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THE SPANISH GAS AND ELECTRICITY SECTOR: REGULATION, MARKETS AND ENVIRONMENTAL POLICIES

Giulio Federico[1]

Abstract

This paper summarizes the findings of a recent report recently published by the Public-Private Sector Research Center of IESE Business School on the Spanish gas and electricity markets. The first part of the paper reviews the recent evolution of the Spanish gas and electricity sectors, whilst the second focuses on environmental issues and policies.

The Spanish gas and electricity markets are continuing to evolve towards a more competitive structure, with particularly significant progress having been made in the electricity wholesale market, but progress towards effective liberalization of the retail markets remains limited. The shortfall between revenues and costs in the retail electricity market also reached record levels in 2008-2009, due to a combination of high wholesale electricity prices (in 2008), and payments to renewable generation (primarily in 2009).

One of the primary challenges faced by the Spanish and European electricity markets is the need to virtually eliminate carbon emissions over the next four decades (based on internationally agreed objectives on climate change mitigation). European policy on this issue currently relies on a mixture of carbon pricing and renewable support. Spain has relied heavily on renewable subsidies to meet its environmental objectives. The regime introduced in mid-2007 has, however, led to a significant increase in the cost of renewable support, which has probably resulted in the over-compensation of renewable output relative to their average social value, and has placed a strain on the electricity system as a whole.

Keywords: energy, environment, regulation, competition policy

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THE SPANISH GAS AND ELECTRICITY SECTOR: REGULATION, MARKETS AND ENVIRONMENTAL POLICIES

Introduction

The European and Spanish gas and electricity markets remain characterized by major policy challenges due to the complex and strategic nature of these markets. Public policy issues that are at stake in these markets include: the challenge of introducing effective competition and regulation to ensure that market outcomes are competitive and the European market is successfully integrated; the need to manage the high levels of dependency of European energy markets on external sources of input (especially gas); and the difficulties posed by the transition to a more sustainable model in line with current European and global environmental objectives.

This paper summarizes the findings of a report recently published by the Public-Private Sector Research Center of IESE Business School on the Spanish gas and electricity markets. The article focuses on the recent evolution of competitive segments of the Spanish gas and electricity markets (namely, gas procurement, electricity generation and the respective retail markets), and analyzes in more detail the environmental issues at stake in the European and Spanish electricity markets.

Section I of the paper updates and extends the analysis contained in the first edition of the Public-Private Sector Research Center Report *Competition and Regulation in the Spanish Gas and Electricity Markets* (published in 2008) by including a review of the key regulatory and market developments that characterized the Spanish energy markets during the 2008-2009 period.

Section II of this article is devoted to the specific analysis of environmental policy in the European and Spanish energy sector. Environmental issues have taken centre stage in the design of European electricity markets due to the stringent climate-change mitigation objectives implied by mainstream climate science and partially reflected in current E.U. policies. According to international projections, Europe will need to significantly reduce its greenhouse gas emissions over the next two decades (with required reductions of more than 40% by 2030, compared to 1990 levels) if global environmental objectives are to be met. These objectives in turn imply the need to decarbonize the power sector even more rapidly by achieving a 70% reduction in emissions by 2030 (relative to 1990) and the virtual decarbonization of the sector

by 2050. These are clearly very challenging objectives that will require radical changes in the way electricity markets are organized. Section II of the paper reviews some of the policy issues associated with climate change and the performance of E.U. and Spanish environmental policy to date.

The Annex to this paper contains all the tables and figures that are referred to in the main body of the article.

The Evolution of the Spanish and Electricity Markets, 2008-2009

1. The European Energy Context

The overall European context in which the Spanish gas and electricity markets are situated remains one of significant external dependency, active competition policy and evolving regulation (with respect to both market structure and environmental issues).

External energy dependency remained at over 50% at the E.U.-27 level (and around 80% for Spain) in 2009. The economic crisis of 2009 has moderated the recent increase in energy dependence, given the reduction in energy demand and imports resulting from the overall decrease in economic activity. At the same time, domestic renewable energy sources have continued to increase, which has also contributed to mitigating external dependence. Nonetheless, medium-term projections hold that European gas dependence is set to increase over time (e.g., to 80% by 2030) as domestic resources become depleted. The implementation of stringent environmental policies could, however, moderate the absolute increase in gas imports over this period by reducing the demand for gas (see Annex Figure 1).

The European gas market still primarily relies on pipeline imports from its main suppliers (Russia, Norway and Algeria), even though the weight of Liquefied Natural Gas (LNG) in overall imports has increased (reaching almost one quarter of all imports in 2009). Significant increases in both pipeline and LNG import capacity are planned over the medium term, but uncertainty remains as to which of the competing import projects will go ahead (partially due to uncertainty of the future level of gas demand). Under some scenarios on new infrastructure developments, European dependence on Russian gas could increase significantly above current levels.

In terms of sector regulation and competition policy at European level, 2009 has been a particularly active year, with the publication of the revised gas and electricity directives (as part of the so-called Third Legislative Package), two additional directives on renewable energy and emissions trading, and the completion of several antitrust cases.

Under the Third Legislative Package, the European Union has refined its approach to unbundling in the energy industry by allowing Member States to choose between a full structural option (ownership unbundling) and lighter forms of functional separation.

At the same time, the European Commission has pursued several “abuse of dominance” cases against energy incumbents (in France, Germany, Italy and Belgium). These cases have centered on the potential foreclosure strategies followed by vertically integrated incumbents in liberalized retail markets. As a result of these investigations, the incumbents in most cases have offered commitments which have either reduced or eliminated their vertical integration (e.g., in

cases involving RWE, ENI and E.On (electricity)), or weakened their control of the market (e.g., as in matters relating to EDF, GDF/Suez and E.On (gas)). Moreover, the European Commission reviewed and cleared four large mergers between energy companies during the 2008-2009 period. These mergers have all resulted in fairly extensive structural divestments relative to the expected competition issues associated with the transactions. These trends show that competition policy remains a fundamental part of the broader deregulation and internal market agenda pursued by the European Commission in the energy sector (see Annex Table 1).

2. Regulation and Competition Policy in Spain

The key regulatory developments in the Spanish gas and electricity markets since late 2007 have been the introduction of "tariffs of last resort" (TLR) in both gas and electricity (in mid-2008 and mid-2009, respectively); a reform of the mechanism for the determination and recovery of the tariff deficit; a continuation of the program of procurement auctions (CESUR) used to establish the cost of energy for residential electricity customers, but the discontinuation of the Virtual Power Plant (VPP) program applied to the largest generators; and measures on solar subsidies and domestic coal-fired generation (see Annex Table 2).

The introduction of TLR in the residential gas and electricity markets does not increase the liberalization of the respective retail markets *per se*, since the TLR remains a regulated tariff which is set by the government, with respect to the non-energy component. On the other hand, the trends towards greater retail liberalization in both gas and electricity have continued after the introduction of TLR. Moreover, regulated electricity tariffs for high-voltage, SME and large residential customers were abolished between mid-2008 and mid-2009, thus further supporting the drive to deregulation of the retail market.

Another positive feature of electricity TLR, relative to the previous system, is that the energy component is now directly related to a market-based mechanism (the CESUR procurement auctions), which helps ensure that tariffs move in line with the market. Access charges, however, remain regulated at a level that is below cost, which has led to large tariffs deficits in both 2008 and 2009.

The reform of the tariff deficit introduced in April 2009 (through Royal Decree Law (RDL) 6/2009) should, in principle, improve the arrangements for the recovery and future determination of the deficit by securitizing a significant amount of the pre-2009 deficit (€10 billion), and limiting the annual deficits to be incurred during the 2009-2012 period. However, the deficit incurred in 2009 exceeded the limits introduced by RDL 6/2009, thereby suggesting that this measure lacks full political commitment.[1] Moreover, the abolition of the measure to remove the estimated additional profits from free carbon allowances for the period between mid-2009 and the end of 2012 (a measure which had been applicable in Spain since 2006) places further upwards pressure on the deficit.

The Spanish electricity VPP program came to an end during the first quarter of 2010, after having been first implemented in mid-2007. A maximum of close to 2.6 GW of baseload and peak output has been affected by the program, equivalent to 5%-7% of Endesa and Iberdrola's respective capacity. A review of the program carried out by the sector regulator (the *Comisión Nacional de Energía*, CNE) in 2009 indicates that the scheme might have been effective in

[1] The limits on the tariff deficit were, in fact, revised upwards in December 2010, through RDL 14/2010.

promoting retail competition and market liquidity, but not necessarily in making wholesale market outcomes more competitive. The latter finding can be partially explained by the relatively small size of the VPP during the lifetime of the intervention (see Annex Figure 2).

