for the RES generation facilities. Mainly, the support schemes that the producers are entitled to request are: *green certificates (GCs), feed-in premium tariff (Conto Energia), all-inclusive feed-in tariff (tariffa onnicomprensiva) and feed-in tariff (CIP6)*, among others. While for trading the produced electricity, they can rely in the following services offered by GSE: *indirect sale through dedicated withdrawal (ritiro dedicato) and net metering (scambio sul posto).*

3.6.1.Green Certificates ("Certificati Verdi")

The *Legislative Decree 79/1999* has introduced the mechanism of GCs for incentivizing the production of electricity from RES[26] (except for solar technologies). From the beginning with the *Financial Act 2008*, GCs are issued licenses to RES producers (commissioned since 1st April, 2009) in proportion to the energy generated (1 GC = 1 MWh), *without distinction for the different sources*, for a period of *twelve years*. As the conventional generators are obliged to comply with their QO[27] (Quota Obligation), these certificates are sold in order to allow them fulfilling that requirement of injecting RES electricity to the power grid. The unsold GCs are bought back by GSE. The underlying electricity sold in the market by the RES producers represents an additional source of revenue. The last two modifications of this scheme were: for plant commissioned after 31st Dec. 2007, the support period is extended to *fifteen years* and the number of GCs issued to the produced energy is different *depending on the type of source*.

The GCs are released according to the net energy produced by the plant (E_N), which is the gross energy measured at the terminals of generation units, reduced by the electricity consumed by auxiliary services and losses[28]. The net energy produced, however, is not always directly the benchmark for calculating the number of GCs payable[29].

$\mathbf{E_{CV} = E_I}$ being E_I function of the plant technology's category and E_N

As the second last modification stated, the number of GCs, as well, depends on the differentiation of source technology from which the renewable energy is produced. Thus, for issuing GCs to the producers, E_I must be multiplied by a K factor which is listed in the following table 11, according to each technology:

$\mathbf{E_{CV} = K \times E_I}$ being E_I function of the plant technology's category and E_N

[25] GSE
[26] Support scheme in force since year 2003, and applied to power plants with capacity over $1MW_e$.
[27] Quota Obligation for conventional producers or importers for year 2012 was set according to the Legislative Decree 79/1999, in 7,55% (5,3% in 2009, 6,8% in 2011).
[28] Losses in transformers and losses up to the point of delivery of electricity to the network.
[29] There are several types of plant technology (new construction, activation, enhancement, total or partial reconstruction) that are entitled to get the incentive of all or part of the electricity produced.

Table 11 - Multipliers to calculate the number of GCs (extracted from Financial Act 2008, as amended by Law No. 23/7/2009.

Category acc. Law 244/2007	Source	K factor
1	Wind On-Shore	1
1-bis	Wind Off-Shore	1,5
3	Geothermal	0,9
4	Tidal and wave	1,8
5	Hydraulic	1
6	Biodegradable waste, biomass different from the category 7	1,3
7	Biomass and biogas from agricultural products, livestock and forestry, produced under sectoral agreements, framework agreements, or short lines	1,8
8	Landfill gas and sewage gas and biogas purification processes different from those of category 7	0,8

The price of GCs incentive is formed under the supply and demand law. The transactions of the issued certificates are performed in the organized market with the GME (Gestore dei Mercati Energetici) or by bilateral contracts, as well being registered by GME. Defined the price of the GCs to be sold (P_{CV}), the incentive value (I_{CV}) is given by the following relation:

$$I_{CV} = P_{CV} \times E_{CV}$$

The service of offering the GCs is being held by the GSE, which has the power to administrate all GCs issued in the market, acquire the new issued certificates to a price equal to the average of the precedent three years and since 2012[30], retire the GCs which are expiring, to a price equal to the 78% of GCs issuance price (difference between 180 €/MWh and the average price of electricity, PUN[31], from the previous year).

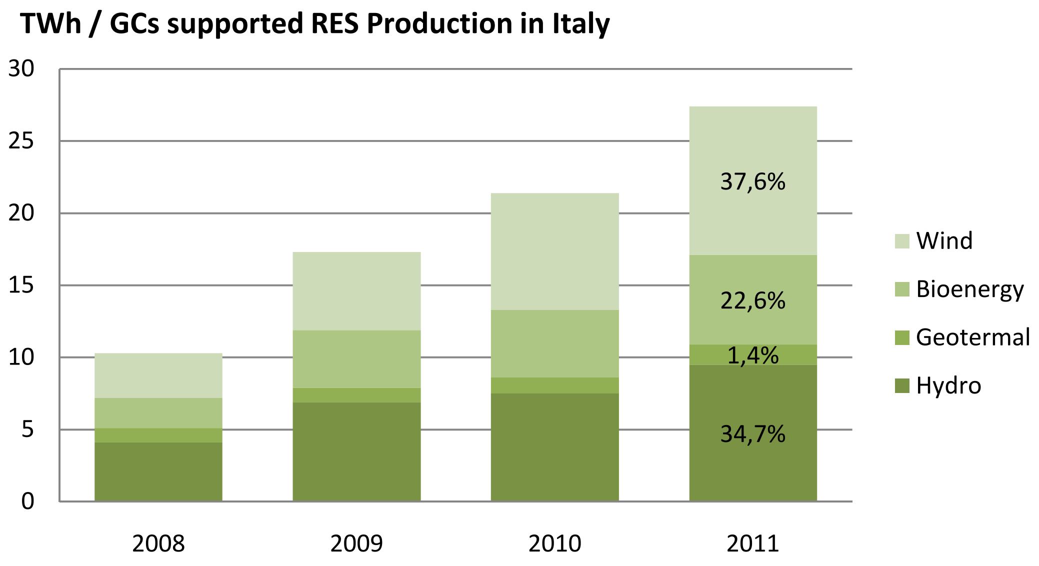

Figure 30 - GCs RES production (Source: AEEG)[32]

[30] According to the Legislative Decree 28/11 of 3rd of March, Art 25.
[31] Prezzo Unico Nazionale.
[32] It is not considered the amount of GC issued for CHP and heating sources (around 1,6 TWh for 2011). Source: *Stato di utilizzo ed integrazioni degli impianti alimentati da fonti rinnovabili,* AEEG. 2012.

The total energy production from RES with GCs support has reached almost the 21,4 TWh in 2010, increasing the following year 2011 to the amount of 27,4 TWh (figure 30). During 2011, the GSE has issued almost 30 million of GCs (including CHP, from which only around 9 million were demanded) spread in between mainly three technologies: *hydro, bioenergy and wind*. The last one, with the higher share of 37,6% (supporting a production of 10,3 TWh).

Although the *Legislative Decree 28/11* of March 2011 has implemented the gradual removal of GCs (see table 12) to be completed by 2015 (with exception of those needed to cover the demand to fulfill the QOs until that deadline), it is clearly observed that there are three mainly technologies granted with this support mechanisms. For the objective of Italy, the wind and bioenergy are the ones (also solar, which is not supported by GCs) which need to reach the *grid parity* in order to be self-sustained and supply their contribution to the 2020 target.

Table 12 - QO gradual reduction until 2015, acc. L.D. 28/11 of 03.2011 (Source: AEEG)

QO [%]	6,80%	7,55%	5,03%	2,52%	0,00%
Year	2011	2012	2013	2014	2015

Although the offer of GCs exceeds a demand (generating an extra cost for the system which is covered by the final consumer by the A3 tariff[33] in their bills[34]), which has decreased during the last years, what the law requests with the gradual removal of GCs, can be considered a satisfactory measure for market adequacy if the projections of the production to be covered with QO were known in advance for the following years. This play can be understood as the next move to achieve the market closing, obviously, if the offer of GCs is enough to cover the QO of the conventional producers. Therefore, this new modification with the aim of tuning the GCs market, without a clear and *sharp projection* of the energy to be produced by conventional and RES generators, can induce many uncertainties and volatility of the ongoing investments. Thus, as a support scheme for developing the RES needed to reach the 2020 target, it is clearly understood that the GCs market stability and the ongoing incentive support efficiency, which is going to replace GCs, are key issues for the sustainability of this support in Italy.

3.6.2.Premium tariff ("Conto Energia")

The major support mechanism to promote solar PV systems is a *premium tariff* which, in Italy, it is called "Conto Energia". The producers which are granted with this premium tariff are not entitled to perceive either GCs or all-inclusive feed-in tariff (tariffa omnicomprensiva)[35]. The support is provided to the producers as of the date of commissioning of the plant during a period of *twenty years*, being the tariff constant along this period, but different according to the plant capacity and type of integration.

Since the first launch of the "I Conto Energia" with the Ministerial Decree of 28th July, 2005, the mechanism has been amended in four opportunities until the last "*V Conto Energia*[36]" issued

[33] Tariffa componente A3 – Since 1992, Italian consumers have funded the system of promotion of renewable energy sources (and "assimilated" energy sources, i.e. sources deriving from processes, like CHP) by paying the A 3 tariff, which is included in the price of electricity. The tariff paid by the consumers goes to the fund for new systems that generate renewable and assimilated energy. This fund covers the GSE's costs arising from the generation of electricity from renewable energy sources.
[34] In 2010, the cost of buying back the not demanded GCs by GSE reached the 1,3 billion of Euros (Source: AEEG).
[35] Until 2012, the Conto Energia incentive consisted of a fixed premium on all the electricity produced. **From the V Conto Energia, instead of a premium on all the energy produced, a premium will be paid on the share of the energy produced for own consumption and an "all-inclusive" tariff on the portion of energy supplied to the grid**. The "all-inclusive" tariff is set at a value which includes the incentive component and the market component.
[36] DMof 5th July 2012, in line with the implementation of art. 25 of LD 3rd March 28/2011.

on 5th July, 2012[37]. This Decree applies to photovoltaic systems coming into force after 27th August, 2012[38] until the accumulative annual indicative cost of the incentives estimated in 6.7 billion euro is reached.

During the development of the present study, a transition in the Italian incentives support scheme has been witnessed, while the V Conto Energia has been studied by the Italian authorities. Thus, before describing the modification introduced by the last version, the IV Conto Energia has to be mentioned.

The amendments in each of the version of the Conto Energia have been done as a response to the dynamicity of the market, considering that:

- costs of the PV components and plant investment are being reduced by the engineering and R&D (necessity to adjust the incentives to the decreasing trend of the market costs);
- the PV industrial sector is being developed locally;
- the economical impact on the electrical sector has to be mitigated;
- the incentives need to be aligned to the European Level.

Therefore, in order to increase the efficiency and stability of the support mechanism, and mainly ensure the development of the PV sector guaranteeing a financial feasibility for investors, the *Conto Energia* is updated periodically. Indeed, with the PV capacity installed during 2011 (around 10 GW, see figure 31), the total capacity installed in Italy has reached around 13 GW (when the target of the IV Conto Energia was fixed for 2016 in 23 GW). Moreover, the main consequence due to the implied costs derived from the incentive (almost 5,7 billion euro), that have accumulated with the last year, almost the available budget for sustaining this mechanism, was the issuance of the “V Conto Energia”.

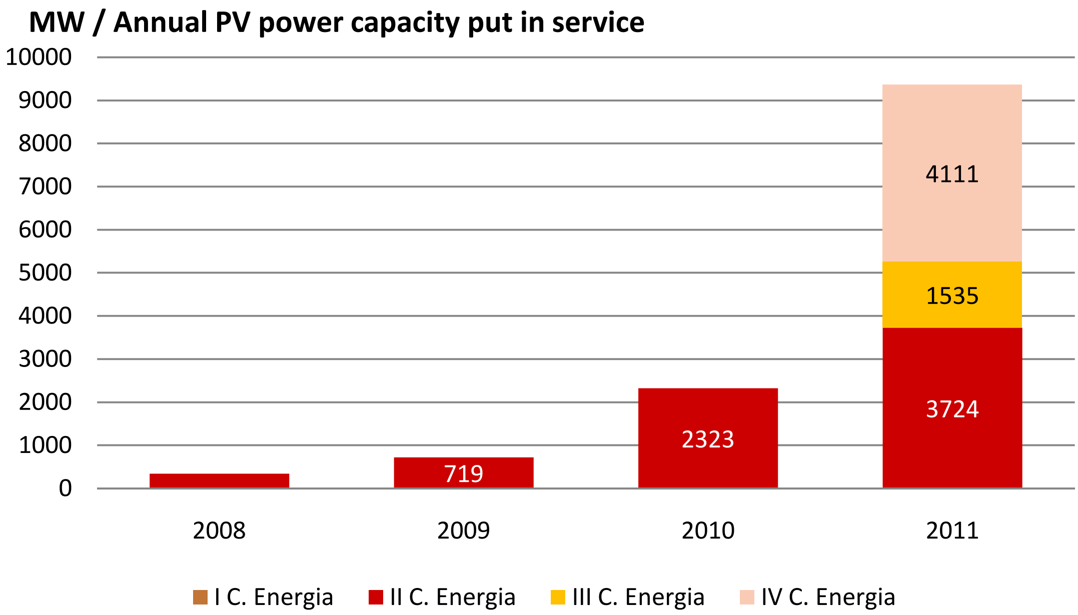

Figure 31 - Annual PV power capacity put in service according to Conto Energia support mechanisms (Source: ESG)

[38] According to the official communication of the regulation Authority for Electricity and on 12 July 2012 no. 292/2012/R/efr, according to which, on the basis of the actual incentives, an aggregate annual cost of 6 billion Euros has-been reached.

The "IV Conto Energia" scheme issued by MD 05/05/11 distinguishes basically between the following categories of PV systems, which are entitled to be granted:

- PV systems (section II of the same MD);
- Integrated PV plants with innovative characteristics39 (section III of MD);
- Concentration PV systems (section IV of MD);
- PV plants with technological innovations (Art. 19 of MD).

Basically, for the first category, the scheme sub-classifies the technologies between PV systems to be installed on building's roofs and "other PV" (including grounding types), and according to the capacity, between small power plants and big power plants (see figure 32).

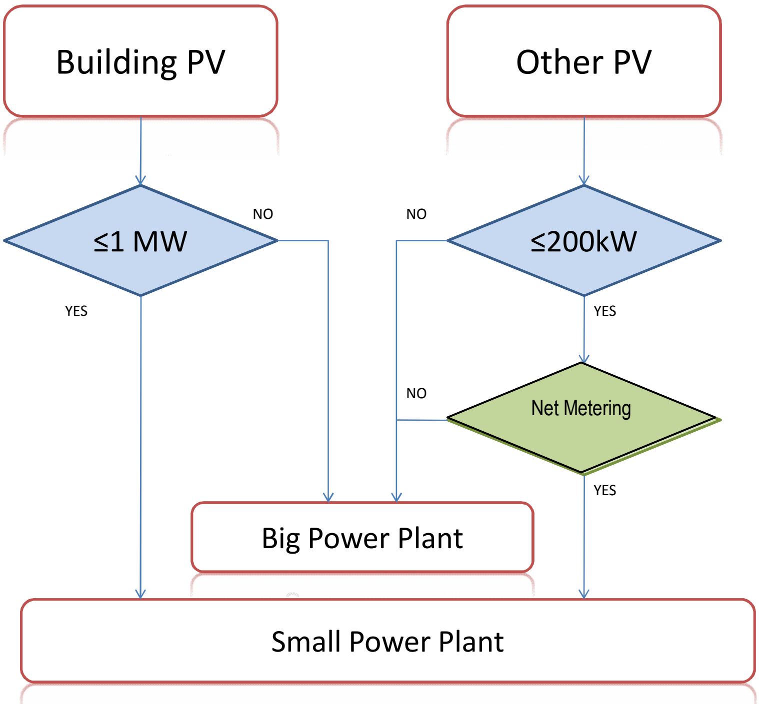

Figure 32 - IV Conto Energia granted PV systems (section II)

This type of incentive scheme is based on a "budget control" mechanism, which allows the control of costs deviation from the total budget assigned periodically for the promotion of each technology. In case the actual incentive costs in a semester exceed the estimated costs for the same period (Art. 4 MD 05/05/11), the tariffs for the coming periods are reduced according to the calculation of the Annex 5 of the same MD.

The rate of granted tariff is differentiated not only on the type of technology and capacity, but as well on its location[40]. Up to the year 2013, the tariffs are granted for the full energy produced. According to the IV Conto Energia, from 2013 onwards, the tariff for the premium incentive was planned to be granted for the self-consumed energy, while for the injected, the technology would be supported by an "all-inclusive" tariff. However, as the new decree imposed the entrance of the V Conto Energia before 2013, we are not going to observe the conditions of IV Conto Energia in 2013 but the new implications and modifications of the V

[39] For Integrated and Concentration PV systems: only new components or components which were not used in other systems shall be used (for the case of integrated PV, replacing modules or building architectural components are considered as "innovative"). The PV systems shall be connected to the electricity grid or to a small, isolated grid so that each plant has a single connection point to the grid. Nominal power shall be between 1 kW and 5 MW. For Integrated PV systems, They shall be owned by legal entities of public entities.
[40] See Annex 5 of DM 05/05/11 for further tariffs details.

Conto Energia. Apart from the important amendment mentioned in the above paragraph, the V Conto Energia will introduce the following modifications.

- Tightening of the incentive budget for a limited supported capacity by year (2-3 GW/year according to a new aggregated budget of 6,7 billion euro/year), with a level of financing of about 700 million euro/year.
- Extension of the access procedure (booking)[41] for all the plants over 12 kW of nominal power, throughout a "registration" with cost cap[42] for each registry (called every 6 months) and access to incentive priorities/ranking according to functions[43].
- Bonus for self-consumed production (similar to the German mechanism) in order to reduce PV injected energy and therefore, the networks congestion produced by lack of hosting capacity in low and medium voltage.
- Bonus for PV plants with new features, with levels decreasing between 2013 and 2015 (from 20 to 5 euro / MWh) and for systems installed in replacement of asbestos roofing, with levels decreasing between 2013 and 2015 (from 30 to 10 euro / MWh).
- The degression rate on the incentives tariff for the plants entering in operation during the next years, compared to the IV Conto Energia, approaching to the general EU average reduction trend. For systems up to 1 MW: FIT (it is paid on the electricity sold to the GSE). For plants greater than 1 MW: a premium tariff (it is paid for electricity produced which is not sold to GSE). For installations for self-consumption purposes, a special tariff.

The levels of tariffs for each technology are according to the following tables, whose regression rates are applied every six months (a semester), during the first five semesters, from which further 15 % would be reduced for the following periods.

Table 13 - PV incentives tariffs per technology acc. to V Conto Energia

ORDINARY PV TARIFFS	Euro/MWh			
First Semester	Rooftop plants		Other plants	
Capacity in kWh	Feed-In Tariff	Self-consumption	Feed-In Tariff	Self-consumption
1 <= P <= 3	208	126	201	119
3 < P <= 20	196	114	189	107
20 < P <= 200	175	93	168	86
200 < P <= 1,000	142	60	135	53
1,000 < P <= 5,000	126	44	120	38
P > 5,000	119	37	113	31

[41] With exception of PV integrated in buildings and using innovative technologies, for concentration plants, for plants built by public institutions, for plants with capacity up to 20 kW for which a 20% tariff cut is applied for, and for plants on asbestos rooftops with capacity up to 50 kW.

[42] Cost caps consisting in 140 million euro for the first register, 120 million euro for the second register, 80 million euro for the further registers up to the cost cap of V Conto Energia is reached.

[43] Ranking criteria defined as: Rooftop plant over energy saving buildings (D category or higher) in replacement of asbestos roofs, rooftop plant over energy saving buildings (D category or higher), rooftop plant in replacement of asbestos roofs, plants using exclusively EU/EEA components, plants built in polluted sites, plants built over military ownerships, in exhausted waste disposal areas, in unused rock-mines, or in depleted mines, plants with capacity up to 200 kW connected to industrial activities, rooftop plants, greenhouses, plants over small pergolas, plants over small rooftops, plants over gazebos, sound barriers.

TARIFFS FOR NEW TECHNOLOGIES	Euro/MWh	
First Semester		
Capacity in kWh	Feed-In Tariff	Self-consumption
1 <= P <= 20	288	186
20 < P <= 200	276	174
P > 200	255	153

It can be considered that these modifications would affect the upcoming investments, due to the reductions of the internal rates of return for the projects, but this amendment will be reinforced with another indirect financial support scheme like tax reductions or investments financing facilities. As well, these constant changes in the regulation are affecting the planning of all the PV industry sector, due to the impossibility of the local supply chain to make investments in long term, in this way allowing the technology to reach sooner the *grid parity* and at the same time benefitting the local PV industry.

Of course the issue of the economical crisis could be understood as a cause of this incentives reduction. But the technology has not reached the *grid parity* in Italy. With the further reduction of components and turnkey projects costs during the upcoming years, the fact of Italy reaching *grid parity* for PV in some regions would not be an impossible objective, in fact, depending of mainly three factors:

- size of the power plant;
- location of the power plant;
- ratio of self-consumption/commercialization of the energy produced.

In order to allow the approximation of these technologies to the *grid parity* and being self sustained, the incentives should be prorated along the upcoming years until fulfilling this objective with aim to reach the target imposed for 2020.In a whole, the V Conto Energia amendment is focusing to reach the 2020 targets, developing RES in a gradual level, aiming to support the PV sector until reaching the *grid parity,* and allowing the local industry to have a market incidence with constant growth towards the best cost/benefit ratio.

3.6.3. All-inclusive feed in tariff ("Tariffa omnicomprensiva")

As an alternative to GCs, in accordance with the Financial Act of 2008, the small RES producers (except PV systems) with an installed power of less 1 MW or 200 kW (for wind energy), are entitled to be granted with a FIT.

The system consists of fixed rates for electricity supplied to the grid, paid for *15 years*, differentiated according to technology. The value of the all-inclusive tariffs includes both the incentive component and the sales component for electricity produced and supplied to the system.

Table 14 - All-inculsive FIT rates for RES plants commissioned up to 31 Dec, 2012

Source	Tariff [EUR/kWh]
Wind turbines for systems smaller than 200 kW	0.30
Geothermal	0.20
Tide, wave, ocean	0.34
Hydroelectric other than in the preceding point	0.22
Biomass, biogases and bioliquids (EU Regulation 73/2009)	0.28
Landfill gas, sewage treatment plant gas, biogases and bioliquids	0.18

RES generation supported by the TO in 2011 was almost the double in comparison with that incentivized during 2010. Biogases technologies were the most benefited from this support scheme, during the last three years, showing a remarkable growth during last year (59% of the whole supported production), when they have almost reached to triple 2010's production.

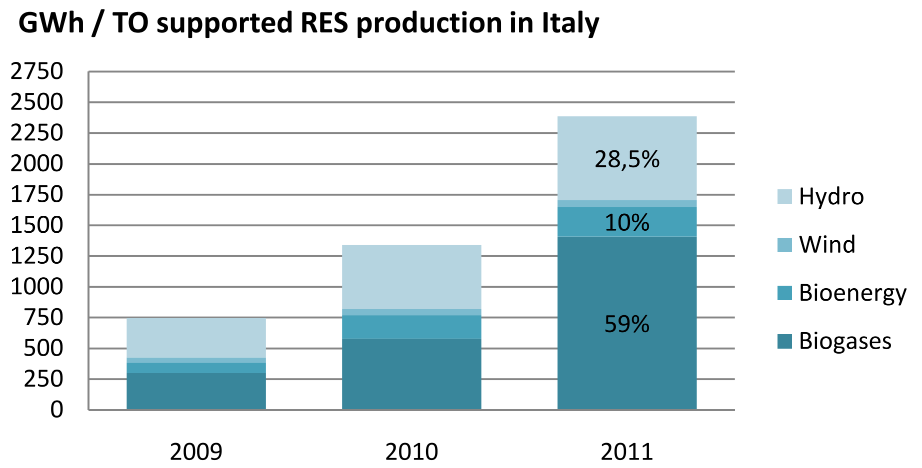

Figure 33 - All-inclusive FIT RES supported production in Italy (Source: AEEG)

This TO incentive scheme supports eligible plants commissioned before 31st December, 2012, date from which the new incentive mechanism will be put into force.

3.6.4.RES incentives Ministerial Decree 2012

From 1stJanuary 2013[44], a new support scheme has been put into force by Ministerial Decree of MiSE (Economic Development Minister), issued under DM 6th July 2012, given the implementation of art. 24 of LD 3rd March 2011 N° 28, defining the incentives for generation of electricity from RES other than PV.Before deepening in the new modifications of this scheme, it is important to get round that the re-setting of the 2020 national target for RES-E (electricity consumed being generated by renewable sources) within the NREAP, has been established into 32/35%, due to the current progress achieved and being projected to the year 2020.What is being sought by the new scheme is mainly to try to develop a mix which gives priority to

[44] Althought this DM is put into force from 1st January 2013, all plants that are accepted to go into operation by 30 April 2013 could decide to be still admitted to the GCs regime (but they will not be allowed to apply for the tariffs defined into the new regime).

those sources that meet the following objectives: lower cost/unit, major economic benefit on local industry and lowering the environmental and grid impact. The system introduces three mechanisms to govern the new annual installed capacity, avoiding excessively rapid growth, depending upon the capacity of the plants.

Table 15 - Capacity range new incentive mechanisms for Italy (Source: MiSE DM 6 July 2012)

Power range	Mechanism applied
Small power plants[45]	**Free accessto incentive** systems after commissioning
From limit stated above – 5000 kW (50 kW – 10 MW for hydro and 20 MW geothermal)	Access guaranteed through **tariff booking** according to ex-ante non-directly competitive **registration** process and adequacy within annual capacity limits
>5000 kW (10 MW for hydro and 20 MW geothermal)	Access guaranteed after reverse **auction procedure** basis (tender with the winning bid being the offer for the lowest possible tariff level) and adequacy within annual capacity limits

The quotes of capacity to be installed, per technology, under this scheme and in correspondence with the size of plant/access mechanism have been established until 2015.

Table 16 - Register and Tender quotes to be installed per year acc. to DM 6 July 2012

	2013		2014		2015	
Source	Register	Tender	Register	Tender	Register	Tender
Onshore Wind	60 MW	500 MW	60 MW	501 MW	60 MW	502 MW
Offshore Wind	0	650 MW	0	0	0	0
Hydro	70 MW	50 MW	70 MW	0	70 MW	0
Geothermal	35 MW	40 MW	35 MW	0	35 MW	0
Biomass and biogas	170 MW	120 MW	160 MW	0	160 M	0
Waste to Energy	30 MW	350 MW	0	0	0	0
Tides and Waves	3 MW	-	0	-	0	-

Apart from this quotes, the Decree establishes a quote cap for the refitting installations of the already existing plants.

For plants with capacity up to 1 MW a FIT is applied (paid on the electricity sold to GSE), but the operator is entitled to request the regime of the bigger plants. For plants over 1 MW a premium tariff is applied (paid on the electricity generated which is not sold to GSE).

The tariffs are applicable since the starting of commercial operation of the power plants and can be consulted on the Annex 1 of the RES incentives DM MiSE of 6th July 2012. Lastly, it is important to emphasize that a gradual and controlled spending growth up to 5.8 billion euro/year and subsequent stabilization by 2020 has been assigned to support this new incentive mechanism.

[45] Small power plants are understood as: (i) wind and oceanic streams with capacity not exceeding 60 kW, (ii) hydro streams with capacity not exceeding 50 kW, (iii) biomasses streams with capacity not exceeding 200 kW, (iv) biogas streams with capacity not exceeding 100 kW, (v) geothermal with medium and high enthalpy with re-injection up to 5 MW, (vi) other categories detailed in the DM.

3.6.5.CIP 6/92

The CIP 6, issued in 1992, is a type of FIT incentive which is no longer in force for new projects (in 2000 it was completely replaced by GCs); however it continues to promote those RES producers which have been granted during the lifetime of their supply. It consists in a form of remuneration for the supplied energy, by an incentivized rate whose value is updated over time.

GSE is in charge of buying this energy and selling it into the power exchange. The charge resulting from the difference between the sold price and the costs is then covered by final users with the electricity tariff component A3. During the last years, the RES production supported under CIP 6 has diminished due to the expiration of the old agreements.

3.6.6.Other support schemes

In addition to the main support schemes detailed before, there are two fiscal regulations in force, which aim to lighten the investment costs throughout ***tax reductions*** as:

- Reduction in VAT: Since 1993, it has been promoted the production of electricity from PV and wind energy through a reduction of 10% on the value-added tax[46] for investments in wind power plants and PV energy systems and investments in DN to host this RES production.
- Reduction in real estate tax: The Financial Act of 2008 gives municipalities the opportunity to grant a reduction in real estate tax[47] to buildings installing RES systems from 2009 onwards. The amount of this tax reduction depends on the valorization of the property and differs from municipality to municipality.

3.6.7.Type of selling

Among the services offered by GSE in order to buy the electricity produced by the RES generators, the Italian market counts on two systems, a *dedicated withdrawal* and a *net metering* system.

3.6.7.1. Dedicated withdrawal (“Ritiro dedicato”)

The dedicated withdrawal (“ritiro dedicato”), in force since 1st of January 2008, can be applied to plants of less than 10 MVA (any RES source) or producers from non-programmable renewable sources of any capacity. The AEEG, with Resolution *No.ARG/elt. 103/11*, has described the new structure and new values of the guaranteed minimum prices (PMG) applying from 1st January 2012, from that date by source differentiation and, in case of solar photovoltaic and hydro, defined for a progressive scale of energy.

Generally, the dedicated withdrawal is an "indirect" way of selling, recommended for plants which offer to inject to the grid the energy that systematically exceeds their needs, as an alternative to the direct selling into the spot or OTC markets. Thus, the GSE acts as a third party, or an intermediary between the producer and the market.

[46] Aliquota agevolata del 10 per cento, instead of 21/100.
[47] ICI: imposta comunale sugli immobili.

In the last years evolution (see figure 34), in particular year 2010, the amount of electrical energy withdrawn was equal to about 11,5 TWh, being produced by 13.090 power plants from around 9 GW of power capacity. Among these, about 12.000 plants (primarily mini-hydro and solar PV), a power of 2,4 GW have taken the benefit of the guaranteed minimum prices, translated to a cost for the tariff component A3 of slightly more than 100 million euro. In 2011 (preliminary figures), the amount of electricity within the dedicated withdrawal amounted to about 17,1 TWh, produced by 35.486 facilities, with a total capacity of about 17 GW. Among these, 33.657 plants (mainly small hydro and solar photovoltaic), with a capacity of 7 GW, have taken the benefit of the guaranteed minimum prices, meaning a cost for the tariff component A3 of around 130 million euro. For 2012 it is estimated that the amount of electricity withdrawn from the GSE increases further to above 20 TWh, with a cost contribution for the tariff component A3 in reduction, due to the effects of the revision of minimum guaranteed prices made by the Authority.

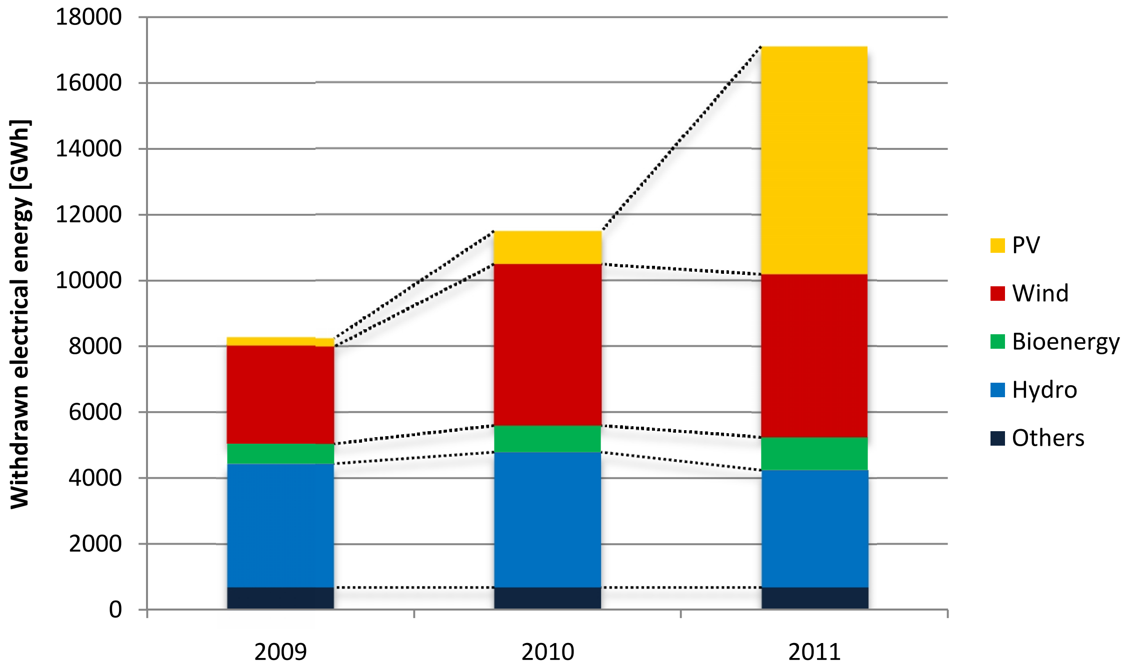

Figure 34 - Electrical energy traded through dedicated withdrawal in Italy (Source: AEEG)

3.6.7.2. Net Metering ("Scambio sul posto")

The net metering allows the producer to enhance the energy fed into the grid according to a financial compensation criterion with the value of the energy taken from the network. In general terms, the conditions offered by the net metering are more profitable than those offered by dedicated withdrawal because one can reward the energy fed into the grid at market value plus the variable unit cost of energy services, associated with its bill of supply to the amount of electrical energy exchanged.

The net metering is in force since 1 January 2009, and can be applied to plants using renewable sources and/or high efficiency CHP up to 200 kW.

Since the two Ministerial Decrees for supporting RES were issued, this system is expected to be put out of force. As the V Conto Energia is introducing an incentive tariff for self-consumption, this selling mechanism would be put out of practice.

3.6.8. The support schemes costs

The need to promote the growth of RES through the aforementioned incentive systems, generates an increase in cost scheme of the electrical system that ends up being covered by the final consumer through their electricity bills. To support the above mechanisms, the Italian system has increased their costs according to the following evolution chart (figure 35).

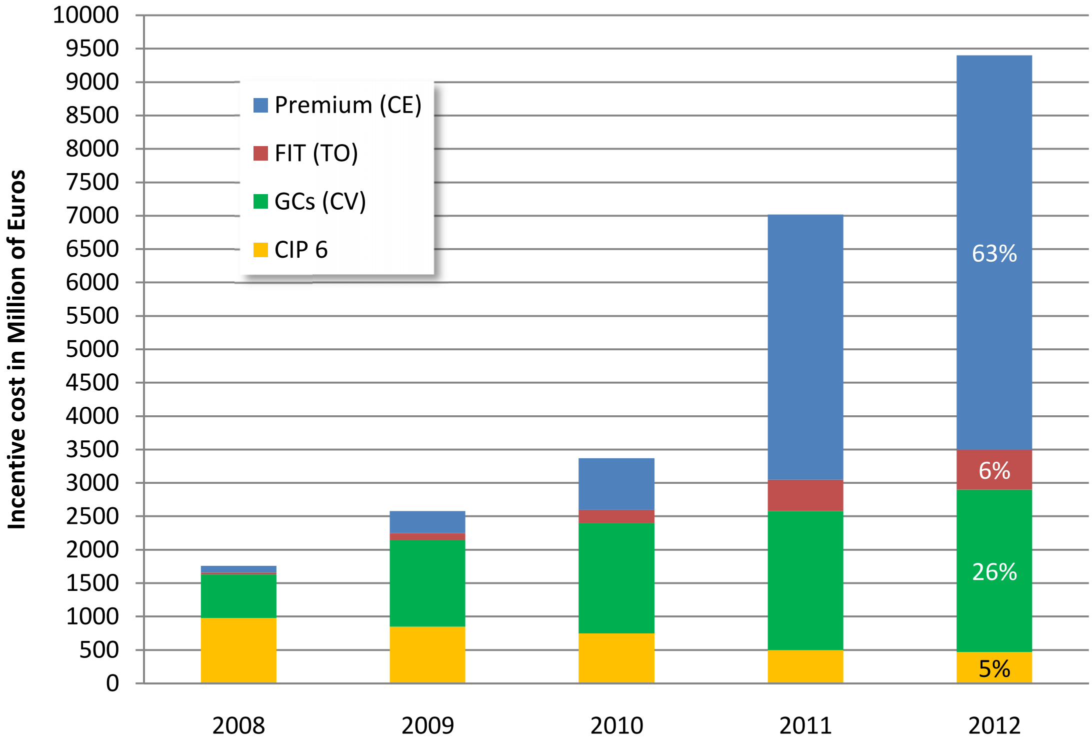

Figure 35 – Italian RES support schemes costs evolution and projection for 2012 (Source: AEEG[48])

The costs arising from promoting renewable sources are covered by tariff component A3, with the exception of costs associated with GC transactions that are not subject to withdrawal by the GSE. It is estimated that, by the year 2012, the costs arising from supporting renewable sources would be approximately 9.4 billion euro (costs arising from direct incentives), plus the addition of those attributable to the services provided by the GSE (*dedicated withdrawal and net metering*), deriving to the A3 component a total amount close to 10.5 billion euro. As it is stated in the NREAP for the projected costs in order to reach 2020 targets, it had been estimated an incentive budget for the whole 2020 year of about 10-12 billion euro, which forces to conclude that the referenced projections have been *underestimated*.

As shown in the previous figure, the biggest share of incentives budget is earmarked to the *premium tariff (Conto Energia)* in first place (almost the 63% of the estimated costs for 2012) and *GCs (certificati verdi)* in second place (with almost the 26% of the estimations for 2012), with a remarkable increase during the last two years for the first scheme. Regarding the *all-inclusive feed in tariff (tariff omnicomprensiva)*, the increase rate is relatively low, but still differentiated, while for the closed *CIP 6* mechanism it is observed its reduction as a consequence of the expiration of the old agreements.

[48] The data for 2011 are preliminary, while the figures of 2012 represent the best estimate to date as posible.

Regarding the quantity of RES production, these mechanisms have allowed the promotion of an amount of electrical energy which, during 2011, has exceeded the 45 TWh, and for 2012 the estimations are (as shown in figure 36) around 58 TWh.

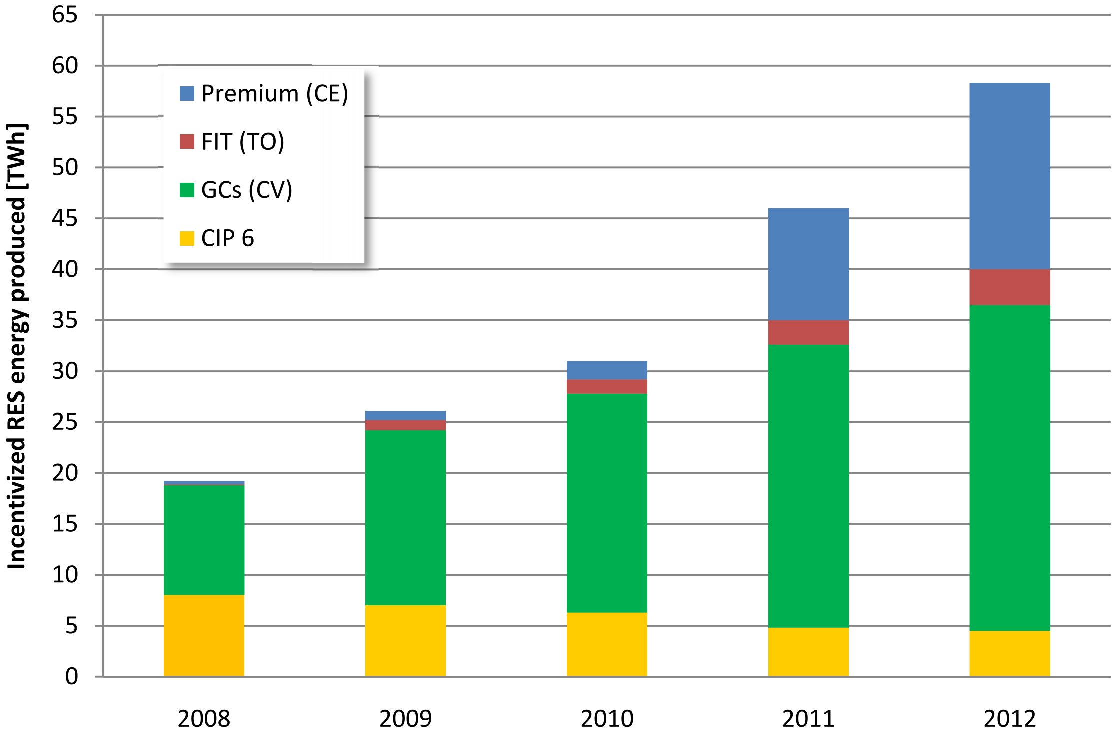

Figure 36 - Italian incentivized RES energy produced and projection for 2012 (Source: AEEG).

As the costs assignment per incentive reflects, the *GCs* and *premium tariff* have achieved the most of the RES share of energy produced during the last two years[49]. As mentioned before, a special attention has to be taken in the costs assigned for the previous version of the *premium tariff (IV Conto Energia*), which has reached to demand an amount close to the 6 billion euro (when it had estimated a cap of 6-7 billion euro for the year 2016), giving place to the enforcement of the new issued V Conto Energia, which has estimated another 6.7 billion of euro/year as cap of expenditures.

This situation, relatively seen as a simple underestimation of the 2016 target (and 2020 in the whole context) if the rate of energy produced was certainly in the line of the expectations; or can be considered as a symptom of a low efficiency incentive scheme, if the rate of consumption of the financial resources is extremely high compared to what should be assigned for the upcoming years, in order to expect a future competitiveness of the supported technology (in this case, PV technologies), and a consequently prorated expenditures in order to meet 2016 target.

The last idea should be carefully taken into account, considering that an incentive scheme is a way of supporting a technology towards reaching the *grid parity* (and not a way to promote excessive plant capacity in the shortest available time), and the rate of consumption over time of the financial budget (aiming to fulfill a capacity target) is a key parameter for determining the efficiency of the support scheme.

[49] Note that, in relation to GCs, the assigned costs for a year cannot be directly associated to the amount of electrical energy promoted in the same year. This is because GCs issued each year are valid for the next three years.