The government's decision not to continue the VPP program beyond the last auction (held in March 2009) seems to have been vindicated by the recent reduction of concentration in the Spanish electricity market, and by market outcomes during 2009 and early 2010, which have resulted in effectively competitive electricity prices (primarily due to a combination of lower concentration, additional renewable output and lower demand). It would have been preferable, however, to determine whether the VPP scheme should be continued on the basis of a transparent review of the Spanish generation market structure (for example, by relying on the periodic assessments of competition prepared by the CNE). This would have provided an objective basis for future decisions on similar schemes and would have given market operators more time to adjust to the change in regulation.

Energy markets also continue to be a key area of application of competition policy in Spain. In terms of merger control, the main concentration assessed by the competition authority (the *Comisión Nacional de la Competencia*, CNC) was the merger between Gas Natural and Unión Fenosa (approved in early 2009). This transaction brought together the gas incumbent with the third largest electricity firm, which also had a significant presence in the gas market (through its 50% stake in Unión Fenosa Gas). The CNC approved the merger subject to a remedy on Unión Fenosa Gas's behavior in the retail market, and on structural divestments in the generation and residential gas markets (namely, the sale of 2 GW of gas-fired generation capacity, and of gas distribution networks with associated residential customers[2]). The absence of a structural remedy directly aimed at the wholesale and industrial gas markets (where Unión Fenosa Gas had become a major competitor of Gas Natural) was a notable feature of the CNC decision. It effectively signaled the CNC's confidence that competition in the wholesale and industrial gas markets in Spain is sufficiently intense, and that the increase in market concentration brought about by the transaction would not have adverse effects on gas consumers.

The CNC also took an abuse of dominance decision against incumbent electricity distributors for withholding commercial information from a downstream competitor (Centrica Energía). This decision reflects a continuing concern for vertical integration between distribution and retail supply, and is consistent with the general preference for ownership unbundling expressed by the European Commission.

No new abuse of dominance decisions were taken by the CNC in relation to the issue of the pricing of transmission congestion relief (*restricciones técnicas*), following the four decisions taken in this area over the 2006-2008 period. However, this area remains under the close scrutiny of the competition authority, which opened new investigations on this issue in late 2009 involving practically all the generators in the market. The question of how to appropriately reward the output of generators located in congested areas is not only a competition law issue, but also affects the overall remuneration regime for thermal power plants in a context with growing amounts of renewable generation.

[2] These divestments were subsequently revised by the CNC, in February 2011.

3. The Evolution of the Spanish Gas Market: 2008-2009

The Wholesale Gas Market

During the 2008-2009 period, the Spanish wholesale gas market was primarily characterized by significant demand volatility, a growing reliance on LNG imports, a continuing lack of flexibility in the form of sufficient domestic storage and interconnection capacity, and significant structural changes due to the Gas Natural/Unión Fenosa merger. These and other principal developments in the wholesale gas market are briefly set out below:

- **Spanish gas demand grew by 10% between 2007 and 2008** (mainly due to growth from the electricity sector), **but then fell drastically between 2008 and 2009** (by almost 11%), due to the contraction in economic activity, as well as a reduction in gas-fired electricity output partially due to the continuing increase in renewable generation. Convergence between the gas and electricity markets remains strong, with the electricity component accounting for 40% of total gas demand.

- **The weight of LNG imports in total gas volumes has continued to increase**, reaching almost three quarters of all imports in 2009 (well above the E.U.-15 average of less than one quarter). The Spanish gas market remains well diversified relative to other European markets (most notably Germany, but also France and Italy) and has access to significant regasification capacity, at least six major gas sources, and no reliance on Russian gas (unlike most of Europe). These features of the Spanish gas market make it less vulnerable to potential disruptions in supply (see Annex Figure 3).

- In terms of **gas infrastructure**, **investments continue to be made in the Spanish system** with expansions by Enagás at the Barcelona and Cartagena LNG terminals and further expansion at the Sagunto facility. The new pipeline with Algeria (Medgaz) is also due to come on line by the end of 2010. This might lead to a significant increase in dependence on Algerian gas (which could be considered excessive in light of the price dispute that took place between Gas Natural and Sonatrach in 2010).

- However, **major infrastructure deficiencies remain in terms of domestic gas storage and interconnection capacity** with France (especially in export mode). The domestic gas storage capacity in Spain (including LNG plants) only accounted for roughly 10% of annual demand in mid-2010, well short of levels in other major European markets such as Germany, Italy and France. Access to domestic gas storage will become increasingly critical in the Spanish gas market, as gas-fired power generation is expected to operate in a more flexible mode in the future (e.g., to deal with greater levels of intermittent renewable generation). The new facility being developed by Enagás at Yela (expected to be operational in 2011) will increase Spanish underground storage capacity by roughly 50%, and represents a critical project to increase the flexibility of the Spanish gas system.

- **The secondary OTC market continues to grow**, providing an important source of gas flexibility for LNG imports. However, it does not represent an adequate substitute for a liquid and transparent wholesale gas hub, which has not yet developed in Spain.

- **The structure of the Spanish wholesale gas market is still characterized by the pre-eminent position of the incumbent firm**, Gas Natural. However, Gas Natural's share of

wholesale gas imports has declined steadily with the liberalization of the sector and the entry of independent LNG, falling from close to 80% in 2004 to 50% in 2009. This decline in market share was partially reversed in 2009 through the acquisition by Gas Natural of joint control of Unión Fenosa Gas (which accounted for an additional 13% of the Spanish wholesale market in 2009). Notwithstanding the effective increase in market concentration observed in 2009, the Spanish wholesale gas market remains less concentrated than those of most other European countries, which tend to have highly concentrated gas markets (with the exception of the United Kingdom and Germany) - see Annex Figure 4).

The Retail Gas Market

The Spanish retail gas market remains characterized by a continuing yet gradual liberalization, a concentrated market structure, and limited customer switching away from the incumbent providers at regional level:

- **The Spanish retail gas market is effectively liberalized** in terms of gas volumes, with over 90% of demand being transacted at market-determined prices. In terms of customer numbers, however, liberalization remains incomplete, with more than 45% of customers purchasing gas at regulated TLR in the first quarter of 2010. The share of customers on regulated tariffs has, however, fallen steadily since 2004 (when it stood at close to 80%) - see Annex Figure 5.

- **The retail gas market remains highly concentrated**, however, with a Herfindahl-Hirschman Index (HHI) in 2009 well in excess of 2,000 (i.e., the standard threshold used for a highly concentrated market). As in the wholesale market, effective market concentration increased during 2009, following the acquisition by Gas Natural of a 50% stake in Unión Fenosa Gas. The retail divestments which followed the CNC merger clearance decision reduced concentration in the residential market, but not in the overall retail market (due to the relatively low gas volumes associated with residential consumption).

- **At the regional level, market concentration in the residential market remains very high**, since a significant share of customers remains on regulated tariffs, and those who switch to market-determined prices tend to remain with their incumbent operator. By the end of 2009, only an average of around 15% of all customers had actually switched gas providers in each region. In spite of the relative slow progress in residential gas competition, the performance of the Spanish market compares favorably with those of the other main gas markets in Europe, with annual consumer switching rates above the levels seen in Germany, Italy and France (but below those of the United Kingdom and the Netherlands) - see Annex Figure 6.

4. The Evolution of the Spanish Electricity Market: 2008-2009

The Wholesale Electricity Market

The Spanish wholesale electricity market has experienced very significant changes since early 2008, as a consequence of shifts in relative fuel prices (including CO_2), significant demand

fluctuations and the continuing growth of subsidized special regime generation (mostly renewable). The main market developments are summarized below:

- **Wholesale electricity demand fell for the first time since market liberalization**, dropping by close to 5% between 2008 and 2009. Over the course of the present decade, however, cumulative demand growth in the Spanish electricity market has been very high (close to 35%), well in excess of the E.U.-15 average of just over 7%.

- **The generation mix in the Spanish market has undergone drastic changes in the last two years**. The major trend has been the significant growth in subsidized baseload generation (under the special regime) which, coupled with stagnant or falling demand, squeezed the output of flexible thermal output (especially coal-fired production). The structural changes experienced in the Spanish electricity market highlight a trend towards a 'greener' electricity system with significantly lower carbon intensity than in the past, considerably more renewable generation and more flexible operation by thermal generators (in particular combined-cycle gas turbines (CCGTs)) - see Annex Figure 7.