According to a recent study[50] from EPIA (European Photovoltaic Industry Association), *dynamic grid parity* would be reached in Italy in 2013 in the commercial sector first, and then it would be spread out in the rest of EU markets, due mainly to the southern location and thus, higher solar irradiation levels compared to the rest of the countries. The prices of the PV systems, could decrease by about 0,83 – 1,59 €/W_p (between the 36% to 51% of reduction) depending on the market segment (see figure 37), during the next ten years.

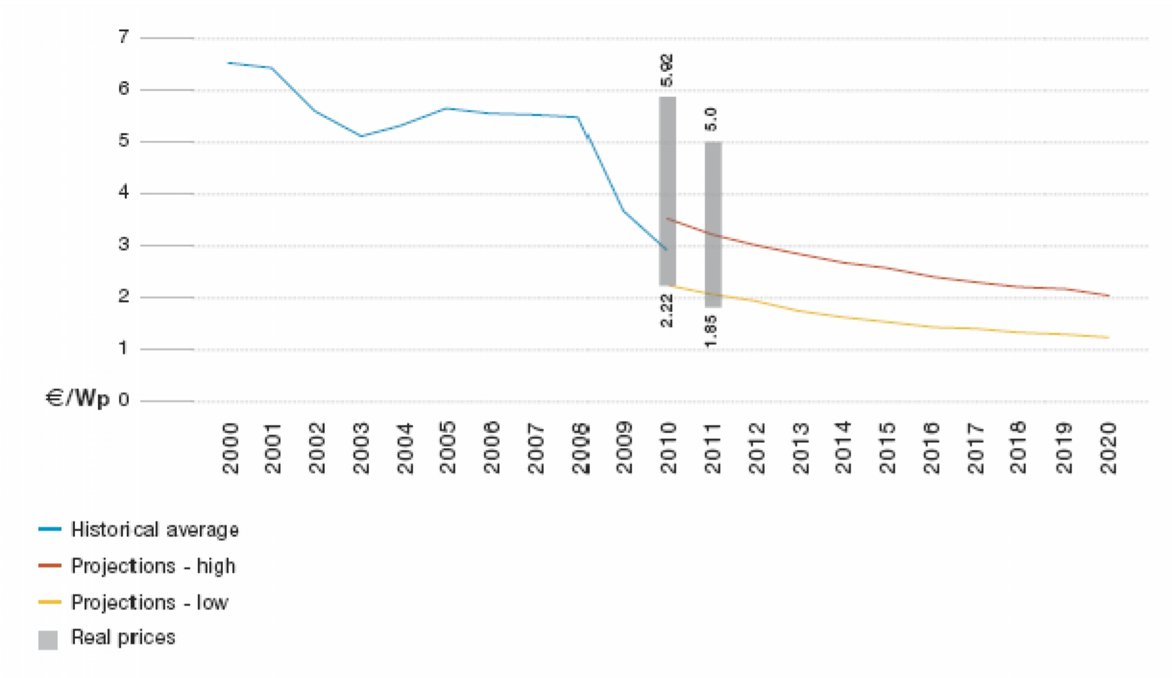

Figure 37 - Evolution of PV system price in EU

Therefore, if the Italian support schemes remain in place until full competition occurs then, those schemes can be phased out as competitiveness approaches. Moreover, the incentives budget can be efficiently invested in order to reach the targets set, in a scheduled total expenditure, as long as the competitiveness of the technology is achieved in parallel.

3.7. ITALIAN ACCESS TO THE GRID MECHANISM

In Italy, system operators must give priority grid access to RES generators; there also is a rule, to fulfill the requirement of giving priority dispatch for those technologies, in line with the security of the system. In addition, the producer is entitled to require the operator to develop the network if it is necessary for its network connection.

3.7.1.Procedure

All RES producers have the right to be connected to the national network upon request, as it detailed in the *Legislative Decree 79/99*. After reaching the contractual agreement between the producer and the system operator, the last one must perform its activities within a timeframe referred to the *TICA* (Integrated Text of Active Connections), in which the procedure for grid connection is described.

[50]EPIA, *On the road to competitiveness.* September 2011.

After the application is submitted to the operator, the procedure for connection consists of the following steps:

Table 17 - Access to the grid procedure and timeframe steps for the Italian electricity national system

Procedure step	LV / MV	HV / EHV
Estimation of costs *DSO/TSO must respond and deliver cost estimate within…*	-20 working days for capacities of up to 100 kW -45 working days for capacities from 100 kW to 1 MW -60 working days for capacities of more than 1 MW up to 10 MW	-90 working days for capacities of more than 10 MW
Acceptance of cost estimate *The applicant must accept the costs estimation within…*	45 days for capacities under 10 MW	-120 days for capacities of more than 10 MW
Request for authorization	**Applicant** (for construction and operation of the plant): -LV: within 60 working days -MV: within 90 working days	-HV: within 120 working days -EHV: within 180 working days
	Operator (for construction of the connection system and grid expansion)**:** -LV: within 30 working days -MV: within 60 working days	-HV: within 90 working days -EHV: within 120 working days
Authorization procedure	This procedure starts within 30 days from the date in which the request of authorization is received (Art. 12, c. 3 DL 387/03) and can last up to a maximum of 90 days	
Beginning of works *The Applicant is obliged to start the construction of the production plant within…*	-6 months for connections in LV -12 months for connections in MV	18 months for connections in HV or EHV
Connection *The DSO/TSO must connect a system within the following timescales…*	-30 working days for basic works -90 working days for complex procedures, plus 15 working days for every km of connection line except the first km	The transmission grid operator must connect a system within the timescales specified in his terms and conditions

Regarding the costs for connections, the mechanism is divided among LV/MV and HV/EHV. At the moment of submitting the application, the future generator must pay to the system operator (DSO/TSO depending on the power of the plant) an administration fee according to the following table:

Table 18 - Administration charges to pay to the system operator upon application submittance

Capacity	Administration Fee [Euro]
< 50 kW	100
50 - 100 kW	200
100 – 500 kW	500
500 – 1000 kW	1500
>1000 kW	2500

3.7.1.1. Low and Medium Voltage

Regarding RES, Hybrid and CHP[51], the TICA provides easier payment terms as compared to conventional plants. For this type of connection, the cost is given by the lowest value between A and B, which are computed as follows (in euro):

[51]Combined heat and power plants.

$$\mathbf{A} = CP_A \times P + CM_A \times P \times D_A + 100$$
$$\mathbf{B} = CP_B \times P + CM_B \times P \times D_B + 6000$$

where:

- CP_A = 35 €/kW, CM_A = 90 €/(kW× km), CP_B = 4 €/kW, CM_B = 7,5 €/(kW× km)
- *P is the requested power*
- *D_A is a conventional distance between the connection point and the nearest transforming station MV/LV*
- *D_B is a conventional distance between the connection point and the nearest transforming station HV/MV*
- *Connection charge is increased in the case of underground cable (coefficients CM are duplicated) or some particular geographical locations (CM/CP are triplicated)*

The connection cost is required to be paid by the plant owner to the DSO in the following stages: 30% on acceptance of the estimate and the remaining 70% at the time of communication of completion of the strictly-necessary works for the physical production of the connection.

3.7.1.2. High Voltage

For HV and EHV connections for RES, the Italian TSO (Terna) employs the *shallow* allocation cost method[52] (only the connection charge is paid by the producer). At the time the application is submitted in order to obtain the STMD[53] (minimum technical requirements) the producer shall make a payment to the system operator to cover the management activities and technical analysis relative to the formulation of the STMD. The prices fixed for RES power plants are reduced to a 50% and to a 20% in the case of CHP plants.

CC_{HV} [Euro] = 1.250 + 0,*5 €/kW x P* *[up to a maximum of 50.000 Euro]*

In the case the producer does not pay entirely the allocation cost for the connection upon acceptance of the STMD, before the start of the network interventions he should present, upon request by the TSO, a bank guarantee, equal to the share of the compensation for the connection not yet paid.

One important issue has risen as a consequence of this connection procedure that, in Italy, was called “virtual saturation” of the grid. The same was caused by the high number of connection requests received by the DSO. After proceeding for booking grid capacity for the upcoming producer, in a network zone where the network capacity is a scarce resource, the capacity of the grid is considered “virtually saturated” in the area. This means that the grid is not physically congested, but all its available capacity is reserved by connection requests and no additional capacity can be allocated. In these situations, the DSO can not comply with its obligations with the connection procedure, forcing the same to provide alternative solutions or producing delays in the administrative procedure.

This situation is related to a strong development of RES in certain areas where the incentive schemes have produced high effects and where the grid is characterized by a weak and not sufficient meshed structure.

[52] A Shallow cost allocation requires the renewable energy producer to pay for the cost of connection only. In such models it is often the TSO or DSO who is required to pay any grid reinforcements. The costs of grid reinforcement in a shallow allocation model are often socialized, that is they are passed onto the consumer in their electricity bill. Source: *Reneable Energy grid connection*, Research and Library Service Briefing Paper. November, 2010.
[53] Soluzione Tecnica Minimia di Dettaglio.

In Italy, by the end of 2010, connection requests have reached to a total of 128 GW on the transmission lines and to 22 GW on the distribution lines (AEEG 2011), exceeding the total power capacity of the system.

3.7.2.Use of the Grid

The TSO is obliged to concede priority of dispatch to electricity from RES (art. 3.3 DL 79/99). Specifically, priority must be given in the case of several producers offering their electricity at the same price. This benefit is possible as long as the HV network security level is granted. Electricity produced from intermittent sources is considered with the highest priority.

Regarding the *injection*, relevant RES non-programmable units (above 10 MVA) define an injection's program to be delivered to the TSO. This schedule is performed by the operators in line with a support mechanism which can be considered as a *premium tariff, which* is called the ***incentive mechanism for the correct prediction of relevant non-programmable RES units***[54].

This system consists of a bonus incentive for producers of electricity (with power higher than 10 MVA) from intermittent RES, which is used if the actual power production coincides with the predicted energy production. The amount of the bonus payment is directly proportional to the accuracy of the forecast. For each dispatching point, Terna calculates the difference between the energy actually produced and the production estimate on an hourly basis. In case this difference is lower, in absolute value, than the produced energy multiplied by the S_{rif} *parameter* (0.2 for 2011 and 0.15 from 2012 onwards), Terna pays the producer an amount (CCP) equal to a premium (€ 3 per MWh) multiplied by the difference between the S_{rif} *parameter* multiplied by the produced energy and the misalignment in absolute value between the produced and the programmed energy:

$$\mathbf{CCP} = 3\,€/MWh \times (S_{rif} \times E_{inj} - |E_{inj} - E_p|),$$

being E_i = energy injected and E_p = energy programmed

On the other side, this promotion mechanism encourages the producers to improve their forecasts, reducing as a consequence the costs caused to the electrical system, and increasing the security level of the network. Although the Italian Authority has introduced this incentive mechanism in order to improve the accuracy of the forecasted program, producers are far from achieving efficient estimations. Under these conditions, when the amount of electricity effectively fed into the grid by those units is different from the estimated amount, the higher derived costs for the system are not charged to the RES producers (they are passed to the final consumers instead), and no penalty is applied to the non-compliance of the forecasted production. This fact, moreover, induces a higher cost for the final consumers due to the increase of reserve margin needed for security, to be offered by conventional units.

In order to encourage the commitment of the generators in responding to this mechanism, currently, the AEEG is studying under issuance of a consultation document, the possibility of charging the unbalances caused by the non-programmable to the renewable sources producers (DCO 35/12 “Guidelines on adjustment of the dispatching service to be applied to units of production of electrical energy, with particular reference to those not programmable”). This mechanism would force the producers to counter their own "non-

[54] AEEG 111/06. Meccanismo di incentivazione per la previsione corretta delle unità di produzione alimentati da fonti rinnovabili non programmabile.

programmability" and the impact it has on the quality performance of the network. This topic will be developed deeply in the sensitivity section in Chapter 5, considering the imbalances costs derived from the new regulation. In the case of not relevant non-programmable RES producers (less than 10 MVA), injection programs are defined on a zonal basis by GSE, acquiring the data by satellite. For those production units, therefore, the forecast charges do not fall upon the producers.

Regarding *dispatching services*, RES non-programmable units are requested to offer the following services (compulsory for new wind power plants[55] and for existing ones in the most critical areas); such services are not required for other non-programmable RES:

- voltage regulation;
- active power regulation capacity (only reduction);
- power reduction/*curtailment from the grid* (in case of congestion or over-frequency);
- reactive power regulation capacity.

These dispatching services, which are compulsory for wind power plants, are not remunerated in the dispatching market. In the case a reduction of power is requested, the producer buys back the energy (making no profit) but they are granted for lost of production with a specific fee which is charged to the final consumers. Considering that the priority of dispatch is always respected in the case that the security of the system is kept under control, for the cases in which the same is considered highly risky, a power *curtailment* of RES non-programmable sources is requested to the operators by the TSO. In Italy, this is regular in critical areas of the south (Apulia and Sicily), for certain type or technologies, especially for wind power generation (given the high penetration of this source at certain hours and the weakness of the grid infrastructure), which is called "*Mancata Produzione Eolica*". As well, given the high development of PV technology during the year 2011, this would be a reason to request power curtailment (*Mancata Produzione Fotovoltaica*) from this technology in the cases the TSO registers a threaten for the security of operation. It is important that these sources could comply with all dispatching services offered by conventional units, but as this is technically an impossible task, due to the unpredictability of the weather conditions, only some of them are offered. Moreover, the high penetration of non-programmable RES adds an instability quote to the system, forcing the system operator to count on a suitable conventional energy generation in order to answer to any eventual network unbalance, causing higher costs for the system, and higher greenhouse emissions due to the combustion mode used to operate gas turbines at partial load. Therefore, as much as these dispatching services are not provided, higher are the costs inefficiencies for the system. For this reason, the challenges for manufactures to develop technical improvements in order to fulfill in a higher grade this requirements, for producers to estimate with accuracy their forecasts and for networks to be developed towards the smart grids, are extremely important at the moment of reaching a high RES integration in the system.

3.8. ITALIAN ELECTRICAL SYSTEM AND MARKET

3.8.1.Generation

The structure of the Italian electricity system is characterized by a typical situation of a country with a continental/insular geography, thus the risk must be differentiated, in terms of security, against a potential power outage in the area of Sicily, first, and in Sardinia, in second place, mainly due to the fact that the national network has a bottleneck in the interconnections of

[55]Resolution ARG/elt 5/10.

the mainland to the islands[56]. Therefore, except for this situation, we can say that the Italian national system holds a reliable electrical structure given to excess generating capacity (46.7% of the capacity required to meet the peak demand on July, 13th 2011) and the over sizing of the productive capacity of conventional thermal power plants (65% of the total capacity, up to 2011), that despite of prevailing over other generation sources, the proportion has been reduced by 6% compared to 2010, given the leap from RES installed during 2011 (10.326 MW[57]). This last factor makes an important contribution to the evolution of the electric grid to less dependence on fossil fuels.

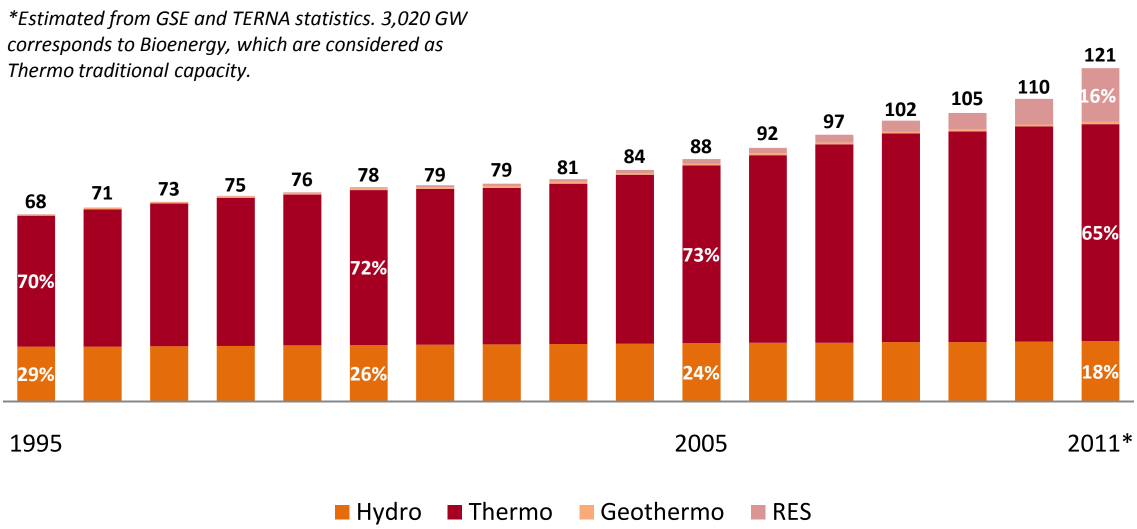

Figure 38 - Evolution of gross efficient power capacity (GW) installed in Italy (Source: GSE / Terna)

For the achieved rates during the year 2011, the new installed RES power capacity has grown up by 11.068 MW, increasing the total generation capacity at the beginning of year 2012 approximated up to 121.000 MW (+10 % on the 2010 basis). From the total RES contribution on installed capacity during 2011, 9.280 MW were increased by photovoltaic sources and 1.046 MW due to wind energy.

Table 19 – Estimated RES installed power up to 2011 in Italy (Source: Terna)

Gross Efficient Power installed (MW)	2011	% 11/10
Hydro	17.950	0,4%
Wind	6.860	18,0%
Solar	12.750	267,4%
Bioenergy	3.020	28,4%
Total RES	**41.352**	**36,5%**

3.8.2. Wholesale

Regarding the annual demand for electrical energy, the consumption in 2011 has increased +0.6% on a 2010 basis, fact that represents a positive variation for the second consecutive year after the 2009 drop (-5.7%). In 2011, the electricity demand has reached 332.300 GWh, which coverage was made in a 86.3% by domestic production and the remaining part (13.7%)

[56] The situation should improve in 2014 with the operation final acceptance of the new interconnection with the continent (Sorgente Rizziconi line). The improvement of the situation in Sardinia is rather due to the entry into full operation of the second SAPEI cable, which occurred in late 2011. *Source: AEEG, Relazione 56/2012/I/COM.*

[57] Terna, *Provisional data January 2012*.

allocated by the balance between imports and exports which increased by 3.3% compared to 2010. The maximum peak for hourly average power demand was reached at 12 p.m. on July 13th, with 56.474 MW, amount that represents nearly the 46,7% of the total national capacity.

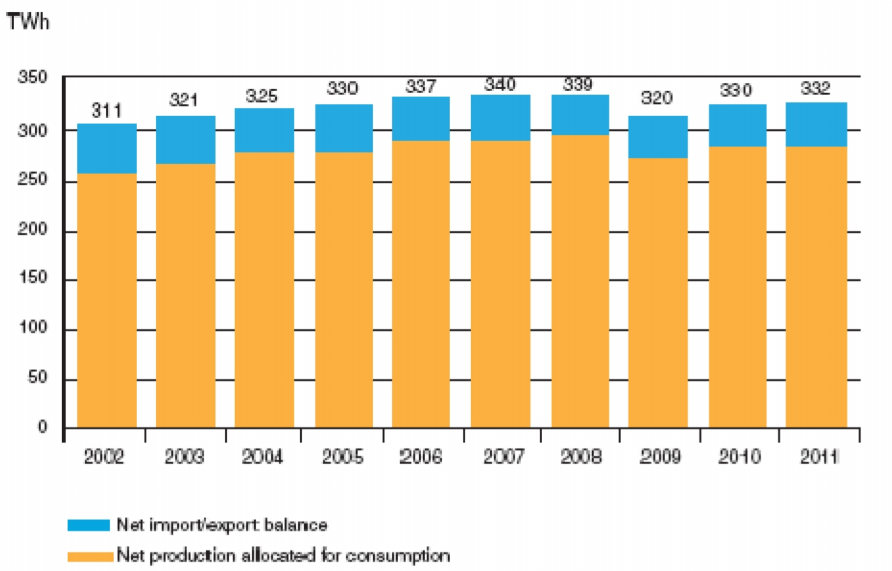

Figure 39 - Demand evolution in Italian market (Source: Terna)

The net production allocated for the energy local demand during 2011 was covered by thermal sources mainly (71%), which showed a slightly drop from previous year (73,3%), from hydro in second place (16%) and from rest of renewable sources, which have reached a remarkable increase (46,39% compared to 2010 contribution), mainly due to the new photovoltaic generation capacity installed during the year 2011, which contribution to the demand coverage was increased by a 3% compared to 2010. Totally, with the other RES production, the amount covered by this type of technologies, reached during 2011 a share of 29% of the total domestic production.

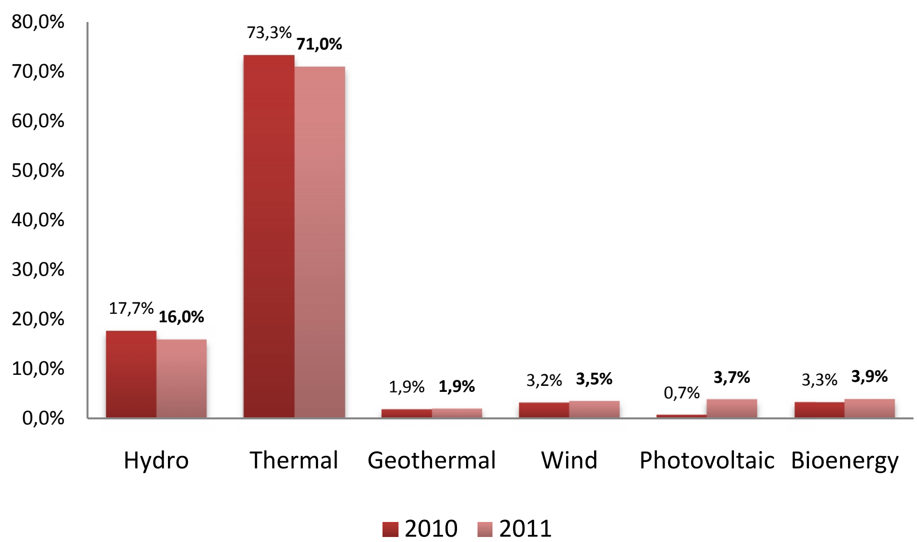

Figure 40 - Italian demand coverage during 2010/11 (Source: Terna/GSE[58])

[58]Figures taken from Terna and GSE first estimations from year 2011.

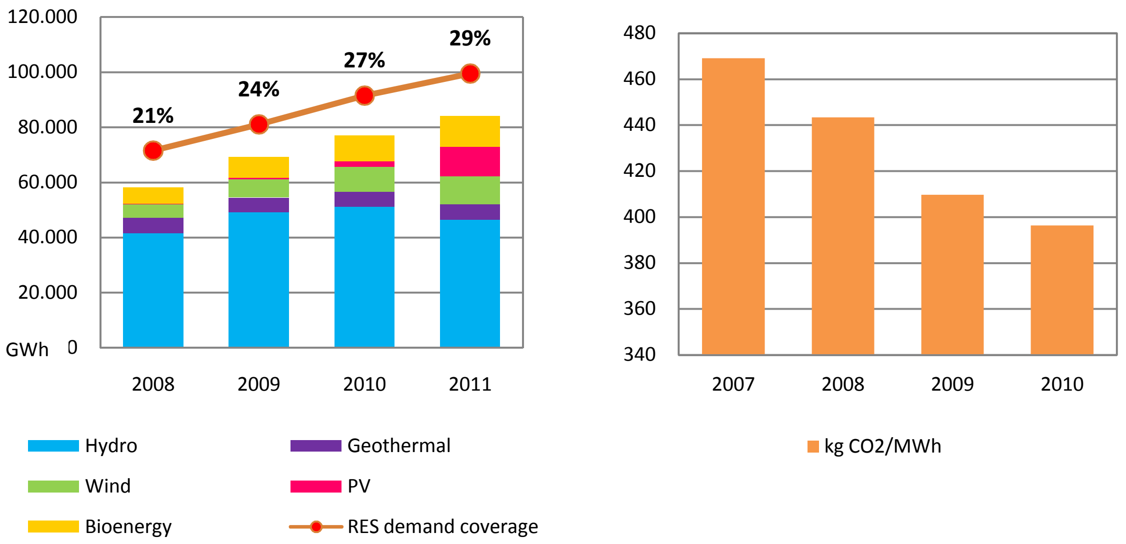

Figure 41 - Evolution of RES coverage for domestic demand and emission factor (Source: Terna/GSE/ISPRA)

As mentioned above, in the last year RES had a remarkable participation in the coverage of local demand, especially given by the availability of new generation capacity from non programmable sources (wind and PV), that despite the drastic reduction participation of hydro sources, have made this share to increase by 2% during 2011. As well, the effects on the CO2 emission factor can be observed as a consequence, which has evolved positively (396.34 kg_{CO2}/MWh, recorded in 2010[59]) due to the gradual incorporation of combined cycles and the new sources of zero emission which have allowed the reduction of generation based on fossil fuels.

3.8.3.Price development

The year 2011 can be considered as a hinge for the Italian market structure into the RES integration. Beyond the fact that the energetic matrix is still considered highly dependent on fossil fuels, which has an impact on the market price of electricity, it should be noted the significant leap that the photovoltaic has given, slightly reducing this dependence, as a consequence of regulatory policies carried out by the regulator AEEG, in 2011, through the incentive mechanisms of *premium tariff* (*Conto Energia*), the III and IV Conto Energia, which have added 7.835 MW[60] into service during the year 2011. In turn, this factor is reflected in the final price of electricity, due to the costs generated by the diverse incentive mechanisms which are implemented to promote the entry of new RES capacity.

In the Day-ahead Italian market (MGP[61]), after the clearance, consumers pay what is called the PUN[62] (National Unique Price), regardless of the area to which they belong. This is calculated as the weighted average of zonal prices. Instead, the accepted selling bids by GME are remunerated at zonal price. This system is a peculiarity of the Italian market.

At European level, it can be said that the competitiveness of Italian electricity market presents some degree of criticality, not as an effect of the falling demand due to the sharp economic

[59] Source: ISPRA, *Fattori emissione produzione e consumo elettricità.*
[60] Source: Energy Strategy Group, *Solar Energy Report 2012.*
[61] MGP: Mercato del Giorno Prima.
[62] PUN: Prezzo Unico Nazionale.

crisis, but because of a determinative factor that is the presence of two well differentiated zonal prices (both forming the PUN), the first corresponding to the mainland, the second to the islands, the latter presenting the highest values, given the obsolescence of the generation units and the restrictions on the transportation system[63]. But the major component that confers an important degree of criticality (placing the PUN between one of the highest in the EU) is the one which conforms the cost of gas for thermal generation. The latter, in addition to be supplying an energy matrix with high dependence on thermal generation, presents a cost in the Italian market, which is above the European average. The second major component in the wholesale price of electricity is that which corresponds to the incentive costs of RES (A3 component, already described in the incentives section).

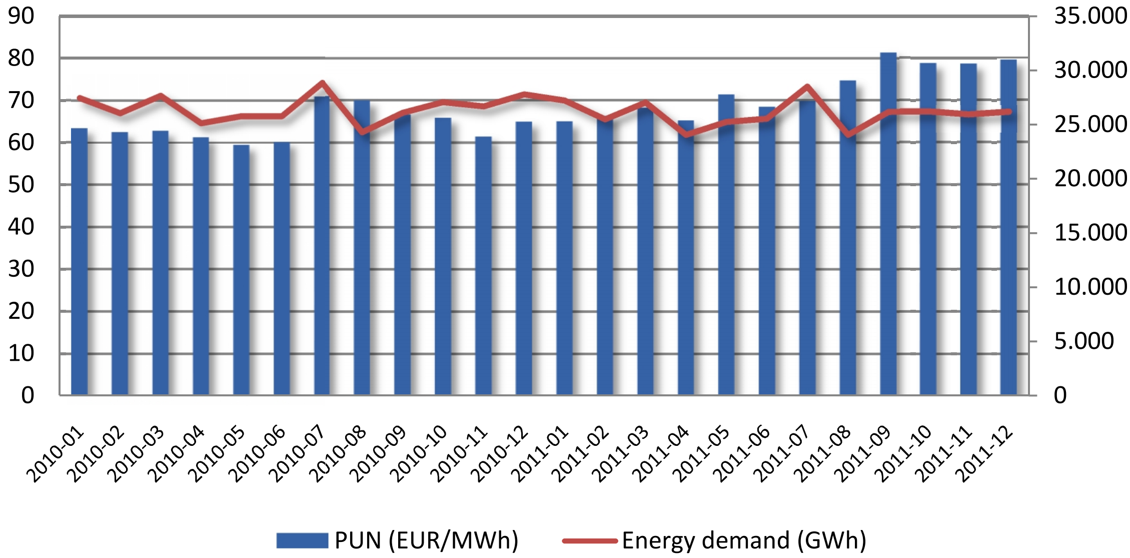

Figure 42 - Evolution of PUN vs. energy demand in Italian market (Source: GME)

3.9. SPANISH ENERGY POLICY REGULATION

One of the countries that have developed the RES earlier than most of the rest of the EU members is Spain. The policy model they have been developing during the last years has achieved astonishing results especially in electrical energy matter, leading the Spanish system to be consolidated in one of the first structural position in the continent. In 2009, Spanish RES have generated approximately 25% of total electricity production in what could be considered as an initial stage of development in this matter. New policies are looking forward to achieve the consolidation of this type of sources. In order to pursue this aim, energy policy in Spain would continue emphasizing in subjects as security of supply, energy savings and efficiency and sustainable economic, social and environmental development. For Spain, it is clear that all of this objectives are behind the target set by the *Directive 2009/28/EC* in *20%* of the final energy consumption by 2020 (exactly the same as the EU target).

Despite the efforts made in recent years, which managed to position Spain not only in the path of sustainable energy development but also in the forefront of renewable technologies, the

[63] In 2011, the performance of the two largest islands has improved, although there are important weak points. The price differential with the continent was reduced but the gap still exists between the prices of Sicily and those of the mainland, mainly due to the obsolete and therefore generally more costly generation facilities. The situation should improve in 2014 with the entry of operation of the new interconnection line. The improvement of the situation in Sardinia is rather due to the entry into full operation of the second SAPEI cable, which occurred in late 2011. This increased capacity has resulted in an alignment of the average prices in Sardinia with those of the Continent in the last three months of 2011. *Source: AEEG.*

present situation of the Spanish economic crisis has impacted heavily on the sector. Up to the point that the current government has adopted, among its cutting measures, the suspension of all economic incentives for renewable energy technologies, with the issuance of the RD 1/2012 of January 27, 2012[64].

Although this government decision would be a temporarily measure, the Spanish energy policy and incentives support schemes carried out in this nation will be analyzed within the scope of this study, due to the above mentioned importance the development of this country has achieved up to this moment, in the field of RES policy framework.

3.9.1.The Spanish National Renewable Energy Action Plan

Under the outlines of the Directive 2009/28/EC, Spanish government issued on 30th June 2010 the NREAP (PANER[65]), in this way answering to the requirements and following the model of national action plans for renewable energy adopted by the EC members.

Furthermore, in parallel with the NREAP, the RD 661/2007[66]had previously announced the issuance of the REP (2011-2020)[67] (Renewable Energy Plan), which was approved by the Council of Ministers of 11 November 2011, setting targets in line with Directive 2009/28/EC on the promotion of the use of energy from renewable sources. The latter includes the essential elements of the NREAP and additional analysis detailing, among other things, the prospects for technological change and the expected costs development. In the framework of an adverse economic prospective for the region and especially for Spain, the REP has set the RES target for 2020 in 20,8%.

The current NREAP targets will be pursued within the framework of a policy model that should consider, among other challenges, an energy consumption rate per unit of GDP higher than the European average, high dependence on foreign energy and high emissions of greenhouse gases.

In the analyzed energy scenario[68], Spain aims to 2020 not exceeding an energy consumption of 97 Mtoe, in a constant growth projection, where the reference energy consumption for 2010 was 93,3 Mtoe. The target of 20% set in the NREAP for Spain, in the current scenario, is surpassed to a projected RES share of about 23% (22,4 Mtoe) for 2020. For the three sectors, the targets set by the NREAP under the energy efficiency scenario correspond to:

[64]RD-Law 1/2012, of 27 January, which is applicable to the suspension of pre-allocation procedures and the removal of economic incentives for new plants producing electricity from cogeneration sources renewable energy and waste, applicable only to all power plants that request authorization starting from the issuance date.
[65] Plan de Acción Nacional de Energías Renovables de España 2011-2020.
[66]Real Decreto 661/2007, of 25th of May, establishing legal and economic provisions for electricity producers under "Régimen Especial". This Decree directly promotes the generation of electricity from renewable energy sources.
[67] The Renewable Energy Plan (PER) 2011-2020, approved by the Council of Ministers of 11 November 2011, following the mandates of RD 661/2007, which regulates the activity of electricity production in special regime and the Law 2/2011, of March 4, of Sustainable Economy.
[68] Total final energy consumption within the energy efficiency scenario (Source: L.W.M. Beurskens, M. Hekkenberg, P. Vethman, Renewable Energy Projections as Published in the NREAPs of the European Member States. Nov, 2011.)

Table 20 - Spanish NREAP RES targets for 2020 (under energy efficiency scenario) (Source: ECN[69])

2020 NREAP RES targets (EE Scenario)	RES-E	RES-HC	RES-T	TOTAL RES
Energy [Mtoe]	*12,9*	5,7	3,9	**22,4**
Share [%]	*40 %*	18,9 %	12,3 %	**23,13 %**

From the current referenced situation in 2010, the evolution of the RES share would represent an increment of 75% of the currently energy consumed in that year from RES. As the figure 43 shows, the objective of reducing the dependence from fossil fuel energy would be reduced by a 7,2% by 2020.

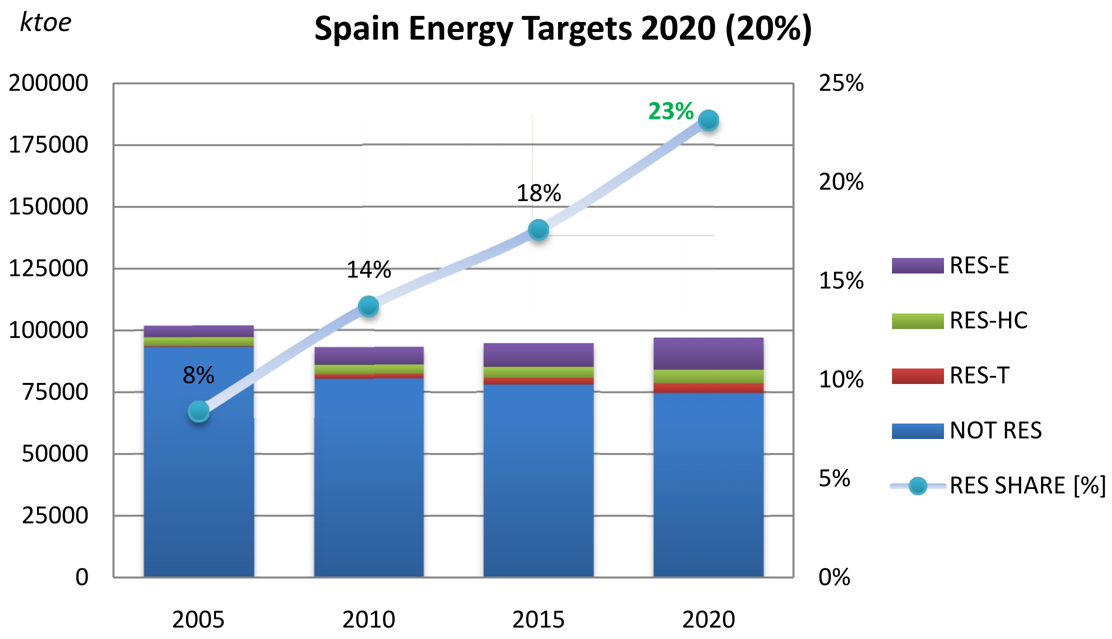

Figure 43 - Spanish energy targets from NREAP to 2020 (Source: ECN)

3.9.2.The RES-E towards 2020

On the role of renewables in electricity generation, its contribution to gross final consumption of electricity increased from 18.5% in 2004 to 28.8% in 2010, implying a total consumption generated from RES-E of 7,2 Mtoe. In the current energy efficiency scenario, the estimations towards 2020 for total energy consumed in the energy sector reach 32,3 Mtoe. The target to be consumed from RES-E from this total amount is *40%,* representing a total amount of 12,9 Mtoe.

[69] ECN, L.W.M. Beurskens, M. Hekkenberg, P. Vethman, *Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States.* Nov, 2011.

Table 21- Spanish electrical consumption according to NREAP towards 2020 (Source: ECN)

	2010	2015	2020
TOT-E [Mtoe]	*25,1*	*28,3*	*32,3*
RES-E [Mtoe]	7,2	9,5	12,9
RES-E SHARE [%]	***28,8%***	***33,8%***	***40%***

From the previous table and the following figure, the evolution of the RES-E share in contrast to the total increasing demand of the electricity sector is observed. The growth differential of RES-E share would be around 1.1% yearly.

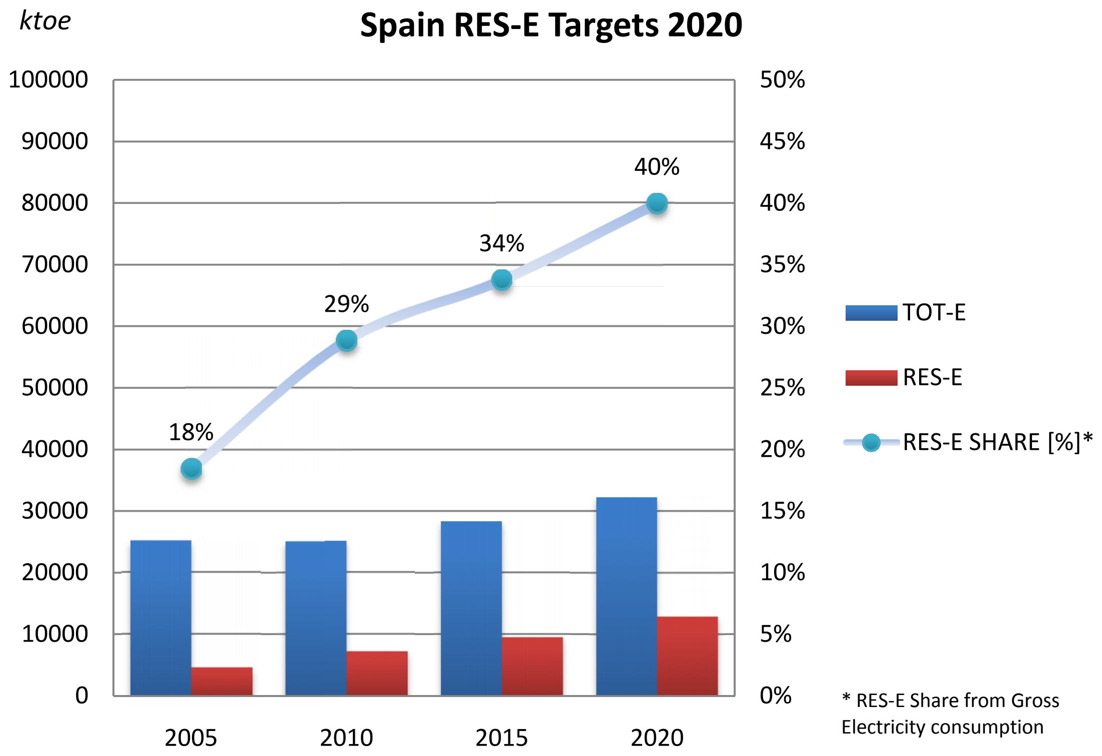

Figure 44 - Spanish renewable energy (electricity) targets for 2020 (Source: ECN)

The efforts towards reducing the fossil oil dependence as well in the electricity sector can be considered a very difficult challenge, but if the difference of electricity demand yearly increased approaching 2020 is supplied by RES-E in the same amount, it can be considered that the fossil oil dependence growth would be appeased.

Considering the current situation and the NREAP target projection towards the 2020, the contribution of wind power is the renewable source with the largest share and the set of technologies that allow the use of solar energy will continue to extend their contribution. Biomass, biogas and waste take-off confirm their significant contributions in the structure of electricity supply, while hydro (although implies the second major share of RES contribution in the mix) shows a small growth towards 2020.

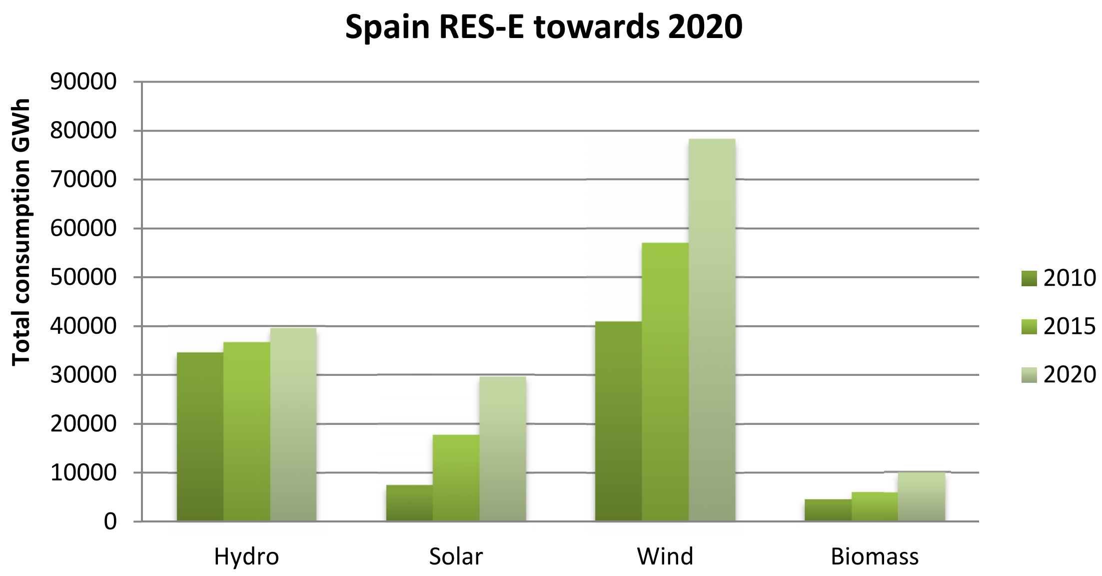

Figure 45 - Spanish RES-E profile to be incentive towards 2020 (Source: ECN)

As figures speaks by their own (figure 46), wind technologies would make the greatest progress in the next 10 years, increasing the supply in almost 37 TWh, reaching a total contribution of 78,3 TWh (52,2% of the mix). The second progress in increasing its contribution would be made by solar technologies, which currently are not representing a high share, but towards 2020 this would be contributing almost the 20% of the RES-E generation mix. Biomass, instead, is showing its first developments, considering that Spain is mainly an importer of fuels of this kind. Final target is 7% for these technologies. And lastly, hydro would remain at reduced growth, but representing the second in importance in the RES-E mix towards 2020, reaching 26% of the total contribution.

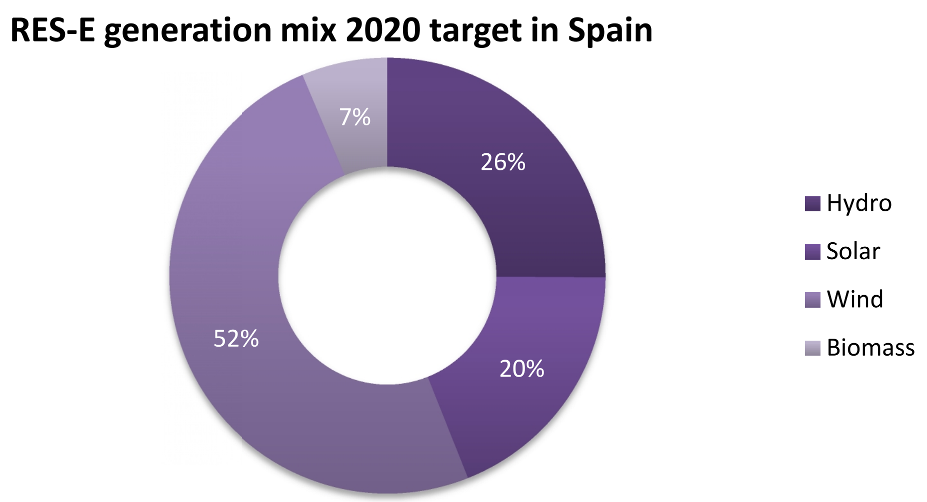

Figure 46 - RES-E generation mix 2020 target in Spain according to NREAP energyefficiency scenario (Source: ECN)

In order to achieve sustainability, provided the entire basket of renewable technologies, to gain maximum benefit from these energy sources, in addition to advancing the technologies that have already reached a certain degree of integration, in the second half of the decade

Spain will begin to incorporate technologies such as geothermal and ocean wave energy, in order to prepare their progressive maturation during the decade 2020 – 2030.

To promote the integration of these RES technologies in the electricity sector, towards the achievement of the NREAP 2011- 2020 targets, Spain has put into force a regulatory framework mainly through price regulation, where producers can access a *fixed feed-in tariff* or a *premium tariff* in addition to the wholesale price. These mechanisms, among others, are being explained in the following section.

3.10. SPANISH ENERGY INCENTIVES

Electricity generation from RES has been supported by the Spanish government throughout a legal framework which prioritizes the sustainable growth of these technologies, giving incentives on a price regulation and financial basis. As mentioned before, in the beginning of this year, the government has decided to curtail temporarily the economic incentives for RES as a measure to confront the current economic crisis in the nation.

In Spain, the electricity production from RES is considered as Special Regime ("Régimen especial") as stated in the Electricity Sector Act, Law 54/1997. This RE is based on a direct support to electricity production, providing certainty to investors through incentive tariff schemes. Only producers whose capacity does not exceed 50 MW[70] are eligible for RE (art. 27 Law 54/1997).

The support scheme is regulated by the RD No. 661/2007 of 25 May[71]. For each RES technology, the incentive scheme applies to a limited maximum production capacity, which are regulated by the same RD 661/2007 (arts. 37 to 42) and the RD 1578/2008[72] (arts. 10, 5). The authority in charge of applying the regulation framework is the National Energy Commission (CNE), created by Law 34/1998.

Table 22 – RES Power plant groups classification from category B, according to the RD 611/2007, chapter I, Art 2.

Group	Subgroup	Classification
B.1	B.1.1	PVs
	B.1.2	Thermal Solar Power Plants
B.2	B.2.1	On-shore Wind
	B.2.2	Off-shore Wind
B.3	B.3	Geothermal, waves, tidal, ocean currents
B.4	B.4	Hydroelectric plants with installed capacity not exceeding 10 MW
B.5	B.5	Hydroelectric plants with installed capacity exceeding 10 MW and not exceeding 50 MW
B.6	B.6.1	Biomass from energy crops
	B.6.2	Biomass from residues from agricultural or gardening
	B.6.3	Biomass from residues from forest harvesting and other

[70] Those facilities over 50 MW of capacity that use as primary energy sources of renewable energy, cogeneration or waste, will be included in the ordinary regime (of conventional generation units), and shall be subject to specific legislation, but shall enjoy economic and legal arrangements in certain aspects, differentiated from the rest conventional technologies.
[71]Real Decreto 661/2007, de 25 de mayo, by which it is regulated the electric energy production in Special Regime.
[72]RD 1578/2008 of 26 September, for remuneration of the production of electricity by solar photovoltaic installations which were registered after the deadline stated by technology in RD 661/2007 of 25 May.

B.7	B.7.1	Biogas
	B.7.2	Biogas anaerobic digesters from waste
	B.7.3	Facilities that use manure as main fuel by combustion and liquid biofuels
B.8	B.8.1	Biomass from industrial plants in the agricultural sector
	B.8.2	Biomass from industrial forestry
	B.8.3	Plants using black liquor fuel from the paper industry

On yearly basis, plant operators can choose between two support schemes, a *fixed feed-in tariff* or a *premium tariff(fixed bonus)*[73], in addition to the wholesale price of electricity market for the last one. There is also the possibility of tax deduction for the new investments required for generation systems and equipment based on RES.

Both remuneration schemes are entitled to perceive further supplementary remuneration for new installations with technological innovation that contribute to network stability. RES generation facilities are given priority access to the grid.

Regarding the RES development control, there is a mechanism in force that limits the planned installed capacity in accordance with RD-Law 6/2009 of 30 April 2009, creating an *administrative remuneration pre-assignment register*[74] *(RIPRE)*, which is required to all special regime producers accessing the grid, as a *sine qua non* condition to start perceiving the special regime benefits.

The objective of this control mechanism is to make close monitoring of the installed power capacity evolution, assuring a price of electricity for final consumers in competitiveness with the EU market, and that the incentive schemes promotes the technologies gradually towards the *grid parity,* up to a competitiveness level of self-sustainability in the local market. In this way, this control mechanism could assure, along with a gradual development of RES technologies, the compliance with the NREAP/REP 2020's objectives.

3.10.1. Development of PV

By RD 1578/2008 a new economic regime was defined and the *register of reassignment payment for photovoltaic technology*[75] (PREFO) was created, which affects facilities that register in the RIPRE definitely from September 2008. This new framework is based on an increasing capacity cap quote and a degressive rate revised every three months, which promotes installations on buildings and ensures compliance, without deviation, from the energy planning.

Cap quote for 2009 of a base power of 400 MW was established and 100 MW of extra quote. The basic quote for 2010 was 413 MW and 87 MW extra. From 2011 and on, no extra quote is given and the quote increases based on the same percentage of the tariff reduction for each defined type of installation.

Two types of facilities were defined for this type of technology, one for those on buildings and another for the rest, each with their respective quotas and tariffs (as seen in following table 23).

[73] Bonus varies on the basis of per-hour market prices. In the case of low market prices, the remuneration is paid guaranteeing a floor price assuring a minimum return to the producer. In the case of high prices, a cap payment applies.
[74] "Registro de preasignación de instalaciones en Régimen Especial".
[75] Registro de reasignación de retribución para la tecnología fotovoltaica (PREFO), RD 1578/2008.

Table 23 - Groups defined in the RD 1578/2008 for PV technologies and incentive tariff for year 2011.

RD 1578/2008		Power	Type of installation	c€/kWh 2011
Type I	I.1	P ≤ 20 kW	Rooftop or building material for residential, services, commercial, industrial, agro. Parkings for those uses.	28,1
	I.2	20 kW ≤ P ≤ 2 MW		19,8
Type II	II	P ≤ 10 MW	Rest, not included in Type I	13

The type of installations on buildings includes two subgroups of facilities: those of less than 20 kW and those between 20 kW and 2 MW. The second type comprises the rest of facilities not located on urban buildings or installations and allows up to 10 MW. The rates go down about 10% annually, depending on how the allocated quota is met.

Two more modifications are amended with RD 1565/2010, which modifies the Type I, specifying that inside installation a supply point for contracted power of about, at least, the 25% of the nominal power of the installation. The second modification is introduced with the RD 1011/2009, which widens the max power limit of installation type I up to 10 MW, although for appliance effects, the limit is kept up to 2 MW.

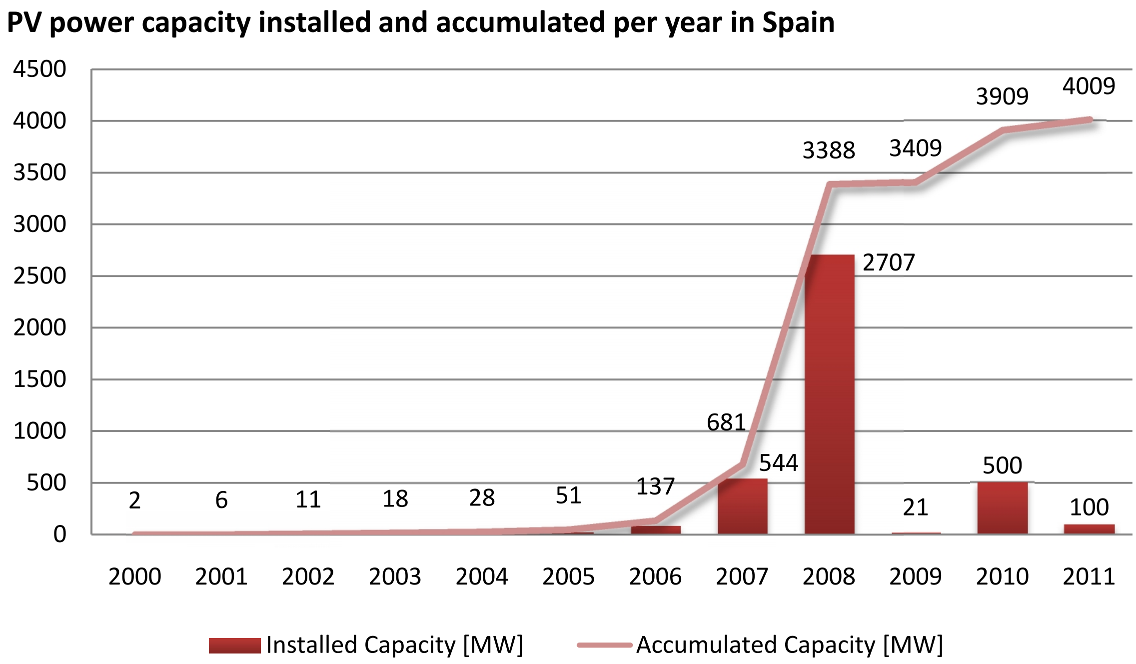

Figure 47 - PV power capacity development in Spain during last 12 years (PAN, MIET)

During 2010, the capacity quote has been fulfilled, reducing the tariff associated for about 10%. In the case the quote is not reaching the 75% of the assigned level for the trimester, the tariffs are kept for the following, invariable. In case it is exceeded the 75%, the degression rate reduces the corresponding tariff proportionally to the capacity inscribed, reaching its maximum reduction of 2.6% if the quote is met at 100%. This is what happened in the type II since the creation of PREFO, and in the type I since 2010. There is an established mechanism that allows transferring power between groups, if it is not allocated in one of them.

Table 24 - Incentive mechanism for PV systems according to quotes and regressive rates (RD 1578/2008)

% cap quote covered during previous period	Rate reduction for following period
0 ≤ 75%	Invariable w.r.t last period
75 - 100%	0 - 2.6% proportional to the quote covered
100%	2.6%

In addition to the reduction of tariffs established by RD 1578/2008, after the second call of 2011, special tariff reductions set out in RD 1565/2010 were applied, which were reduced by 5% the rates of type I.1, a 25% rate the type I.2 and 45% the rate of the type II, reaching the current tariffs for 2011 as stated above in table 23 (groups defined in for PV).Also, RD-Law 14/2010 dramatically and temporally limits the compensation for installations with final registration in RIPRE before September 29, 2008 and covered by RD 661/2007. The limitation is done until 2013 inclusive, expanding up to 30 years the right to receive the regulated tariffs.

3.10.2. Development of Wind Power

By RD 611/2007, as it was stated before, only generators which do not exceed 50 MW in installed capacity are eligible for FIT incentives. This condition applies for *onshore* wind power as well, as listed in the group category B.2.1 from table 23. In the case of wind farm output exceeding 50 MW, a premium on electricity sold to market would be given, equal to that of a 50 MW facility, in the same group (art. 45.2).

For both defined subgroups (onshore and offshore wind power), the generators under RE condition are eligible until the market cap of 20.155 MW of installed capacity is reached according to the Art. 38 of RD 661/2007.

Depending on the type of technology, operators of power plants are entitled to perceive a regulated tariff for the whole eligible period of 20 years, and a reduced tariff for the ongoing years, both being revised every year. According to the last revision[76] of the tariffs, the current regulated tariffs for both technologies are detailed below:

Table 25 - Wind power incentive tariff according to last revision of RD 611/2007 of 1st Jan, 2012

Category	Classification		Reg. Tariff c€/kWh	Ref. Tariff c€/kWh	Sup. Limit c€/kWh
B.2.1	Onshore wind	20 years	8	2,0142	9,4273
		after 20 years	6,7921	-	-
B.2.2	Offshore wind[77]		-	9,3557	18,2009

[76] Tariffs, premiums and limits apply from 1 January 2012 for installations in category b) of Article 2 of RD 661/2007 of 25 May.
[77] Maximum bonus for the purposes according to concurrency procedure laid down in RD 1028/2007 of 20 July, and the upper limit for offshore wind farms.

In the case of the offshore technologies a special RD has been issued, the RD 1028/2007, which stated that the offshore wind generation facilities intended to be placed in the territorial sea must have a minimum installed capacity exceeding the 50 MW. For these facilities, the tariff incentive is granted starting from a minimum of 9.3557 c€/kWh to a maximum cap of 18.2009 c€/kWh, according to the determination of the concurrency procedure for booking the offshore zones described in the mentioned RD.

After proving the enforcement of RD 1578/2008 for photovoltaic technologies, which created the called *register of reassignment payment for photovoltaic technology* (PREFO), the RD-Law 6/2009 established the same mechanism of pre-registration for all technologies included in the special regime.

The purpose of the pre-registration method is to keep better track of the evolution of installed capacity, and ensure compliance with the requirement that the consumer count on energy at a reasonable cost and the technological evolution of these sources of generation allowing a gradual reduction of their costs in competition with conventional power generation technologies. This is to be achieved in an orderly renewable energy target set out in this Plan of Renewable Energy by 2020.

This RD-Law 6/2009 is supplemented by Resolution of November 19, which is published by the Council of Ministers Agreement of November 13, 2009, which is applicable to the management of projects of wind and solar thermal installations which have presented pre-registration, since the registered power associated with these technologies surpassed the goals set out in RD 661/2007 (as seen in the evolution of wind power capacity installed in figure 45, the cap of 20.155 MW accomplished and surpassed in year 2010).

The schedule for the commissioning of wind power facilities is conducted in stages in accordance with the following cumulative implementation cap quote:

- Phase 1: 3719 MW by 2010.
- Phase 2: 5419 MW by January 1, 2011.
- Phase 3: 5419 MW by January 1, 2012.
- Phase 4: rest of the capacity under the provisions of the fifth transitional disposition of RD-Law 6/2009 by January 1, 2013.

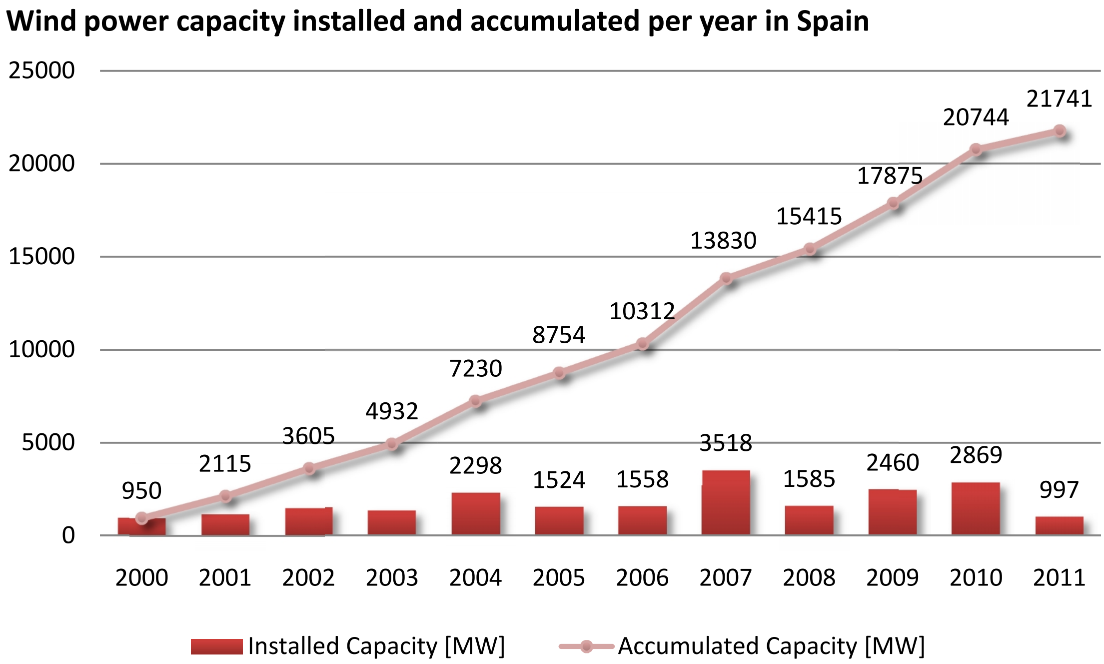

Figure 48 - Wind power capacity development in Spain during last 12 years (PAN, MIET)

3.10.3. Development of Biomass

During the last years in Spain, there has been a time of transition and settlement of the foundations to drive off the biomass sector. Although over the years the expected development has been higher than the results achieved, knowledge, awareness and positive approach to biomass business, have started to happen.

Also, and due to the fact that there are a few electric production plants in Spain and most of the installed capacity comes from facilities located in industries that have secured its own fuel production, this work is not going to take into consideration the influence of this type of technology for the analysis of the Spanish support scheme.

For the electricity sector of biomass power generation, after a period of uncertainty, procedures, primarily premiums and incentive tariffs published by the support framework of the RD 661/2007, there are two essential steps for defining the projects: for one side the biomass type certification process and secondly, once clearly defined energy crops, the implementation of the steps to be considered as such.

3.10.4. Direct selling

The owners of renewable energy generation facilities may choose, for periods not exceeding one year, between two alternatives for energy remuneration from selling:

- Energy paid at regulated tariff by type of technology, according to the *feed-in tariff* stated in RD 611/2007.
- SPOT market sells. Their retribution is according to the price that results in the organized market (or price freely negotiated in OTC), complemented by a *premium tariff*, specific for each renewable technology type.

For this last alternative, the premium levels are variable depending on market hourly prices:

- For low market prices, the remuneration scheme guarantees obtaining a bottom tariff, in order to provide security for the investor of a renewable on minimum rate of return of the investment.
- Moreover, regarding the premium tariffs, the scheme ensures a maximum profit, so that the values are null premiums for high market prices, thereby limiting the additional costs of the system.

For the subgroup B.1.1 (solar photovoltaic) this economic regime will apply only to facilities registered in the administrative record of production facilities under the RE prior to September 29, 2008. For B.1.2 (solar thermal) and B.2.1 (onshore wind) shall apply to those facilities registered in the pre-registration mechanism established by RD-Law 6/2009.

For both types of remuneration, *feed-in tariff* and *premium tariff* system, other supplements are established for those facilities that contribute to the technical stability of the system by applying technological innovations in its installation, in particular the reactive power control service.

3.11. SPANISH ACCESS TO THE GRID MECHANISM

As it is elaborately explained in the German and Italian case, the installation operators, that produce the electricity from RES, have priority in access and connection of their systems to the grid. Thus, as long as the grid stability is conserved and the grid capacity remains available, the RES electricity is contractually entitled to priority use.

In case of any requirement for the grid expansion, occasionally after the request for installation, the grid operator is obliged to take the suitable and economically reasonable action to fulfill the request. The cost for the grid expansion is provided by the grid operator in compliance with the general legislation on energy.

Regarding the relevant legal sources on the grid connection, the framework is mainly defined by the Law 54/1997 which is the legislation on the Electricity Sector. On the other hand, there are some other decrees, which have importance in the determination of the details about the access to the grid, published by the Ministry of Industry, Energy and Tourism such as follows:

- RD 1955/2000 (RD on the Distribution and Transmission of Electricity)
- RD 661/2007 (RD on electricity production through a special FIT scheme, “Regimen Especial”)
- RD 1663/2000 (Real Decree setting the conditions for the connection of photovoltaic installations to the low-voltage grid)
- RD 436/2004 (Real Decree establishing the legal and economic framework for the operation of generators under “Regimen Especial”)
- RD 6/2009 (RD establishing new regulations for the energy sector)
- RD 1578/2008 (RD on photovoltaic electricity generation)
- RD 222/2008 (RD establishing the refund mechanism for the distribution of electricity)

Regarding the connection to the grid, the installation operators that generate electricity should have the following conditions, in order to be entitled under the “Regimen Especial”.

- The installation’s primary source of energy production should be a RES, as stated by the statutory law.[78]
- Systems shall be officially notified of their admission to “Regimen Especial”[79]

[78](art. 2 par. 1 no. 2 b RD 661/2007)

For all the RES systems, there is a requirement of being listed in the Special Regime Administrative Register[80], in order to access the support measures. In addition to that, they must be registered in a preliminary register ("Registro de Preasignacion") to be eligible for the Special Regime Administrative Register.

The procedure for network connection that should be followed by both, the installation operators and the grid operators, is specifically established in articles 53 to 66 of RD 1995/2000 and in Annex IX of RD 661/2007. Furthermore, Red Electrica de Espana's P.O. (Procedimiento de Operacion) 12.1 and 12.2, additionally define the technical proceeding and rules for connection to the transmission network (as in the case of Germany, with specific connection rules of the TSOs).

3.11.1.Procedure

Distribution and transmission network have almost the same steps in the procedure for access and connection, except from the specific deadlines during the process. The procedures for these two different networks are specified below.

3.11.1.1. Low and Medium Voltage

With regards to the deadlines, for the transmission grid they are established in articles 53, 57, 58, 59 of RD 1955/2000: Procedure for connection to the transmission system;

1. The plant operators deliver the access application to the TSO, for which the information is defined in the operating procedure 12.1, published by the TSO.
2. The TSO sends a report, with the mistakes or eventual anomalies, to the plant operator in order to be corrected.
3. The plant operator is required to correct the problems presented by the TSO in 1 month, after receiving the report from the TSO.
4. After all the mistakes and the eventual anomalies are solved, and the correct application is received, the TSO has 2 months to decide on the feasibility of access and connection and communicate with the plant operator for the access license. If the TSO does not inform the plant operator on time about the availability of the capacity, then the plant operator can apply to the regulatory body CNE. In this kind of disagreements between the TSO and the plant operator, the CNE intervenes and give a decision on the conflict, in a period of 3 months. However, the report coming from TSO, about the availability of the capacity for the access, has a validity of 6 months.
5. The plant operator sends the basic project and the program of execution to the transmission company, in order to obtain the connection license.
6. The transmission company has to prepare a report, specifying the technical necessities, and deliver it to the TSO[81], together with the basic project and the program of execution which are taken from the plant operator.
7. The TSO should assess and finally accept the report within another month.
8. The TSO and the applicant shall then negotiate and agree on the connection contract, before the connection construction starts. Then, the plant operator has the access license and successively it gets the connection license.

[79](art. 6-14 RD 661/2007)
[80](art. 9 RD 661/2007)
[81]Red Electrica de España, REE, is the Spanish TSO. However, there are other transmission companies different from REE. Therefore, the transmission company and the TSO are referred to as two different entities although mainly they are the same entity, REE.

3.11.1.2. High Voltage

On the other hand, the deadlines for the distribution grid, that are set in articles 62, 63 and 66 of RD 1955/2000, are more strict in terms of duration, compared to the ones for transmission grid. The step by step procedure is as follows:

1. Each distribution company has their own application model and parallel to this, the plant operators (applicants) send their access applications to the DSOs.
2. As it is the case in the transmission system, in the successive 10 days, the DSO sends a report stating the eventual anomalies and the mistakes which are needed to be corrected.
3. The applicant plant operator corrects the mistakes and the anomalies within 10 days after receiving the report from the DSO (step 2).
4. The 2 months period of analysis after the correct access application for transmission system decreases to 15 days for the distribution system, so the DSO has to communicate with the plant operator within 15 days to inform about the access license and the availability of capacity for the connection. In case of late information or disagreement, the plant operator has a right to apply to the regulatory body, CNE.
   The DSO has to inform the TSO about the access applications with capacities larger than 10 MW, which have a possible effect on the transmission system. The solution, proposed by the DSO, has a validity of 6 months, therefore the applicant has to come up with a connection request after receiving a positive access capacity response from DSO, in this period of 6 months.
5. In order to get the connection license, the applicant plant operator delivers the basic project and the program of execution.
6. The DSO has to prepare a report about the technical necessities and deliver this report to the TSO, together with the basic project, and the program of execution which are taken from the plant operator.
7. The TSO will write a report in a month after receiving the report from the DSO.
8. After these processes, the DSO and the applicant may start the contract negotiation phase as happens in the TSO case. On the contrary case, such as a negative response, both TSO and DSO are obliged to inform the installation operators about the reason of the denial for their access point and provide alternative access points.

If the negotiation and agreement parts of the process result in positively, and the technical conditions has been concluded (art. 16 RD 661/2007), a bank guarantee or so-called deposit of € 500 per kW of installed capacity for PV systems and € 20 per kW for other systems has to be provided (art. 66 bis RD 1955/2000).

This deposit is going to be received back by the plant operator when the plant gets the administrative license for the installation or when the administrative license process is ended negatively, due to the reasons beyond the responsibility of the plant operator.

3.11.2. Costs of grid connection

The connection charges are on the shoulders of the plant operators[82]. Additionally, the operators of plants (or clusters of plants), which are connected to the same access point (over than 10 MW), must be connected to a certain control system which is provided by themselves. All the costs of installation and maintenance for the control systems are borne by the plant operators (including the installation and maintenance of the communication lines to the DSO).

[82]Annex XI no. 8,9 RD 661/2007

Although it is stated that costs of the installations, required for the connection to the grid, are generally paid by the producer, there is no clear legislation in this issue. When the RD 1955/2000 (article 32) is assessed, it is seen that the reinforcements associated to the grid improvements are needed to be included in the planning process and the criterion that makes the producers to bear this costs is only if they are related to the solely themselves. That's why the current legislation leaves possibilities for different interpretations due to the meaning of the solely usage of the reinforcement. Especially for the off-shore wind installations, this uncertainty has a significant importance in dividing the large investment amounts among the participants.

Following this problem, the last Law, RD 661/2007 asks the TSO and the various DSOs to come up with a way or a description of the mechanism to pursue, in order to divide the connection costs between different project developers[83].

There are many examples when the installation operators are not the only one who benefits from the new constructed power line. For instance, when more than one power line is built in order to get a more interconnected grid, instead of building just one radial power line, both the RES producer and the grid operator benefit from the interconnected grid. In this kind of case, the grid operator affords for the difference between the exact cost and on power line construction cost, which would be adequate for the new connected plant. The following figure 49 is the basic example of the situation explained. In the figure the Line B is additionally constructed for the grid reinforcement and is not only for the benefit of the wind producer. The grid operator has benefits from Line B due to the grid expansion and interconnection.

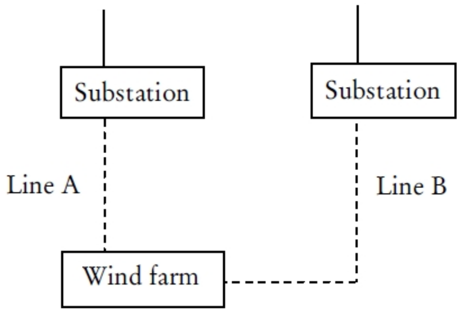

Figure 49 - New wind farm connected to the grid with two power lines

Taking all these issues into consideration, one of the main problems encountered in the grid connection is because of the deep connection fees. These may result in excessive costs in some cases and thus, discourage the investors.

3.11.3. Use of the grid

There is a model contract provided by the Ministry of Energy and Mining[84] for the agreement, that regulates the qualitative and quantitative conditions for the electricity to be exported and transmitted to the grid, between the plant operators and the DSOs. Hence, all the agreements in this purpose have to comply with the model presented.

Regarding the exceeding capacities on the same access point as stated before, there should be a central control system (CECRE) for security reasons. This control system is managed by the

[83]This requirement is a consequence of the articles 7.4 and 7.5 of the EU Directive 2001/77/CE.
[84](art. 20 par. 2, art. 16 RD 661/2007)

TSO and should provide the real-time data from the system in order to guarantee the reliability of the electric system. TSO may send instructions to the RES production plants every 12 second via the CECRE and the generation control centers connected to it. These instructions have to be observed within 15 minutes by the operating plants.

Additionally to the CECRE, each RES plant, which is larger than 1 MW, is requested to transmit real-time telemetry information to the TSO about their operating conditions. In case of an unsafe situation, TSO has a right to curtail the RES electricity from the grid. The curtailment can be done for the following reasons:

- grid stability or short-circuit power warnings
- grid congestion
- inadequate active or reactive power levels
- production variations
- balancing issues and minimum load

As it is the situation in Italy (MPE), wind farms are curtailed more often than other RES installations.

Besides the general criteria of security, regularity and quality of the supply, there are also other specific criteria for the RES electricity producers included in the “Regime Especial” when determining on access to the grid. These criteria were defined in the RD 436/2004 and are modified in the RD 661/2007.

1. The capacity of the RES plant or group of plants included in the “Regime Especial”, and connected to the same power line of DN, cannot exceed 50 % of the capacity of the power line at that access point.
2. The capacity of the RES plant or group of plants included in the “Regime Especial”, and connected to one transformer of the substation, cannot exceed 50 % of the capacity of the transformer at that voltage level.
3. For producers without storage systems, the capacity of the individual plant or that group of plants, sharing the connection point, cannot exceed 1/20 of the grid short circuit capacity at that point.

The main modification difference between the two decrees is the specifications made on the group of the installations on the same point.

3.11.4.Grid Expansion

The contracts signed between the parties (the plant operators and grid operator) oblige the grid operator to expand its grid. In this situation of obligation for an expansion, the grid operator has to come up with a grid expansion plan in co-operation with the Ministry of Industry, Tourism and Trade every four years. The plan takes into account the number of current and new plants[85].

Regarding the duties of the Ministry of Industry, Tourism and Trade, there is an obligation on them to publish a grid development plan containing 6 to 10 years and update this plan every year. As a result of this grid development plan, a detailed annual plan of interventions to be

[85](art. 11 RD 1955/2000)

implemented in the transmission grid infrastructure is published in the Official Journal (BOE – Boletin Oficial del Estado)[86].

As it is explained in the previous section, the costs for general grid expansion are borne by the DSO unless the expansion is to the benefit of the plant operator only.

3.12. SPANISH ELECTRICAL SYSTEM AND MARKET

3.12.1. Generation

The current situation of the Spanish electrical structure, regarding the security of the system, can be considered relatively positive with respect to other European markets. The generation capacity has a remarkable clearance, with a foreseen range of coverage for more than 10%, at least until 2016, indicating that no problem of supply in the medium term exists, unlike the situation of insufficient generation capacity detected in some European countries, like France or UK, or high dependency on fossil fuels such as Germany or Italy. Furthermore, Spain has one of the highest rates of incorporation of electric generating capacity from renewable sources in Europe (27 GW in last 15 years, reaching almost the 33% of total national share), which has contributed to a significant reduction of 44% of CO2 emissions in the electricity sector between 2005 and 2011. Lastly, this evolution has positioned the Spanish market as the EU country with the highest RES penetration within the generation matrix, providing as a consequence a profile with a high grade of diversification of technologies.

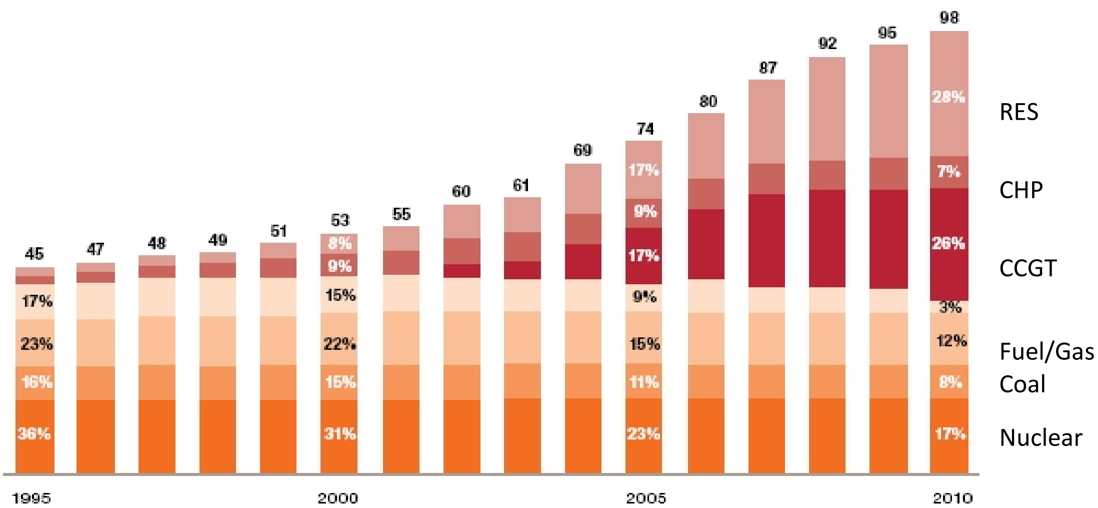

Figure 50 - Evolution of gross power capacity (GW) installed in Spain (Source: REE – PwC)

During the year 2011, the new installed power capacity has grown up by 1.879 MW, increasing the total generation capacity at the beginning of year 2012 up to 100.576 MW (+1.9 % on the 2010 basis). RES have achieved the bigger slice of this increase (93 %) composed mainly by wind power (997 MW) and solar thermoelectric (674 MW).

[86] According to RD 181/2008 of February 8, the BOE is the official journal of the Spanish state and will provide the means of publication laws, regulations and acts of inclusion mandatory.

3.12.2. Wholesale

The annual demand for electrical energy has fallen 1.96 % with respect to the previous year. This drop in consumption has implied a demand by the end of 2011 of 270.364 GWh, a similar value to the one reached in 2006. The maximum peak for hourly average power demand and daily energy demand was reached on January 25th with 44.107 MW, amount that represents nearly the 41,5% of the total national capacity.

Table 26 - Demand evolution in Spanish market (Source: REE)

Year	GWh	Δ Annual (%)
2007	278.023	2.9
2008	281.100	1,11%
2009	267.713	-4,76%
2010	275.773	3,01%
2011	**270.364**	**-1,96%**

The demand coverage in the peninsular system was leaded by nuclear, reaching the 21%, followed by combined cycle with 19% of the coverage. The third place was held by the leading source of the *special regime*, wind power, with 16%, maintaining the same percentage as the previous year. Totally, RES covered 33 % of the demand, 3% points down with respect to 2010, mainly due to the reduced generation of hydroelectric energy (figure 51).

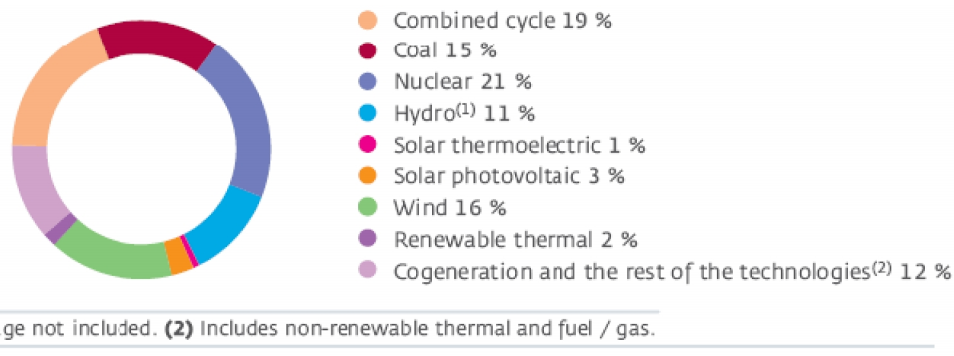

Figure 51 - Demand coverage in peninsular system for 2011 (Source: REE)

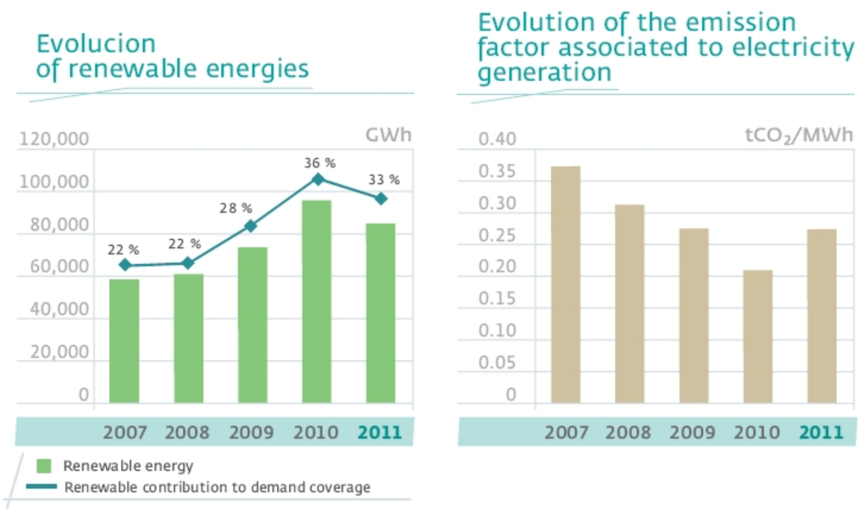

Figure 52 - Evolution of energy supplied by RES and CO2 emission factor in peninsular system (Source: REE)

The contribution from RES generation can be observed, not only in the demand coverage, but as well on the reduction of the CO_2 emission factor, which was evolving in a remarkable reduction until last year, which, as a consequence of the increase of generation from coal source, showed an increase of above 0.05 t/MWh. Breaking down the RES structure (*special regime*), it is observed that wind and solar were the two technologies which have shown the highest increase in production, compared to the previous years. As a consequence of the highest penetration of RES, the evolution of the gross energy yearly production from ordinary regime (conventional generation) has shown a backlash in its contribution (figure 53).

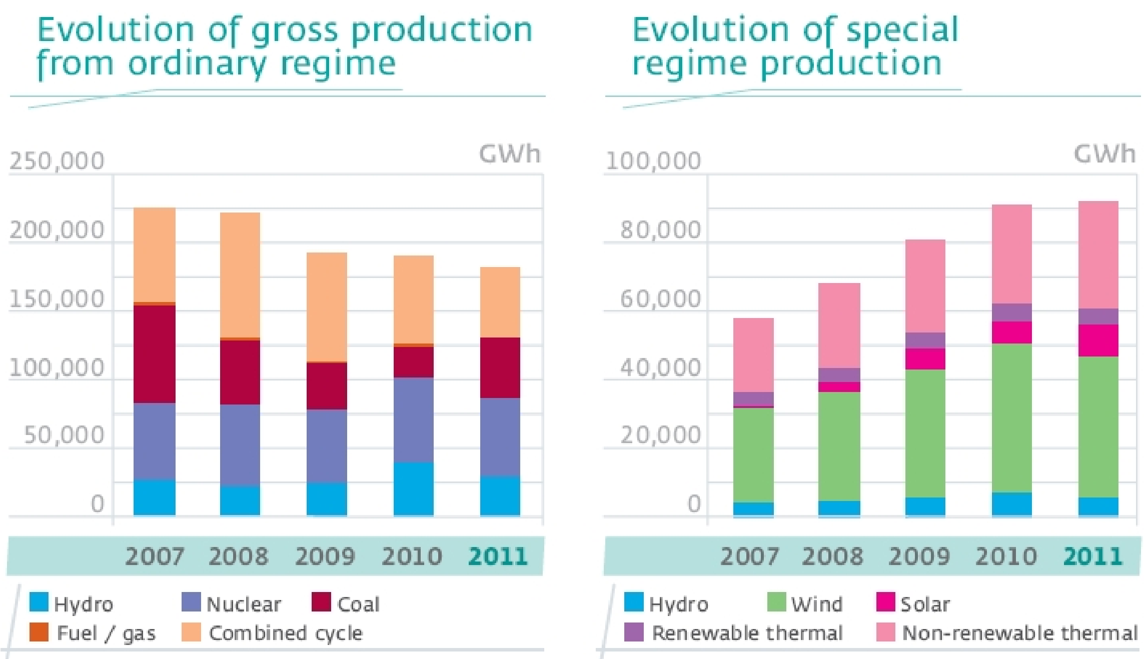

Figure 53 - Evolution of ordinary vs. special regime (RES) in Spain (Source: REE)

A posteriori of what was described above, as a general observation, we can emphasize that the Spanish market model and the regulation performed have promoted, in a guaranteed way, the delivery and quality of service, giving clear signals for investment, and so, it has favored the integration of non-programmable RES, consequently producing lower CO2 emissions.

In terms of regional context, since July 2007, the Spanish market has been integrated with the Portuguese, forming the Iberian Electricity Market (MIBEL), being foreseen in a short-medium term that the coupling with the European market through the border with France occurs.