- **During the 2007-2009 period, special regime output grew by 40%, whilst coal generation fell by over 50%**. By mid-2010, coal generation had fallen even further, to less than a third of the 2007 level. Part of this reduction in coal generation can be attributed to the increase in CO_2 prices after the very low levels seen during 2007 (as Phase I of the Emissions Trading System came to an end). Output by CCGTs grew by 15% over the 2007-2009 period, but the 2009 output level was 14% below the peak achieved in 2008 (with a further reduction experienced by mid-2010).

- **Overall renewable generation (including conventional hydroelectric generation) accounted for roughly 27% of total electricity consumption in 2009**, up from 21% in 2008. This increase in the relative share of renewable output was achieved primarily due to continued growth in wind generation (which grew by more than a third between 2007 and 2009), and solar PV output (which increased almost 15-fold over the two-year period).

- **The most flexible generation technology in the Spanish market remains CCGT generation**, which accounted for close to 50% of total market flexibility in 2009 (defined as the upturn between average generation in the lowest and highest demand decile), above its share of output of less than 30%. By contrast, special regime output only accounted for 14% of flexibility, well below its total output share of 30% - see Annex Figure 8.

- **Integration between the Spanish and Portuguese markets intensified over the 2008-2009 period** with hours of full congestion on the interconnection capacity reduced to 25% in 2009 (down from roughly 80% in the second half of 2007) and the resulting price differential between the two systems falling to roughly 2% in 2009. This can be partially explained by greater convergence in the generation mix of the two markets and an effective cross-border trading mechanism. However, some of the increased price convergence seen since 2008 might also be due to non-structural factors and could be reversed in the future.

- **Integration between the Iberian market and the rest of Europe remained limited, however.** Total interconnection capacity with France remains at less than 1.5 GW (less

than 3% of Iberian peak demand). Moreover, the absence of an effective cross-border mechanism between France and Spain (e.g., market coupling) limits integration between the two markets. For example, in 2008, price convergence between France and Spain was achieved for only 6% of hours. Significantly more interconnection capacity with France (in both imports and exports made) and the introduction of an effective market design are both needed to better integrate the Iberian market with the rest of Europe, and also to optimally manage the growing weight of intermittent renewable generation in Spain.

- **Prices in the Spanish wholesale market have been characterized by high levels of volatility in recent periods**. Annual day-ahead spot prices reached a historical peak of €66/MWh in 2008, but then fell to €38/MWh in 2009, and €30/MWh in the first half of 2010, as demand and fuel prices decreased, and baseload generation grew. Estimated baseload price-cost margins for thermal power plants narrowed considerably in 2009 relative to earlier periods, thus inducing these generators to operate at lower load factors in order to capture higher spot prices - see Annex Figure 9.

- **The wholesale electricity market has become significantly less concentrated in the recent past**, as the result of the continued entry of independent renewable and CCGT generation, corporate restructurings (most notably asset sales by Endesa), and the shift from coal to gas-fired generation (which reduces concentration, since the ownership structure of CCGT plants is more diluted than that of coal capacity). Under a wide definition of the market (including all generation output in Iberia), the market is almost unconcentrated on the basis of conventional thresholds, with an HHI of roughly 1,100 (almost 25% lower than in 2007). Under a narrower and more conservative market definition (i.e., considering only price-setting generation in Spain), the market remains moderately concentrated, with an estimated HHI of approximately 1,450 (over 20% less than in 2007). As a result of these trends, the Spanish market has become less concentrated than several other markets in Europe with the main exceptions of the United Kingdom, the Netherlands and the Nordic countries (see Annex Figures 10 and 11).

The Retail Electricity Market

At the retail level, the electricity market continues to be characterized by limited but growing price liberalization (in terms of customer numbers), slow customer-switching away from the incumbent suppliers, and a significant annual shortfall between regulated revenues and costs (the so-called "tariff deficit"), which reached its highest historical levels during 2008 and 2009.

- **The Spanish retail electricity market remains partially liberalized**, with a significant share of total volumes (more than a third) and customers (more than 80%) purchasing electricity at regulated prices. However, the degree of liberalization has increased rapidly since 2006-2007, thanks to reforms in the tariff deficit mechanism (i.e., the allocation of the deficit to access charges implemented from 2007 onwards), the abolition of high-voltage tariffs and the introduction of TLR (see Annex Figure 12).

- **In terms of market concentration, the Spanish retail market is significantly more concentrated than at wholesale level**, due to the strong position of the incumbent distributors (most notably Endesa and Iberdrola). However, market concentration in the national market has reduced rapidly with the liberalization of the sector in the past two years, with the market HHI falling from over 3,000 in 2007 to roughly 2,200 in 2009.

The presence of extensive price regulation also means that high levels of concentration do not necessarily result in high prices.

- **Consumer switching behavior remains very regional**, as in the retail gas market, with loyalty rates for the main electricity distributors standing at 75%-90% in mid-2009, depending on the network area. This means that very few residential consumers have actually changed electricity providers since market liberalization (even fewer than in the gas market). Switching rates in the Spanish electricity market are below those achieved in several other European markets (most notably in the U.K., Sweden and Netherlands, but also in Germany and Denmark).

- **The defining feature of the Spanish retail electricity market (and indeed of the electricity system as a whole) remains the presence of a large and growing tariff deficit**, due to the persistent annual shortfall between regulated revenues and corresponding costs. The annual tariff deficit hit a peak of over €4.3 billion in 2008, and stood at an estimated net level of €3.8 billion in 2009 (above the annual cap set in Royal Decree Law 6/2009). On a cumulative basis, the debt stood at around €17 billion at the end of 2009, with almost 90% of it yet to be recovered (see Annex Figure 13).

- **The main contributing factor behind the recent increase in the tariff deficit has been the growing level of the remuneration of generation under the special regime** (which includes most of the renewable energy sources). The increase in the total level of special regime subsidies and/or payments between 2007 and 2009 equals or exceeds the level of the net tariff deficit in 2009. More than 60% of the increase in special regime support over this period is in turn due to the payments made to solar photovoltaic (PV) technology (in spite of this technology only providing 8% of total regime output in 2009).

Environmental Policies in the European and Spanish Energy Sector

1. The Economics of Climate Change in the Energy Sector

The need to mitigate the risks associated with climate change is arguably the greatest policy challenge faced by the European and Spanish energy sector at present. Conventional climate change science indicates that there is a strong case for rapidly reducing global greenhouse gas (GHG) emissions over the next four decades so as to avoid the potentially very costly consequences of excessive global warming.

In order to reduce the risk of global temperatures increasing by more than 2 degrees Celsius above pre-industrial levels (which corresponds to the threshold set in the Copenhagen Accord of late 2009), global GHG emissions need to peak within the next decade and start falling rapidly afterwards (e.g., achieving a 50% reduction in 2050 relative to the 2020 peak and a 33% cut relative to 1990).

The implied targets for the European Union are even more stringent, with the need to achieve emission reductions (relative to 1990) of over 20% by 2020, over 40% by 2030, and at least 80% by 2050. The electricity sector in particular is projected to have to shoulder a significant share of the overall abatement effort, due to the possibility for large scale deployment of renewable sources in this sector and the potential to decarbonize other sectors (such as

transport and residential heating). As a result, the European power sector will need to achieve a 70% reduction in emissions by 2030 (relative to 1990) and virtual de-carbonization by 2050 if current environmental targets are to be met.

Economic theory indicates that the most efficient way to reduce carbon emission is to put a price on CO_2, either through a cap-and-trade system (like the European Emission Trading System (ETS)), or through a carbon tax. This can ensure that emissions are appropriately priced, discourage the utilization of carbon-intensive technology and favor production by low or zero-carbon sources (e.g., renewable, nuclear and carbon capture and storage (CCS)). Pricing CO_2 can in principle resolve the main market failure associated with climate change, namely the fact that emitters do not internalize the full social cost of their carbon emissions.