Last but not least, in terms of market competitiveness, the electricity price at a certain moment determines not only the impact of costs but as well the effect of policies being applied during previous years, and in this market, this special issue deserves to be pointed out. In Spain, the market prices have had a direct impact on both the industrial and residential sectors. During 2011 they have been positioned in-between the highest prices of the European market.

3.12.3. Price Development

The evolution of final electricity prices in Spain with respect to other EU countries is originated mainly in the costs assigned to the regulated activities, formerly planned in order to supply not a well estimated increasing demand and with the aim of incentivizing the RES; but another important component was due to the need of financing debts of the electric sector, already existing from the last years due to the incoherence between the incomes and costs of the regulated activities (depth during the last demand decrease due mainly to the economic crisis, and the infrastructure incorporation from last years).

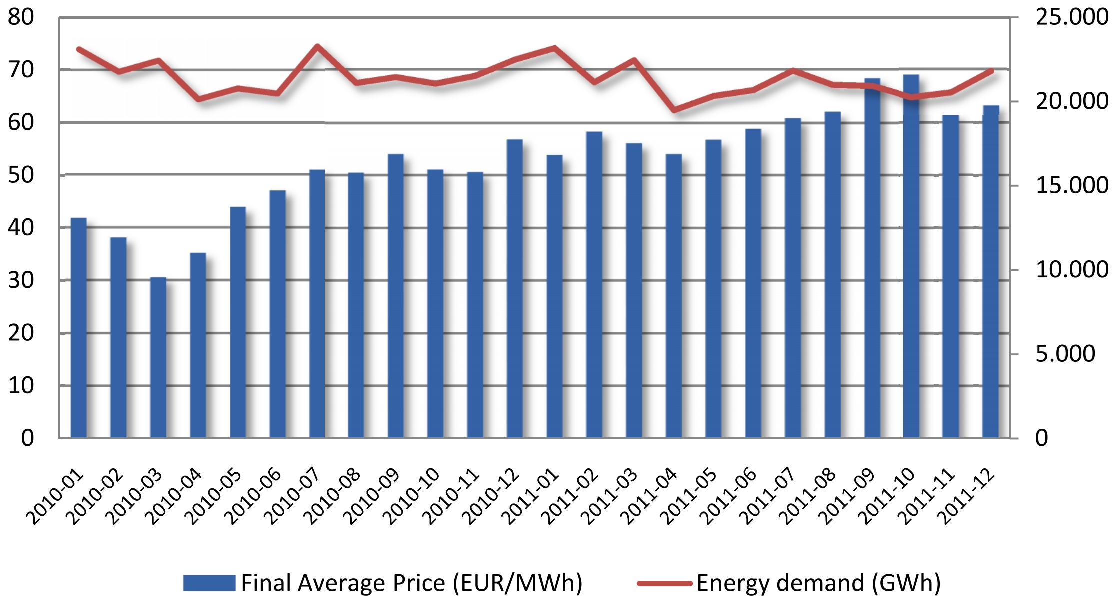

Figure 54 - Market prices evolution in Spain (Source: OMie)

The decisions taken by last governments in regulatory matters have caused the Spanish market to become the only one of EU which has reached a debt with the whole electricity sector, which accumulates year by year, due to the fact that the costs of regulated activities are higher than yearly incomes which are collected through the *access fees*[87] with the aim to cover them. This debt, which has begun to be generated more than a decade ago, is called "*tariff deficit*", and until early March 2012, the same had consisted of 21.812 M€[88], almost 3% of Spanish

[87]Article 17 of Law 54/1997 sets out the arrangements for establishing the access fees to the networks, according to the costs of regulated activities in the system.
[88]CNE, *Informe sobre el sector energético Español.*March 7th, 2012.

GDP. For this reason, an element of complexity is added to the task of the regulator, which should consider, when implementing future regulatory measures, not just the effect they will produce in the progressive indebtedness of the system, but also measures to reduce, in the short and medium term, the *tariff deficit* that remains up to these days.

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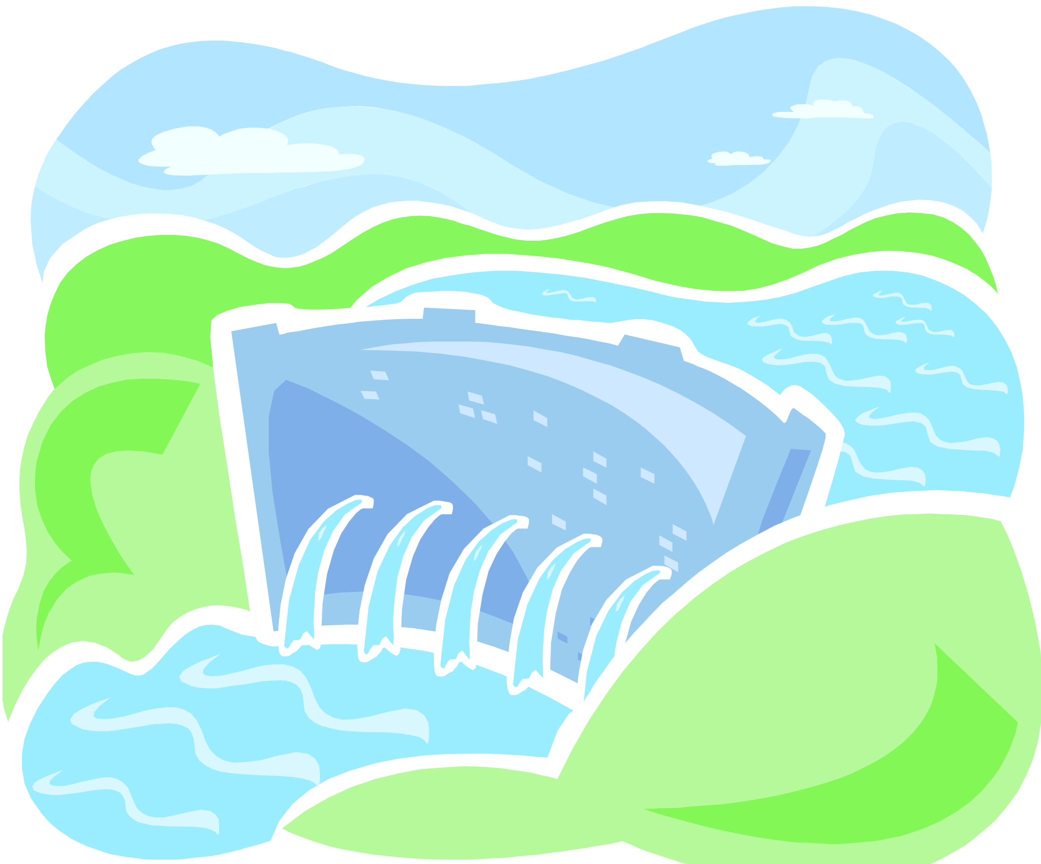
CHAPTER 4

SUSTAINABILITY AND RES REGULATION TECHNICAL IMPACT



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In the previous chapters, the importance of the RES integration to the electricity production in European grid and its possible control with the regulation mechanisms are explained. The significance in the increase of RES-E is mentioned as a relevant issue in recent years. The energy sector has been experiencing a rapid transition. During this transformation, two fundamental developments mainly affected all European Member States: the liberalization of the markets and the growth of new RES-E technologies.

As a result of the liberalization, the electricity system is becoming less centralized and less concentrated, which has caused large and centralized conventional plants to be partly replaced by small, decentralized and intermittent RES. That replacement led to more and various market players involved in electricity generation, transmission, distribution, network planning and development. This diversification brings contradictions arising among the newly participated private actors who follow their own agendas and interests. Thus, in this heterogeneous group of decision makers and stakeholders of the electricity generation and distribution, new challenges have been arising.

First of all, there is a technical aspect which stems from the absence of correlation in the organization of the generation, transmission and distribution of today's electricity networks. The currently improving system lacks a developed interaction between the grid and generation planning, so the reactions to the changes in generation capacities become a challenging network problem. Secondly, the communicative aspect arises as a challenge. It is stated in the previous paragraph about the new players, entering more rapidly to the system, who do not want to cooperate due to the contradicting interests and in some cases because of lack of trust. This new stakeholders have to be more open to cooperate with each other to solve the communicative problems. Third, there is an economic aspect. Transparent market conditions are requested by all the private actors. At the end, this will allow them for more secure long-term planning, or the investments both in RES-E systems and infrastructure of the grid are at risk.

All the briefly explained current conditions lead blockages to the RES integration in different areas and countries of EU. When the expected growth of RES-E is considered in the next 10 years, the adaptation of the grid and overcoming these problems in long term, have to be a crucial task for Europe. The table given below shows some of the main problems that have been observed in the target countries of this work before the detailed analysis of this chapter.

In order to have a healthy regime in the grid operation, both the grid operators and the plant operators have some obligations to fulfill. A significant element of any support scheme for RES is to ensure that all the RES installations have access to the grid; either, through a guaranteed network access, or by a priority access related to a purchase obligation. In this sense, the grid operator has an obligation on it to ensure the network access of RES plants. On the other hand, there are also plenty of different obligations on the producers such as ancillary services, in order to provide a service more suitable and compatible with the existing grid where they operate. The latter situation has been gaining more importance as the number of RES plants has been continuously increasing. That is the reason why much more attention has to be given to the grid operation in the EU countries.

Table 27 - Main barriers to the RES integration in Germany, Italy and Spain

	Main Barriers		
MEMBER STATE	**Grid Connection Phase**	**Operation Phase**	**Grid Development Phase**
Germany	* Communication between stakeholders * Lack of transparency * Definition of technical and legal requirements	* Grid curtailment	* Public opposition * Complicated permission procedures * Lacking financial incentives
Italy	* Administrative barriers * Overload of connection requests * Virtual saturation	* Frequency of curtailment in areas with large RES-E potential	* Administrative barriers to grid development * Public opposition
Spain	* Delays introduced by administrative procedures * Heterogeneity of DSO technical requirements	* No significant barriers detected	* Lack of proper incentives for DSOs and RES developers * Remuneration of distribution level grid development costs

Regarding the technical requirements, the "Directive 2009/28/EC, Article 16(2), 7" sets some criteria about the operation phase and the barriers to RES-E integration. The chosen criteria were:

- presence of purchase obligation or dispatching priority
- grid access regime
- obligations of the RES producer to operate in line with network requirements
- curtailment management

The technical aspects of the RES integration to the grid can be analyzed in two sub-categories: TN and DN, according to its respective inference. In the transmission network, the generation management becomes a crucial element in order to prevent high amounts of energy losses. Apart from that, due to the high capacities in the transmission network, dynamic behavior of large RES plants such as large wind farms gains importance in the grid security conditions. Additionally, ancillary services which are provided by conventional plants are also required to be served by RES plants because of the increasing capacity of them day by day. Taking all these into consideration, authorities have formed grid codes for electricity producers that operate on the electricity network. Regarding the DN, *hosting capacity* comes as the biggest concern and the driving topic of the technical problems occurring on low and medium voltages. It is required to be understood what exactly the hosting capacity is and the ways to improve it without investing on the grid expansion.

4.1. INTEGRATION OF RES IN TRANSMISSION NETWORK

Through the way to sustainable electricity systems, large capacities of RES proved their existence on the transmission networks and showed that they are as important and inevitable as the conventional power plants for the electricity system. Among all the technologies and types of renewable sources, the most significance one for transmission grid network has been the wind energy. When the capacity shares are considered in the HV and EHV, it can be observed that wind energy plants dominate the transmission network within the other renewable (see figure 55).

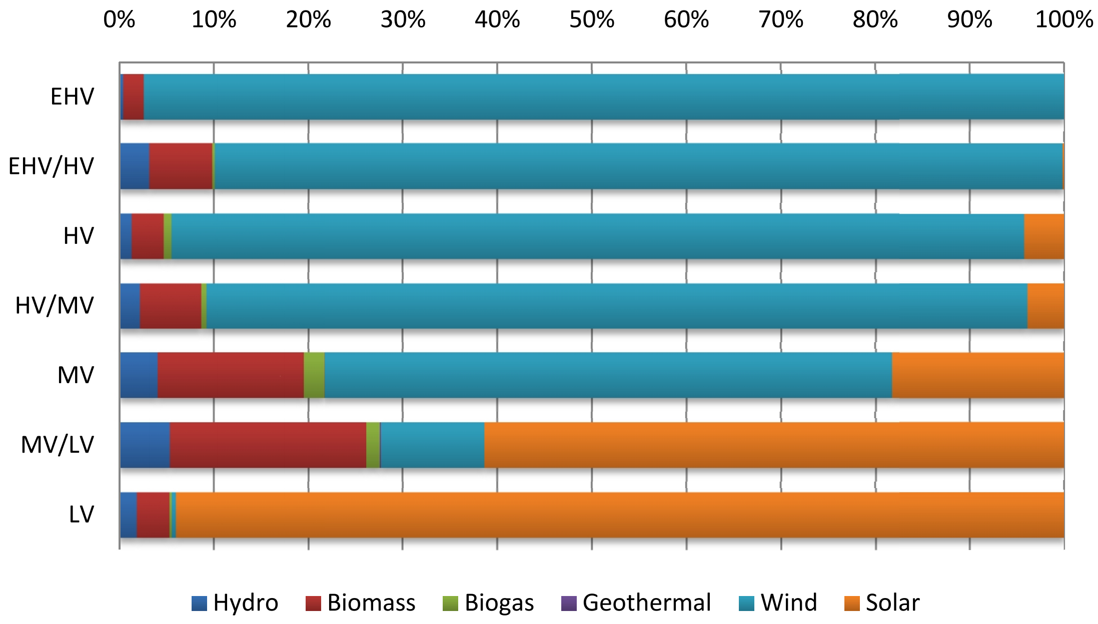


Figure 55 - Share of RES in TN and DN for Germany by 2011

Without the existence of RES integration, the transmission networks were already occupied with the conventional producers with large capacities, so they are already actively managed. Their design should support the high amount of generations coming from conventional generators. In the beginning of the RES integration to transmission network, the capacities were not significant enough to thread the grid. However, there were still requirements for wind turbine electricity generators for their own protection. Due to the increasing share of wind turbines on power generation and connection of wind farms directly the HV grid, this explained situation flipped over and the requirements had started to be determined for the possible impacts of these wind turbines and wind farms on the power system.

This situation let the transmission operators to release grid requirements, known as Grid Codes, on wind turbine connection and operation of the grid. The objectives of the grid codes are to secure efficiency and reliability of power generation and transmission, in order to regulate rights and responsibilities of the players acting in the electricity sector. Among the TSOs, some of them unified the requirements for all production units that include the conventional and the renewable sources together. The results of this unification make it little bit challenging for wind turbine producers and wind farm developers to fulfill. On the other hand, as a better approach, the other TSOs defined special requirements for wind power, based on existing criteria for conventional plants which is more sensible to regulate the renewable power without forcing them to fulfill hard technical tasks. The focus of this part of the work is giving a brief description as stated in the grid codes about the participation of the wind plants in frequency control, voltage control, frequency limits and ride through requirements.

4.1.1. Variability and Uncertainty

Non programmable RES have a special characteristic which can be considered a problem for the reliability of the network, if it is not properly managed. This feature is the intermittency of the injected power due to the unpredictability of the natural sources. This uncertainty in the availability of the energy sources has to be controlled in order to manage the network operation and with the aim of reducing costs derived from the higher reserve availability for balancing. In order to deal with this issue, the most important feature is to improve the forecasting systems. The key measure is decreasing the deviation between the actual production and the forecasted one as much as possible. Being a function of weather, the energy output obtained from RES can be forecasted as close as the actual value by improving the forecasting techniques and incentivizing producers to do it. Due to this fact, countries and the authorities of network have been working on this topic, and have been achieved significant progress in this area. It is obvious that, against the rapid increase of RES in the European electricity system, forecasting is one of the damping factors that have to be developed.

In the following graph it can be observed how the DG technologies can be characterized according to variability and uncertainty, being wind power generation the extreme one and the solar one step below, both with higher grades of variability and predictability.

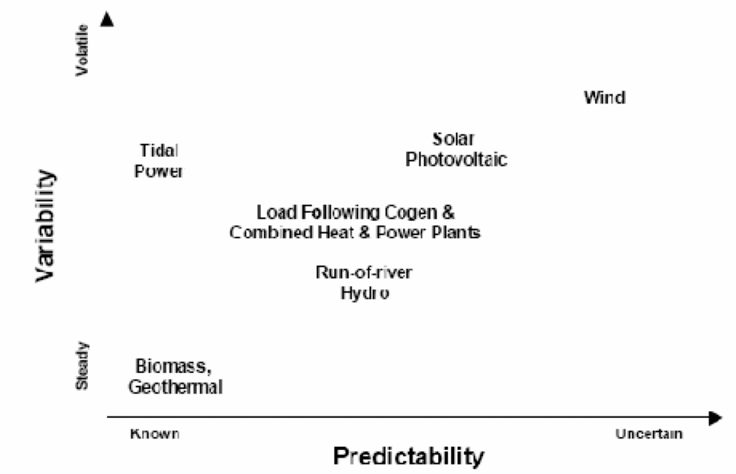


Figure 56 - Variability and Predictability of DG and CHP Generating Resources (Source: GE[89])

Apart from being considered with a high negative grade of correlation coefficient[90] (high production during peak consumption hours), the daily production of solar power is highly predictable due to the dependence on the sun cycle with hardly weather fluctuations. Instead, wind power, which is considered to have a positive correlation factor (high production during low consumption hours, generally at night), will show higher errors within the predictable variation with season and daily cycling.

[89] GE Energy, The Effects of Integrating Wind Power on Transmission System Planning, Reliability, and Operations: Report on Phase 2, Prepared for The New York State Energy Research and Development Authority, City, State, Mar. 2005.

[90] Correlation coefficient with respect to consumption: the correlation coefficient is the normalized covariance. A value near zero implies that there is no statistical correlation between production and consumption. Any positive correlation between high production and low consumption implies that the production is highest when consumption is low. This is the case for wind that tends to be strongest in the night when the demand for electricity is lowest. A negative correlation will be positive for the integration of the DER and results from the controlled dispatch of a hydro power plant. Source: N. Etherden, “Increasing the Hosting Capacity of Distributed Energy Resources Using Storage and Communication”, LUT. 2012.

Table 28 - RES-E variability and uncertainty[91]

RES-E Characteristics	Possible Responses	Policy Instruments
Variability	Turn down RES-E plants	Expose plants to some level of price risk Requires support mechanisms that expose RES-E to market signals and functioning markets.
	Manage maintenance periods taking into account market needs	
	Chose locations that provide favourable generation profile	
Uncertainty	**Improve forecasts**	But not necessarily by exposing individual RES-E generators to balancing risk: Smaller systems are more difficult to forecast Other actors may be better positioned to provide efficient forecasts
	Provide efficient balancing	Critically depends on a competitive market and flexible market design (intraday market etc.) Rather than balancing by individual RES-E generators (may even be counterproductive) Balancing incentives in the support scheme only addresses the smaller part of the problem

Between the two disadvantageous characteristics of RES (variability and uncertainty shown in table 28), uncertainty can be solved and reduced by improving forecasting. There are some alternative ways for forecasting depending on the system actor which handles the work. It can be done by individual generators but, for small systems, it would be difficult to have accurate data. In this content, it would be better and more effective to make the forecasting on a system level by a central player.

4.1.2. Ancillary Services Provision:

4.1.2.1. Frequency Control (Regulation of Active Power):

The exchange of power in the grid has to be kept in balance, which means that the demand and supply should be consistent. An existence of temporary unbalance of the system, due to the sudden changes of supply and demand, affects operating conditions of producers and consumers. This situation is tried to be preserved by adjusting the consistency between power production and the predicted demand.

In this content, the frequency control can be also called as active power control. The purposes of active power control are the following[92]:

- to ensure stable frequency (primary concern)
- to prevent overloading of transmission lines
- to become sure that power quality standards are satisfied
- to get rid of large voltage steps

Although the disconnection of the renewable sources is not desired, and even restricted by law in some countries, TSOs have right to limit the active power injected by wind farms in unbalanced situations. Normally, the conventional plants would react to a possible unbalance by increasing or decreasing their production, but in case of wind farms increasing the

[91] Edoardo Binda Zane, Robert Brückmann, Dierk Bauknecht, "Integration of electricity from renewables to the electricity grid and to the electricity market", Eclareon GmbH, Öko-Institut e.V.
[92] Julija Matevosyan, Thomas Ackermann, Sigrid Bolik, Lennart Söder, "Comparison of International Regulations for Connection of Wind Turbines to the Network", Royal Institute of Technology.

production is not possible as they base on an intermittent source. However, it is possible to decrease the generation until the balance between production and consumption is restored and frequency has stabilized in case of overfrequency.

Regarding the German Grid Code Requirements, in active power regulation, the generating unit has an obligation to be capable of operation at reduced power output level, which is determined in cooperation with the TSO. In that purpose, the Transmission Code of Germany constructed the following figures stating the limits:

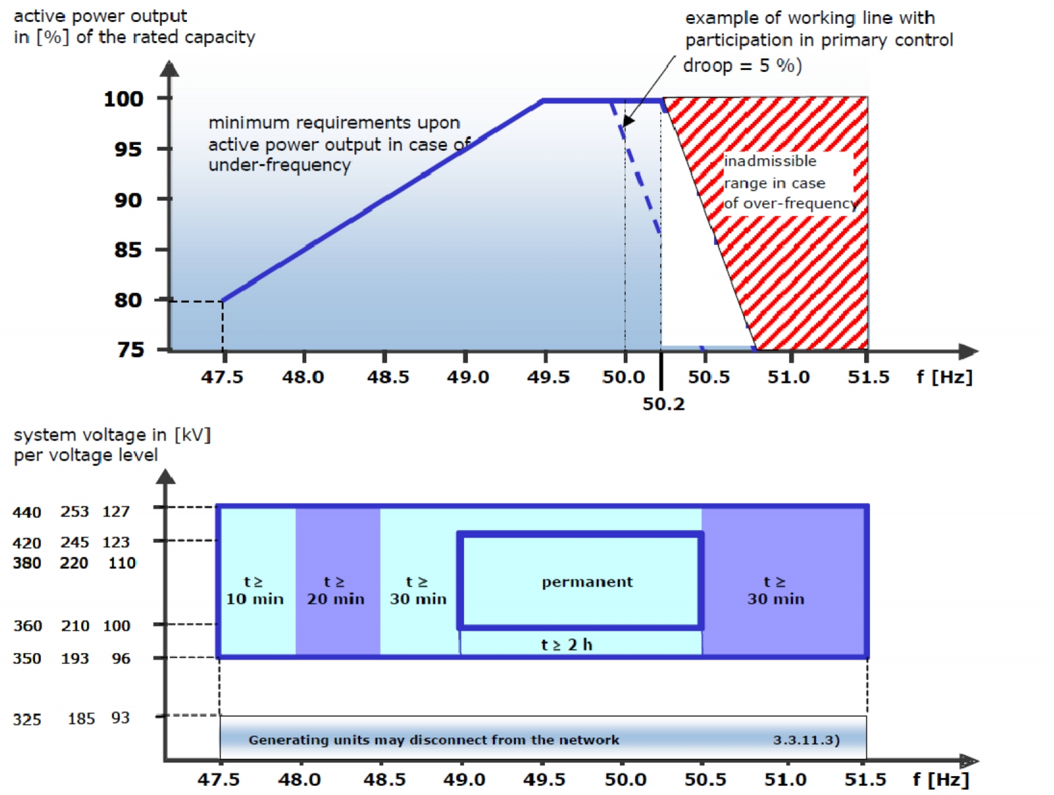
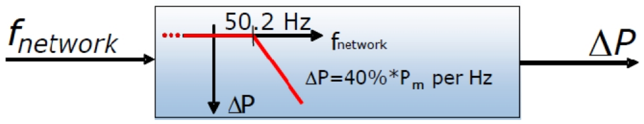


Figure 57 - Operating requirements depending on network frequency[93]

The frequency band, with which the wind turbine must be in operation and be compatible, is between 47.5 – 51.5 Hz. The first picture in the figure 57 shows the active power reduction allowed. According to the graph, the generating unit shall not reduce its active power output at the corresponding frequency conditions below the line. Additionally, the reduction can be done with at least 10 % of the grid connection capacity, per minute, without the wind farm being disconnected from the grid. For instance, at a frequency value of 48.5 Hz (underfrequency case), the active power output should be higher than 90 % of the rated capacity. The second picture is about the voltage levels and the frequency values, and shows the duration to be required to stay connected. The durations are the minimum time spans for ensured operation, depending on the frequency value. The frequency control allowance obliges the producers to decrease the power by 4 % per 0.1 Hz after the frequency goes higher than 51 Hz. All the systems are allowed to fast automatic disconnection when the frequency is out of the limits (47.5 – 51.5 Hz). The German grid code specified a certain equation and conditions for the active power control done by RES. According to this simple equation, all renewable-based generating units must reduce their active power, at the instant that system

[93]Verband der Netzbetreiber, VDN - e.V. beim VDEW, "Network and System Rules of the German Transmission System Operators", August 2007.

frequency reaches more than 50.2 Hz, with a gradient of 40 % of the instantaneous capacity per 1 Hz. The figure 58 given below explains visually this idea.



$$\Delta P = 20\,P_m \frac{50.2\,Hz - f_{network}}{50\,Hz} \quad \text{at } 50.2\text{ Hz} < f_{network} < 51.5\text{ Hz}$$

P_m instantaneously available power

ΔP power reduction

$f_{network}$ network frequency

within the range of $47.5\text{ Hz} < f_{network} \leq 50.2\text{ Hz}$ no limitation

at $f_{network} \leq 47.5\text{ Hz}$ and $f_{network} \geq 51.5\text{ Hz}$ disconnection from the grid

Figure 58 - Active power reduction from RES in case of overfrequency[94]

Control of wind turbine electricity generation shows various applications according to the purpose. First of all, it is obviously understood that the wind speed is the factor which determines the production, which makes the instant power impossible to be increased (but can only be down regulated). Some of the overall control strategies can be presented as follows:

1. *Absolute Power Constraint:* Limiting the total power output of wind to a set value.
2. *Balance Control:* Reducing the power production of the overall wind farm, at a predefined rate, in order to be able to increase it in case of necessity in frequency balancing.
3. *Power Rate Limitation:* Defining a gradient for the increase of the power output and keeping a straight line in the increase graph and controlling the increase. However, it is not possible to limit speed of power reduction as it is done for increase.
4. *Delta Control:* Reducing the amount of total power production of the all wind farm by a predefined setpoint.

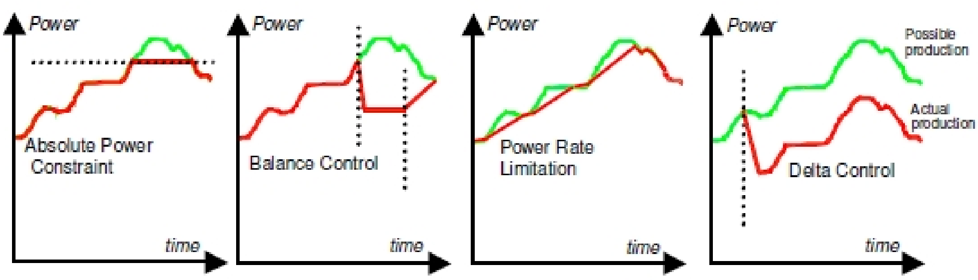


Figure 59 - Control strategies for active power in wind farms[95]

[94]Verband der Netzbetreiber, VDN - e.V. beim VDEW, "Network and System Rules of the German Transmission System Operators", August 2007, p. 28.
[95]Julija Matevosyan, Thomas Ackermann, Sigrid Bolik, Lennart Söder, "Comparison of International Regulations for Connection of Wind Turbines to the Network", Royal Institute of Technology.

Regarding the reserve regulations, in order to keep the balance between consumption and production in the electricity generation, primary and secondary control strategies are used. The primary control units enhance or lessen their production in order to provide a balanced condition on the system. After the balance is restored and frequency is stabilized, they stay in the operation. The time range for the primary reserve control is 1 to 30 s, in which the frequency can not reach its nominal values. In this content, the primary reserves can be understood as first intervention to the frequency unbalance, but not the complete solution. In order to adjust the frequency to its nominal value, the secondary control units are put into use, which its slower intervention is with a time span of 10 to 15 minutes. Therefore, the secondary control leads slower increase or decrease of generation. Additionally to these two, there also exists the minutes reserve (tertiary control), which is a schedule-based request from TSO at the respective suppliers. These reserves are requested by the provisions of the European interconnected power system of UCTE (Union for the Co-ordination of Transmission of Electricity). The following chart briefly shows the differences of the reserve controls according to their activation time ranges and time periods in the operation (blue line, Primary Reserve; purple line, Secondary Reserve and pink line, Tertiary Reserve).

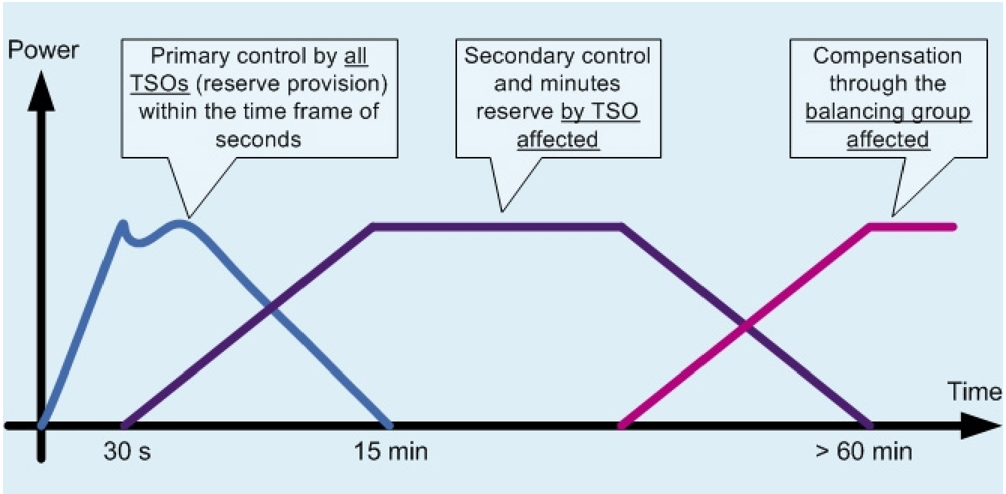


Figure 60 - The provision of reserves within the first quarter hours after a power imbalance[96]

4.1.2.2. Voltage Control (Reactive Power Compensation):

For all power plants and electricity user, equipments operate at certain voltage rating. If the voltage cannot be kept within the required limits by voltage regulation and reactive power control, voltage stability problems arise and damage the utilities. Generally, reactive power compensation has been done by conventional power plants, but in transmission networks, wind turbines are also required to join the voltage regulation as far as technically feasible. The power factor is the key element that enables proper reactive power compensation. In most of the regulations, a power factor is defined at registered capacity or for the whole production range.

[96] Amprion Webpage, "Procurement of control power and energy in Germany", http://www.amprion.net/en/control-energy

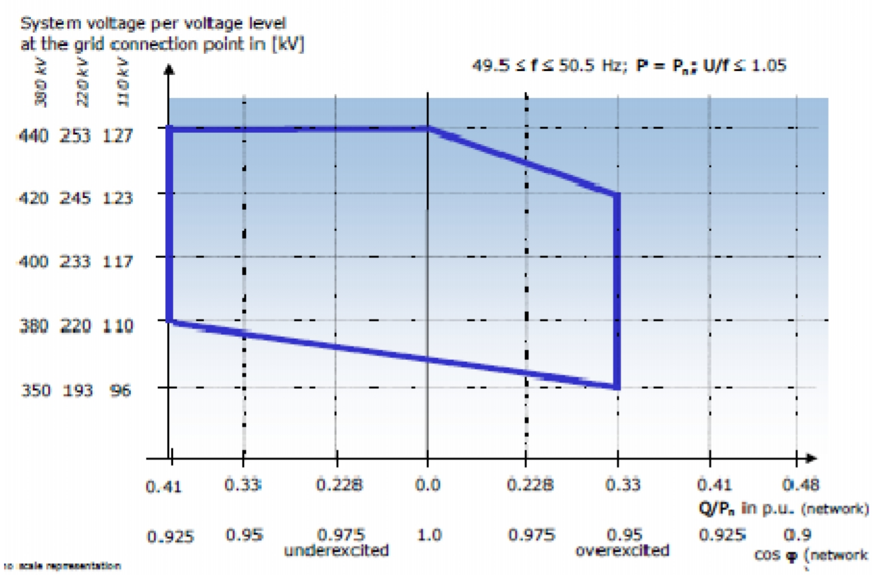


Figure 61 - Operating range within the coordinates of voltage and power factor[97]

The figure shows the German case of requirements upon the network-side supply of reactive power from generating units to the network. In the German Transmission Code, "3.3.8.1 Reactive power supply" section states that each generating unit to be connected to the grid is required to meet the operational requirements at the grid connection point. Moreover, according to the grid code, it must be possible, at any time, to change the reactive power requirements within the agreed reactive power range. Even, in case of necessity, the TSO has a right to determine a different range.

Although the power factor range is determined between 0.95 (inductive) and 0.925 (capacitive), at the grid connection point, a further exchange of reactive power can be valid if that case is contractually agreed with TSO.

One of the big differences that German Grid Codes have with the other Grid Codes is the diversification of the reactive power requirements with respect to various voltage levels. The reason for stating the actual voltage at the bus is that a high reactive power generation induces higher voltages. This natural behavior is not preferable if the initial voltage is already at a high level before the reactive power generation. Among the countries (Italy, Germany and Spain), only the German Grid Code contains a categorization for the actual voltage level as a part of the power factor limits. In Spain, none of the voltage control or frequency control is comprehensively defined as done in Germany[98].

4.1.2.3. Ride Through Requirements:

Wind turbines are actively utilized in network security issues, as have been discussed since the beginning of this chapter. Apart from the other issues, wind turbine generators shall also contribute to the voltage control under symmetrical and unsymmetrical fault conditions. This contribution is provided by obeying to a defined low voltage fault ride through (LVFRT) curve, for a certain minimum fault clearing time.

In the first years of the RES penetration to the transmission system, the TSO requirements were to oblige the wind generators to disconnect during faulty conditions. Thus, they would be saved from a serious malfunction. However, it has been a while that the days of ineffective

[97] Vattenfall Europe Transmission, "Rules of Vattenfall EuropeTransmission GmbH for Network Connection and Utilization, Vattenfall Europe Transmission GmbH, Chausseestraße 23, 10115 Berlin.
[98] Natalia Sangroniz, Jose Arturo Mora, Mateus Duarte Teixeira, "Review of International Grid Codes for Wind Generation".

renewables passed and the intermittent RES have reached a significant amount on the transmission line. Now, if RES generation in the line is disconnected during the fault, the power system would be expose to an additional loss of generation which will lead at the end a crucial frequency drop, or even a blackout. In other words, if the fault happens on the grid and if the large wind farms are suddenly disconnected from the network, this situation would put additional stress on already perturbed system. In this context, the LVRFT curve is the grid code requirement to be followed by the generators.

Regarding the German Grid Codes on this specific condition, first of all the generator has the obligations to take all the required precautions by itself to make sure that auto-reclosures in the network do not lead to harmful results at its generating facilities.

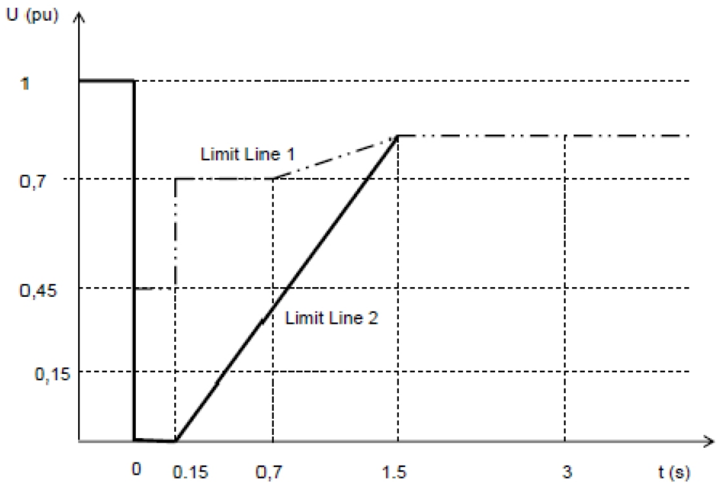


Figure 62 - Limit curve for the voltage in the event of a fault in German grid code[99]

The figure 62 demonstrates the limits for the voltage during of a fault, which is specifically defined by German Grid Code. According to the graph, above the Limit Line 1 the fault-related symmetrical voltage dips must not lead to instability or to disconnection of the generating plant from the network. Additionally to this, as it can be observed on the graph, until the fault-clearing times up to 150 ms, the generating plant should be stable and connected to the grid in the whole operating range.

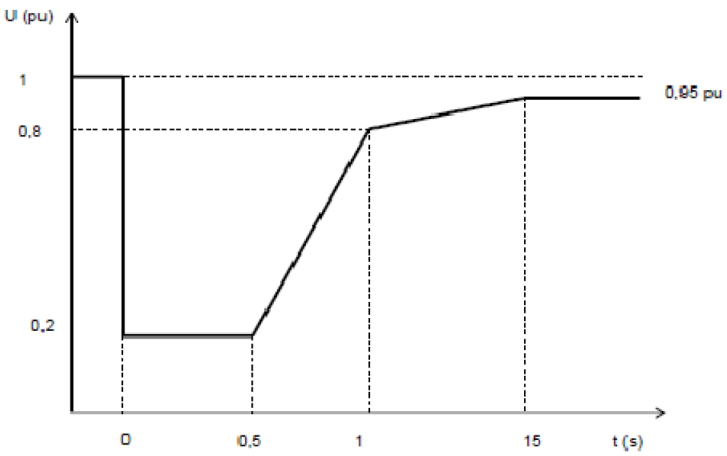


Figure 63 - Limit curve for the voltage in the event of a fault in Spanish grid code[100]

[99] Natalia Sangroniz, Jose Arturo Mora, Mateus Duarte Teixeira, "Review of International Grid Codes for Wind Generation".
[100] Natalia Sangroniz, Jose Arturo Mora, Mateus Duarte Teixeira, "Review of International Grid Codes for Wind Generation".

Similar to German case, according to the Spanish Grid Codes, wind turbines should stay connected to the grid in case of the short circuit conditions as represented in the figure above.

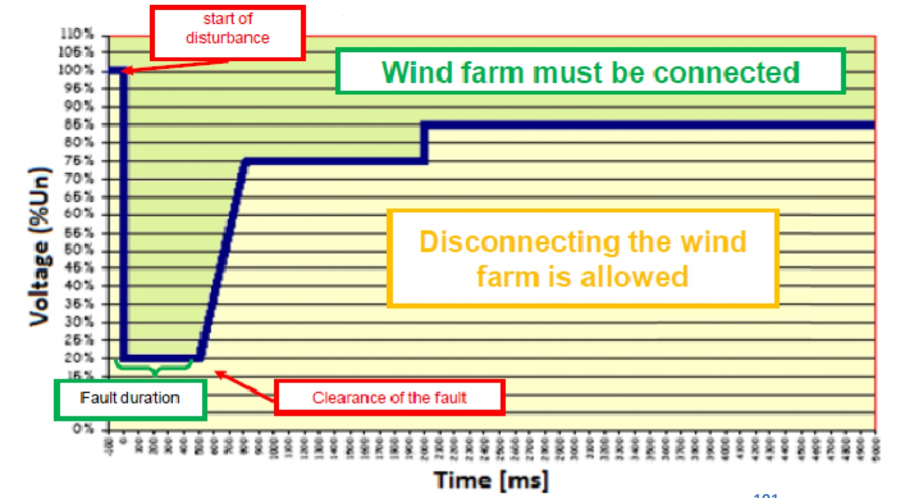


Figure 64 - Limit curve for the voltage in the event of a fault in Italian grid code[101]

As the last figure 64 of the LVFRT curves, the Italian Transmission Grid Code leads to the demonstrated time durations and residual voltage values for the dynamic behaviour requirements of wind farms during disturbances in Italian transmission grid. Although these three graphs show small differences from country to country, all of them serve for same purpose: for ensuring secure and reliable operation of the power systems.

One of the main concerns that can occur after large disturbances on the grid is islanding situation. In other words, the parts of the network can be isolated and electricity generation and consumption at the isolated part can result in an unbalance on the frequency. Most of the grid codes request from the RES generators to take care that possible isolated operation is securely identified and controlled. However, it depends on the country that TSO may or may not require island capabilities for wind farms.

4.2. INTEGRATION OF RES IN DISTRIBUTION NETWORK

The integration of DG (wind and solar) in the DNs has become one of the most targeted issues, during the present days, for the network operators. During many years, DNs have been developed with almost no generation installed on the low and medium voltage levels. Initially, these networks were designed for radial operation, where the energy flows from a primary station (PS) to a lower voltage level, and the presence of DG was not considered in the engineering. But the latter, does not imply that a DG could not be connected to a LV or MV network, it technically means that the integration of this type of energy sources would affect, at certain level, the reliability and the quality of supply, increasing in some way, the risk of service operation[101].

In Chapter 2, the explanations have been developed in policy terms that the three Member States of the present study have been carrying out in order to achieve the 2020 targets of the EU Energy Policy. These increasingly amount of RES, which are promoted by the described support schemes, will produce a considerable impact in the performance of the electricity

[101] M.H.J. Bollen, *Fellow, IEEE*, Y. Yang, *Member, IEEE* and F. Hassan, *Member, IEEE,* "Integration of Distributed Generation in the Power System – A Power Quality Approach".

networks, as it was described before for transmission networks, and it will, for DNs in the present section. However, the effect on the latter will be more direct and shocking than in the first one. The reason is that the present trend shows that DSOs follow a "*fit-and-forget approach*", where the over-sizing of the distribution infrastructure in order to prevent grid congestions during short periods of high DG production, have become the common principles[102]. While the transmission networks were designed for being compatible with generation facilities and the gradual penetration of DG in MV and LV will contribute the transmission network in reducing the system load, on the other hand, the intermittency of this type of sources leading to variations in power output will impact the transmission system.