Supplementary environmental policies might be warranted if there are additional market failures that need to be addressed. However, these policies should not be justified simply by the need to reduce emissions, since this is best addressed through carbon pricing alone. For example, in the case of renewable energy, there might be technology spillovers which investors in renewable projects cannot fully appropriate. If these spillovers are significant, they might warrant an R&D and/or deployment subsidy. There might be other social benefits of renewable support (such as reducing external energy dependence or contributing to an effective industrial policy), even though these are likely to be limited if compared to other forms of low-carbon generation (e.g., nuclear and CCS), or other possible competing uses of public funds.

It is important to properly understand and quantify the technological benefits of renewable support, since promoting renewable energy might come at a social cost, both in terms of the overall affordability of energy and the potential distortion of carbon pricing. The latter is due to the fact that promoting renewable energy through specific support schemes rather than through carbon pricing alone could depress the carbon price (relative to a situation without renewable support or with less support), at the expense of competing forms of low-carbon energy (such as nuclear and CCS in particular, and to some extent also CCGTs). It can, therefore, prevent the adoption of a technology-neutral approach to carbon abatement, and raise the social costs of achieving a given emission reduction target. Distributional considerations may, however, be used to justify a policy which does not solely rely on carbon prices to deliver the required levels of GHG emission abatement.

Projections by the International Energy Agency (IEA) indicate that a mixture of abatement mechanisms will be required in the electricity sector to efficiently reduce GHG emissions in the future. These include renewable energy, nuclear power, CCS and efficiency measures. In particular, it is projected that the share of renewable electricity in total generation in Europe needs to increase to slightly over 30% by 2020 and to 43% by 2030. This prospective increase in renewable generation poses significant challenges for the power sector, due to the need to cope with the intermittency of some renewable technologies (most notably wind). Significant back-up thermal capacity will be required to guarantee security of supply under these circumstances. Thermal plants (in particular CCGTs) will need to increasingly operate in a flexible model at low average utilization factors (e.g., 30% or less). For this to be compatible with a market equilibrium, peak prices in the electricity sector will probably need to increase significantly relative to current levels, and the gas and electricity markets will have to operate with greater overall flexibility.

Global action involving all major emitters is required to meet the ambitious abatement targets implied by climate change science. Action by only a limited sub-set of countries will be largely

ineffective, given the international externality associated with global warming. Europe in particular only accounts for a small share of total GHG emissions (less than 15% in 2009), thus implying that decisive environmental measures in Europe, but not by other major emitters, would not yield the desired outcomes.

2. Environmental policies in the European energy sector

Environmental policies in the E.U. energy sector to date have centered on three main pillars: (a) the commitment under the Kyoto protocol to reduce E.U.-15 GHG emissions over the 2008-2012 period by 8% relative to 1990; (b) the adoption of a 12% renewable primary energy target (corresponding to a 21% renewable electricity level) by 2010; and (c) the establishment of the ETS, a cap-and-trade mechanism in place since 2005.

The Kyoto target for Europe is on track to be met comfortably, with E.U.-15 emissions in 2009 estimated to be roughly 13% lower than 1990 levels (in part due to the economic downturn, which contributed to a 7% reduction between 2008 and 2009). On the other hand, renewable electricity in the E.U.-27 is set to fall short of the average 21% target (standing at approximately 18% in 2009, up 6 percentage points since 1990). The introduction of the ETS has been effective in creating a transparent price for CO_2 in Europe, but has also suffered from several deficiencies in its initial design. These have included most notably an over-allocation of permits in Phase I (between 2005 and 2007), which, together with a lack of "banking" across phases, led to a collapse in the CO_2 price during 2007; and the handing out of significant amounts of free permits to emitters in both Phase I and Phase II (which runs until 2012), which led directly to significant windfall gains for thermal generators (see Annex Figure 14).

A number of important measures were adopted in 2008-2009 to define E.U. energy policy towards the environment for the period up to 2020. These include primarily the 20-20-20 climate and energy package, which commits the European Union to achieve the following targets by 2020: a 20% reduction in GHG emissions (relative to 1990); a 20% share of renewable sources in final energy consumption (up from 10% in 2008); and a 20% improvement in efficiency. The GHG emission target was translated into the design of the ETS through a 21% reduction in emission allowances by 2020 (relative to 2005) starting in 2013, together with a move to full auctioning for the power sector (applicable to most member states). The 20% renewable energy consumption target has been translated into binding country targets, which imply that, on average, the share of renewable sources in electricity consumption will need to reach a share of between 33% and 40% by 2020 across member states.

E.U. environmental energy policy until 2020 will therefore keep relying primarily on a mixture of carbon pricing and renewable targets. The effectiveness of carbon pricing may, however, be undermined by the sharp reduction in E.U.-27 emissions experienced in 2009 (which implies that 85% of the required reduction by 2020 was already achieved in 2009), coupled with the possibility of banking emission reductions across phases of the ETS, and the continued significant direct support for renewable energy (which places downward pressure on carbon pricing). Existing estimates for the expected level of carbon pricing in 2020 are in the range of €20-€40/tonne CO_2, which is likely to be insufficient to make investments in additional low-carbon generation (nuclear and CCS) commercially viable.

Thus, there is an economic case for increasing the emission reduction target for 2020 (e.g., to 30% below 1990 levels) in order to strengthen the price signal given by the ETS and also

achieve a more sustainable abatement profile for the 2020-2030 period (when further reductions will be required).

At the same time, it is quite possible that European renewable energy targets for 2020 have been set too high, and, therefore, actual market failures that should be addressed through policies of renewable support (i.e., most notably technology market failures) are not being properly accounted for. This is likely to increase the total costs of achieving a given reduction in GHG emissions in Europe. In order to reduce the risk that the costs of renewable support will become even higher, more extensive reliance should be placed on market-based measures (e.g., capacity tenders and flexible feed-in systems) to determine the level of renewable remuneration.

3. Environmental policies in the Spanish energy sector

Spanish energy policy on the environment in the last decade or so has largely centered on the promotion of domestic renewable resources. To date, Spain has not actively encouraged other forms of low-carbon generation, such as nuclear power, even though its electricity system still relies on nuclear plants to a significant extent. Moreover, whilst this has not been an explicit consequence of environmental policy, the shift in the generation mix from oil and coal to gas-fired plants in Spain has significantly improved the overall environmental performance of the system (by lowering its carbon intensity). However, total GHG emissions in Spain in 2009 were close to 30% in excess of their 1990 level, well above the 15% burden-sharing target agreed upon as part of the implementation of the Kyoto protocol. This can be largely attributed to the significant increase in overall energy consumption in Spain over the period.

Detailed renewable electricity targets have been set by the Spanish government through a series of national planning documents (in 1999, 2005 and 2010). The renewable target for 2010 was set at just short of 30% of electricity consumption (in order to comply with the European renewable energy targets for the same year). For 2020 this target has been increased to just short of 40% of demand.

The 2010 target is close to being achieved, since renewable electricity accounted for just over 27% of consumption in 2009, thanks to continued growth of renewable output (most notably wind and solar) and the reduction in consumption experienced in 2009. Since the market was liberalized in 1998, renewable generation has doubled in Spain (from 38 TWh to 75 TWh), with three quarters of this increase due to wind generation, followed by solar (which accounts for 14% of the overall increase, due to the growth that it experienced in 2008 and 2009). The levels of wind and solar PV capacity in Spain significantly outperform those of other European countries, with the only exception of Germany (which is, however, a much larger market) - see Annex Figures 15 and 16.

The considerable growth of renewable electricity in Spain has been achieved through a system of feed-in tariffs, which has significantly evolved since its inception in 1994. Up to 2007, the feed-in mechanism in place in Spain worked reasonably well and achieved considerable growth in wind generation in particular at a cost that does not appear excessive (in comparative terms, relative to the rest of Europe).

However, the cost of subsidies to special regime generation (which includes most renewable sources) almost trebled between 2007 and 2009 (going from roughly €2.2 billion to over €6 billion), with total payments (i.e., the subsidies plus remuneration from the market) almost

doubling. Most of this increase in subsidies and payments is accounted for by the remuneration of solar PV technology, which increased by approximately €2.4-2.6 billion, following the entry, much faster than expected, of solar plants taking advantage of the subsidy established by the government in mid-2007. Solar PV capacity increased from 0.3 GW in May 2007 to 3.5 GW at the end of 2009 (almost 10 times than the original planning target for solar PV capacity in 2010).

By the end of 2009, the cost of solar PV subsidies accounted for over 40% of the total subsidy to special regime generation (which also includes non-renewable co-generation plants), but solar PV output only constituted 8% of special regime generation. Subsidies to solar PV were cut by almost 40% between late 2008 and mid-2010, whilst still attracting investment in new capacity. This illustrates the fact that the subsidies paid out in 2007-2008 were probably set at excessive levels, since the tariff reduction implemented since then is likely to exceed the drop in costs experienced over the same period.