This kind of behavior will set a limit to the amount of RES that can be connected to the system. The challenges will be set through the path of finding the manner of increasing this tolerance, which is called "*hosting capacity*", not by investing in network expansion (infrastructure such as transforming stations, power lines and wiring), but by facing towards future technologies and development throughout grid management, demand-response, communication technologies (ICT), energy storage and smart grids, with the aim of integrating new consumption and production sources.

The RES are not always available when the day by day demand requires it, or when the situation is completely the opposite, the energy produced by this sources is available but not exploitable, meaning that the wind is strong and/or the sun is bright but its conversion cannot be at full power injected because of network limits, it will be needed to implement new techniques and methods to manage this energy potential to be as much as possible exploitable. And, as it was explained before, DG units have a special characteristic that makes the task even more difficult, the unpredictability and intermittency of sources.

In the transmission section described above, the RES integration to the German network has been presented (figure 55), as an example to understand the importance of wind sources being connected to HV/MD. In the case of distribution grids, not only this technology plays an important role, but the decentralized generation units like the solar ones are the source that takes the most attention at this level. For example in Germany, around the 90% of the electricity generated in LV is originated from solar PV. In an overview of the Italian structure, it observed that DG units are present in its majority in the MV network (around 75%), as shown in figure 65.

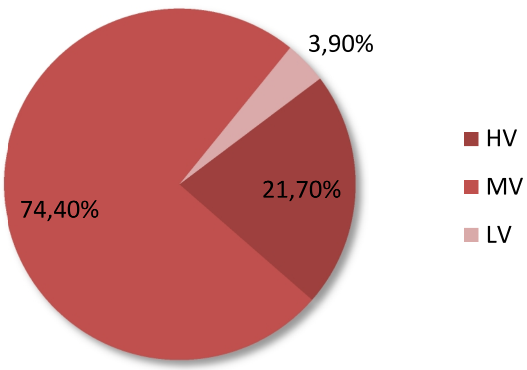


Figure 65 - DG share in Italian Network in 2010

[102]M. Delfanti, M. Merlo, G. Monfredini, V. Olivieri, M. Pozzi, A. Silvestri, *"Hosting Dispersed Generation on Italian MV networks: towards smart grids*", Politecnico di Milano.

The most important technical challenge, at distribution level, is the network capacity. And for understanding the magnitude of this challenge, the concept of "*Hosting Capacity*" has to be introduced, as the *maximum DG that can be integrated to a specific network, without exceeding its performance limits (like power quality and security issues) and becoming unacceptable in the case of surpassing those limits.*

4.2.1. The Hosting Capacity Approach

Large fluctuations in power flow are caused by the variability of consumption and production peaks, becoming a challenge for all DSOs. The maximum power flow determines the network capacity. This power flow must be kept in between the limits of maximum values of production and consumption (figure 66)[103]. When production exceeds this maximum limit, net power flow surpassed hosting capacity (shown in first and third case, blue line). The same situation occurs when maximum consumption leads to an excess of net power flow, surpassing 100% of hosting capacity.

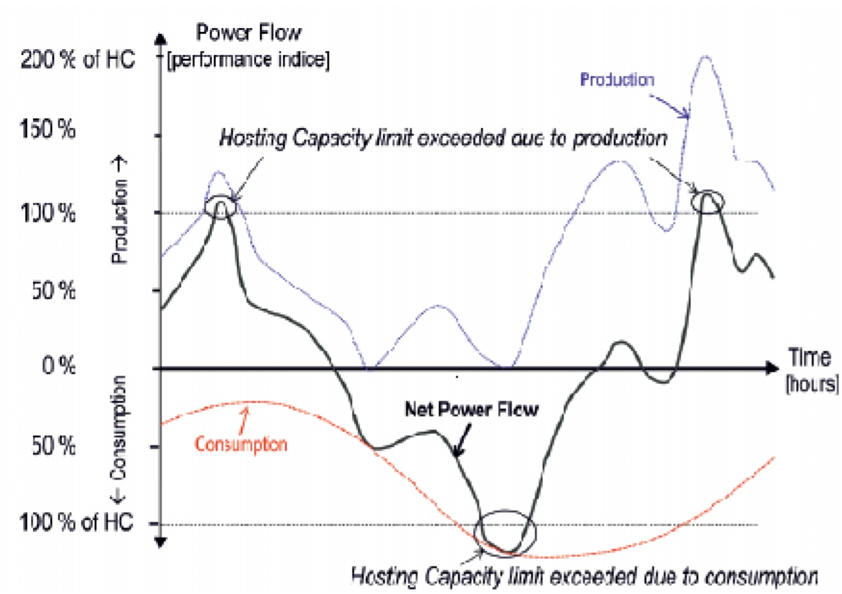


Figure 66 - Consumption and production difference producing hosting capacity exceeding limits (Source: LUT)

If the peaks in production or consumption are managed accordingly, more DG could be integrated without increasing network capacity, inducing in infrastructure costs for expanding the system. In order to avoid this, many studies have been developed in specific networks by a "*Hosting Capacity Approach*". In this method, a determined number of performance index limits are set, and quantified by certain parameters. These parameters are evaluated in a range, in function of the DG increasing penetration level. When those limits are exceeded, the performance becomes unacceptable and the *hosting capacity* is determined (see figure 67). For each performance limit this study is carried out in order to define *hosting capacity*.

[103] Nicholas Etherden*, Increasing the Hosting Capacity of Distributed Energy Resources Using Storage and Communication,* Luleå University of Technology, Department of Engineering Sciences and Mathematics - Division of Energy Science. 2012.

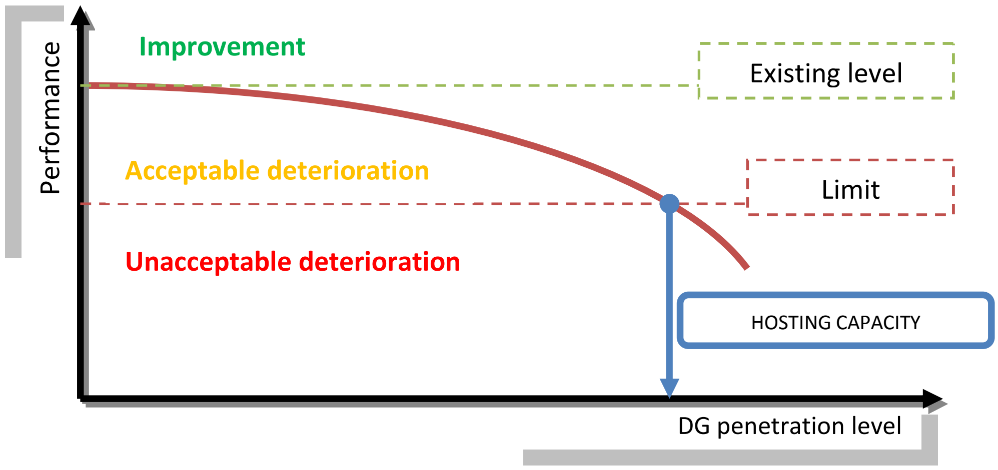


Figure 67 - Hosting Capacity approach: a performance index is considered in order to evaluate the network deterioration as function of increasing level of DG. When this performance index exceeds a lower bound, the deterioration becomes unacceptable, determining the hosting capacity[104].

The most typical parameters with which the performance levels are tested are overvoltage, overcurrent and transformer power rating. Indeed, in the paper accepted for presentation at the 2011 IEEE Trondheim PowerTech by N. Etherden and Math H.J. Bollen[104], the hosting capacity approach was carried out in order to test the network by evaluating two limits, overvoltage and overcurrent. First results thrown were that increasing the intermittent source energy penetration level would not affect performance index (previously considering a transformer upgrade), and secondly that total injected energy would decrease with the availability of the energy resources. Hosting capacity would be exceeded just during the few hours of overlapping of wind and solar production, for which the energy curtailment is then studied as a method to increase hosting capacity. Finally, it is concluded that in real connection cases, the studies are carried out in worst study scenario, thereby the increasing of hosting capacity would be achieved by implementing enhanced communications capacity, which day by day is becoming more economically viable to be applied in DNs.

In another paper issued by M. Delfanti, M. S. Pasquadibisceglie and others[105] for the 20th International Conference on Electricity Distribution, a similar study in order to determine the *hosting capacity* of specific primary busbars of a MV Italian DN, in a data based model consisting of 400 MV lines, representing the 10% of the real size of MV grid of Italy (with 4.000 MV lines totally). This study is carried out by testing three operation limits:

- SVV (Supply Voltage Variation) as a voltage limit for a bus
- RVC (Rapid Voltage Change) as a sudden change due to trip
- LTL (Line Thermal Limit) as current limit for a bus

The DG is simulated by an increasing power output in a specific bus (up to a maximum value of 10 MW, which represents ten times more the allowed connecting capacity for an Italian MV network according to CEI 0-16 standard), and determining the *hosting capacity* when one of the previous defined limits are surpassed.

Voltage limits were evaluated under power flow calculations according to the EN 50160 standard[106] (see table 29), which applies for all EU members. This standard defines the voltage

[104]Nicholas Etherden, and Math H.J. Bollen, *Fellow, IEEE, "Increasing the Hosting Capacity of Distribution Networks by Curtailment of Renewable Energy Resources"*, Paper accepted for presentation at the 2011 IEEE Trondheim PowerTech.
[105] Maurizio DELFANTI, Marco Savino PASQUADIBISCEGLIE, Mauro POZZI, Massimo GALLANTI, Riccardo VAILATI, "*LIMITS TO DISPERSED GENERATION ON ITALIAN MV NETWORKS*", Politecnico di Milano, Cesi Ricerca. Prague, 8-11 June 2009.
[106]CENELEC, 2007, Technical Standard EN 50160, "Voltage characteristics of electricity supplied by public distribution systems".

parameters and voltage ranges at customer's point of common coupling in LV and MV distribution systems, under normal operation conditions.

According to this standard, the voltage profile of a passive network is allowed to decrease within the limits established under normal operating conditions (excluding the periods with interruptions) for **SVV**, which are ± 10 % of the declared voltage Uc (see figure 68).

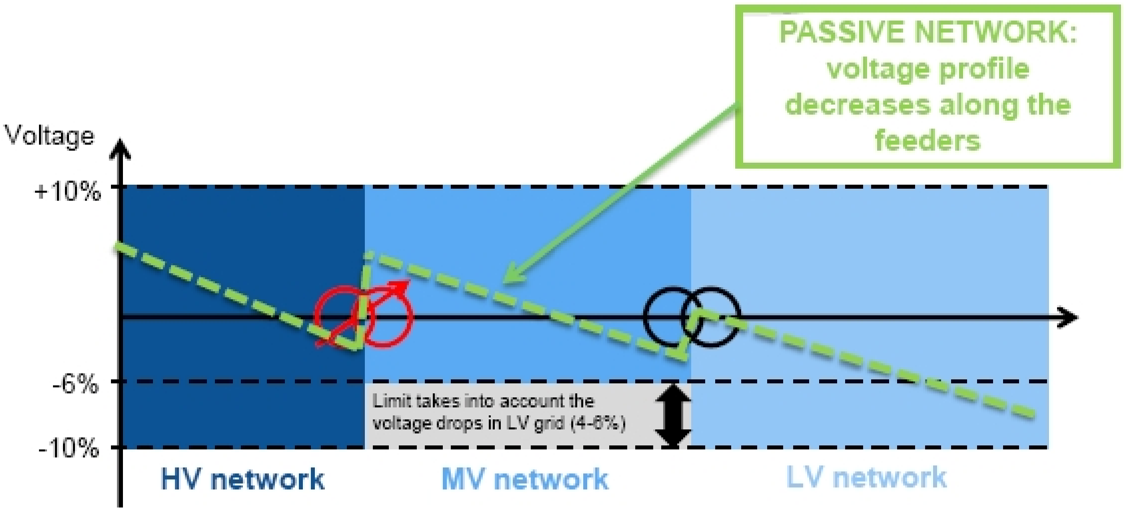


Figure 68 - Voltage profile for passive network according to EN 50160

When the network becomes active by means of integrating a DG source (feeder 48, as seen in figure 69), the the r.m.s. value of the voltage at a given time at the supply terminal can result in an overvoltage of the bus, violating the permissible limit by the standard, 110% of Uc.

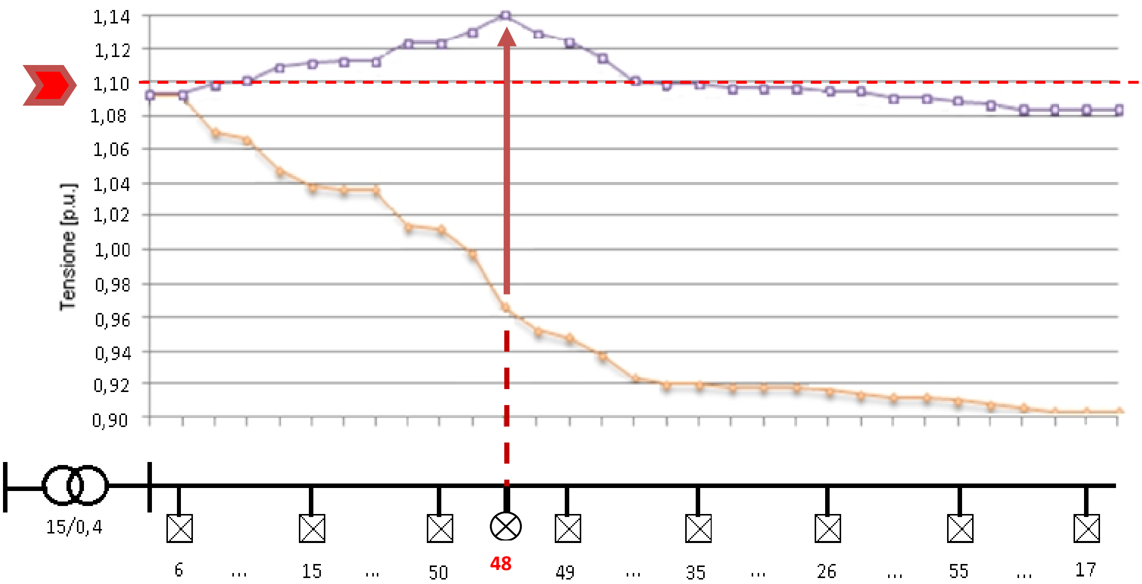


Figure 69 - Voltage profile for a given bus with DG generation producing overvoltage

This kind of situation is the one that can be produced by a massive penetration of DG sources, leading to voltage regulation issues in the MV/LV network. The amount of DG that can be connected increases as function of certain parameters: decreasing electrical distance and increasing load downstream of the bus (at feeder level). Instead, it can decrease in function of the load condition at system level (higher system voltages values registered at minimum load – off peak hours) or as function of the low load at feeder level and HV set point at PS bus bars.

Table 29 - EN 50160 / Main supply voltage characteristics for MV-LV (Source: Wroclaw Univ.)

No	Parameter	Supply voltage characteristics according to EN 50160
1	Power frequency	LV, MV: mean value of fundamental measured over 10 s ±1% (49.5 - 50.5 Hz) for 99.5% of week -6%/+4% (47- 52 Hz) for 100% of week
2	Voltage magnitude variations	LV, MV: ±10% for 95% of week, mean 10 minutes rms values
3	Rapid voltage changes	LV: 5% normal 10% infrequently $P_{lt} \leq 1$ for 95% of week MV: 4% normal 6% infrequently $P_{lt} \leq 1$ for 95% of week
4	Supply voltage dips	Majority: duration <1s, depth <60%. Locally limited dips caused by load switching on: LV: 10 - 50%, MV: 10 - 15%

Regarding the **RVC**, which is the single fast variation of the r.m.s. value of the voltage, they are calculated by contrasting two load flow calculations, as the differences between bus voltages obtained with the DG in operation and bus voltages without the generator[107]. According to the EN 50160 standard, the requirements for LV/MV are listed in the above table, point 3: RVC in MV generally do not exceed 4 % Uc, but changes of up to 6 % Uc with a short duration of the sustained level might occur sometimes per day under some circumstances. RVC are mainly caused by loads or DG power output fluctuation, changes in networks installations, by switching or by trip/faults.

Lastly, **current limits** were set at 250 A, as assumed for all branches considering standard MV wirings, overhead lines and protections settings in line with technical specifications of the manufacturers. After setting this limit, the **LTL (line thermal limit)**, the maximum amount of DG that can be integrated in the network will be the one that does not exceed this limit. The LTL is evaluated by calculating the current flow in the line with DG in operation. Important variables for this parameter are the load/injection by DG in the bus, the nominal voltage of the network and the current flow in the feeder section upstream the bus. With the given definition of the most typical voltage and current limits considered for *hosting capacity* studies, the results from the above mentioned paper and the conclusions of a second publication by Politecnico di Milano[108] states that in particular, RVC limits are a constraint mostly affecting busses downstream of the PS busbar, while LTL are the bottle neck of busses close to the PS. Instead, SVV limit is less significant than the first two. And these observations can be derived

[107] International Electrotechnical Commission (IEC), 2008, Technical Standard IEC 61000 "Electromagnetic compatibility (EMC) - Part 4-30: Testing and measurement techniques - Power quality measurement methods", Edition 2.0, IEC, Geneva, pp. 1-130.
[108] M. Delfanti, M. Merlo, G. Monfredini, V. Olivieri, M. Pozzi, A. Silvestri, *"Hosting Dispersed Generation on Italian MV networks: towards smart grids", Politecnico di Milano.*

from the simulation results obtained for the MV Italian case, where the study has thrown a *hosting capacity* of at least 3 MW for the 85% of the analyzed busses.

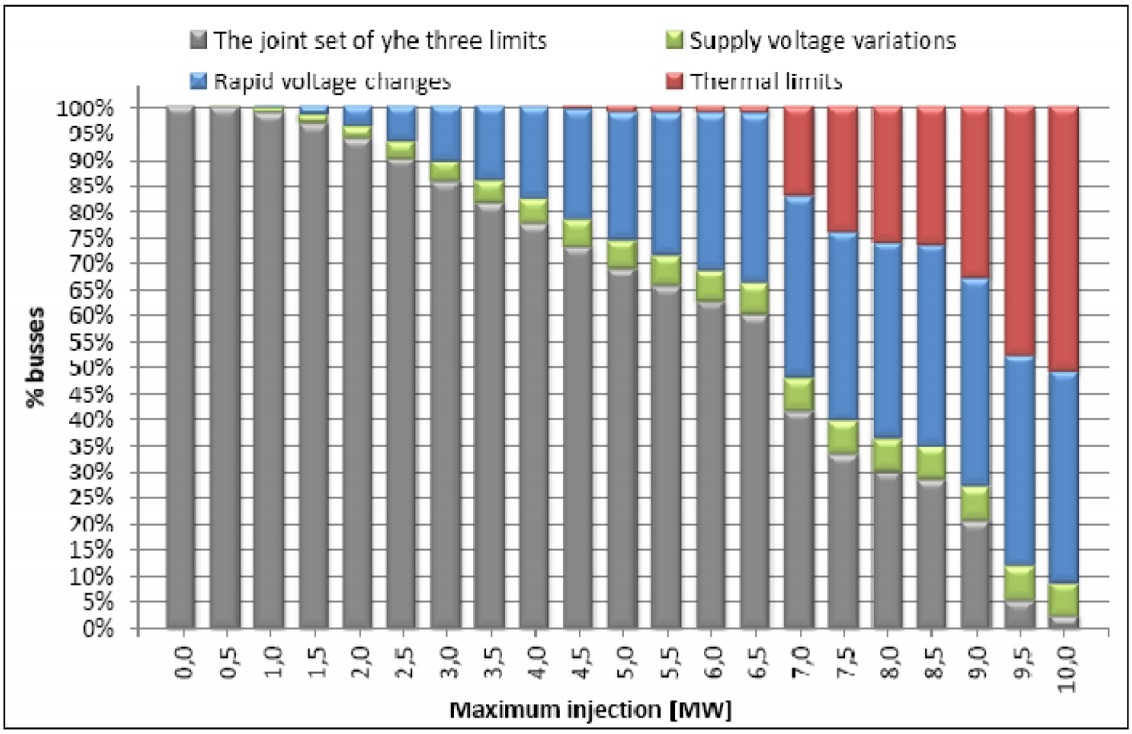


Figure 70 - Hosting capacity voltage and current limits for a study case of the MV italian network (Source: AEEG)[109]

Above figure 70 shows the simulation results for the DG increasing power in compliance with all the limits, from where it can be observed that RVC and LTL were the two most important constrains imposed to the system. From these two, it is remarked that RVC can be overcome with communication management investment (as well as SVV, with voltage regulation management), but the last one, LTL, really represents a network structure bottle neck, for which the only realistic way to overcome this issues is by grid expansion investment.

4.2.2. Interface Protection system

The influence of a high penetration level of DG is directly related to the stability of the system. As it was explained at transmission level, also the fact is of significant importance at distribution level. DGs are designed to be disconnected from the grid under particular operational conditions, when loss of mains occurs typically due to a fault. A massive unwanted tripping of DG due to frequency transients at transmission level or the disconnection of DG due to automation failures or unwanted islanding at distribution level can be extremely critical for the TSOs and DSOs respectively. Thereby, it is of extremely importance that after a fault, the DG shall remain connected to the grid as the much as the technical specifications of the generator allow its operation.

For this purpose, the DG units are equipped with a protection device which is called **IPR (interface protection relay)**. In case of fault or frequency transient, this device will be configured under specific settings (according to system operator's grid codes), under which the DG shall remain connected. If the settings are exceeded by the large system disturbances, then

[109] AEEG, Delibera ARG/elt 25/09, "Monitoraggio dello sviluppo degli impianti di generazione distribuita in Italia per l'anno 2006 ed analisi dei possibili effetti della generazione distribuita sul sistema elettrico nazionale", Allegato A, Allegato 2. 16th march 2009. Web: www.autorita.energia.it/docs/09/025-09arg.htm

the IPR will disconnect the DG from the grid until the fault is cleared or the frequency is stabilized, otherwise severe damages to the units could be induced.

For the case of the fault, the voltage stability during a voltage drop was explained in the transmission networks section as **FRT (fault ride through)**. At distribution level, the dynamic grid support requested from the DG is being performed under the same principle, according to the EN 50160 standard, with the purpose of ensuring the safety and reliability of the network operation with the increasing share of decentralized power plants in MV.

For the specific case of DG using inverters (PV, for example), the next figure 71 shows the limiting curves settings during a fault. If the voltage drop above limit 1, the generator must keep continuous and stable operation, between limit 1 and 2, it may disconnect in accordance with the grid operator, and below limit 2 and 30% Uc, the producer may disconnect.

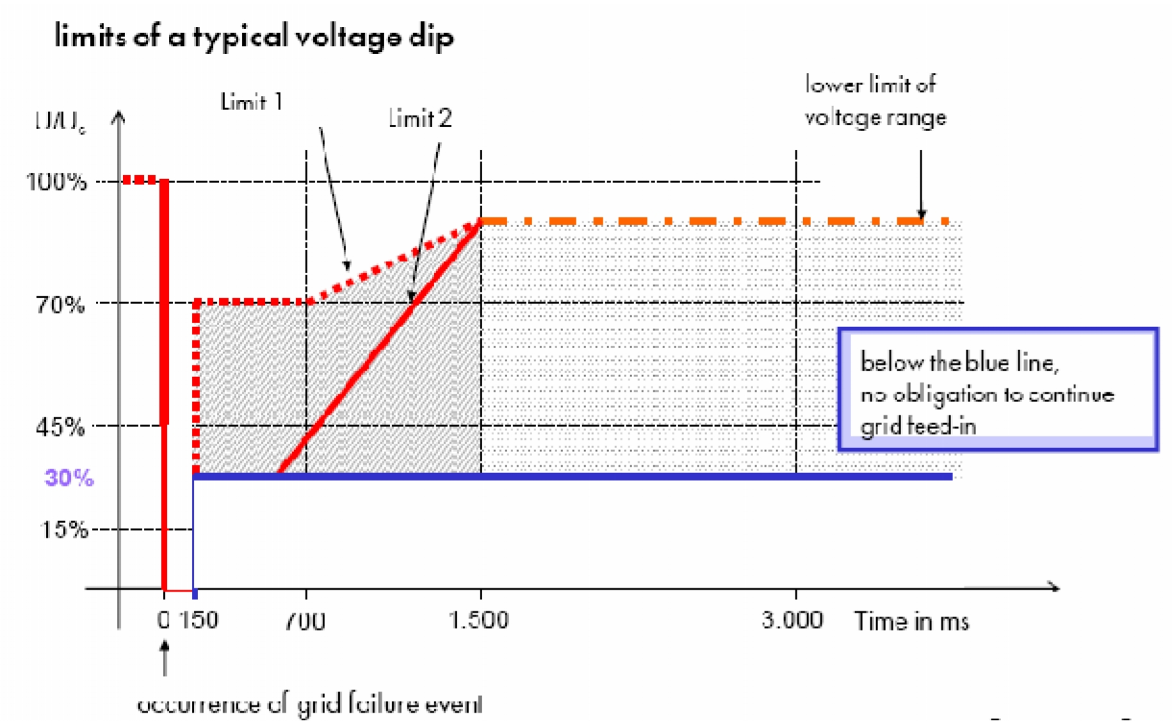


Figure 71 - Voltage dip limits for MV DG connected with inverter (FRT)[110]

But not only the last function is requested for DG at MV level, in order to keep system stability. During a voltage fault the generator also must provide reactive current.

For the case of a frequency transient, the impact can be originated in the DN, but effective at national transmission level. All EU interconnected network is set to work, at normal operation conditions under 50 Hz. In the case of a frequency disturbance, IPR will trip the DG units according to the following settings, which are specified in the European standard EN 50438:2007[111] (table 30):

[110] E. Troester, "New german grid codes for connecting PV systems to the Medium Voltage power grid", 2nd international workshop of concentrated PV power plants.
[111] CENELEC, EN 50438:2007, "Requirements for the connection of micro-generators in parallel with public low voltage distribution networks". December 2007.

Table 30 - IPR frequency trip settings according to EN 50438:2007

EU Memeber	Parameter	Maximum clearence time	Trip setting
Germany*	Overfrequency	0,5 s	51 Hz
	Underfrequency	0,5 s	47 Hz
Spain	Overfrequency	**	50 Hz + 2%
	Underfrequency	**	50 Hz - 2%
Italy	Overfrequency	0,1 s	51 Hz
	Underfrequency	0,1 s	49 Hz

* Protection shall ensure that feeding power to DN will only commence after frequency on DN have been whithin limits of IPR settings for a minimum of 30 seconds (in compliance with DIN V VDE V 0126). ** No clearance times are specified.

If the frequency of the network is not reestablished within the given ranges in the specific clearance time frame, the IPR will automatically disconnect the generator. This situation, governed by a massive instantly tripping of all DG, will put the entire national system into a huge risk of black-out.

In order to understand the magnitude of this issue, it can be said that during the major black-outs occurred in Italy on September 28th, 2003 and in the EU on November 4th, 2006, it was not possible to avoid the massive disconnection of generators (from all sources) following the frequency severe disturbances originated by two different sources: trip of a TN line in the north of Italy, in the first case, and an uncontrolled switching proceeding in the north of Germany, in the second one. For those years, the generators protection settings for frequency trips were narrower than the current ones. Thus, in order to avoid massive unwanted islanding of DG, due to the increasing penetration, these settings were widened. But the question of whether these ranges are wide enough to provide a secure and reliable operation of the system still remains. In principle, Italy TSO Terna has requested to extend this settings from current ones (49 – 51 Hz) to 47,5 – 51,5 Hz and it is requesting them to DG in case of emergency cases or recovery situations. This would avoid a massive disconnection (over 10 GW) of DG producers in case of overfrequency/underfrequency disturbances, produced by incidents on the TN.

4.3. RES CURTAILMENT

Regarding the dispatching of electricity, each technology has a different versatility at the moment of responding to the daily-season variability of the load curve (see table 31).

Table 31 - Role of generation technologies in the load curve (Source: NREL).

Generator type	Attributes of generator	Technology (typical)	
		Conventional	Renewable
Must-take	Dependent on variable resource. Requires additional generation capacity.	-	CSP w/o storage PV Wind
Peak Load	Provides power during peak demand. Ramps up and down quickly.	Natural gas combustion turbine	PV and CSP[112]
Intermediate Load	Varies production to follow demand. Predictable availability.	Natural gas combined cycle	CSP with storage[113] Hydropower
Baseload	Low fuel and operating costs. Constant rate of production. Often very large to benefit from economy of scale.	Coal Nuclear	Biomass Geothermal Hydropower

CSP = Concentrating Solar Power; PV

Each generation technology has a different attribute which fulfills load requirements, but no single source can meet all. The table above shows the importance of a grid mix, in which RES are gaining importance day by day. In a matrix where the integration of "must-take"[114]RES (wind or solar, where the resource must be taken or, otherwise, lost) are increasing, all management efforts in the network must be focused on using this availability as much as possible, without affecting the reliability of the system. This electricity has to be analyzed well in order to be utilized in the grid.

In some cases, the renewable energy produced by the intermittent sources, which are in the "must-take" principle according to the table, has to be curtailed in order to provide the security of the network. Although these actions are for the wellness of the grid, it is not acceptable to lose instantly that amount of power. All the countries analyzed in this paper have started taking steps in order to provide real-time visibility and accurate forecasts of electricity from DG (dispersed generators). However, despite the continuous actions taken all the time, German TSOs had taken curtailments, almost daily, to protect the grid reliability. Spain and Italy suffer from the high amount of wind power losses due to the curtailments.

There are important conditions in curtailing RES from the system. Thanks to the legal rights for their connection criteria, it is not that straight-forward to disconnect a renewable source from the grid. For instance, German law requires that TSOs have to assess all available market options before curtailing the renewable, as a last option; but this does not mean that even in case of a threading situation for the security of the all transmission system, they cannot be

[112] Although they do not meet the rapid response requirements of peaking generators, solar PV and CSP generation coincide with summer demand peaks caused by air-conditioning loads, especially in the sunny southwest.
[113] With sufficient thermal energy storage, CSP plants can run as baseload generators. The US Dept of Energy is funding research to explore baseload CSP systems.
[114] Concept taken from an Energy Analysis publication from NREL, "*Solar Power and the Electricity Grid*", from National Renewable Energy Laboratory, http://www.nrel.gov/solar/

curtailed. TSOs are allowed to curtail any of the generator's production in transmission system and also in the distribution system, if it is required.

The main reason of the curtailments is having a highly unbalanced situation between the demand and the supply, where excessively high RES energy is produced. The figure demonstrates the idea of the excessive production coming from the available RES power in an unexpected time band. The red area in the figure is the curtailed amount of energy; in other words, this amount of energy is undesirably wasted.

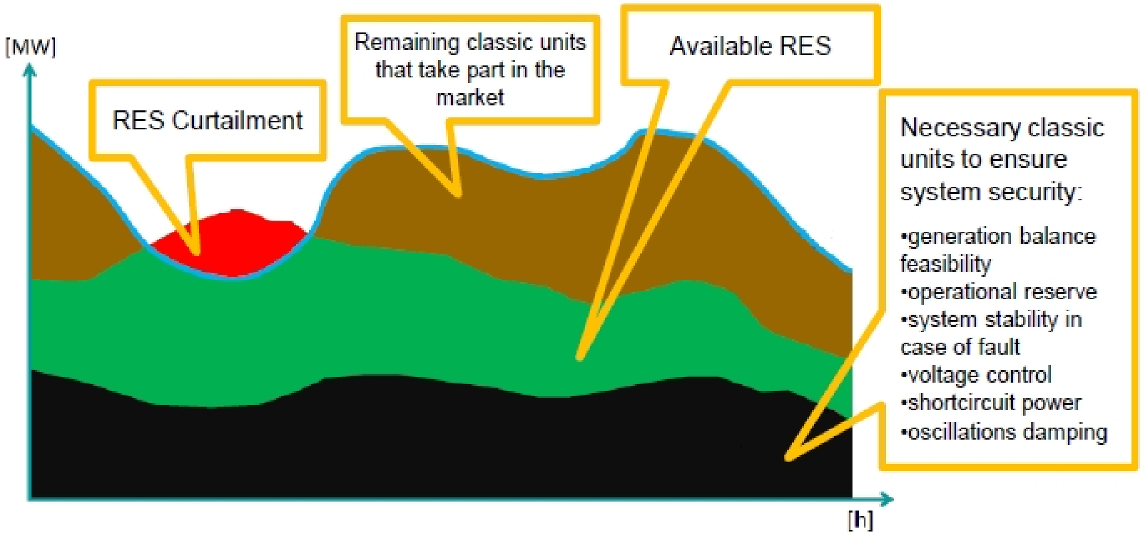


Figure 72 - RES curtailment in case of excessive RES production

Generally, the explained situation occurs in some specific areas where there is a high concentration of renewable electricity generation and a low load density. Lower Saxony and Schleswig-Holstein, Germany and Puglia, Italy can be given as examples for this specific situation with the high concentration of wind farms on the regions. Thus, in these areas, occasionally RES production is required to be limited to provide the balance between production and consumption. In Spain, the reasons for curtailment are congestion, net work stability, short-circuit power concerns, inadequate active/reactive power levels and minimum load. The various reasons stated above have affected the Spanish transmission grid. Up until late 2009, the majority of curtailments were because of the congestion in the grid. Then, in 2010 the curtailments mostly occurred due to the wind generation, being greater than minimum load. That development stemmed from the significant increase of wind plants on the regions.

The Red Electrica de España (REE), TSO of Spain, formed a central point, which is called the Control Centre for Renewable Energies (CECRE), for the control of interconnected RES greater than 10 MW. The purpose of this institution is to provide a high level of integration for RES without damaging system security. Under this purpose, CECRE supervises all generation units as necessary by means of supervisory control and data acquisition (SCADA) systems, and uses General Coordination Centers (GCCs) to achieve the supervision. Therefore, there is an obligation for the RES plants greater than 10 MW to be connected to a GCC with an ICCP protocol. Active power, reactive power, connectivity, voltage level, available wind speed and direction and available ambient temperature form the data profile that is transferred to the CECRE by wind farms in real-time. Thanks to this transferred data, CECRE does the necessary estimations for the maximum power output of the wind farm and measures the possible results of this power on the stability of the grid. This analysis leads the act of curtailment or safe operation[115]. This phenomena is also valid in Italy under the provision of TERNA, even if no ad-hoc control center is yet in place.

The amounts of recent curtailments are significant and must be prevented in some way, when the importance of energy is considered. Regarding the German system, between 2004 and 2006, 74 GWh of wind power were curtailed and wind power companies had lost revenues of € 17,600/MW in only 2006[116]. In the beginning of 2009, in spite of the grid management practices on this situation, there still existed instances of curtailment among wind power facilities connected to the E.On Netz distribution system. These curtailments have affected approximately 1080 MW of wind capacity. Apart from the power capacity, the duration of the curtailment also presents an important measure of the curtailment phenomena. Below, the mentioned major curtailment incidents and their durations can be observed with the given maximum reduction percentages. The data is taken from the reports of E.On Netz presented on its grid management website:

Table 32 - Wind Power Curtailment on the E.On Netz Distribution System (January – June 2009)[117]

Date	Duration (minutes)	Region	Maximum Reduction
January 20	82	Nordfriesland, Schleswig-Holstein	60%
March 17	305	Dithmarschen, Schleswig-Holstein	30%
March 17	164	Ostholstein, Schleswig-Holstein	60%
March 22	131	Lower Saxony	60%
March 22	136	Dithmarschen, Schleswig-Holstein	60%
March 23	164	Ostholstein, Schleswig-Holstein	60%
March 24	62	Ostholstein, Schleswig-Holstein	60%
May 6	247	Ostholstein, Schleswig-Holstein	60%
May 18	27	Nordfriesland, Schleswig-Holstein	60%
May 27	95	Nordfriesland, Schleswig-Holstein	30%
May 28	27	Ostholstein, Schleswig-Holstein	60%
June 12	159	Nordfriesland, Schleswig-Holstein	60%
June 26	199	Ostholstein, Schleswig-Holstein	60%
June 26	180	Dithmarschen, Schleswig-Holstein	60%

This on-going curtailment problem, that has been one of the most crucial topics of German authorities, continues to be experienced by the TSO regions in Germany. One recent example is the situation in the 50 Hertz Transmission Network, on 28 to 29 March 2012. Due to high wind power generation with peaks up to 8477 MW, there existed very high loads on the transmission network of 50 Hertz. In order to provide the stability safety of the system, all the actions are taken according to the EEG § 13 (1) Energy Act. The substations Perleberg (Brandenburg) and Siedenbrünzow (Mecklenburg-Vorpommern) were at risk because of the overloading of the network capacity by massive feed coming from the 110 kV networks of the DSOs E.ON edis and WEMAG.

Therefore, the following curtailments are done in the specified time periods[118]:

[115]A. Cena Lazaro, J. Gimeno Sarciada, "The Spanish Experience in the Integration of the Electricity from Wind Power Plants into the Electrical System", 7th International Workshop on Large Scale Integration of Wind Power and on Transmission Networks for Offshore Wind Farms, May 2008.
[116]Sara Knight, "Owners Compensated for Lost Production", Windpower Monthly, September 2009, p. 84.
[117]E.On Netz Einspeisemanagement Einsatze, available at: http://www.eonnetz.com/pages/ehn_de/EEG__KWK-G/Erneuerbare-_EnergienGesetz/Einspeisemanagement/Einspeisemanagement_Einsaetze/index.htm#tabelle

The Substation – UW Perleberg

28.03.2012	from 14:30 to 15:45 60 MW	(40 MW E.ON edis / 20 MW WEMAG)
	from 15:45 to 16:15 120 MW	(80 MW E.ON edis / 40 MW WEMAG)
	from 16:15 to 18:00 180 MW	(120 MW E.ON edis / 60 MW WEMAG)
	from 18:00 to 24:00 120 MW	(80 MW E.ON edis / 40 MW WEMAG)
29.03.2012	from 00:00 to 03:00 120 MW	(80 MW E.ON edis / 40 MW WEMAG)
	from 03:00 to 07:00 60 MW	(40 MW E.ON edis / 20 MW WEMAG)

The Substation – UW Perleberg

28.03.2012	from 16:00 to 18:30 20 MW	(E.ON edis)

The recent observations demonstrate that the German grids are frequently loaded to the capacity limits. An unstable German grid would construct a possible thread to the bounding countries. This fact makes the observations on the German grid more important.

With regard to Spain, the percentages of the wind power curtailment are also as considerable as in Germany. In 2007, 23.9 GWh of wind energy generation was curtailed, which represented 0.09% of total wind production of that year. In the following year 2008, the percentage was increased to 0.3 % of total wind production. Then, in 2009, 54 GWh of wind generation was curtailed, which was 0.15 % of total wind production. Compared to these values of the three years, in the first three months of 2010, 1 % of the total wind production was curtailed and resulted in a loss of profits of around 10 million euros. This progress demonstrates that wind power curtailments are expected to increase in the future and with the possibility of rising up to 6.8 % of total wind production[119].

On the other hand, the other most important example of curtailments happens in Italy with significant amounts. During 2010, the loss wind production (*MPE*) was 480.4 GWh, which corresponded to 5.6 % of total wind production on the Italian transmission system. In 2009, this value was 10.7 %.

[118]“Angespannte Netzsituation in der Regelzone von 50Hertz Transmission im Zusammenhang mit einer Starkwindfront vom 28.bis 29. März 2012”, available at: http://www.50hertz.com/transmission/files/sync/Netzkennzahlen/MassnahmenEnWG/Information_EEG11_mit_13-2_vom_28.03.2012_bis_29.03.2012.pdf
[119]Jennifer Rogers, Sari Fink, Kevin Porter, “Examples of Wind Energy Curtailment Practices”, Exeter Associates, Inc., July 2010.

Table 33 – Wind Power generated in Italy in 2010 (Source: GSE120)

GWh	Actual Generation	Curtailed Generation	Potential Generation	Curtailed / Actual
Piemonte	21.4	-	21.4	
Valle d'Aosta	0.0		0.0	
Lombardia	-	-	-	
Trentino Alto Adige	2.2	-	2.2	
Veneto	1.7	-	1.7	
Friuli Venezia Giulia	-	-	-	
Liguria	34.8	-	34.8	
Emilia Romagna	24.7	-	24.7	
Toscana	76.1	-	76.1	
Umbria	2.3	-	2.3	
Marche	0.0		0.0	
Lazio	15.1	-	15.1	
Abruzzo	329.3	0.8	330.1	*0.2%*
Molise	532.3	10.2	542.6	*1.9%*
Campania	1,333.2	158.1	1,491.3	*11.9%*
Puglia	2,103.2	309.9	2,413.0	*14.7%*
Basilicata	458.3	-	458.3	
Calabria	952.3	-	952.3	
Sicilia	2,203.0	0.0	2,203.0	*0.0%*
Sardegna	1,036.1	1.3	1,037.4	*0.1%*
ITALY	9,125.9	480.4	9,606.3	*5.3%*

As mentioned, due to the high penetration of PV power plants in Italy in the last year 2011 (> 10 GW of total capacity installed), as a result of the IV Conto Energia (premium tariff), this technology was subject of curtailments (*Mancata Produzione Fotovoltaica*) in some regions of Italy (not necessarily southern regions due to the decentralized distribution of DG along the national territory) like Emilia Romagna[121]. This situation was produced in moments of low demand during summer holidays (last august 2012) and high availability of natural resource when the sun irradiance was at its maximum value, in a similar case to wind energy, when strong winds are made available in the southern regions of Italy. In order to contemplate this PV curtailment issue, the new Italian support scheme “V Conto Energia” foresees for the producers a “delayed pay-back” of the producer’s profit loss due to the curtailments, consisting in an extension of the tariff applicable life. At the same time, in the market currently being offered insurance services are for covering the potential curtailment risk the producers are exposed to.

From the producer point of view, the curtailment orders coming from the TSOs negatively affect the revenues for the RES electricity generation installations. That’s why compensations are defined due to the loss of production for RES producers. For instance, R.O ARG/elt 5/10

[120]Published in GSE Statistical Report 2010, Renewables Energy Power Plants.

[121] Source: article from Qualenergia.it: “La rete elettrica alla prova delle rinnovabili”. August 28th, 2012.

defines the compensations of revenue for the wind plants due to the loss of energy produced in Italy. On the other hand, in Germany the compensation is divided depending on DSO and TSO payments. In case of DSOs, the compensation is equal to lost revenues. Regarding the TSOs, the compensation is also defined as the lost revenues but in the Curtailment Procedures part of the bilateral contracts. If a possible congestion threat remains after all the other methods have been applied, there is no payment or compensation for curtailment. In Spain, the curtailment strategies are divided into two sub-categories as programmed (before day-ahead market is closed) and real-time (in the intraday markets) curtailments. According to this categorization, the former curtailment type does not provide compensation for the curtailed generation which is programmed in advance, while the latter offers 15 % of the wholesale price for each hour without premium which is multiplied by the production amount stated in the forecasts.[122]

Taking everything into consideration, due to the rapid growth of wind power and the lack of improvement attempts to support the infrastructure for the grid, the curtailment problem for wind farms is going to be more and more significant. Although the best investment is on grid expansion, the future of the transmission lines control management, in line with the smart grids, will be to increase the capacity with what is called “Dynamic Thermal Circuit Ratings” (DTCR) which, by making available a continuous real time thermal information of the overhead lines, will enable the operator would be capable of increasing capacity by reducing the risk of tripping.

4.4. RES FORECASTING

Over the past decade, due to the confrontation with the increasing portfolio of intermittent generation in wind and solar power in Germany, German TSOs increased their cooperation with different private and public meteorological research organizations, in order to make use of the forecasting services. The four TSOs in Germany have been working with the public research institute known as IWES[123]. IWES provides wind forecasting and a methodology for it, which uses combination of data from wind forecasts from meteorological services and online wind measurements from all over Germany, this example is one of the leading and most advanced in Europe. Their purpose is to derive wind forecasts for increments from 15 minutes to 2 days in advance. Besides the German TSOs, these models of IWES have been utilized by other different European TSOs. The forecast accuracy of IWES models is above 95 % as it can be observed in the figure 73 with the development from 2001 and 2009.

[122]Jennifer Rogers, Sari Fink, Kevin Porter, “Examples of Wind Energy Curtailment Practices”, Exeter Associates, Inc., July 2010.
[123]Fraunhofer-Institut für Windenergie und Energiesystemtechnik, that is located in the towns of Kassel and Bremerhaven.

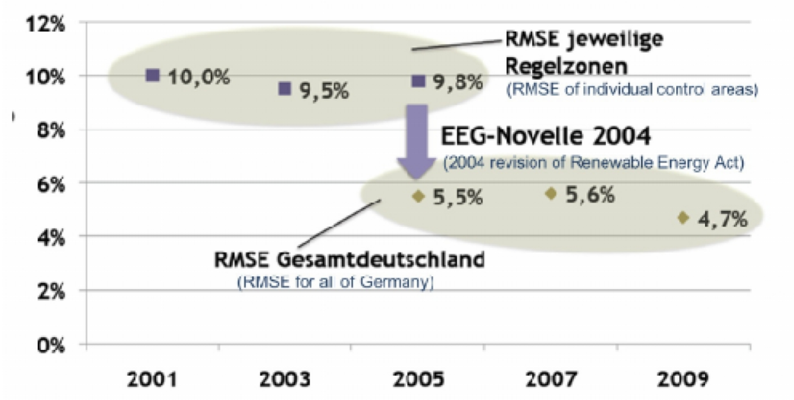


Figure 73 - Error percentages for day-ahead wind power forecasts in Germany from 2001 to 2009[124]

The previous figure demonstrates the decrease in the root mean square error below 5 % for individual control area, for wind power forecasts.

Additionally to the wind power, solar power forecasting has the same importance. The corresponding tools and methods were also developed. The German TSOs use the data coming from IWES and two other private companies, which are Meteocontrol and Suncast. This data for solar forecasting is a combination of weather forecasts, satellite data on radiation, statistical methods and quarter-hour online data for specific amount of PV installations. As it is explained for wind power, similarly the aim is to derive 15 minutes to 4 days forecasts in advance. The accuracy has almost the same values as the wind power forecast. For instance, Suncast reported a RMSE about 4.5 % for day-ahead forecasts in 2010. In spite of the reported numbers of errors in forecasting and the well-going profile of forecasting in Germany, on September 6, 2010 an increase in the errors resulted in activation of 100 % of all contracted operating reserves for plenty of hours. This undesired incident invoked the German regulatory authority to make a policy intervention. By this policy intervention, the regulatory authority published a “reference metering procedure” for solar forecasting and this implementation was aimed at an increase in DSOs’ forecast and extrapolation capabilities to provide better data to the corresponding TSOs for distributed generation of renewables. After April 1, 2011, large DSOs implemented the requirement in coordination with TSOs. As a result, this reaction from German regulatory authority made DSOs to make regular use of tools for wind and solar power forecasting, which were mainly used only by TSOs.[125]

According to the Dena Grid Study II (2010), by more improved wind energy forecast quality, the balancing energy, which must be provided in 2020, can be predicted as:

- Positive secondary and minute reserve : 4200 MW
- Negative secondary and minute reserve : 3300 MW

The given values are lower than what was presented in the Dena Grid Study I (2005). Therefore, as the differences in the two progressive studies demonstrated, a decrease for required reserves can be provided by necessary acts taken in forecast developments[126]. The highest forecasting accuracy will reduce the balancing costs.

Regarding the obligations on the shoulders of RES-E producers in the issue of forecasting, in Spain, with the RD RD 661/2007, the RES-E are obliged to deliver daily production forecasts.

[124] Neubarth, Jürgen, “Integration Erneuerbarer Energien unter besonderer Berücksichtigung der Regelenergie”, Presentation at E-world 2010, Essen, February 9, 2010, p.11.
[125] KEMA, Incorporated, “European Renewable Distributed Generation Infrastructure Study”, December 2011.
[126] German Energy Agency (DENA), “Integration of Renewable Energy Sources into German Power Supply System in the 2015-2020 period with Outlook to 2025”, November 2010.

This makes them to utilize the required forecasting methods and determine their production. Before the stated decree, this obligation was only valid for the installations with a power capacity higher than 10 MW (RD 436/2004). In case of exceeding or missing the amount of forecasted production, they are penalised with a certain fee. This application provides a better integration for wind energy into the electricity market.

In Italy, the TSO (Terna) has the national management of the internal forecasting for all wind parks in the country, at transmission level. The system works with hourly forecasts of next 24h by region or transmission system node and hourly stochastic forecasts of total production. The programs of this wind farms are matched in the daily market. At distribution level, the forecasting is managed zone by zone in by one player, the GSE, which then informs the TSO.

For the small non relevant producers, under the resolution ARG/elt 4/10, the Authority has authorized the GSE to make the aggregate for each market area, acquiring satellite, real-time data on the availability of the source and the consequent production. For bigger producers (over 1 MW) the DG is responsible (but not obliged) for delivering a forecast program to the GSE. This function, in order to be promoted, is being supported by an incentive scheme which was explained in *the Italian Access to the Grid (Chapter 2),* as the CCP[127] contribution, but not all the DG make use of it, or in other cases, they do not practice accurate forecasting programs. As this function is not a must for the non-programmable producers, it is becoming difficult for the TSO to manage the network in a cost effective way, due to the high costs deduced from the high levels of balancing reserve that have to be available in order to overcome a possible unbalancing event caused by this lack of accuracy in the dispatching programs. Because of this reason, as mentioned before, the local authority (AEEG) has issued the *Consultancy Document* DCO 35/2012/R/efr with the objective of analyzing the possibility of charging the producers that would not provide an accurate forecasting, reducing the risk of imbalances and promoting a more efficient forecasting practice especially with the aim of aligning the Italian wind market to those of the European markets. This measure is thought not to be put in force before 2013.

While in Italy the forecasting is foreseen up to the hour 17 of the previous two days of the effective production, in countries like Germany, Spain or UK this program is delivered up to two hours before, reducing the error of the predictions significantly. Moreover, in Spain, which has a more evolved market in this topic, the unbalancing charges can be socialized in between all the DG plants from a same producer, producing an "aggregated effect" that contributes in reducing the unbalancing costs[128].

After the implementation of these significant charges for non programmable DG inducing imbalances, the Italian producers will have to be more efficient in forecasting by implementing new technologies and methods. This support mechanism will reduce the system costs (mainly the A3 tariffs being paid by final consumers) and will promote the use of intelligent forecasting systems in combination with some storage capacity, facing the DG to be gradually integrated into the smart grid paradigm.

Commercially available wind forecasting capability can substantially reduce the costs associated with day-ahead uncertainty. In one major study[129], state of the art forecasting was shown to provide 80% of the benefits that would result from perfect forecasting. Implementing wind plant output forecasting in power-market operation and system operations planning in

[127] AEEG 111/06. Meccanismo di incentivazione per la previsione corretta delle unità di produzione alimentati da fonti rinnovabili non programmabile.
[128] Energy and Strategy Group, *Wind Energy Report 2012.* Italy, July 2012.
[129] GE Energy, The Effects of Integrating Wind Power on Transmission System Planning, Reliability, and Operations: Report on Phase 2, Prepared for The New York State Energy Research and Development Authority, City, State, Mar. 2005.

the control room environment is a critical next step in accommodating increasing amounts of wind penetration in power systems[130].

4.5. FUTURE INTEGRATION of DG

Situations like the ones exposed before, when the system stability is exposed to operation risk due to technical impact of the DG penetration, will become more and more probable as much as the RES are integrated in the national networks. This last means that the current grid architecture needs to be adapted to the new growing technical requirements structure.

The process of the evolution of the network can be described step by step, as shown in the figure 74[131]. As a first measure, in order to support the grid evolution towards the future increasing integration of DG, system protections update can be considered the short term solution that can adapt these current requirements, implying a low level of investment. But the last would not imply an architecture change if no investment is made in network infrastructure reinforcement. Thus, for this reason, the crucial step towards the challenge of reconfiguration the network in a midterm horizon would be the planning and developing of the distribution grid structure and redesign new interconnection interfaces that could ensure stability at all levels.

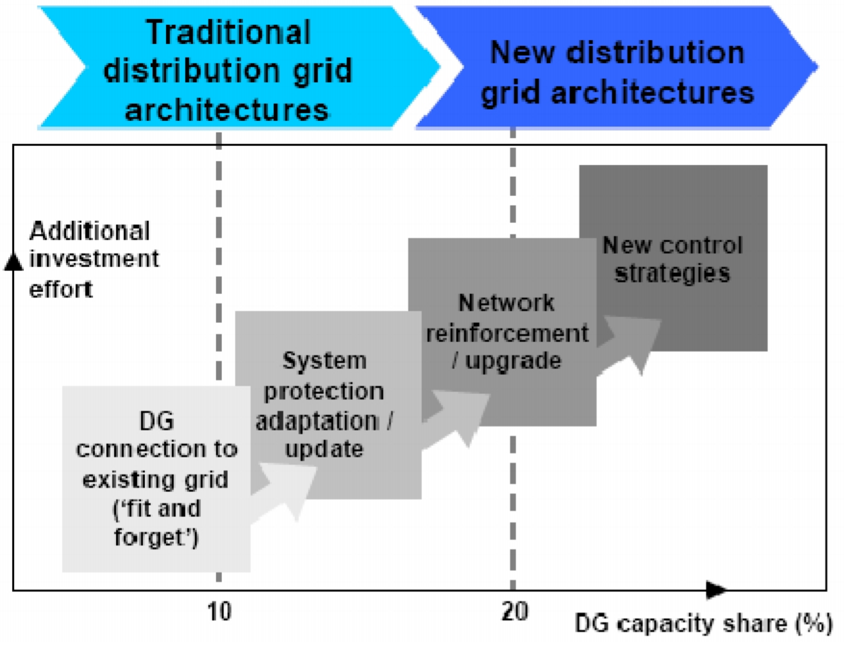


Figure 74 - Distribution grid possible evolution stages towards a higher RES integration (Source: JRC – EC)

But the future itself will require efforts beyond the previous ones, not only in terms of investments, but in terms of engineering, communications, regulations and mainly, social change. New control strategies have to be enforced in order to allow the EU Members to reach 2020 and further targets in RES integration. It has to be understood that, in order to face this grid evolution, new control methods, like an accurate forecasting of non-programmable DG,

[130] J. Charles Smith, *Senior Member, IEEE*, Michael R. Milligan, *Member, IEEE*, Edgar A. DeMeo, *Member, IEEE*, and Brian Parsons, "Utility Wind Integration and Operating Impact State of the Art". IEEE TRANSACTIONS ON POWER SYSTEMS, VOL. 22, NO. 3, AUGUST 2007.
[131] Angelo L'Abbate, Gianluca Fulli, Fred Starr, Stathis D. Peteves, "*Distributed Power Generation in Europe: technical issues for further integration*", Joint Research Center, Institute for energy, European Commission. Netherlands, 2008.

the availability of energy storage facilities and increasing the system balancing and reserve from these sources shall be developed in order to support the network stability, reliability and quality of service. But these last strategies will also require coordination and management in order to be enhanced, and those functions will be comprehensively performed by what is known as a "*smart grid*" and its *ICT* interface.

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CHAPTER 5

TOWARDS A SUITABLE SUPPORT MECHANISM

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After analyzing target member's RES support schemes described in *chapter 3*, it was understood the level and purposes of deployment of the energy policies towards the EU Energy targets 2020. The strategic aim of setting a foothold in these three markets has configured the main mechanism to compensate the investors for that difference in cost competitiveness between conventional and renewable sources. As alternative technologies have gained acceptance through the greenhouse emissions reduction, the energy efficiency and the need to reduce oil dependence paths, the competitiveness of the renewable technologies will become potentially achievable due to technology development and parallel decrease of generation costs. Each of these technologies will be able to rely gradually in a lower level on financial supports granted by these schemes, allowing a phasing out of those support mechanisms.

Under the policy scenario described before, the purpose of this chapter is to determine the *feasibility* of achieving the *grid parity* of RES technologies in the target EU countries, by carrying out a competitiveness analysis of the driver technologies (PVs and wind power) towards achieving the EU targets 2020. This study will consider some important variables which will affect directly the competitiveness.

In *chapter* 4 the derived technical impacts produced by a high RES penetration under the described support schemes perspective have been analyzed. After considering the *feasibility of achieving the grid parity* for the mentioned technologies, under the *BAU* (business as usual) conditions, the study will go on by stating the main *barriers* affecting the current RES development and the path towards their self-sustainability. The chapter will conclude with the identification of some improvement points and some recommendation on how to overcome those barriers and inefficiencies by proposing suitable modifications and incentive strategies. By this method, we will finally explain how grid parity can be achieved sooner, keeping a sustainable RES development beyond the 2020 EU targets.

5.1. THE WAY THROUGH COMPETITIVENESS

RES and the improvements on their technologies have shown that they are becoming important shares of the EU electricity production mix and the current improvements drive them through the EU target of 20 % by 2020. This process has been analyzed and explained in the previous chapters. Throughout the progress in the technologies of RES, the cost reductions of current technologies for RES help them to reach grid parity in certain market segments. The driving forces for reaching this purpose are applying the right policy and having suitable market conditions in the leading EU countries. Due to these facts, to have a brighter energy future in Europe, the technology in RES should become more cost-effective and competitive compared to the conventional energy sources, in order to become a suitable alternative energy production investment.

In this context, one of the most important steps, to have an idea about how the competitiveness can be achieved, is the comprehension of the elements of the generation cost and how to reduce them. Additionally, the electricity price stands as another important factor affecting the grid parity.

5.1.1.Generation Costs Evaluation

Depending on the specific type of RES such as solar and wind, the prices for the installations have been significantly decreasing over the last two decades. Additionally to this trend, the system prices keep on decreasing in the upcoming years, fact which is going to trigger the grid parity.

The generation costs can be analyzed by considering the concept of *Levelized Cost of Electricity* (LCOE). In this concept, all the investment capital costs and operational costs in the lifetime of the installation are included, to have a detailed idea of the cost per kWh of electricity produced by the specific installation. That calculation allows different technologies or ways of producing energy to be compared when alternative scales of operation, investment or lifetime periods exist. For instance, the LCOE could be used to compare the cost of electricity generated by a wind power plant with that amount electricity from fossil-fuel generating unit or another RES. It simply combines all the stated costs of the installation from the capital cost to each operational cost and converts them into a common unit as €/kWh.

$$LCOE\ (€/kWh) = \frac{CAPEX + NPV\ of\ total\ OPEX\ (during\ the\ lifetime)}{NPV\ of\ total\ Electricity\ Production\ (kWh)}$$

As it is demonstrated in the equation of LCOE, the calculation includes the lifetime of the installation, the investment costs (CAPEX), maintenance and operational costs (OPEX), the discount factor on the capital and the location of the plant, which affects the production due to the environmental factors.

5.1.1.1. LCOE for PV SYSTEMS

As an initial step for the consideration of LCOE calculation, the capital investment costs can be taken into account by dividing them into elements. Among the RES, PV systems are one of the most important contributors on the energy mix and reaching the competitiveness from PV technologies is a current topic in Europe.

Regarding a PV system capital investment, the following elements have significance in the analysis of the cost reductions:

- PV modules;
- inverter;
- structural components (the more efficient the system developed is, the fewer structural components are required);
- cost of installation.

The most crucial cost share, among the stated elements, is the cost for PV modules (around 60% of total investment). Additionally to the capital costs, to assess the generation costs as a whole, the costs made over the entire lifetime of the PV system have also to be taken into account as follows:

- OPEX;
- cost of another inverter installation (because of having a shorter lifetime for an inverter during the lifetime of the whole system);
- land cost (when the system is large and ground mounted);
- cost of recycling (after the end of the lifetime).

These costs, during the lifetime of the plant, are discounted in the present value by a certain discount rate which changes according to the market segment and the country that the plant belongs to. The discount rate is determined in function of the financial conditions on that specific country and the risk of investments. For example, for Germany, Italy and Spain for the residential market segment they are as 4.4 %, 5.5 % and 6.1 %.[132]

Regarding the cost reductions on the system elements, there is a concept called “learning factor”, which indicates the trend of decrease in the price and the related features. The learning factor is found according to the assumptions made through the past trend of the prices and the projections on the future. For instance, based on the report by EPIA, the initial learning factor for PV modules has been assumed as 20 %, which means 20 percent of decrease in the price whenever the cumulative amount of PV modules sold are doubled (the concept is similar to the “economy of scale”). The graph given below demonstrates the trend of the PV module prices in Europe and it can be observed that the average price of 1.2 €/W in July 2011 was 70 % lower than the price in 2000.[133]

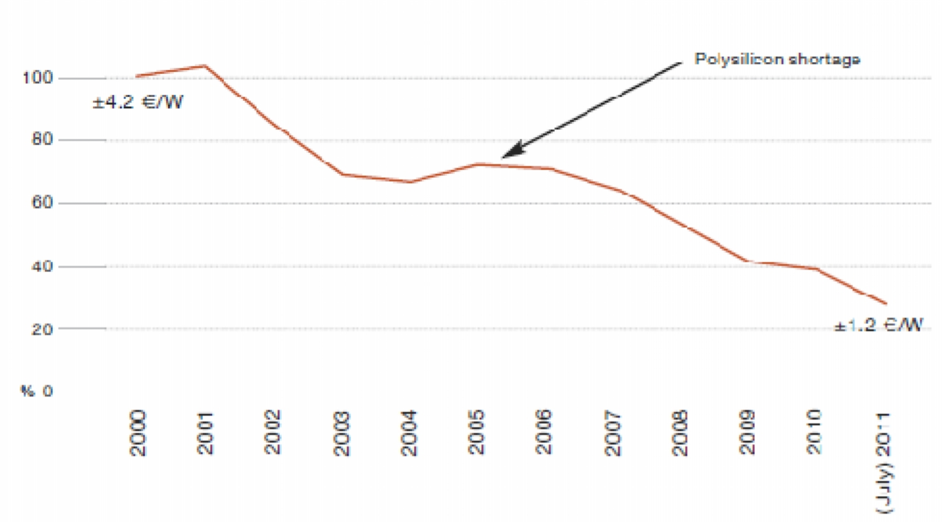


Figure 75 - The average PV module price in Europe from 2000 to 2011[133]

There exist unexpected variables which can affect negatively the ongoing trend, such as the polysilicon shortage shown in the figure. That unexpected shortage caused the PV module prices to increase for a one-year period instead of following the decrease.

With regards to the inverter price, the learning factor assumption is done according to price reductions in the PV industry since 1990s and is assumed as 20 % for small-scale inverters and 10 % for large ones.

Taking all the effects and variables into account, the generation costs are also depending on the market maturity of the country where the calculation is done. Among all the prices, Germany presents the lowest ones: They have the most mature market. Apart from the lack of maturity, there are other factors to explain the price differences among the countries, such as political choices that only support the most expensive PV systems, administrative barriers and connection request procedures, which make the integration harder. All these could have an effect on price level, and prevent the trend of decrease in the prices.

About the LCOE range in the European countries and the projections through the 2020, the following figure can be helpful to understand the idea of price variances and the trend of the

[132] EPIA, “Solar Photovoltaics Competing in the Energy Sector – On the road to competitiveness”, September 2011.

decrease. According to the graph, average European Photovoltaics LCOE were 0.239 €/kWh in 2010 and 0.203 €/kWh in 2011.

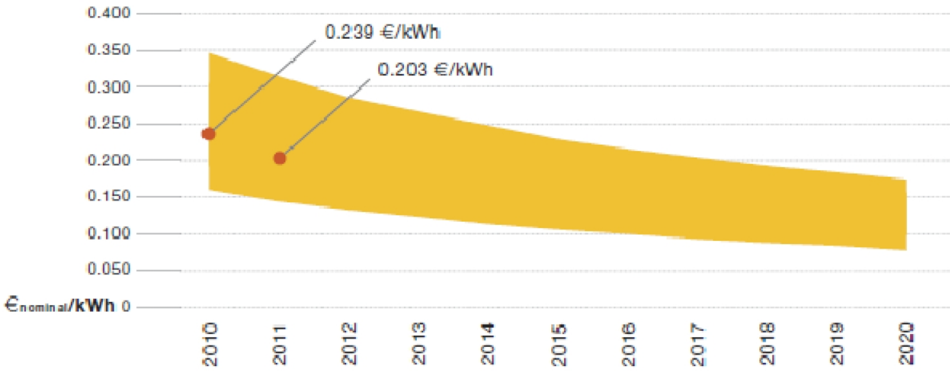


Figure 76 - European PV LCOE price differences and projection through 2020[133]

This expected decline in generation costs is the same for all the market segments and can be observed below categorized as residential, commercial, industrial and utility scale.

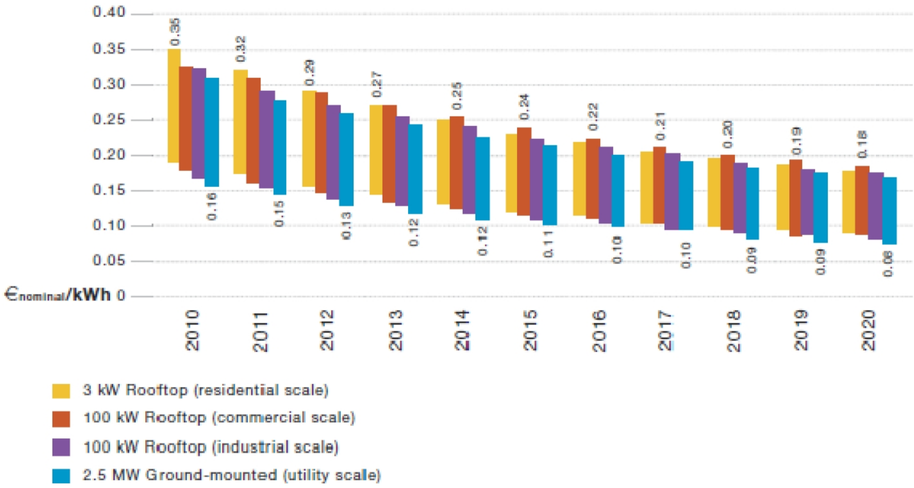


Figure 77 - European PV LCOE price differences specified for the market segments[133]

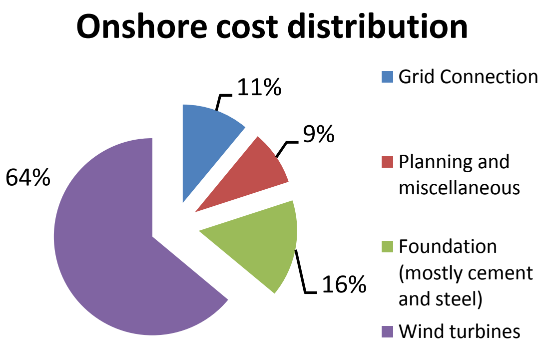
When the global market of PV is analyzed, it is observed that 80 % of this market is located in Europe. From the world PV production, the 65% of the PV modules are produced in China and the main export destination of this production is EU, accounting for the 80 % of their sales. This fact puts emphasis on the importance that the international trade dynamics have on the price of PV systems and the relevant reductions. Therefore, the fluctuations of the US Dollar and the Chinese Renminbi against the Euro have an obvious effect on the PV system prices in EU due to the improvements on this specific subject in China and US. Recently negotiations have taken place between the German and Chinese governments in order to reach an agreement, with the aim of not jeopardizing both interests after the situation had reached a point of possible legal intervention from the EU against a dumping practice accusation to the Chinese PV producers in the local market[133]. However, on 6th of September 2012, the EC has launched an anti-dumping investigation into solar panels and its components imports (cells and wafers as example) originated in China, with the aim of determining if there has been

[133] Qualenergia.it, "*Dalla Merkel acqua sul fuoco per la guerra del fotovoltaico".* August, 31st 2012.
Link: *http://www.qualenergia.it/articoli/20120831-dalla-merkel-acqua-sul-fuoco-per-la-guerra-del-fotovoltaico*

dumping practice from an exporting market into the EU that has produced material injury to the local industry union[134].

5.1.1.2. LCOE for WIND TURBINES

Similar to the element categorization done for PV, the same methodology for generation price assessment can be also done for wind turbines. Among the cost components of a wind turbine, the biggest share is formed by CAPEX. This situation of having a significant amount of capital investment occurs as being a renewable source like all the other RES. However, after the commissioning, there is no fuel price risk, which occurs for the conventional producers due to the fluctuations on the fuel price. Although, there are some significant differences between the onshore and offshore wind installations, regarding the operation or the installation, in the end, having a dominant share of capital cost in the total costs is the same feature that both of them have. This CAPEX is formed by some specific subcategories that can be seen in the following pie charts as distributed:



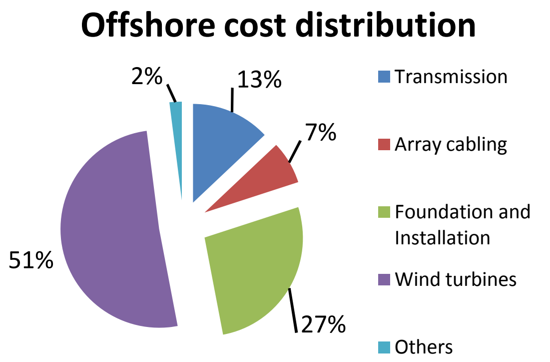


Figure 78 - Capital cost components for typical onshore and offshore wind installations[135]

Parallel to the same method used for PV systems, the capital investment cost for wind turbines can be categorized into 4 elements such as: the turbine cost (blades, tower and transformer); civil works (construction costs); grid connection costs; and other capital costs (the construction of building, control systems, project management etc.). Hence, these key component costs have to be reduced in order to achieve significant reductions in the LCOE of wind. According to the current case, the growth in the average size of onshore turbines leads a reduction on the LCOE of the wind by having larger blades and hub heights. The reason lies under the fact that the energy yield of a turbine depends on the swept area of the rotors and wind speed, which is higher at higher altitudes.

The key cost reduction areas for wind turbines as listed below[136]:

- ***Turbine Blades:*** the blades of the wind turbine are the most significant component that requires research and development in terms of performance enhancement. The material used (mostly carbon fiber) and the design process in improving the efficiency, make this part of the system to become approximately one-fourth of the turbine costs. The expected cost reductions until 2020 for turbine blades are possible as 10 to 20 percent.

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[134] European Commission, Memo/12/647. Brussels, September 6th, 2012.
[135] Blanco, M.I. (2009), The economics of wind energy, Renewable and Sustainable Energy Reviews,Elsevier, Vol. 13, Issues 6-7, pp. 1372–1382.
[136] Douglas-Westwood, "Offshore Wind Assessment in Norway", Douglas-Westwood, The Research Council of Norway, Oslo, 2010.

- ***Tower:*** mostly constructed by steel, which makes the costs depend on the steel prices. However, the expansion of the specific market for this area and the integration of lightweight materials increased the competition leading an expected cost reduction in the tower prices by 15 to 20 percent by 2030.
- ***Gearbox:*** although this part of the system does not have the same amount of effect as the two previous ones, there are studies for research and development for gearboxes to improve reliability and reduce costs. The expected cost reductions could reach 15 percent by 2020.

All the cost components are more or less the same for onshore and offshore wind turbine installations, but currently the capital cost of offshore wind is around two times higher than onshore wind (due to the higher costs in logistics and lifting operations during the EPC, and higher maintenance costs). Thus, in order to obtain more competitive offshore wind, it is needed to encourage reductions on the capital and O&M costs for offshore wind technology. Through the current trend, the design improvements and learning effects gained by the increase of installed capacity of offshore wind are going to lead significant cost reductions in the long term.

An analysis is done on an installed capacity of 40 MW located both onshore and offshore. By the contribution of all costs (and many assumptions on the financial factors), the LCOE (€/MWh) is calculated for 2010, 2020 and 2030. The reduction on LCOE and the projections on 2020 and 2030 can be seen below in the figure 79.

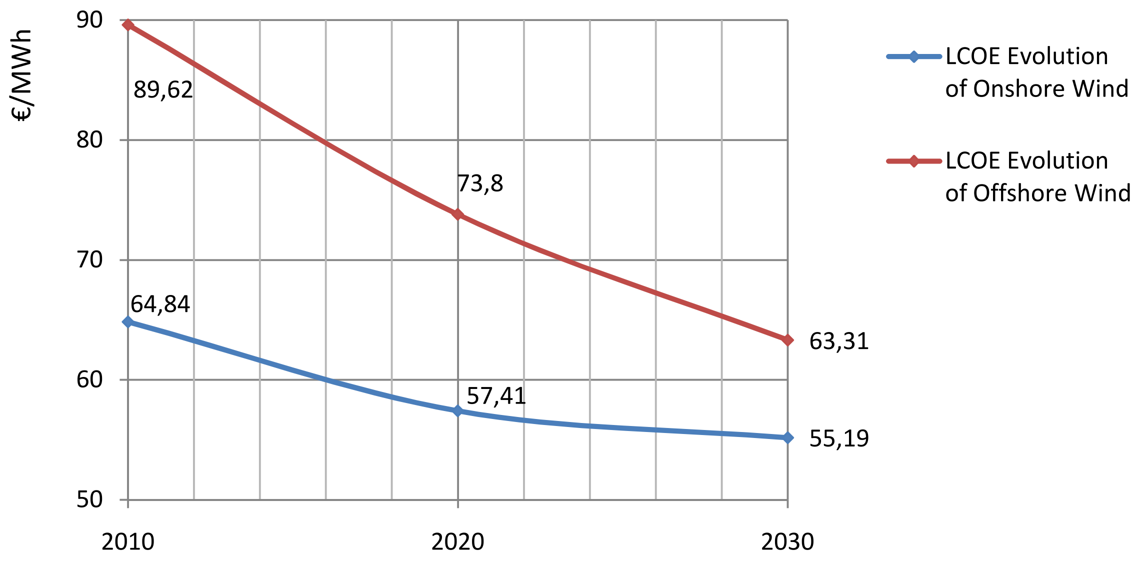


Figure 79 - Comparison of LCOE Evolution for onshore and offshore wind (2010-2030)[137]

Due to the assumptions taken for the analysis and its broad range on all Europe, the specific data for each country can show differences from the figure sketched above. For instance, in Italy the trend of LCOE of onshore wind installations, from 2005 to 2012, is depicted as follows.

[137]For the data calculation, the online tool of EWEA is used. In this tool, the LCOE projections are calculated for 2020 and 2030. http://www.ewea.org/index.php?id=201

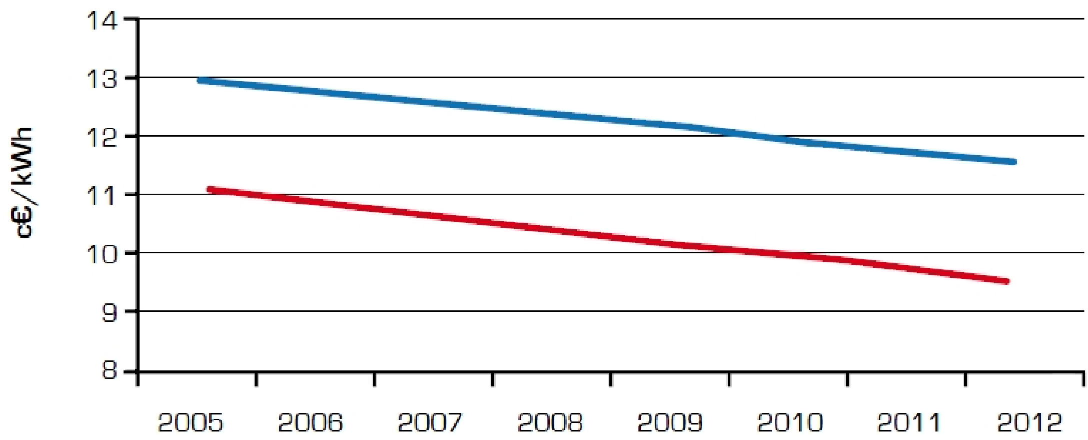


Figure 80 - Trend of LCOE of Wind Energy in Italy from 2005 to 2012

In the figure, the blue and red lines differ from each other according to their production rates: while the red line stands for 1700 MWh/MW, the blue line demonstrates 1400 MWh/MW.

5.1.2.Grid Parity Concept

The approaching of the competitiveness of the renewable energy technologies with the one of the conventional sources is a fact. During the last years, due to this reason, the incentive schemes have been gradually phasing out as support strategies for RES generation technologies to be one important role-player in the generation mix of all the EU States Members.

As this gap is getting *narrower*, the concept of "*grid parity*" is introduced as the *moment* in which that competitiveness is reached. "Parity" refers to the achievement of the equality between the present value of the long-term earnings produced by the generation of a RES technology with the long-term cost of acquiring the same energy from the grid. Therefore, from that moment and on, that technology would become self-sustainable, meaning that the investment would be feasible even without the support of an incentive scheme.

In order to reach that analysis, some variables have to be considered as the main influencing factors towards the grid parity. For one side the purpose will be to reduce the costs associated to investment (affecting LCOE, as explained before) and on the other side, to increase the earnings. Depending on these variables, each technology, for each segment of market, is going to be characterized by a specific grid parity value. These variables are listed below.

1. *EPC investment cost of the RES power plant according to segment of market:* each technology has an initial investment cost which includes, among the main categories, technology components, manpower, project management and administrative costs. These categories are going to vary according to the economy of scale that the power plant size will reflect in each segment of market: residential, commercial or industrial segments.

2. *Operational cost:* O&M costs to be expensed during the life of the project, which are more difficult to predict due to market variations.

3. *Geographical position of the installation:* this will be an important factor, but considered a constant for the assigned location of the power plant. With this factor, the sun irradiation

or the wind flow for each geographical region will determine the level of power generated and capacity factor.

4. *Price of Electricity*: although the main component of the market electricity price is the fuel used for conventional generation, being subject of high volatility, it will be considered with a constant evolution for the sake of simplicity, under the assumptions which are going to be considered later.

From the previous variables, the most globally affecting the analysis of grid parity are the first one in a first grade, and the second one, in a second grade. Both decreasing trends, as they were explained in the previous section, are going to be considered as one of the two terms of the grid parity equation from which the solution will be determined. For the purpose of the grid parity analysis, it has to be understood that the aims of the efforts in technology development and cost reductions due to R&D are going to produce a reduction in the competitiveness gap and a sooner approach to the grid parity, and this is the reason why these variables are the most important.

As the geographical characteristics of the sources are inherent to the power plant location, it can be said that grid parity will be favored in the southern regions of Europe for PV (increasing sun average irradiation) and in strong wind areas, determining both the competitiveness advantages of characteristics of each country.

With regards to the price of electricity, the second term of the grid parity equation, many assumptions have to be made in order to trace the trend. First of all, a full incentives phase out scenario is considered. Second, the segment of market has to be distinguished, in order to define the amount of self consumption, which is going to be translated into savings, and the earnings incoming from the selling of the excess of production.

For the target of this work, in order to define the grid parity of the PV in EU Member States, the methodology employed in the EPIA study published in September 2011[138] will be taken into consideration as a source of the analysis.

In order to observe the price trend, projected to 25 year (the lifetime of the project), the PV sector was divided into three segments:

- residential customers with system of around 3 kW;
- commercial customers with systems of around 100 kW;
- industrial customers with systems of around 500 kW.

For each of the detailed segments, shares of the amounts of savings and earnings from selling the excess of production were assumed as following.

[138]EPIA, “Solar Photovoltaics Competing in the energy sector”. September 2011.

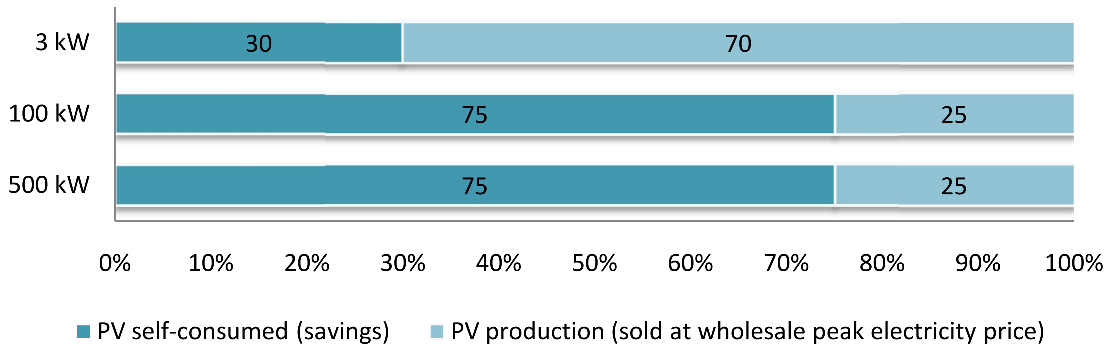


Figure 81 - Self-consumption and energy sold shares assumed in the study (Source: EPIA)

For residential facilities, 30% share is kept for self-consumption and 70% is injected on the network; for commercial (100 kW) and industrial applications (500 kW), a higher share is assumed for self-consumption (75%), as PV is producing during weekdays in correlation with the peak of consumption.

While the previous shares were assumed as the amount of electricity self-consumed and sold to the market, now the price of that electricity has to be determined. The projections were assumed according to the average price of electricity on the wholesale market while the PVs were producing (from 8 am to 8 pm during weekdays, not considering weekend days).

Table 34 - Wholesale market peak electricity prices assumed for target countries (Source: EPIA)

	€/MWh	2007	2008	2009	2010
Germany	Average	56	88	51	57
	Maximum				180
Italy	Average	103	113	82	76
	Maximum				175
Spain	Average	46	71	40	42
	Maximum				91

The electricity prices growth trend were assumed for both the retail price (in order to estimate total savings due to self-consumptions) and wholesale peak electricity prices for the estimation of the income thanks to the electricity sold. These assumptions, in the report taken as reference, were made under historical data and therefore the estimations are rather conservative. The retail market prices for consumers are estimated to grow from 2% to 5.4% yearly depending on the country.

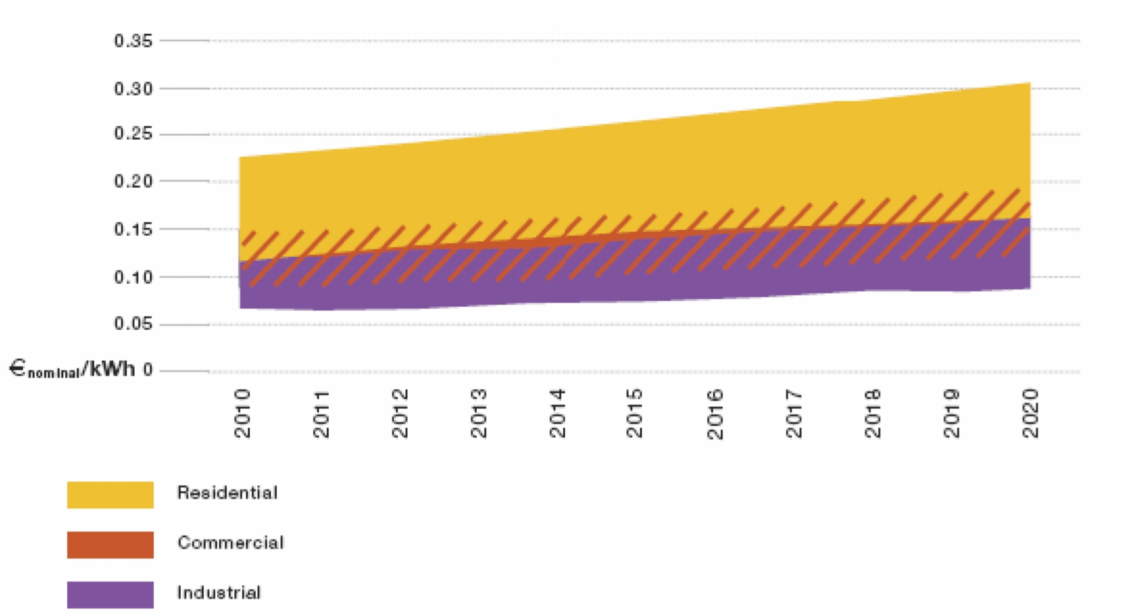


Figure 82 - Estimated retail price growth projections for consumers in EU

For the case the wholesale market price at which the excess of PV electricity would be sold, the expected growth is in the range of 3.8% and 6.7% yearly, depending on the country.