The Spanish experience with solar PV subsidies represents a vivid illustration of the economic dangers of relying on an imperfectly designed system of feed-in support for renewable generation (with no quantity limit on the total amount of subsidies promised to investors). Whilst a feed-in system can be effective in providing certainty to investors, it also places strong informational demands on policy makers when they set the subsidy level. Costly mistakes can be made (especially if the costs of technology fall more rapidly than expected), resulting in prices being set above costs and investments at those prices being much greater than anticipated (thus increasing the total costs of renewable support).

Primarily as a result of payments to solar PV plants (but also because of the decline in market prices), the total special regime subsidy reached record levels in 2009 (over €6 billion), equivalent to almost 60% of total wholesale market expenditure (defined as total wholesale market volumes times the final wholesale market price). The subsidy per unit of avoided CO_2 emissions achieved by renewable generation in Spain in 2009 can be estimated at €200-€250/tonne CO_2, 14 to 17 times above the current market price for CO_2 (which in principle measures the social benefit of carbon abatement). This suggests that the overall subsidy levels paid in 2009 are likely to be in excess of the social benefits of promoting renewables (over and above their direct environmental impact, which, as discussed above, should be reflected in carbon pricing alone) - see Annex Figure 17.

The increase in the level of the special regime subsidies and overall payments since 2007 has exacerbated the problem of the electricity tariff deficit, as noted above. The recent increase in the cost of renewable support has led to the emergence of a largely structural wedge between regulated costs and revenues, since special regime feed-in tariffs are fixed for long periods of time (i.e., typically 20 to 25 years). Moreover, any retroactive measures to reduce the cost of renewable support would undermine the regulatory credibility of the system and were largely avoided by the Spanish government (as of November 2010[3]) (see Annex Figure 18).

The evolution of the overall generation mix in Spain will determine the ability of the market to efficiently comply with environmental targets. At present, nuclear generation is a key technology in terms of the containment of carbon emissions, since it accounts for over 40% of

[3] A retroactive measure in relation to PV feed-in tariffs in particular was adopted by the government in December 2010, through RDL 14/2010.

total carbon-free electricity in the market. Most Spanish nuclear plants will come to an end of their useful lives in the 2020s. A key decision to be taken for the post-2020 period will therefore be whether to extend the useful life of this capacity (e.g., by an additional 20 years). There is an economic and environmental case for doing so in order to reduce the total costs of carbon abatement in Spain and rely on a portfolio of technologies to reduce emissions. The extension of the useful lives of nuclear plants is likely to generate additional economic rents for the current owners of these plants. In due course (i.e., as the end of the current 40-year-life approaches), these could be evaluated and clawed back in order to partially finance the cost of renewable support (along the lines currently being proposed in Germany). These issues ought to be assessed in the context of a broader review of the case for extending the useful life of nuclear capacity beyond the 2020s.

CCGT and coal generation remain central and competing technologies in the transition to a low-carbon power system, especially as sources of flexibility. The increase in CO_2 prices since 2007, coupled with the reduction in demand, has severely hit the production of coal plants (especially less efficient plants burning domestic coal). This is largely a market response to the signal provided by carbon pricing. The Spanish government is, however, seeking to artificially support the production of power plants using domestic coal through specific legislation (enacted in October 2010 after receiving E.U. state aid approval). This measure risks significantly distorting the market (at the expense of more efficient imported coal and CCGT plants) and increasing system costs at a time when overall revenues are already insufficient to cover total costs.

CCGT generation in Spain is an increasingly important source of system flexibility, especially as a back-up for intermittent renewable generation. As renewable capacity increases further in the future, the load factors of CCGT plants are expected to decline. For this to be compatible with market equilibrium, spot market prices at peak times are likely to need to increase significantly to allow existing plants to cover their annual fixed costs (including gas access charges). For this to be possible, the current price cap in the spot market (set at €180/MWh) should probably be revised and the mechanism for the pricing of congestion relief services should also be improved. Moreover, the current level of capacity payments in Spain approximately covers fixed operating and maintenance costs for a period of 10 years, but not other types of fixed costs (including gas TPA charges and capital costs). It might therefore not be sufficient to promote security of supply and it might also need to be reviewed.

Conclusions: Main Policy Challenges in the Spanish Gas and Electricity Markets

The Spanish gas and electricity markets remain in a state of flux. They have been subject to a number of interrelated market and regulatory ‘shocks’ in recent years that have affected their performance and are also likely to shape future developments.

In some ways, the public policy issues faced by the Spanish gas market are less complex than those present in the electricity market. The main challenge at the wholesale level is posed by the continuing convergence between the gas and electricity markets. This means that the gas market will have to become increasingly flexible in the future as the demand of gas-fired electricity generators becomes more volatile. Greater flexibility of the Spanish gas system will

be key to the efficient integration of growing levels of renewable electricity in the Spanish energy system.

These considerations imply that greater levels of domestic gas storage and interconnection with the rest of Europe will be required. Underground gas storage in Spain is limited and well below the levels present in other major European markets. Investments in this type of facility are crucial, therefore, and should be a key focus of future infrastructure plans. Similarly, greater export capacity towards France would allow the Spanish gas system to use gas more efficiently and cope better with domestic demand volatility. The creation of an effective single domestic gas hub would also help achieve greater flexibility in the domestic gas market and should be an important aim of future reforms of the design of the Spanish gas market.

At the retail level, the main challenge is still the imperfect degree of liberalization of the residential gas market in 2009. A significant number of customers remain on regulated TLR and, at the regional level, only 15% of customers have actually switched supplier since the market was opened to competition. More effective dual-fuel competition is required to render the gas market more dynamic and encourage further liberalization.

The Spanish electricity market continues to be characterized by complex and increasingly controversial public policy challenges. These are the result of past policy failures (most notably the emergence of a large tariff deficit since 2002) and new pressures on the system coming from the need to comply with increasingly stringent environmental objectives. The two issues have become closely related in recent times, since the increase in the cost of support to renewable electricity is one of the main determinants of the current level of the annual tariff deficit.

The central policy issue in the electricity market over the short to medium term is, therefore, how to contain and gradually eliminate the current shortfall between regulated costs and revenues. Given the large size of the accumulated debt and current deficit, action is likely to be needed on both the revenue and cost sides.

In terms of regulated revenues, a credible, gradual program of increases in access charges is necessary to move tariffs towards a more sustainable level (contrary to the strategy pursued in 2010, which did not increase electricity access charges).

In terms of regulated costs, an effective and economically coherent way to reduce the level of costs borne by the electricity system would be to shift part of the costs of renewable support to a broader base of contributors (e.g., all taxpayers or all energy consumers). This measure would be justified by the fact that promotion of renewable electricity has a social value in the context of action against climate change that benefits the entire population, not just electricity consumers. In the future (i.e., after 2013), part of the costs of renewable support could also be financed by proceeds from auctions of emission permits.

The case for acting on market-determined energy costs (e.g., clawing back potential super-normal profits accruing to baseload generation) rests on an inherently complex legal and economic evaluation which would need a specific assessment that is beyond the scope of this report. However, implementing a measure of this kind entails significant risks, since it has the potential to undermine the principles behind market liberalization.

Nonetheless, as discussed, future rents arising from the potential extension of the useful life of nuclear plants could be transferred to the government in due course. Moreover, a final

settlement of the stranded cost payments (*costes de transición a la competencia*, CTC) made to generators between 1998 and 2006 might lead to a one-off reduction in energy costs if it turns out that there was over-compensation.

There are several other challenges faced by the Spanish wholesale electricity system that require specific policy responses. These include:

- The need for a better and more market-based design of the feed-in system for renewable producers as a way of reducing the risk of excessive compensation being paid to new investors.
- The review of nuclear policy, especially with respect to the desirability of extending the current 40-year lifetime of nuclear plants beyond the 2020s.
- The need for an economically coherent policy towards the domestic coal industry to avoid distorting the rest of the electricity market and increasing the costs of the system, which seems to be the likely result of current legislation.
- The prospect of more effective integration with the rest of Europe, which requires greater interconnection capacity and a better market design (e.g., a market coupling arrangement with France).
- Possible changes in the design of the wholesale electricity market (e.g., with respect to peak prices, capacity payments and congestion pricing) to allow thermal plants to efficiently cover their operating costs and face continuing incentives to provide the required levels of system flexibility.