Table 35 - Assumed annual growth rates for the wholesale electricity market price for target countries

	Forecast Annual Growth Rate 2011-2020
Germany	6.2%
Italy	3.8%
Spain	6.6%

After calculation the LCOE which will be decreasing for the next years according to what was shown before, and crossing these estimations with the PV revenues given by the price projections for each market in the EU, which are expected to grow, the grid parity intersection can be found in the overlapping area between both trends. In the following figures, for each segment of market, the intersection area can be observed between the LCOE and the revenues, which are going to be bounding the possible grid parity point for different geographical positions in each country dynamic.

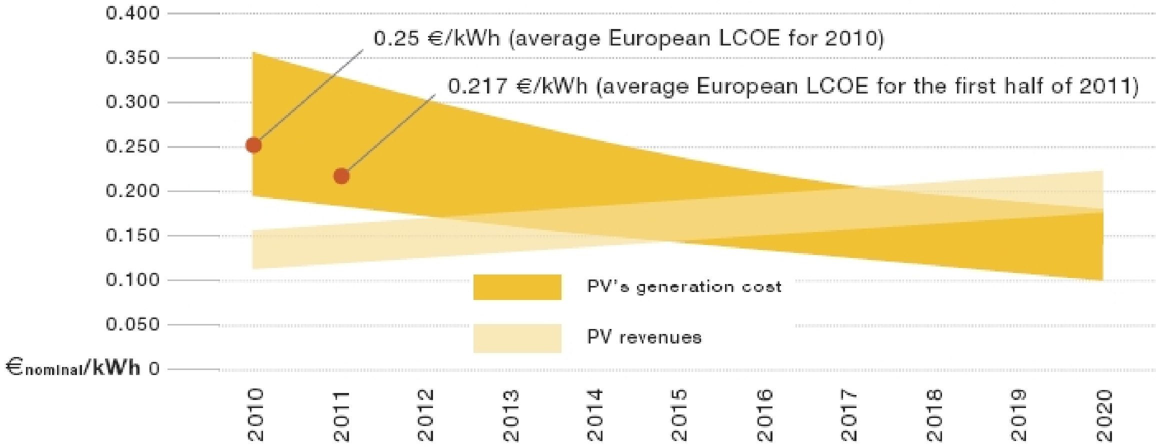


Figure 83 - Grid parity for residential PV system in EU (Source: EPIA)

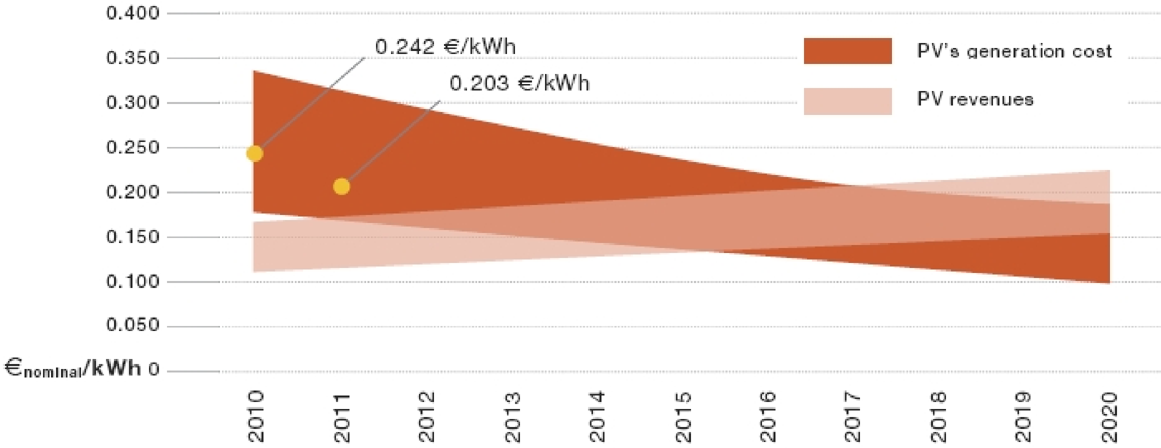


Figure 84 - Grid parity for commercial PV system in EU (Source: EPIA)

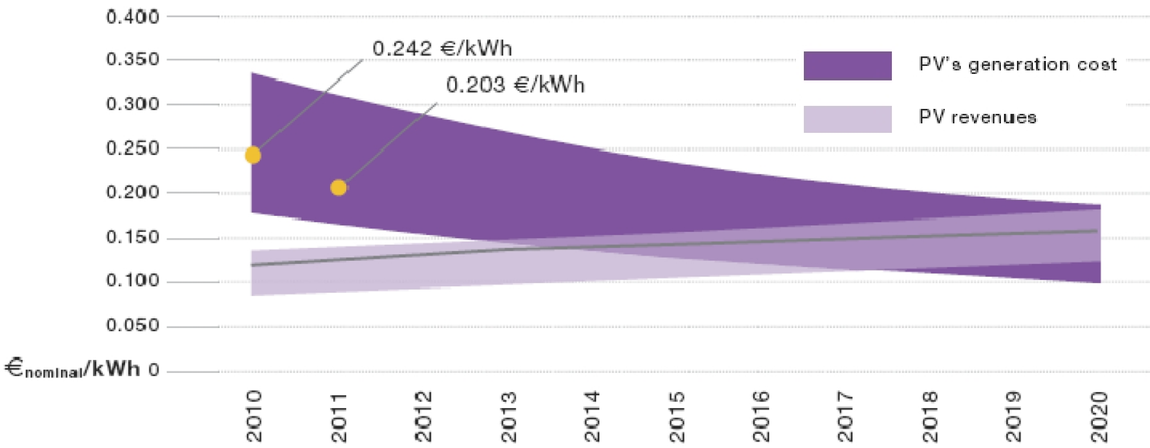


Figure 85 - Grid parity for industrial PV system in EU (Source: EPIA)

As explained before, the competitiveness moment will not happen in all EU countries at the same time because it will be function not only of the different irradiation factors (increasing from north to south), but at the same time of the market segments and electricity prices trends. Considering these three last important factors, the EPIA report stated that Italy would be the first country in reaching competitiveness in the commercial segment in 2013, spreading the achievement across the continent in the oncoming years by 2020. This last conclusion was made considering the higher irradiation factor present in the southern regions of Italy and the higher prices of the electricity compared both to Germany and Spain.

Table 36 - Grid parity moment of achievement per country and market segment (Source: EPIA)

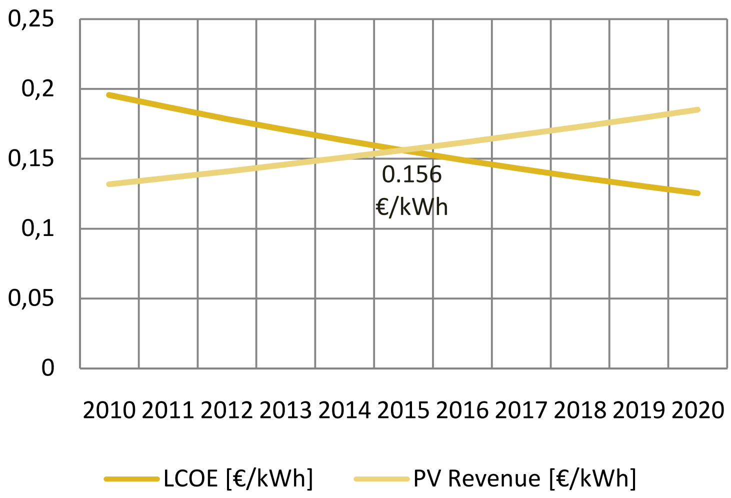
	Residential	Commercial	Industrial
Italy	2015	**2013**	2014
Germany	2017	2017	2017
Spain	2017	2014	2017

From the competitiveness estimations, we can conclude that Italy will be the first country in reaching grid parity in all market segments, due mainly to higher irradiation factors and electricity prices, and following Spain, although the electricity prices are lower than in Germany, the higher irradiation factors are relevant for this estimations. In summary, according to the reference report, almost all EU markets would achieve grid parity in most of the segments before the year 2020.

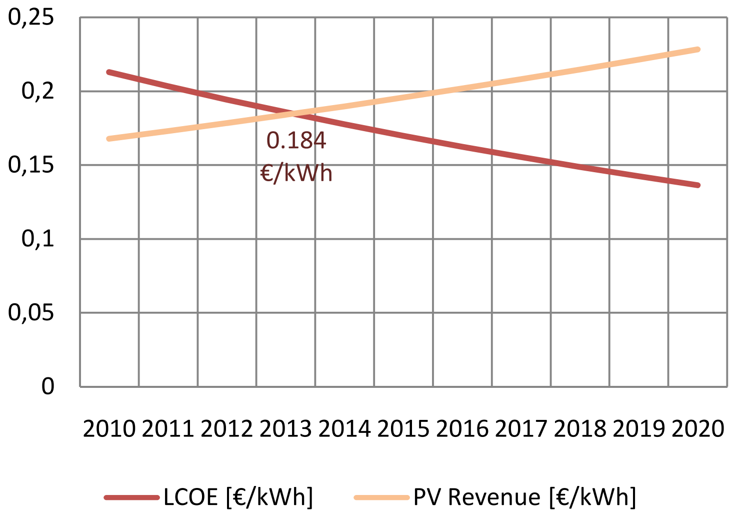
In the recently issued Solar Energy Report 2012[139], from the Energy and Strategy Group, it is concluded that, after a similar study of PV competitiveness in the different segments of market along the north-south territory extension of Italy, the PV market is not far away from achieving the *grid parity* after a full phasing out of FIT incentives (indeed, for some applications, in the south of Italy it is considered to be achieved). At the same time, it is shown that the IRR (internal rate of return) of the EPC projects of smaller sizes (3 kW, 200 kW) located in the south of Italy are considered relevant for the evaluation carried out fully without incentives, under the net-metering ("Scambio sul posto") selling regime, while higher capacity plants (400 kW and 1MW) are farther from reaching competitiveness.

Taken the former assumptions made in the original referenced study from EPIA, in this thesis work the grid parity for each target country is analyzed according to the relevant market segments stated as residential, commercial and industrial. The following figures, where the results for the evaluation of the LCOE and PV revenues for each sector in Italy, Germany and Spain are schematized, demonstrate the moment in which each of the analyzed projections are crossed, the moment in which the competitiveness of the technology is met.

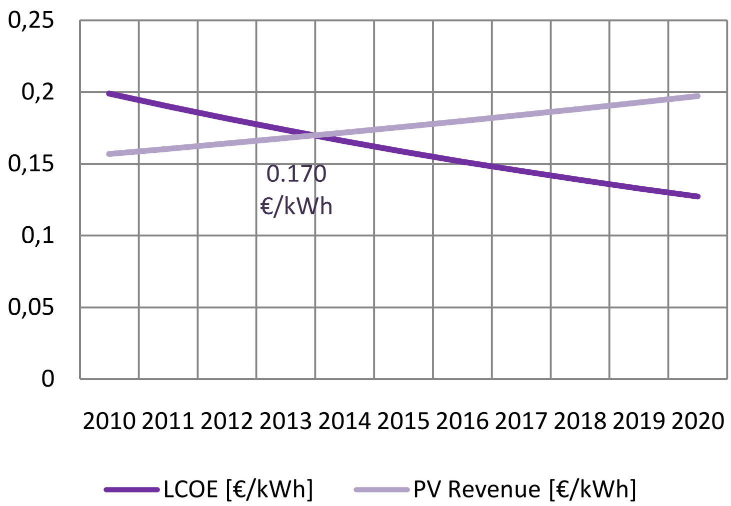
[139]Politecnico di Milano, Energy and Strategy Group, "Solar Energy Report 2012". April, 2012.



ASSUMPTIONS *Residential* 3 kW - Italy	
Installed Capacity (kW)	3
Capacity Factor (%)	19
CAPEX (€/kW)	3500
Cost Reduction Rate (%)	5
OPEX (€/kWh)	0.02
Discount Factor (%)	5.5
Lifetime (year)	20
Retail Electricity Price Annual Growth Rate (%)	3
Wholesale Electricity Price Annual Growth Rate (%)	3.8
Self-consumption (%)	30
Electricity sold (%)	70

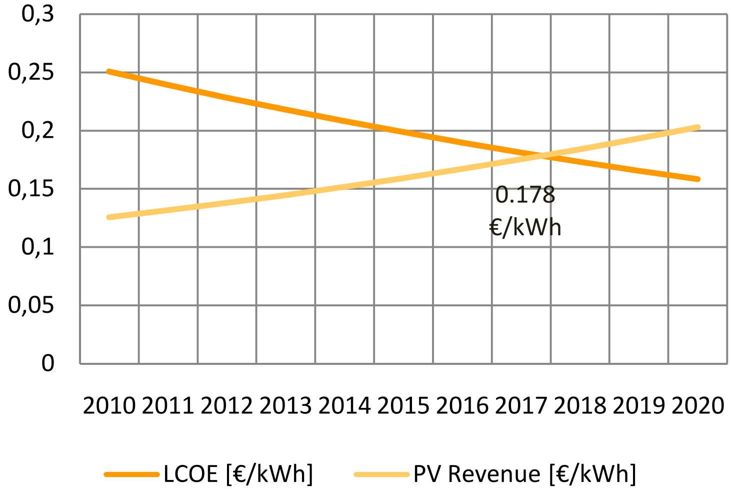


ASSUMPTIONS *Commercial* 100 kW - Italy	
Installed Capacity (kW)	100
Capacity Factor (%)	19
CAPEX (€/kW)	3200
Cost Reduction Rate (%)	5
OPEX (€/kWh)	0.022
Discount Factor (%)	7.6
Lifetime (year)	20
Retail Electricity Price Annual Growth Rate (%)	3
Wholesale Electricity Price Annual Growth Rate (%)	3.8
Self-consumption (%)	75
Electricity sold (%)	25

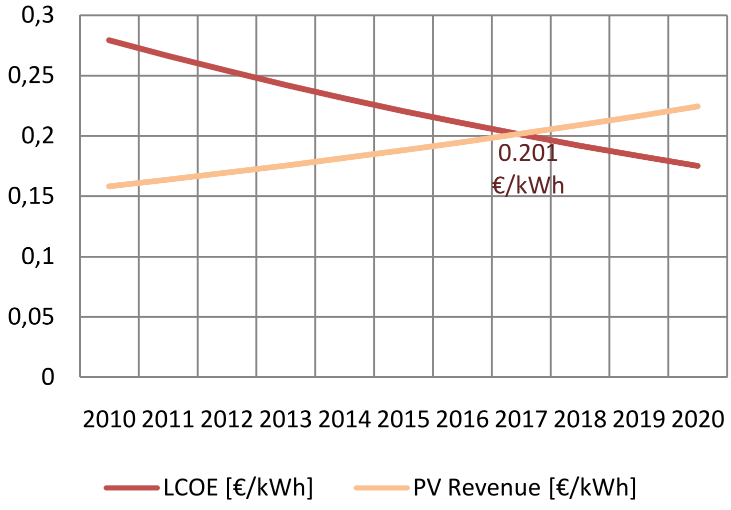


ASSUMPTIONS *Industrial* 500 kW - Italy	
Installed Capacity (kW)	500
Capacity Factor (%)	19
CAPEX (€/kW)	3000
Cost Reduction Rate (%)	5
OPEX (€/kWh)	0.02
Discount Factor (%)	7.6
Lifetime (year)	20
Retail Electricity Price Annual Growth Rate (%)	2
Wholesale Electricity Price Annual Growth Rate (%)	3.8
Self-consumption (%)	75
Electricity sold (%)	25

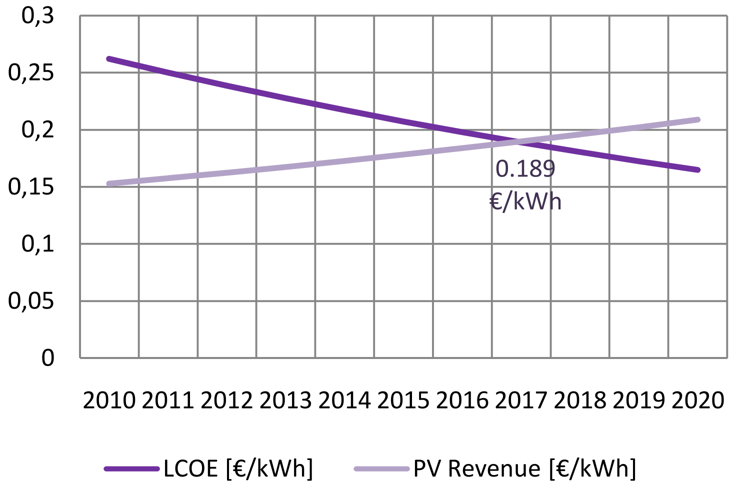
Figure 86 - Grid parity achievement in Italy PV market



ASSUMPTIONS *Residential* 3 kW - Germany	
Installed Capacity (kW)	3
Capacity Factor (%)	12
CAPEX (€/kW)	3200
Cost Reduction Rate (%)	5
OPEX (€/kWh)	0.02
Discount Factor (%)	4.4
Lifetime (year)	20
Retail Electricity Price Annual Growth Rate (%)	3
Wholesale Electricity Price Annual Growth Rate (%)	6.2
Self-consumption (%)	30
Electricity sold (%)	70

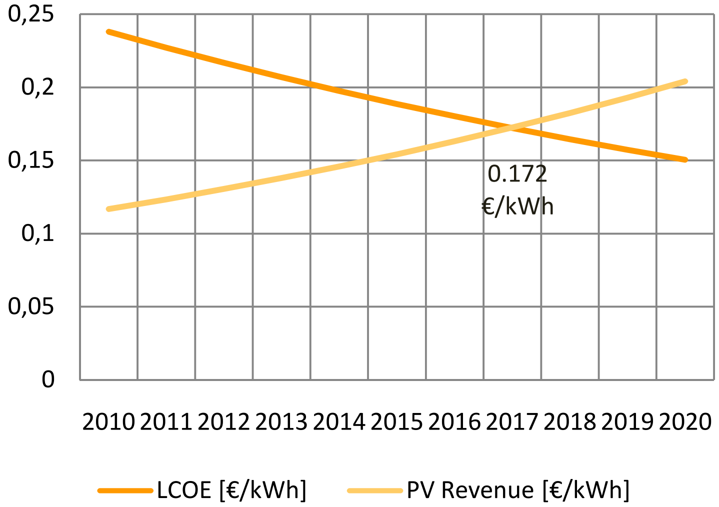


ASSUMPTIONS *Commercial* 100 kW- Germany	
Installed Capacity (kW)	100
Capacity Factor (%)	12
CAPEX (€/kW)	3000
Cost Reduction Rate (%)	5
OPEX (€/kWh)	0.02
Discount Factor (%)	6.5
Lifetime (year)	20
Retail Electricity Price Annual Growth Rate (%)	3
Wholesale Electricity Price Annual Growth Rate (%)	6.2
Self-consumption (%)	75
Electricity sold (%)	25



ASSUMPTIONS *Industrial* 500 kW - Germany	
Installed Capacity (kW)	500
Capacity Factor (%)	12
CAPEX (€/kW)	2800
Cost Reduction Rate (%)	5
OPEX (€/kWh)	0.02
Discount Factor (%)	6.5
Lifetime (year)	20
Retail Electricity Price Annual Growth Rate (%)	2.5
Wholesale Electricity Price Annual Growth Rate (%)	6.2
Self-consumption (%)	75
Electricity sold (%)	25

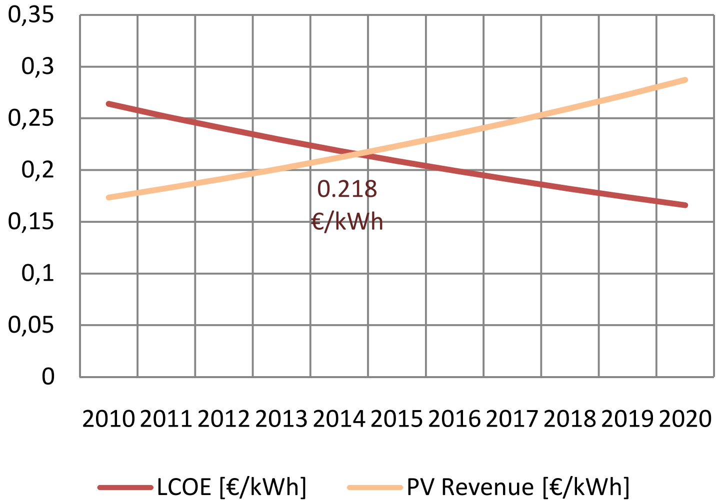
Figure 87 - Grid parity achievement in Germany PV market



ASSUMPTIONS

Residential 3 kW - Spain

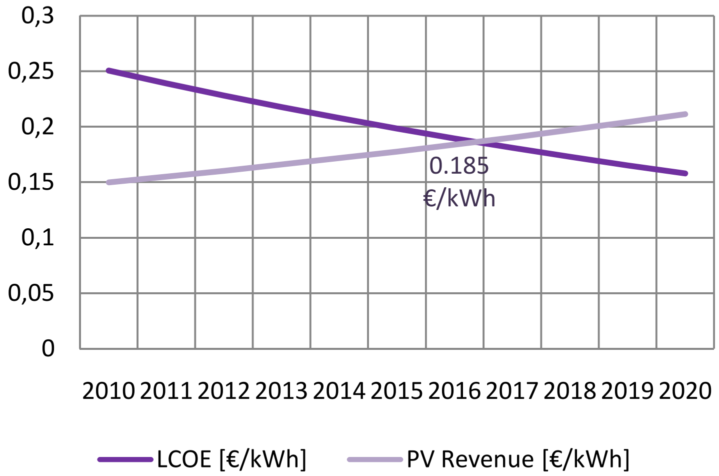
Installed Capacity (kW)	3
Capacity Factor (%)	17.5
CAPEX (€/kW)	3800
Cost Reduction Rate (%)	5
OPEX (€/kWh)	0.02
Discount Factor (%)	6.1
Lifetime (year)	20
Retail Electricity Price Annual Growth Rate (%)	5
Wholesale Electricity Price Annual Growth Rate (%)	6.6
Self-consumption (%)	30
Electricity sold (%)	70



ASSUMPTIONS

Commercial 100 kW- Spain

Installed Capacity (kW)	100
Capacity Factor (%)	17.5
CAPEX (€/kW)	3600
Cost Reduction Rate (%)	5
OPEX (€/kWh)	0.02
Discount Factor (%)	8.2
Lifetime (year)	20
Retail Electricity Price Annual Growth Rate (%)	5
Wholesale Electricity Price Annual Growth Rate (%)	6.6
Self-consumption (%)	75
Electricity sold (%)	25



ASSUMPTIONS

Industrial 500 kW - Spain

Installed Capacity (kW)	500
Capacity Factor (%)	17.5
CAPEX (€/kW)	3400
Cost Reduction Rate (%)	5
OPEX (€/kWh)	0.02
Discount Factor (%)	8.2
Lifetime (year)	20
Retail Electricity Price Annual Growth Rate (%)	3
Wholesale Electricity Price Annual Growth Rate (%)	6.6
Self-consumption (%)	75
Electricity sold (%)	25

Figure 88 - Grid parity achievement in Spain PV market

If all the graphs are taken into account, a timeline on the way to *grid parity* can be drafted. According to the findings from the intersections of the LCOE calculations and the price trends for the specified countries, the following timeline would be the expected schedule for reaching the grid parity.

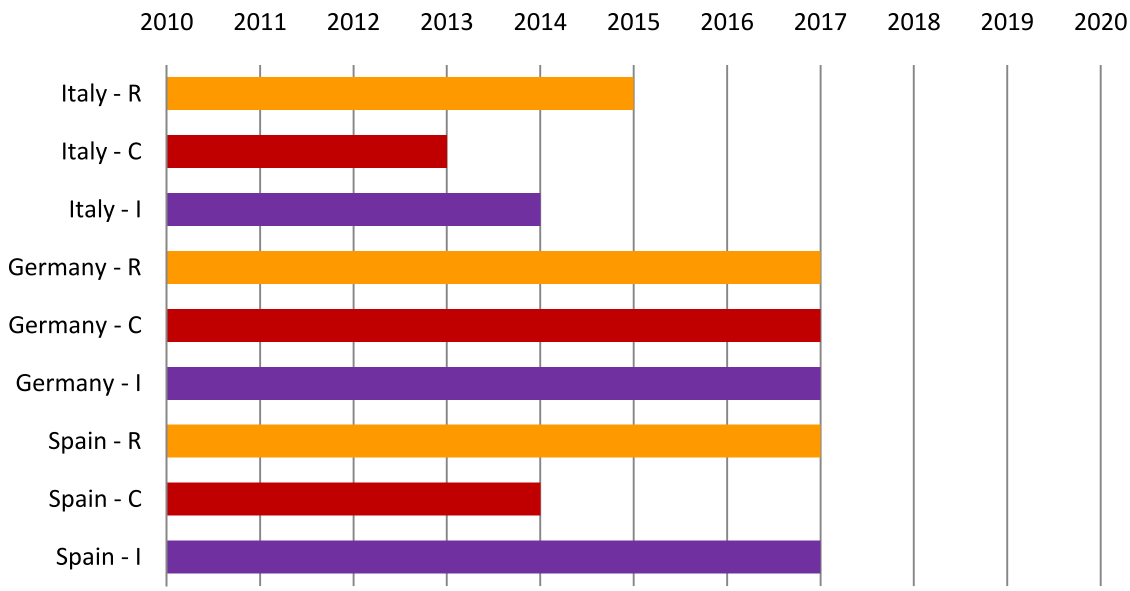


Figure 89 - Timeline for the grid parity categorized into the market segments in Italy, Germany and Spain

5.2. IDENTIFYING THE BARRIERS and RECOMMENDATIONS

In the previous chapters, the support schemes that the target countries have deployed, and the main technical impacts, due to the unbalanced growth of RES, are explained.

In this chapter, the fundamentals of the RES business *leitmotiv*, have been treated by understanding that under the present technology development and market conditions, these RES could not be integrated without the support of incentive schemes. The last ones will help until the competitiveness of each technology is reached, in order to allow the later self-sustainability of the business.

Although the present situation of the EU financial crisis can be considered as the main barrier to overcome by the governments, in order to promote the future development, social and economical integration of the RES has to be achieved. Apart from this situation, many other barriers should be overcome in each of the countries, allowing an internal higher development the sector.

On the way through the renewable energy deployment strategy, in order to encourage sustainable development, all the environmental, social and economic effects are taken into consideration. All the potential barriers are needed to be overcome and the opportunities for renewable energy deployment should be exploited. The potential barriers can be described under three subcategories: socio-cultural, information and awareness and economic barriers, all of which pose a threat to the renewable energy deployment in the sustainable development concept.

Regarding the socio-cultural barriers, despite the positive public opinion about the renewable sources, that is known as environmentally friendly, and something necessary for brighter future, in many examples one can observe an increasing public resistance to new large power plants. This situation can be seen as the typical rejection of "not in my backyard" type[140]. The socio-cultural barriers, in other words public concerns, against the RES, are related mostly to societal and personal values. In order to overcome these barriers and increase the acceptance of renewable technologies in the public, more attention should be given on the socio-cultural concerns. For instance, one of the most common effects on the rise of public concern is about the changing landscape when the installations are constructed. European countries suffer from this kind of aesthetics originated oppositions due to the increasing wind power plants on the sites. Besides, another example can be given as the people who are left with the necessity to move from their land due to large hydro power plant constructions. According to the World Commission on Dams (2000), 40 to 80 million people suffered from this resettlement issue and have been displaced. In the light of this issue, the social problem arises due to the possibly upcoming insufficient economic compensation for the affected populations. From the public awareness and acceptance point of view, paying attention to this kind of results and trying to prevent them before happening is important in the need to rapidly increase of renewable energy deployment. In reaching the large scale implementations of RES, the public support and public understanding have a big incidence in the whole pie.

Awareness and information about the renewable energy systems and options among the investors and customers are crucial determinants for the improvement of the area and for gaining a strong place in the energy market. However, barriers in this field do not have a significant effect on large investments, which are done by international and experienced equities; on the contrary, they slow down the development of small and medium enterprises which have an important contribution to economic growth.

Regarding the market failures and economic barriers, grid size and technologies are key determinants of the competitiveness of renewables against conventional sources. The importance of location on the grid, and the specific technology, give the possibility to investors to start the installation or choose another alternative option, due to corresponding higher costs of RES. Besides the costs of the technology, the grid connection costs and their administrative procedures become important burdens for RES integration in most of the countries. In the purpose of overcoming these barriers, policy and entrepreneurial support systems are required along with renewable energy deployment, in order to encourage economic growth and sustainable development.

The most common barriers that the majority of the European countries suffer from are: permitting procedures, grid connection rules and technical standards, grid connection procedures and grid capacity issues. Among all, the duration of the procedures, high amount of money paid for the connection fees and the necessities for excessive labor slow down the improvements on the RES integration process. Some of the crucial barriers and the proposed solutions that can be applied on them are given under the title of recommendations for the three target countries.

[140] Devine-Wright, "Beyond Nimbyism: Towards an integrated framework for understanding public perceptions of wind energy", 2005, pp.125-139.

5.2.1.Italy

In the last two years, Italy has witnessed an outstanding development of RES technologies, especially for the PV technology sector, thanks to the favorable support mechanisms implemented with the Conto Energia. However, in the last version of this Ministerial Decree issued during this year (the Vth version, also with the MD of 6th July/12 for rest of RES technologies but PV), new administrative requirements were introduced for medium and big power plants, enlarging and complicating the administrative procedures, instead of shortening and streamlining them and allowing a reduction of the financial costs of the mechanism.

The following table 37 lists the barriers that the Italian system is subject to, in the administrative procedure, grid connection and operation field and future development, towards the integration of new RES facilities. Each of these barriers is suggested to be overcome by the recommendations listed aside of each barrier.

Table 37 - List of barriers and recommendations for the Italian RES support system (Source: EPIA[141] / ECLAREON[142])

CATEGORY	BARRIERS	RECOMMENDATIONS
Administration procedures	Complex and long administrative procedures for medium and big power plants operators (>12 kW for PV – "V Conto Energia" and 5 MW for other RES – DM 6th July/12).	• Elimination of the booking procedure by replacing it for land planning assignation (based on technical studies) and standardization of the registration procedure for all technologies and sizes.
	Non transparent and speculative market for authorization procedures.	• Homogenization of the authorization procedure at national/regional level and public communication of all authorization procedure status by one responsible institution.
Connection to the grid	Complexity of connection procedure and fragmentation in responsible bodies.	• Simplification of procedure for different plant sizes and concentration of the connection management in one key player.
	Virtual saturation of the grid.	• Concentration of the registration and booking procedures by one role key player. Introduction of a "milestone" approach as the French model (explained below).
Operation of the grid	Hosting capacity issues causing grid curtailment for wind technologies (5,6% in 2010) in the south and perspective grid curtailment also for PV.	• Supporting producers to develop more complex and confident forecast profiles. • Supporting the installation of storage devices like PSH in the weak areas for demand-response management. • Implementing DCTR in overhead lines.
	Missing expansion of transmission and distribution grid capacity.	• Foster more investment on grid infrastructure and smart grid solutions.

[141] EPIA, "PV Legal, REDUCTION OF BUREAUCRATIC BARRIERS FOR SUCCESSFUL PV DEPLOYMENT IN EUROPE". February 2012.
[142] ECLAREON, Oko Institut e.V., "Integration of electricity from renewables to the electricity grid and to the electricity market – RES-INTEGRATION, Italy Report". December 2011.

	Massive DG islanding risk due to frequency transients tripping IPRs.	• Widening of IPR frequency settings and implementation of Smart Grids "innovative DG Interface Protection with transfer trip" function.
	Lack of accurate forecasting for production due to high system costs.	• Defining an incentive scheme for allowing producers to install higher efficiency technologies.
RES and grid development and future integration	RES and grid unbalanced development due to incompatible authorizing time procedure.	• Prioritize grid development investments for medium and long term planning (new architecture) at the same level of RES integration. • Development of smart grids and implementation of pilot projects.
	Lack of support schemes for grid development and adequacy.	• Deployment of more budget and clear incentives for development of smart grids and network investments.
	High and unexpected budget expenditures for RES supporting schemes.	• Prorating of incentives budget by capacity caps year by year in order to allow the reduction of the LCOE in future and the approaching to *grid parity*, considering it can be reached before 2015 in all the market segments and technologies.

From the listed above, the virtual saturation of the grid connection can be considered as one big barrier in the current Italian scenario. Therefore, the proposed solution would be in line with a "milestone" process where the applicant would go through a step by step authorization procedure in a time frame (first, submitting building permissions; second, certification of financial guarantees and further accreditation of documents) until the future producer is in conditions of booking the capacity. In case of expiration of any of the steps, the producer would have to restart the procedure again. From the authority side, one improvement would be to define and concentrate the registration and booking authorization milestones in only one key player, in order not to delay the process, and streamlining the booking in a shorter time.

Regarding the operation of the grid challenges, as described in detail in *Chapter 4,* Italy is suffering of grid curtailments for both wind and PV sources (MPE/MPF) and a way to overcome these issues would be to support high efficient forecast methods for allowing the availability of dispatching programs for TSO, and therefore, the possibility of managing the grid congestions in an efficient way, reducing its costs of operation. This enhancement would need to be supported by an incentive scheme in order to allow the producers to encourage and implement the installation of the respective technologies. In the same line of these barriers category, as it was explained as well in the closure of *Chapter 4*, the new investments to overcome these grid operation challenges have to be in line with the evolution towards the new *smart grids* concept. In the medium and long term, TERNA is in charge of ensuring the network expansion planning. For that purpose, under the *Legislative Decree 79/99* and *AEEG Resolution 99/08,* the TSO was empowered to expand the grid to allow connection of new plants. And with AEEG resolution 125/10, the same was instrumented in order to allow short term planning for the specific critical areas like the ones with high generation and weak grid infrastructure. Thus, under the previous decrees, TERNA has categorized its grid development planning in two areas: *congestion reduction and net transfer capacity increase* and quality and *safety of the service*.

As far as it is known, TERNA is putting hands into work by developing the transmission system in order to allow the integration of RES specially in the south of Italy, by allocating about 3 billion € from 2010 to 2020, in what it is known as the energy action plan 2011 for the upcoming 10 years (figure 87).

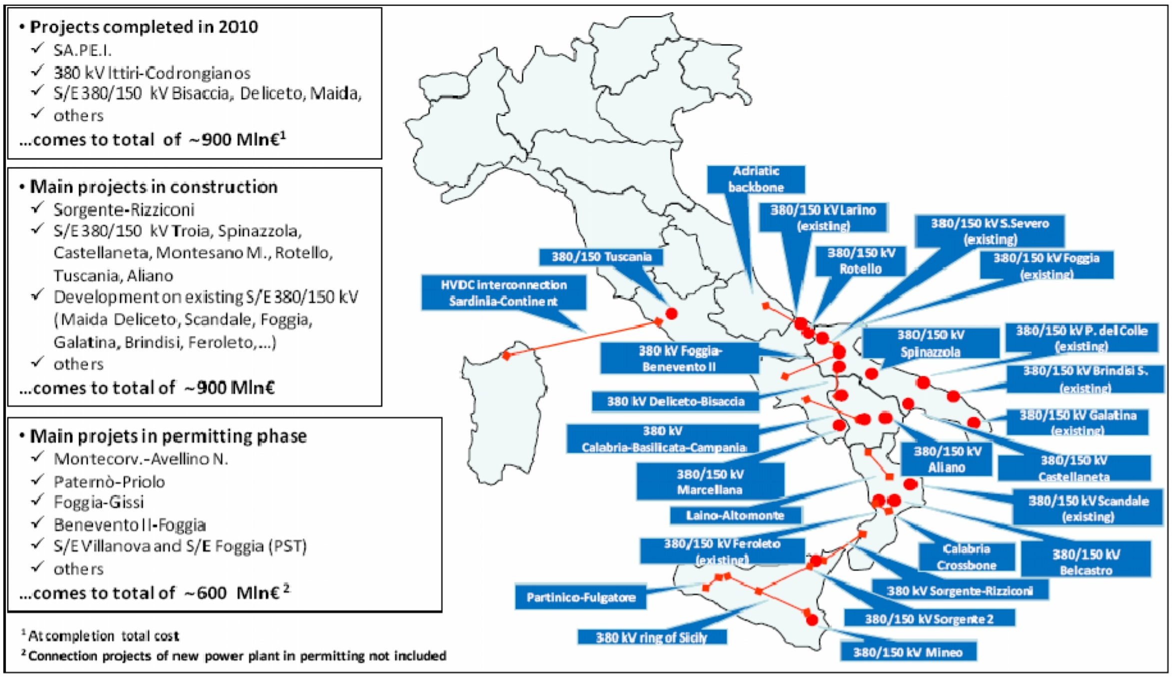


Figure 90 - Italian Transmission Network Development Plan 2011 - Energy Action Plan: 10 years of network investment for RES (Source: Terna 2011).

With regards to the DN interventions, it is a must the prompt action needed of the National Government in order to develop the grid adequacy for the integration of RES, given the high development of PV DG during the present 2012 (almost reached 15 GW of installed capacity). Therefore, it is urgently needed the prioritization of the grid model developments at the same level of importance with which the RES investments are considered if the growth is requested to be balanced and sustainable to the entire system. For this purpose, members of the Ministry of Economic Development and the DSO have agreed a program in order to adequate the grid to the PV development in line with the smart grid implementation in the southern regions of Campania, Puglia, Calabria and Sicily, with the financing support of the AEEG to develop pilot projects and forecasts systems for non-programmable sources.

Lastly, if the high and unexpected budget expenditures for the last RES supporting schemes (which forced the authority to issue the new revision of the Conto Energia when the assigned budget for 2016 was expended in just one year) are considered, a new recommendation can be expressed for this issue. By prorating the incentives budget by capacity caps year by year, the reduction of the technology LCOE in future and the approaching to *grid parity* can be expected (considering it can be reached before 2015) in all the market segments and technologies. Therefore, part of this budget could be efficiently assigned (and not by reassigning more budget in a new revision of the incentives schemes) and other share of the budget could be shifted from RES promotion into grid development, ensuring a balanced and sustainable growth at lower costs.

5.2.2.Germany

As done for Italy, the barriers affecting the RES integration in Germany are listed in the following table in four categories. Some of the barriers were substantially tackled by the new amendment of renewable energy support mechanisms (the EEG 2012) and some of them still have an important place towards the optimum integration.

In addition to the barriers stated, the possible solution options for each one and recommendations to tackle them are given on the table.

Table 38 - List of barriers and recommendations for the German RES support system (Source: EPIA[143] / ECLAREON[144])

CATEGORY	BARRIERS	RECOMMENDATIONS
Administration procedures	Complex permission processes resulting in long procedures.	• More simplified permission procedures.
	Especially for PV installations, the building laws often hinder the construction of PV systems.	• One option to tackle this barrier can be waiving the building permits for all rooftop PV systems.
Connection to the grid	Lack of communication and cooperatioN between RES industry and some DSOs in the process of the defining technical standards.	• Participation of the RES sector authorities in the definition of the technical standards by establishing a regular communication platform. • Set up an independent mediation office to efficiently resolve conflicts between parties (already in action named the Clearingstelle EEG).
	Lack of an obligation for the grid operator to perform a preliminary grid connection study which leads lack of clarity for the PV system developer about the most appropriate connection point assignment.	• Defining a legal entitlement for the grid operators to perform the necessary connection study. • Defining clearly the steps resulting in the right connection point.
	Long waiting times due to ineffective legal processes.	
Operation of the grid	Increasing grid curtailment incidents by the continuous integration of RES to the grid.	• Curtailment measures are needed to be regulated in greater details. (This barrier was widely tackled by the reforms in the feed-in management part of the new amendment of EEG 2012)
	Some DSOs miss the necessary guidance for technical requirements to allow remote control for curtailment.	• The definition for technical solutions and guidance should be improved by having better coordination.

[143] EPIA, "PV Legal, REDUCTION OF BUREAUCRATIC BARRIERS FOR SUCCESSFUL PV DEPLOYMENT IN EUROPE". February 2012.
[144]ECLAREON, Oko Institut e.V., "Integration of electricity from renewables to the electricity grid and to the electricity market – RES-INTEGRATION, Italy Report". December 2011.

RES and grid development and future integration	Missing extension of the DN capacities.	• Providing incentives in order to compensate the reinforcement costs of the grid operators for grid infrastructure. • Penalizing grid operators for insufficient development of the grid (Resulting in grid curtailments) • Evaluate grid extension costs by regulator • Developing regional grid concepts by DSOs
	Insufficient development of grid capacity and resulting bottlenecks in certain regions due to developing renewables.	
	The rules for incentivization in grid development are not clear and mainly focused on the TN and not on DN.	• The required modifications should be done by the regulatory authorities and addition to the transmission grid, the distribution grid has also to be given necessary importance.
	Existing uncertainties for wind offshore projects which also cause delays in infrastructure projects.	• There should be a draft of an offshore wind turbine plants master-plan for supporting the coordination of offshore development.

Regarding the administrative procedures, one example can be given about the building permit which is not clearly defined by the law. Due to this unclear definition, some of the rooftop PV systems require to get a building permission. However, the authorities have been working on this specific barrier and trying to remove it partly for the PV systems. On the other hand, one of the most important difficulties during the administrative procedures rises due to the authorization process from the regional entities, which represent serious barriers in Italy, as discussed before. However, in Germany, this barrier was already tackled by so-called the German "bound decisions" principle[145], which should be a prior practice example that the other countries suffering from the problem should imitate. According to the principle, if the installation operator fulfills all the requirements for the permission defined by law, the regional authority has to give the permission, no matter what the situation is. In the opposite case, the installation operator is granted from the German law to search for its rights and find legal solutions.