At the residential electricity level, the main policy issue remains the progress of market liberalization, which has been even slower than in the residential gas market. This can be largely attributed to the distortion historically caused by the tariff deficit. The move to the *ex ante* deficit (which shifted the deficit to the access component of the tariff, leveling the playing field in retail competition) and the introduction of TLR has rendered the residential market more dynamic, as indicated by recent data on switching rates. However, the experience of the gas market suggests that residential switching costs can be considerable, and that even the elimination of some of the regulatory distortions might not be sufficient to reduce residential concentration levels. Over time, the greater scope for dual-fuel competition rendered possible by removing some of the distortions in retail electricity will hopefully enable the residential gas and electricity markets to become more dynamic, thus allowing for full price liberalization.

Annex: Tables and Figures

Table 1

Key European antitrust cases in the energy sector, 2007-2010

Firm	Alleged conduct	Status
Distrigaz (Suez)	Foreclosure of Belgian gas market through long-term contracts.	Commitment to 30% cap on long-term contracts in October 2007.
E.On (electricity)	Output withholding and vertical foreclosure in the German electricity balancing market.	Divestment of 5GW of generation capacity; and sale of electricity transmission network in November 2008.
RWE	Foreclosure of the German gas market through refusals to supply and margin squeeze.	Divestment of RWE's gas transmission network, accepted by the Commission in March 2009.
ENI	Foreclosure of the Italian gas market through quality degradation, hoarding and under-investment.	ENI has committed to divest its stakes in the relevant gas pipelines. The Commission accepted this commitment and closed the investigation in September 2010.
E.On – GDF/Suez	Market-sharing agreement in the French and German gas market between the incumbents in place until 2005.	Parties fined €553m each for infringement of Article 81 (horizontal agreement) in July 2009.
EDF	Foreclosure of the French electricity market for industrial users through long-term contracts.	EDF has committed to release to the market 65% of the electricity it contracts with large industrial users in France each year. Commitment accepted by the Commission in March 2010.
SvK (Swedish TSO)	Limits on interconnection capacity in order to reduce domestic congestion.	Commitments offered to increase effective interconnection capacity. Accepted by the Commission in March 2010.
GDF/Suez	Foreclosure of the French gas market through long-term reservations of import capacity and underinvestment.	Commitment to release a significant share of long-term bookings, and reduced share of GDF to below 50% Accepted by the Commission in December 2009.
E. On (gas)	Concern that competitors foreclosed by long-term capacity bookings.	Commitment to 'significant, structural' reduction of long-term reservations offered by E.On in December 2009, and accepted by the Commission in May 2010.
Electrabel (GDF/Suez)	Foreclosure of the Belgian retail electricity market through long-term contracts.	Proceedings initiated in July 2007. Case dropped by the Commission in February 2011.

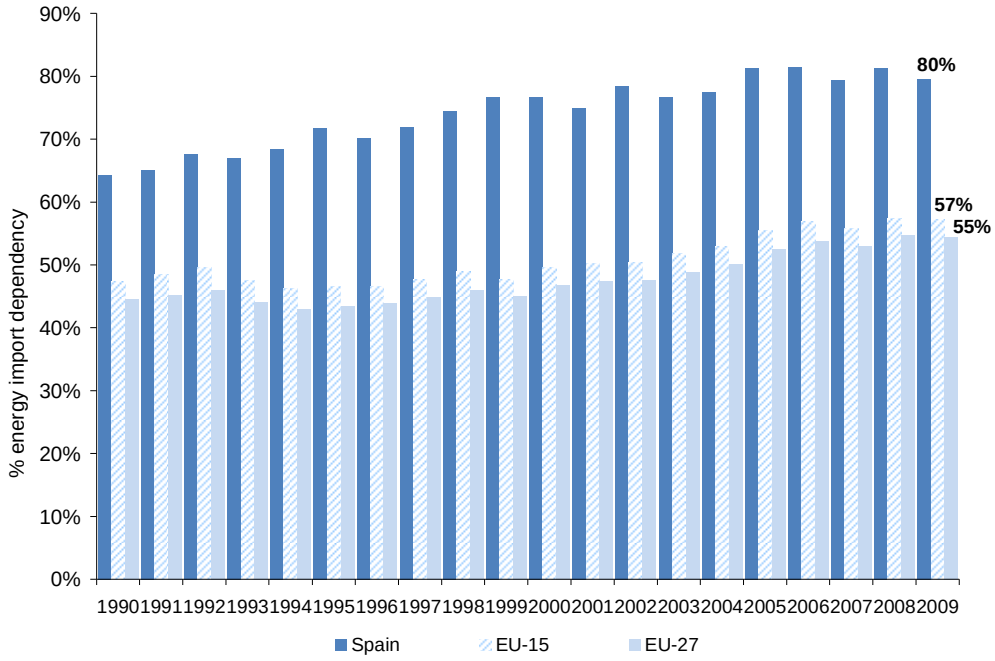
Table 2

Summary of Key Regulatory Reforms in the Spanish Gas and Electricity Markets, July 2008-October 2010

Item	Date	Description
Tariff of Last Resort in Gas Sector	July 2008	Tariff of last resort introduced in the residential gas sector for all consumers with annual requirements below 3GWh. Consumption threshold lowered to 50 MWh from July 2009.
Subsidies to PV solar energy (RD 1578/2008)	Sept. 2008	Subsidy regime for photovoltaic installations reformed, reducing the level of subsidies and introducing a quota-based system to determine the future remuneration of solar PV plants.
Completion of VPP program	March 2009	The 7th and last Virtual Power Plant auction was held in March 2009, for the period April 2009-March 2010. Overall seven VPP auctions were held since June 2007, reaching a maximum total affected capacity of 2.4-2.5 GW during the second half of 2009.
Reform of Tariff Deficit (RDL 6/2009)	April 2009	Binding limits introduced on annual deficits for the period 2009-2012. Deficit to be eliminated by January 2013. Past deficits (up to €10,000 million) and future deficits to be backed by sovereign guarantee. Electricity system costs associated with supply to islands gradually transferred to the general budget. Abolishes recovery of windfall gains associated with carbon pricing and free emission allowances from July 2009. Introduces social tariff obligation on electricity suppliers.
OCSUM (RD 1011/2009)	June 2009	Establishes Office of Retail Switching (*Oficina de Cambios de Suministrador, OCSUM*), tasked with supervising residential switching in the gas and electricity markets. Also provides for unconditional access to information on consumer details to competing suppliers.
Tariffs of Last Resort in Electricity Sector	July 2009	Tariffs of last resort introduced in the residential electricity sector, for consumers with capacity below 10 kW. Penalties introduced for large residential and SME consumers that do not switch to the liberalised market.
Support of Domestic Coal (RD 134/2010 and 1221/2010)	Feb. and Oct. 2010	Approval of decrees aimed at maintaining a minimum level of output for domestic coal plants, by modifying the economic merit order in the generation market. The European Commission granted state aid approval in September 2010. Final legislation was introduced in October 2010.

Figure 1

Evolution of energy import dependence, 1990-2009



Source: Eurostat, 2010.

Figure 2

Evolution of VPP volumes (baseload and peak combined), Q3 2007 – Q1 2010.

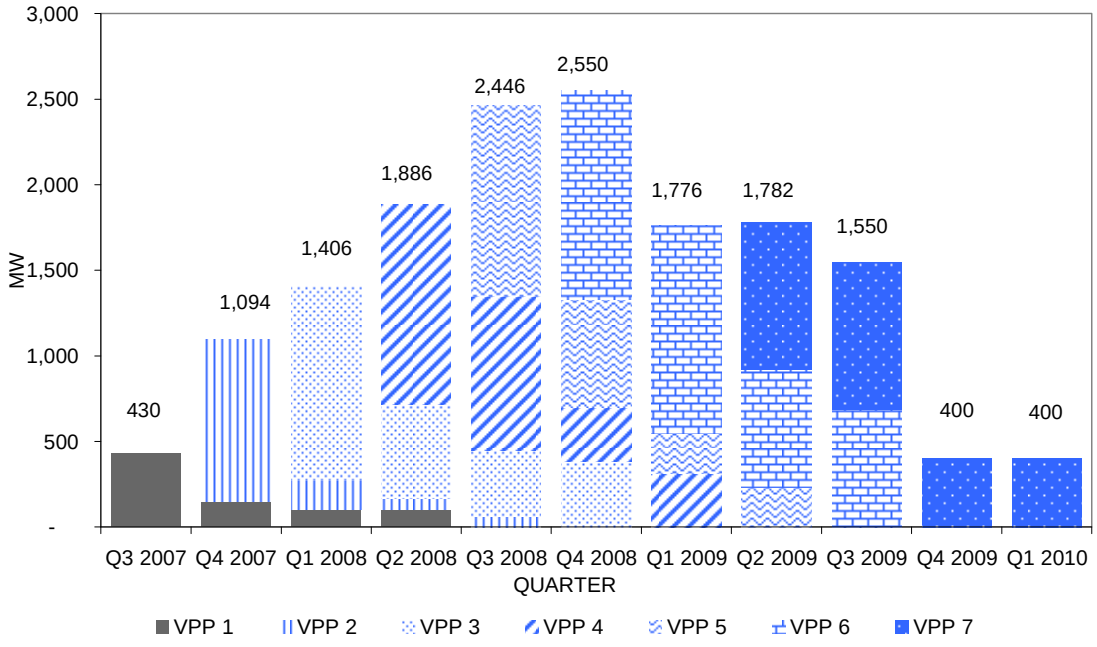
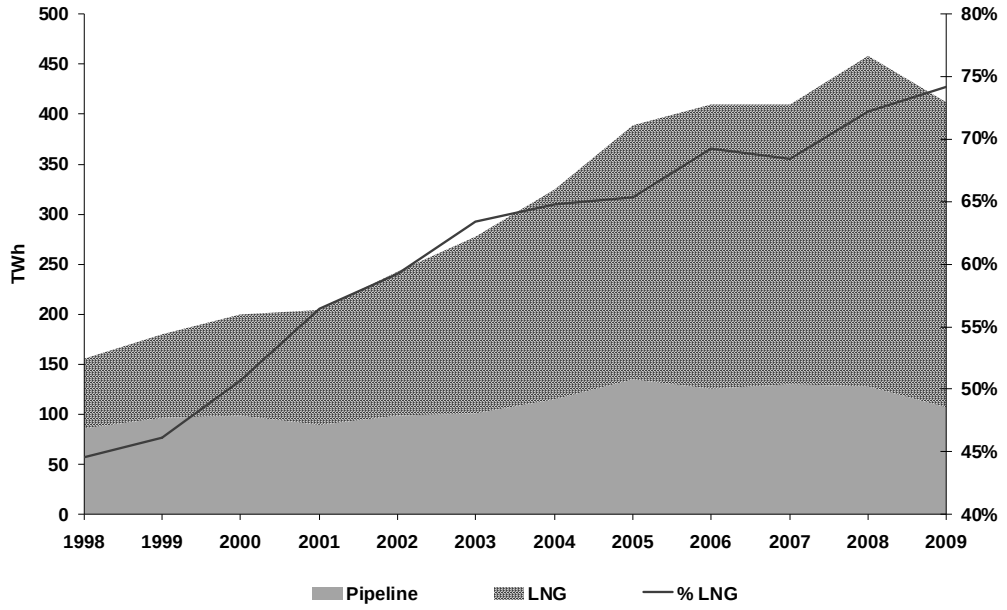


Figure 3

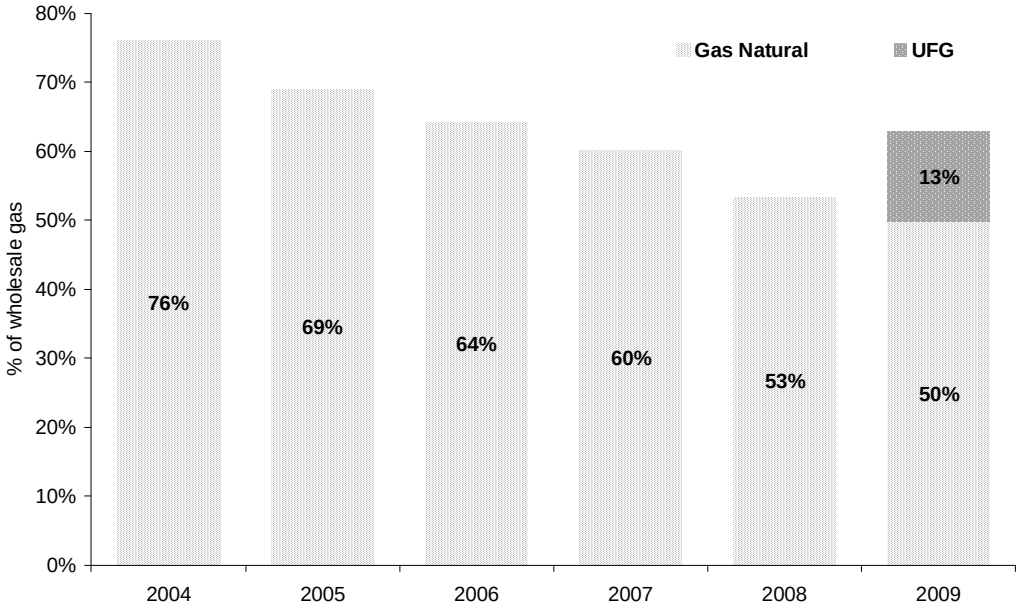
Evolution of volumes in the Spanish gas wholesale market, 1998-2009



Source: CNE, Enagás.

Figure 4

Evolution of Gas Natural's share of the wholesale gas market, 2004-2009

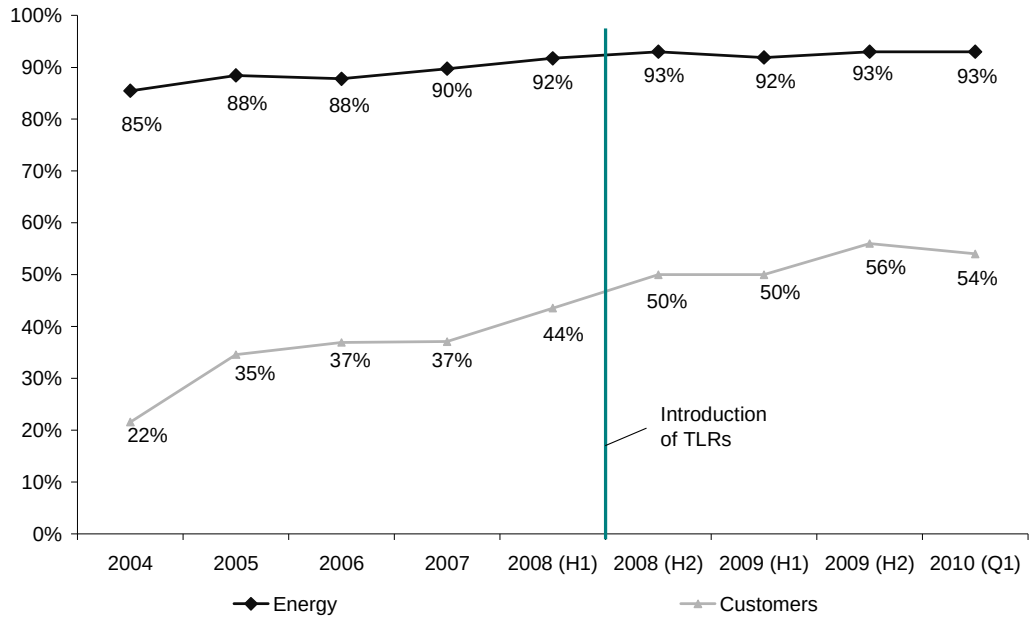


Source: Gas Natural, CNE.

Note: Gas Natural's share of wholesale gas is computed as the sum of its retail sales, sales to third parties and sales to the regulated market.