With regard to the grid connection rules in Germany, the technical standards are defined by the DSOs and this situation causes the PV industry (BSW-Solar) to be scarcely represented and stay out of the definition process, which leads lack of communication among the stakeholders in the definition process as stated on the table. Until 2011, the technical guidelines for grid operators stated that a network incidence causing an overfrequency (reaching 50.2 Hz) situation results in a successive shutdown of power plants within 200 ms. This technical standard means that in Germany, during high sunshine periods, 12 GW of PV power or more could have been lost within a short period which brings a significant supply shortage. The PV industry recognized this problem and then immediately proposed a solution to the FNN (the German body responsible for the definition of technical standards for grid protection). According to this proposal, a more variable reaction for PV systems was ensured. Instead of going off the grid, they would perform a gradual shutdown which avoids the simultaneous loss

[145] EPIA, "PV Legal, REDUCTION OF BUREAUCRATIC BARRIERS FOR SUCCESSFUL PV DEPLOYMENT IN EUROPE". February 2012.

of newly installed PV systems during the critical situation. This proposal was a proper solution for a foreseen problem and should have been applied on the moment of the recognizing. However, what happened was different. In the FNN, the voting of the proposal by the representatives of the DNs was against the solar industry's idea. The representatives viewed the shutdown issue insignificant at the DN level. This move delayed the necessary actions that should have been taken at that day, but at the end, implemented. Taking all these into consideration, if the solar industry had been better represented in the committee on that process, the technical features and the importance of the proposal could have been more comprehensively described and the decision taken from the committee could have been more in favor of the grid stabilization and security[146].

Apart from all, another barrier that is clearly perceived in Germany is the lack of discussion and coordination between regional governments or cooperation between TSOs. This barrier is one of the main concerns for the development of a Trans-European Electricity Network. In the institutional level, this stems from the lack of coordination between governments and regulatory bodies and slows down the development of a Trans-European Electricity Network. About the support schemes, the shares of RES by transnational projects are not well organized in terms of support mechanisms and are required to be clarified. To propose a solution, an approval procedure for a European infrastructure would be necessary. In order to tackle this barrier successfully, member states have to cooperate and define common guidelines[147].

Among all the target countries observed in this report, by taking into account the barriers identified for each of them, Germany is at the most advanced position.

5.2.3.Spain

From the three target countries that are being analyzed, Spain is in the most particular situation due to the current government measures taken, following the reductions of the public expenditures which, as it was mentioned before, have reached the target sector by the curtailments of all the incentive supports for the RES business under RD 1/2012 of January 27, 2012[148]. By considering today that the target business has not reached yet the competitiveness for any of the RES technologies, as it was shown in the previous section, the situation stated above can be considered the main barrier to overcome in Spain. Otherwise, none of the technologies would be able to continue its contribution to the RES development in a short term scene, generating a pause in the growth that can threaten the achievement of the NREAP 2020 already fixed targets. Besides the present situation, Spain RES development registers many other obstacles that avoid the industry to grow in a cost, technical and economical efficient way towards the targets. In order to understand these inefficiencies, the following table shows most of the main considered barriers to be overcome.

[146] EPIA, "PV Legal, REDUCTION OF BUREAUCRATIC BARRIERS FOR SUCCESSFUL PV DEPLOYMENT IN EUROPE". February 2012.
[147] Ecorys Research and Consulting, "Assessment of non-cost barriers to renewable energy growth in EU Member States", 2008.
[148] RD-Law 1/2012, of 27 January, which is applicable to the suspension of pre-allocation procedures and the removal of economic incentives for new plants producing electricity from cogeneration sources renewable energy and waste, applicable only to all power plants that requests authorization starting from the issuance date.

Table 39 - List of barriers and recommendations for the Spanish RES support system (Source: EPIA[149] / ECLAREON[150])

CATEGORY	BARRIERS	RECOMMENDATIONS
Administration procedures	High fees to access building permits and very long and bureaucratic process to access the pre-allocation register.	• Lower the fees and taxes for RES systems and simplify the pre-registration procedure.
	Non transparent, complicated and long time permit proceedings.	• Homogenization of the authorization procedure at national/regional level and public communication of all authorization procedure status by one responsible institution. • Exempt small systems under 10 kW of getting permits.
Connection to the grid	PV installations connected to HV must adapt to the new technical requirements of voltage dips and control centers.	• Extend the expiration date set by the government to comply with the requirements of voltage dips.
	Deep connection fees at distribution level create high financial barriers for Investments.	• Re-examination of connection fees and reduction of connection costs to attract investments. • Conversion from deep to shallow approach. • Allow RES connection in areas according to grid infrastructure expansion planning.
	Variability of norms and communication problems creates barriers for DSOs to deal with RES-E growth and its connection time.	• A standardization of norms and establishing a regular platform of communication between plant operators and grid operators would streamline the process
Operation of the grid	Lower stability and hosting capacity at distribution level due to not directly managed instructions from DSO to generators, causing grid curtailment.	• Real-time telemetry and operation instructions to DG must be managed directly by DSO at distribution level, with real-time update to REE through the CECRE, in order to reduce grid curtailments.
	Grid curtailment caused by lack of interconnection capacity with bordering countries.	• Foster more investment on interconnection infrastructure with France and Portugal and smart grid solutions implementation.
	Missing expansion of transmission and distribution grid capacity.	• Foster more investment on grid infrastructure and smart grid solutions.
	Lack of accurate forecasting for production due to high system costs.	• Defining an incentive scheme for allowing producers to install higher efficiency technologies.
RES and grid development and future integration	Grid development does not keep pace with RES installation growth due to: • Sub-optimal DSO remuneration model (not taking grid expansion costs into account);	• Revise DSO remuneration model, introducing a shallow connection cost approach and recognizing grid expansion costs to DSOs (*linked with second barrier of connection to the grid*).

[149] EPIA, "PV Legal, REDUCTION OF BUREAUCRATIC BARRIERS FOR SUCCESSFUL PV DEPLOYMENT IN EUROPE". February 2012.
[150] ECLAREON, Oko Institut e.V., "Integration of electricity from renewables to the electricity grid and to the electricity market – RES-INTEGRATION, Italy Report". December 2011.

	• Administrative procedures delaying grid development and capacity expansion; • Long lead times.	• Analysis of existing processes in order to identify and improve existing inefficiencies.
	Lack of support schemes for grid development and adequacy to RES growth.	• Deployment of more budget and clear incentives for development of smart grids and network investments.
	No legal obligation to reinforce the grid for connecting new RES plants.	• Introduction of an obligation in order to stimulate further RES investment and development.

The long and complicated administrative procedures needed for the pre-allocation register process produces the most important impact for the Spanish market. In order to overcome this, producers were expecting, before the announcement of incentives curtailments, a legal-administrative improvement for small RES installations of through the adoption of a net-metering scheme. This new scheme could avoid having to go through the pre-allocation register which considerably slowdowns the development of the market, but the RD has not yet been issued.

At connection level, the most important barrier to overcome is the deep approach connection cost that has to be covered by the new generators in order to be connected to the network. While at transmission level, the connection costs and network updates are under a shallow approach, being recognized by the system to the TSO, at distribution level this policy represents a barrier that discourages investors to enter into the business. Based on this, the first option would be to convert the approach to a shallow cost as at transmission level, charging the DSO and system for the grid development and updates, until the technology achieves competitiveness, in a way of supporting the RES investments. A second solution could be to establish and coordinate a regional approach for directing connection requests according to DSO's own expansion planning, in a way such that the connection charges are optimized for both parts.

Despite that the grid system operation is very efficient in Spain, grid curtailment can be considered the most important barrier at grid operation level, caused by the lack of interconnection lines with the bordering countries, which would be overcome by further investments and smart grid developments. But the main cause of grid curtailment, to be considered as inefficiency, is due to the missing communication interface between the DSO and generators. First of all there has been a lack of uniformity in the real time telemetry information format being used by the generators to inform the system operator (by this moment it is expected to be solved.) But the main problem was due to the concentration of the communication platform at transmission and distribution level by the REE through the CECRE[151]. Thus, instead of implanting a direct communication platform with DG at distribution level by the DSO, in order to instruct them accordingly for more efficient operation, the communication is made more complicated by the REE managing of the network throughout many interfaces.

Lastly, in terms of the grid development and future RES integration, the most important barrier has to do with the fact that there is no legal obligation for a system operator (at transmission or level), to address the requests of a RES generator to further reinforce the network in order

[151]*Centro de Control de Régimen Especial: was set up by REE with the aim of coordinating the operation of special regime RES-E generators and integrating them at best in the overall operation and management of electricity generation, transmission and distribution activities. The principal function of the CECRE is to relay in real time to the System Operator the information about the RES-E generation activity and to make sure that these installations work as instructed, in harmony with the overall system's requirement for security and efficiency. Source: ECLEARON.*

to allow dispatching of the potential production. Therefore, it should be understood that in order to foster grid development towards a higher and efficient RES integration, this obligation must be introduced. But it should be taken into account at the same time that, in order to mitigate the risk of unbalances in such context, if the introduction of this measure is not made in a sustainable way, it can become very risky for grid operators implying higher costs for the system operators. Therefore, its implementation should be accomplished by other regulatory measures addressing the compensation of grid operators, in competence with the shallow costs approach mentioned in the previous paragraph.

5.3. SENSITIVITY ANALYSIS

After identifying the barriers for the RES electricity sector in the target countries, the following step will be to translate the improvements proposed to overcome those barriers, into quantitative figures, in order to analyze the performance sensitivity of the competitiveness by inputting those values.

With the current scenario described before, specifically for the PV market in the target countries, the *grid parity* moment could be approached under the previously defined assumptions. By introducing the figures assumed as descriptive for the policy recommendations, the sensitivity analysis will be focused on showing the achievement of the “new” *grid parity.*

Italy will be the scope of this sensitivity analysis, for being the closest country among the others in achieving the competitiveness. Consequently, the case will be considered for the final outlined conclusions of this section.

5.3.1.Administrative and connection barriers

In the first category of barriers, administration procedures, complex; long processes were reported, which are translated, within the life of the project, into costs and time extensions in the investment schedule, delaying the beginning of the operation of the plant, and consequently, the starting of the PV revenues. Therefore, these problems have been considered in the previous scenarios as extra costs that could be avoided from the LCOE; thus, in the case of overcoming these barriers at different levels, the first sensible parameter that it is going to be changed by reducing it, is the LCOE.

As a second parameter affecting the LCOE, we can consider the virtual saturation of the grid. In the light of the mentioned issue, especially considered a significant bottle neck in critical lines or areas, the AEEG has amended[152] the TICA (Integrated text for active connections) by introducing a fee of 20,25 €/kW[153] to be paid by the future producers to the network operator in terms of the grid booking capacity. Therefore, for the virtual scenario of this barrier surpassed by the regulatory introduction of a confident capacity booking which would reduce speculations and would force the producers to take commitment with the system, the CAPEX would be reduced by 20,25 €/kW producing a second reduction of the LCOE for the technology.

[152] AEEG, 22 dicember 2011, ARG/elt 187/11.
[153] AEEG, “Relazione annuale sullo stato dei servizii e sull’ativitá svolta”. March 31st, 2012.

Lastly, as a way of approaching the sensitivity analysis by studying the effect of this CAPEX and consequently, the LCOE components, the investor's risk will be taken into consideration at the same time. Bearing in mind that, by reducing the complexity and time extensions of the administrative procedures, and mainly, by the potential removal of the virtual saturation issue, the investor would be reducing the risk of potential incomes delay due to the sooner starting of operation of the power plant, the analysis will be introduced by showing the effect of reducing the CAPEX in 50, 100 and 200 €/kW.

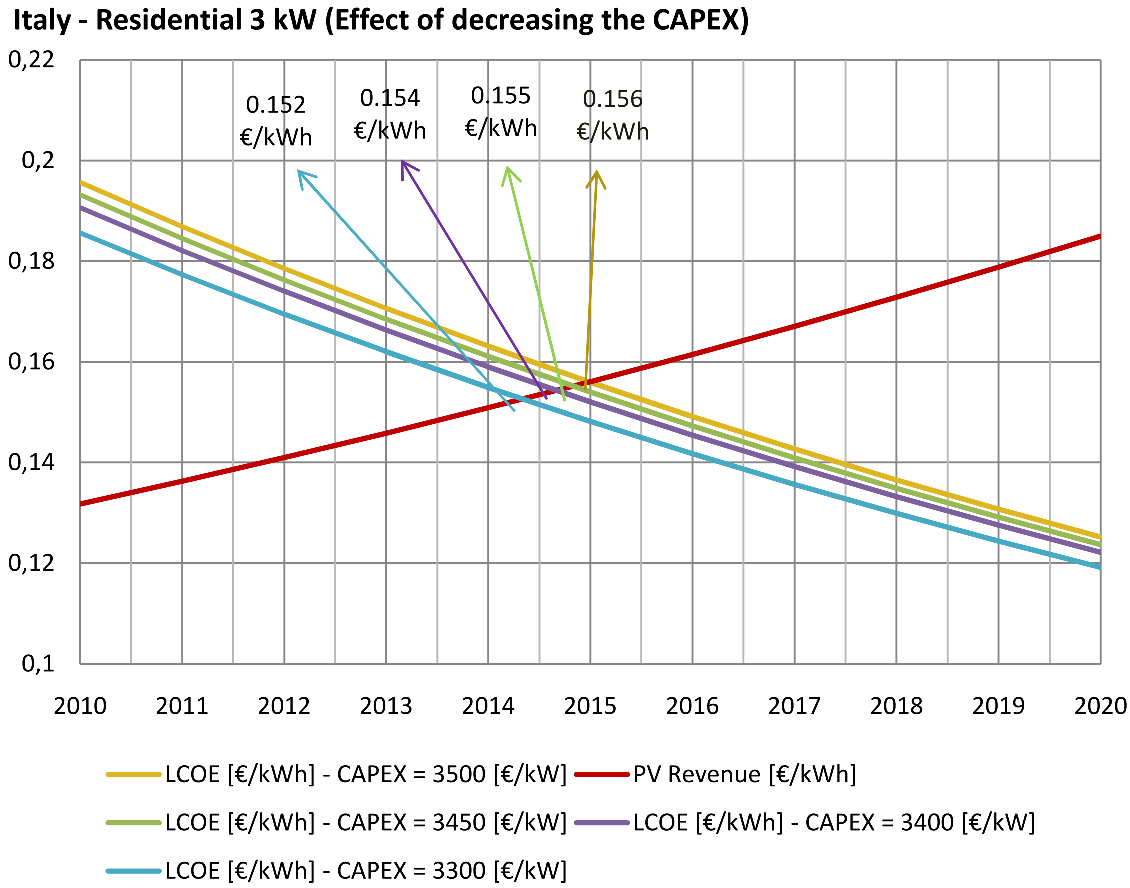


Figure 91 - LCOE versus PV revenues sensitivity for residential market segment as function of the CAPEX, reduced by administrative and virtual saturation barriers improvements.

From the analysis shown above (figure 88), the effect of a potential reduction of LCOE trends due to administrative and virtual saturation barriers improvements can be observed. According to the results, competitiveness in the Italian PV residential segment could be advanced almost a year, expected to be at the end of 2014, if this potential scenario would be put into force. For the cases of commercial and industrial segments, the analysis throws a similar behavior for both markets, achieving a potential parity on the beginning of 2013 for both of the segments.

5.3.2.Tackling the barrier of grid curtailments

In the previously identified barriers for RES integration, under the subcategory of operation of the grid in Italy, the problem of grid curtailment stemming from the hosting capacity issues has been discussed. Although the specified grid curtailment problem is mostly common on the wind power generation, some curtailment issues on the PV electricity generation are foreseen. The current situation and the statistical data on PV curtailments may not constitute a significant concern on the grid security and mass power loss issues, but parallel to the increase in the installed PV capacity, the situation would lead to gain more importance as it does for wind power. Hence, the curtailments of the PV systems and tracking this barrier will have an important place through reaching the competitiveness sooner. Specifically on the analysis done, the effect of decreasing the amount of annual grid curtailments is represented in the capacity factor by an increment. By means of increasing the capacity factor, a resulting enhancement is observed on the NPV of total production which will decrease the LCOE. While the LCOE values decreasing, there is no change on the PV revenues per unit production therefore, only the LCOE line shifts left on the graph, as presented in the following figure.

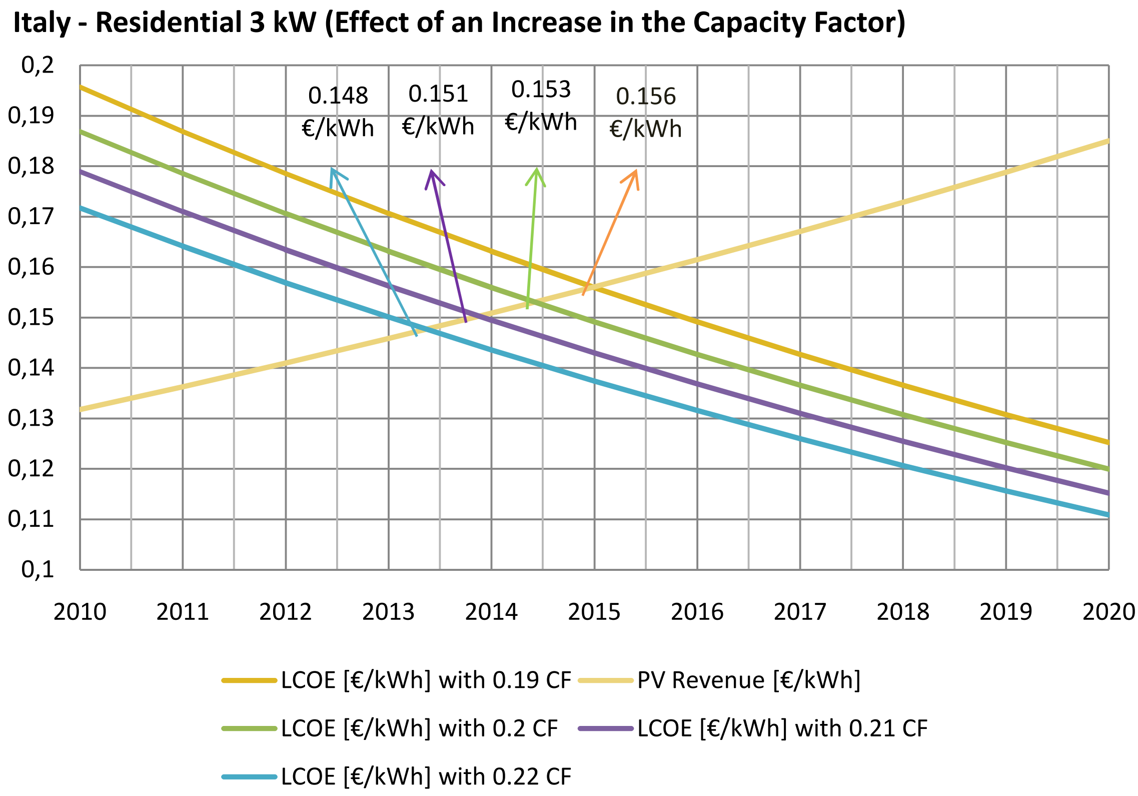


Figure 92 - LCOE versus PV revenues graph for residential market segment with the effect of varying the capacity factor

The original average capacity factor assumed for Italy in the competitiveness analysis was 19 %. For the sensitivity analysis, the capacity factor has been increased by 1 % and the acceleration on reaching the grid parity is observed. If it is assumed that tracking the barriers for grid curtailment have increased the capacity factor by 1 % of its original value, the grid parity would have been reached approximately 5 months earlier, which would correspond to the first half of 2014, instead of 2015 for the residential market segment. Taking this significant effect of the capacity factor into account (approx. 5 months of shift in grid parity time for each

1% change), there should be necessary actions in order to prevent the danger for grid curtailments. In this content, the most rational idea and progressive projects are done for the expansion of the grid. Through the smart grid concept, there are many investments and researches that the authorities have been working on. As stated in the barrier tables, the missing expansion of transmission and distribution grid capacities have crucial role on operation of the grid. On the other hand, the risk of unnecessary islanding for DGs due to the narrow range in frequency states another concern. These barriers can be solved by more investments on grid infrastructure and smart grid solutions such as widening the ranges on frequency, by suitable IPR settings, and innovative DG interface protection mechanisms, by using transfer trip.

The reflection of these ideas into the quantitative analysis is different from the one that is done for grid curtailments. Although the effect of grid expansion and smart grid solutions lead an increase in the capacity factor, the graphs presented for the analysis of grid expansion are not the same as the ones given before, according to the capacity factor change. It is obvious that the grid expansion and development of the smart grids will be projected in the medium and long term. Due to this fact, in the analysis, the increase in the capacity factor is taken into account after the year 2020, counting 8 years from now on. According to the explained situation, the findings by increasing the capacity factor are as follows:

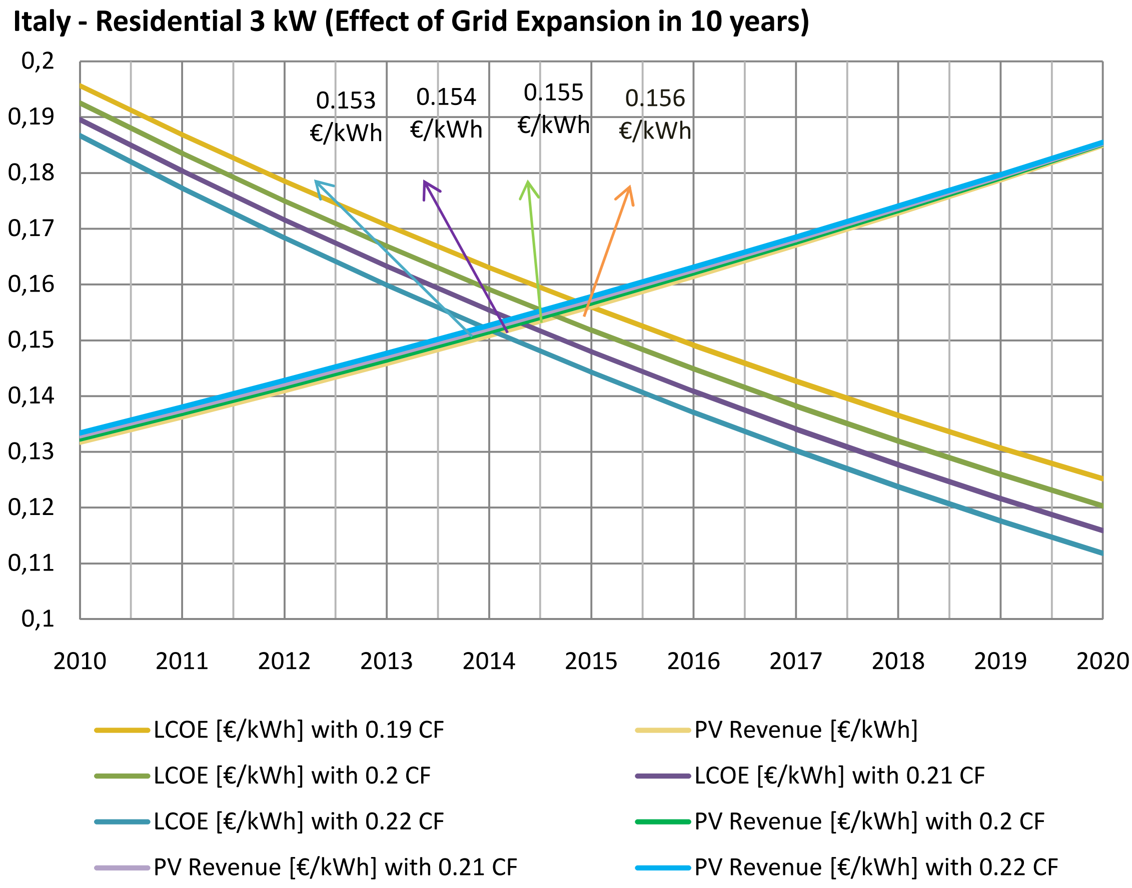


Figure 93 - The effect of grid expansion and the smart grid solutions on the approach to competitiveness

As demonstrated on the figure, the grid expansion and following increase in the capacity factor result in remarkable decrease in the LCOE (shift to the left) and correspondingly less increase in PV revenues. By combining the both effects on the curves, the grid parity would be reached sooner than the current scenario if the importance given to the grid expansion is enhanced. The same effect is achieved for the other two segments.

5.3.3.The effect of region's irradiance on the capacity factor

One of the most determinant variables which affect the capacity factor is the solar irradiance, as it was stated before. Hence, the variability of the solar irradiation depending on the location of the site should be examined. In the specific example of Italy, which is a country covering a wide range from north to south, the solar irradiance shows a considerable change among its regions. This, results in different capacity factors on the PV installations for each latitudes. In this analysis, five big cities are selected to show the differences on the time schedule that each region's grid parity's sensitivity is going to give. On the following table, the statistical solar irradiance ranges for the chosen cities are presented. According to the irradiance, the corresponding capacity factor is determined for each city.

Table 40 - Solar irradiation data of the selected points in Italy from north to south[154]

Italian Cities from North to South	Solar Irradiation (kWh/m2)	Capacity Factor	Total equivalent hours
Milan	1261-1300	0.16	1200 hrs/yr
Florence	1301-1340	0.17	1275 hrs/yr
Rome	1461-1500	0.20	1575 hrs/yr
Naples	1501-1540	0.21	1650 hrs/yr
Catania	1581-1620	0.23	1800 hrs/yr

[154] PHOTON - Il Mensile del Fotovoltaico (www.photon-online.it), dati Meteotest (www.meteotest.com)

Figure 94 – Global solar irradiation along Italian national territory (Source: Solargis).

As it is expected, in the south part of Italy (Catania - Sicily), the geographical location results in higher capacity factor and leads the region to be competitive in terms of PV electricity generation before the north part. However, when Italy is considered as one piece, the overall competitiveness has not been reached yet. The following figure gives the time span of the calculated schedule for achieving the grid parity, depending on the location in Italy.

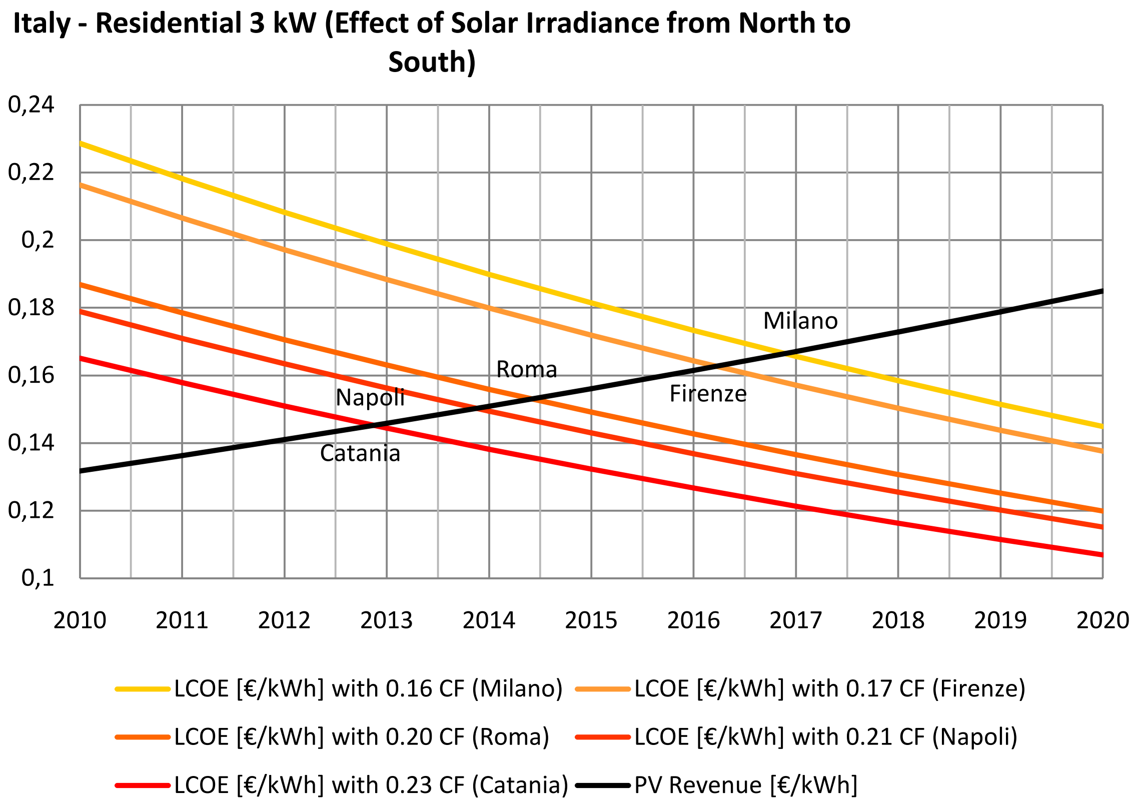


Figure 95 - Solar irradiation effect on the grid parity in Italian PV electricity generation

As a result of the effect seen in the time span, the incentive schemes have to be arranged properly by the regulator bodies in order not to support the regions which does not need incentives anymore, due to the achievement of grid parity. On the other hand, in order to have a better balanced system through the way to full competitiveness in PV technologies, the diversification of the incentives has to be done by paying more attention to the regions which are far behind from the others, which are closer to the grid parity.

5.3.4.Draw-backs of not improving the forecasting

The last barrier identified for grid operation in Italy was the lack of accurate forecasting in the non-programmable RES producers, producing an increase in the system costs due to the imbalances derived from this operation inefficiency.

Currently, for the production units powered by non-programmable RES, the actual amount of unbalance produced by generation is paid at the Day-Ahead Market price at the location of the dispatching point (the price MGP), so if the energy electricity actually delivered to the grid by these units is different from that forecasted, the higher costs induced on the system are not on the shoulder of the producer, but they are socialized. In this manner, the described approach can be considered as an additional implicit incentive for non-programmable producers. Also, it means that the dispatching user is not prompted to take an active part in the management of the interrelationship between plant and network, thus neglecting various activities (such as forecasting and planning of electricity fed into the grid), which instead are normally performed by all other users, creating further distortions in electricity prices. In addition, it was explained before that with the aim of improving this commitment, producers over 10 MVA are granted with the CCP (ARG/elt 5/10), but during the last months the AEEG has issued the DCO 35/2012/R/efr with the aim of evaluate the possibility of introducing a cost reflective adjustment for the imbalances produced by this sources (avoiding the costs to continue to weigh only on consumers). After that evaluation, the AEEG has recently issued the resolution 281/2012/R/EFR which is making this regulation effective from January 2013. From that date, the new regulation will carry part of the costs induced by the RES system for producers themselves. During the next year, there will be a franchise in which imbalance charges will continue to be supported by consumers. Out of that exemption, the costs of imbalances will charge on producers. For the first semester it will be equal to 20% of the binding program modified and corrected for the dispatching point, and during the last 6 months it will be reduced to 10%, being soon revised for the oncoming years.

Currently in Italy, TERNA have grouped the national system in regional zones according to the dispatching service market (MSD)[155]. Each of these regions is characterized by an hourly dispatching service market price, when a balancing service is required in order to keep the system security. According to the type of aggregated imbalance (of a whole zone, given by all the imbalances produced at zonal level), the zone is considered to have a positive (+) imbalance (overfrequency) or a negative (-) imbalance (underfrequency). In addition, each of the RES producers contributes to those imbalances when they produce less (-) or more (+) than the amount of energy sold in the Day-ahead market (MGP). This situation generates four types of imbalance fees:

Table 41 – Type of imbalances zones according to aggregated imbalance and RES imbalance

	TYPE I	TYPE II	TYPE III	TYPE IV
Zonal aggregated imbalance	+	+	-	-
RES produced imbalance	+	-	+	-

From the four possible imbalances situations exposed in the table 41, the most difficult in terms of operational conditions and system costs is the last one, the zone IV, the one which is going to be assumed for this sensitivity study.

When the new resolution comes into force next year, the potential imbalances costs attributable to a PV generator (500 kW of capacity assumed[156]), as the one we are assuming for the industrial previous sensitivity cases, for one hour of produced effective imbalance, will be calculated as follows:

$$\mathbf{IC} = E \,.\, P(MGP) - IP \,.\, \text{Max}\,[P(MGP);P(MSD)][€]$$

Being :

E = energy sold to the MGP [kWh]

P(MGP) = price of energy sold to MGP [€/kWh]

IP = amount of effective imbalance produced [kWh]

P(MSD) = zonal price of MSD [€/kWh],

155 AEEG, Annex A from resolution 9th june, 2006, N° 111/06.

156 For the purpose of this analysis, the producer is assumed to be less than 10 MW, as the resolution only applies for big plants up to this moment. But the idea is to show that a similar effect will induce a non significant change of delaying competitiveness if the imbalances costs are charged to the producers, in a possible future scenario.

where the imbalance cost (IC) is calculated by the difference between the energy sold at the price of MGP and the effective imbalance produced times the maximum value of the price of energy at MGP or the zonal price of MSD.

Thus, for our estimations we will assume an E(MGP) equal to the previous one (0,076 €/kWh), and an P(MSD) with the higher value registered by TERNA, 0,184 €/kWh. The value to be changed will be the IP, which will be 50 kW, 100 kW, 200 kW.

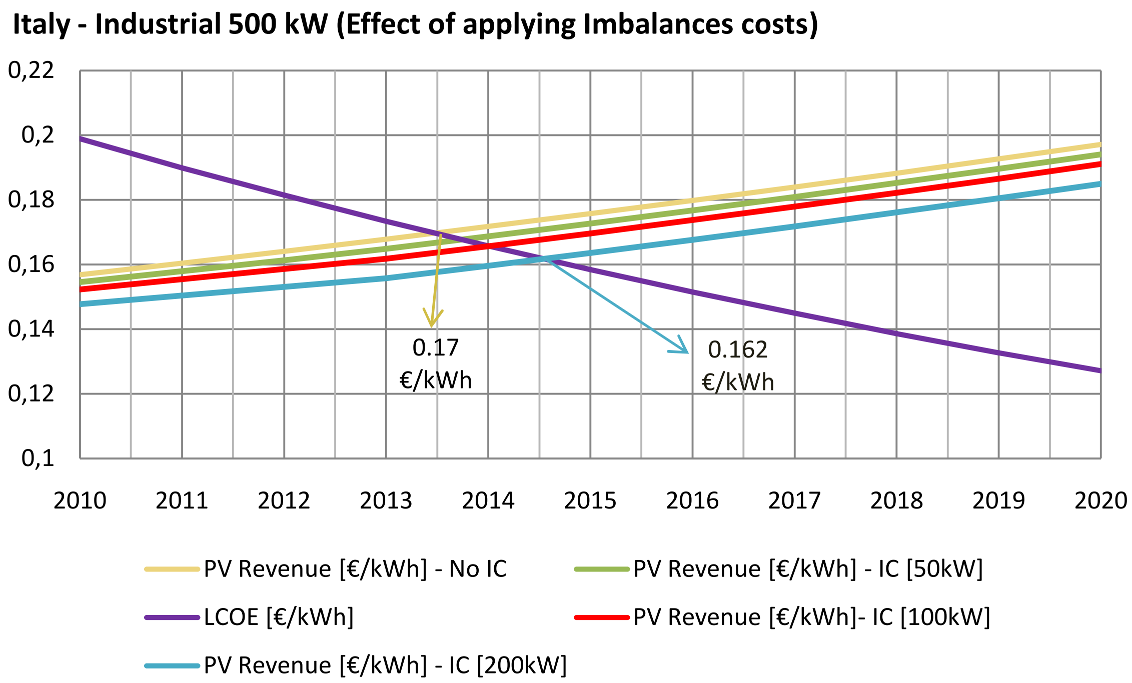


Figure 96 - Grid parity delay effect after the application of imbalance costs for PV producers

As one can observe in the figure 93, the application of the resolution 281/2012/R/efr would delay almost half a year the grid parity for the industrial sector (red line), if the imbalances produced under the assumption of 1 hour per day are around the 100 kW (20% of power plant capacity). For an extreme case (200 kW – 40%), the grid parity would be delayed by almost a year.

In conclusion, there are plenty of key variables that affect the schedule in reaching grid parity. While some of these variables cause to delay the process, some of them accelerate. This way towards the competitiveness is mostly drawn by the right policies. For instance, it has been observed in the analysis how unnecessary margins and local administrative costs keep the capital investment prices high and cause the LCOE curve to shift right, which would delay competitiveness. With a proper policy, both the administrative costs and the timetable through the connection to the grid can be decreased. On the other hand, although it has not been taken into account, PV revenues line can shift left and accelerate competitiveness by an unexpected rise in the electricity prices due to an increase in the fossil fuel prices. Additionally, the self-consumption of electricity can also increase PV revenues by ignoring the grid costs which are included in OPEX. Among all the arrangements and variables, the most effective and sensitive component is determined as the capacity factor of the plant. Thus, it is normal that some parts of certain countries can reach the grid parity sooner than the others due to the solar irradiance factors registered in each location. For this reason, it is really significant the fact of increasing as soon as possible the grid operation efficiency in countries where the original constraint is in the low irradiance, like Germany, thereby increasing the capacity factor upstream the source absorption. Then, the policies like grid expansion, smart grid solutions and prevention of grid curtailment are still required to be supported in order to increase the capacity factors of the plants and accelerate competitiveness.

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CHAPTER 6

CONCLUSIONS

6. CONCLUSIONS

The energy industry is witnessing a substantial worldwide change in terms of economy, technology and social-environmental concerns, considering that on one side, for certain countries a promising future is glimpsed on the paths of already known shale gas, and on the other side, clean and secure supply from the conversion of renewable sources. The excess of extracting the energy from fossil fuels is menacing the environmental global health. In addition, is not a minor concern the fact that some governments have decided to phase out nuclear power development, like Germany, due to the recently Fukushima accident. Thus, under this context, the science development has introduced the alternative of converting energy from renewable sources into mechanical or electrical energy, technologies that were practically unaffordable in the beginning, but during the last years have been approaching to a competitive plane in the near horizon. The option that made this alternative feasible until reaching its self-sustainability was the supporting throughout policy frameworks.

The present work was focused in analyzing the EU support schemes for the RES electricity sector, which are in line with the EC Directive 2009/28/EC, from the economical and technical point of view, in three of the most representative countries of the EU, Germany, Italy and Spain. These three Members have launched the first RES projects (and currently, which have the higher wind and PV installed capacity), opening a new path to an alternative way of producing electricity from renewable sources, and spreading the development to the rest of the EU Members, providing a cleaner and secure energy supply. Thanks to the first support schemes which were enforced, the foothold for these first steps of development was set, and the first RES technologies, like wind and PVs, started to gain more participation in the generation mix. But from 2010, the new EU 2020 energy policy targets came into force, and with the issuance of the NREAP's in each of the EU Members, RES technologies growth has crossed out an inflexion point in its development, especially in the three target countries.

Besides that in the discussed countries, there were already in force many support schemes based on *feed-in tariffs* or *premium tariffs*, among others, the new mechanisms have reinforced the integration of higher capacity and new technologies. The present work has shown the results of the last implemented support schemes (*premium* and *all-inclusive feed-in tariffs*), the *EEG* in Germany, the *Conto Energia* and *GCs* (*QO*) in Italy, and the *Special Regime* in Spain. During the last two years, the deployment of RES has taken a leap to a greater extent in wind, solar and bioenergy generation technologies, putting into risk the security of the electrical networks and demanding a continuous intervention by the authorities and the system operators, with the aim of containing these effects, and allowing a higher integration of RES. Indeed, in some specific areas, the high growth of some technologies, like wind in southern areas (Puglia and Sicily) of Italy or north regions (Schleswig Holstein and Lower Saxony) in Germany, have forced the TSO's to introduce *grid curtailments* in order not to risk the security of the national and EU network, making the regions to be considered as critical because of the lack of infrastructure development, inducing an unbalanced development of the system.

The Italian case has many reasons to be considered of special attention: from the economical point of view, due to the unexpected expenditure of financial resources assigned to IV Conto Energia during the first year, instead of being prorated according to schedule; and from the technical point of view, due to the high penetration level of PV that has taken place as a result of the versions II and IV of Conto Energia, which made partially the PV capacity to reach the 15 GW in august of 2012 (11 GW since 2011). Thus, under this situation, not only wind technologies will be exposed to grid curtailments, but PV as well, being now a strong motive of concern for the TSO's, and especially considering that PV generators are connected to the medium and low voltage networks, forcing the DSO's to take the main role in managing the information and operation of the grid at that level, and requesting a dynamic real time communication, bidirectionally, both with the TSO and with the DG. When it is understood that originally the DNs were not designed to allocate generators, but only consumers instead, it comes to the mind the fact that reengineering and redesign have to be the drivers of adequacy of the current architecture in order to allocate the increasing penetration of DG producers. Indeed, this latter is true, but in a medium and long term. TSOs and DSOs both have to start planning the future network infrastructure developments. With the exception of the investments which have to be done in the present in order to ensure system reliability, there is a short/medium term solution to drive the higher integration of RES in the distribution grids, which was presented as *smart grids*.

In the last chapter of this thesis, the current business market situation of the main RES technologies was analyzed under certain assumptions, taking as a driver of the study the PV technology in the three market segments in Italy. After the thrown results, it was concluded that the *grid parity* of PV technology would be reached first in Italy (around 2013, starting from southern regions), mainly because of the higher irradiance factors and electricity prices, and then spread to Spain and Germany. But as the general acknowledgement, all the three countries would reach competitiveness before 2020 (and extending it to wind and biomass technologies). Thus, phasing out of the support schemes for RES-E should be considered the option, not meaning that the financing of new projects should be reduced suddenly, but in a gradual level, depending on the country and the segment of market.

Maybe the Spain situation is the extreme case, but despite the decision of the government of temporarily suspend the incentives for the new investments, after the evaluation of the present EU financial situation, it can be said that the point of development reached by the three countries is complying, by projections, the achievement of the 2020 RES-E targets. Spain might be exposed to a freezing of the investments, but it could be for a short period, until the activity could be restored or even emancipated from the incentive schemes. With more reason, it should begin to be thought that the possibility of reaching *grid parity* will arrive soon to give a second breath to the development race in the target countries. In fact, the beginning of the financial crisis in 2009 produced a sudden decrease in the prices of equipment due to the high offer and the decrease of the demand, and considering that the costs of investments are continuing to run down, as it was shown under the assumptions, market competitiveness is just around the corner.

But if it is considered that the only option is to go through the path of improving the efficiency of the networks operation, overcoming all the identified barriers and not just relying on the financial speculation, by acting on a concrete field, it can be said that the phasing out of financial resources budgeted for supporting the RES-E can be the source of financing the future network investments and *smart grids* infrastructure. In one word, it would be "to shift" resources from one field to other one. In this context, balancing the sustainable growth by supporting grid development and therefore, increasing the hosting capacity at distribution level, reducing the criticality of areas by applying DCTR or building new lines, and improving the efficiencies of forecasting systems, in an attempt to smooth the way for the RES self-sustainability race beyond 2020.

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