Figure 5

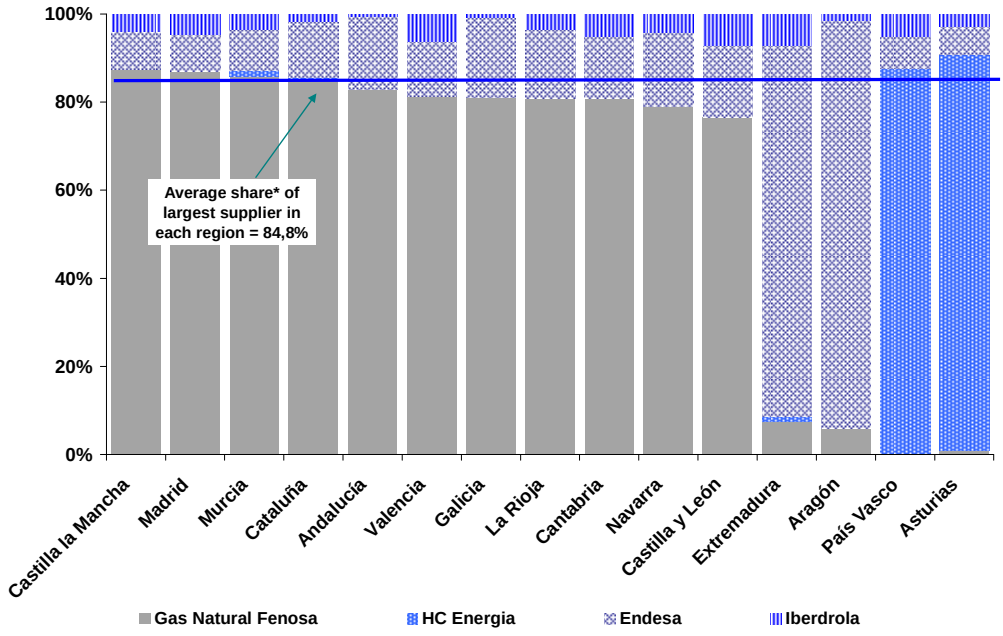
Share of the retail gas market on market-determined prices



Source: CNE.

Figure 6

Regional shares in the gas retail market, by customer number in 2009

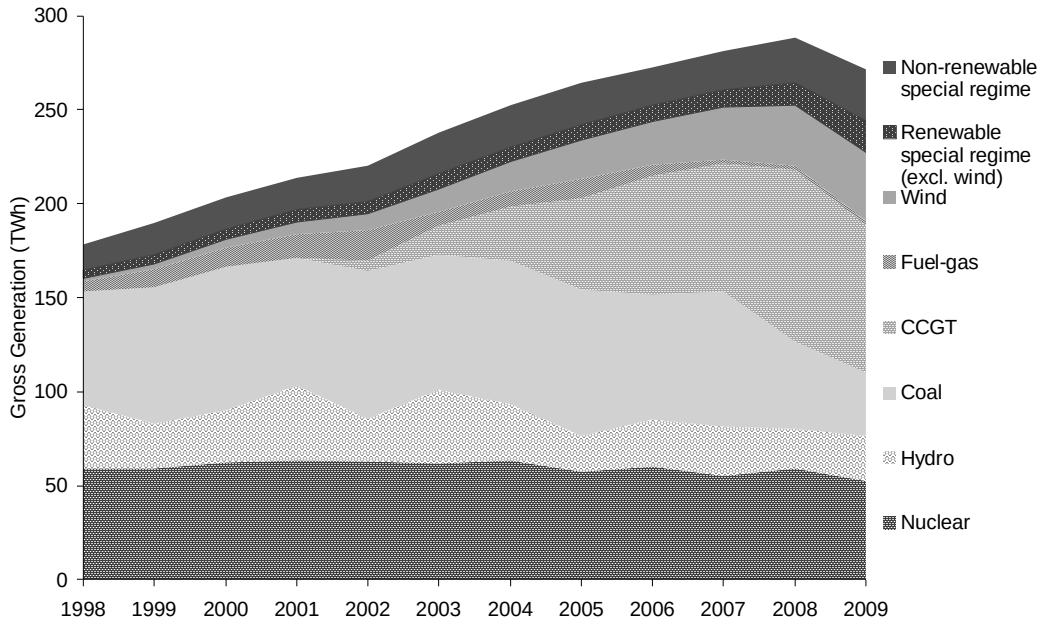


* Weighted average by number of customers in each region

Source: CNE.

Figure 7

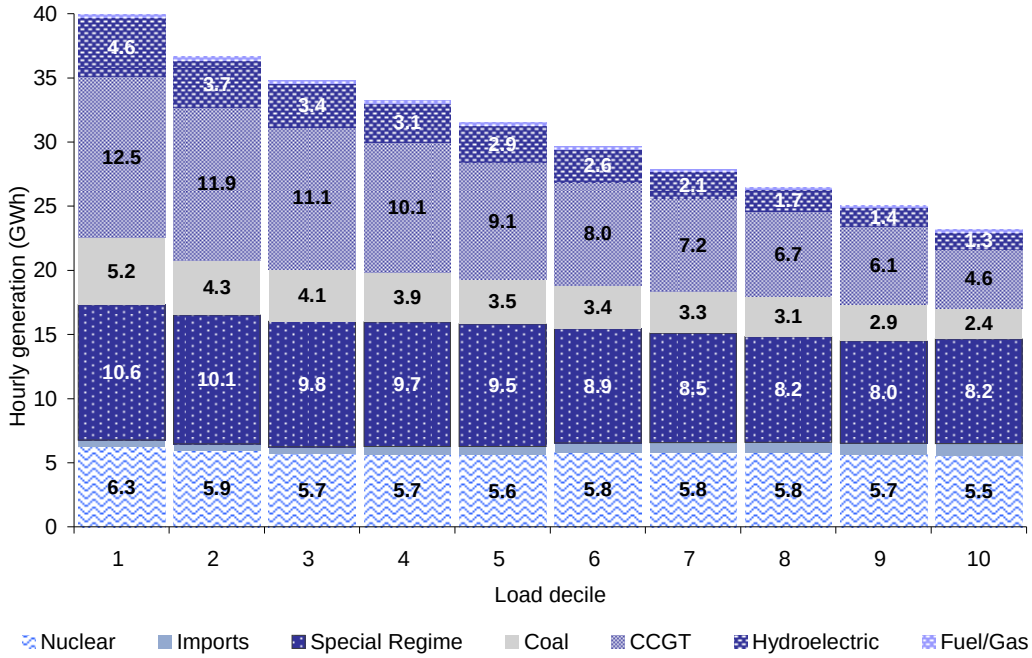
Evolution of generation output by technology, 1998-2009 (mainland Spain)



Source: REE

Figure 8

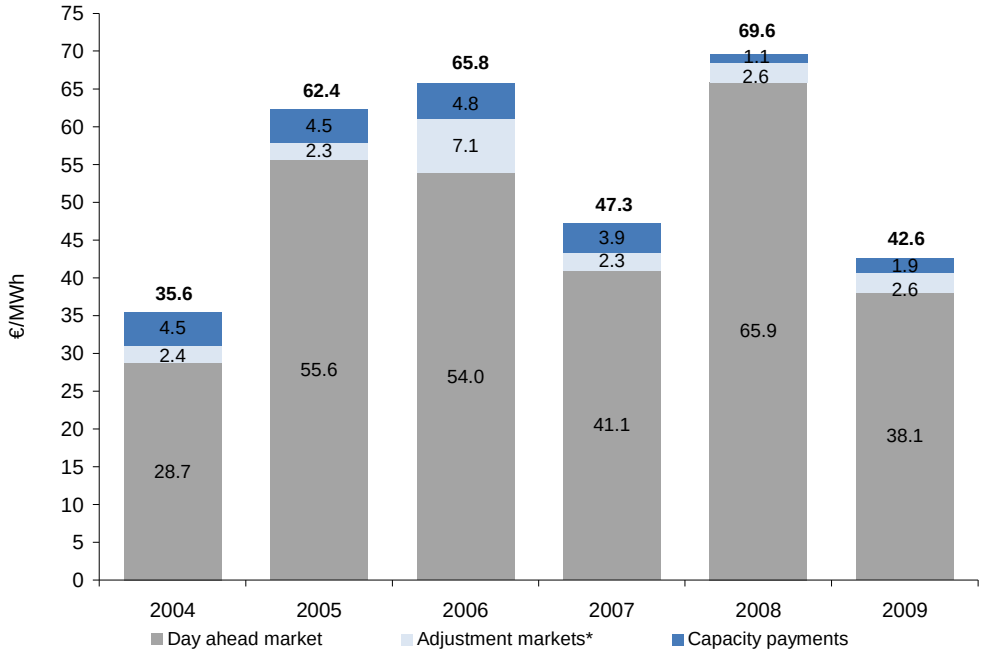
Average hourly generation levels by technology in each demand decile (from highest to lowest) in 2009, GWh



Source: REE; own analysis.

Figure 9

Evolution of wholesale electricity prices, 2004-2009

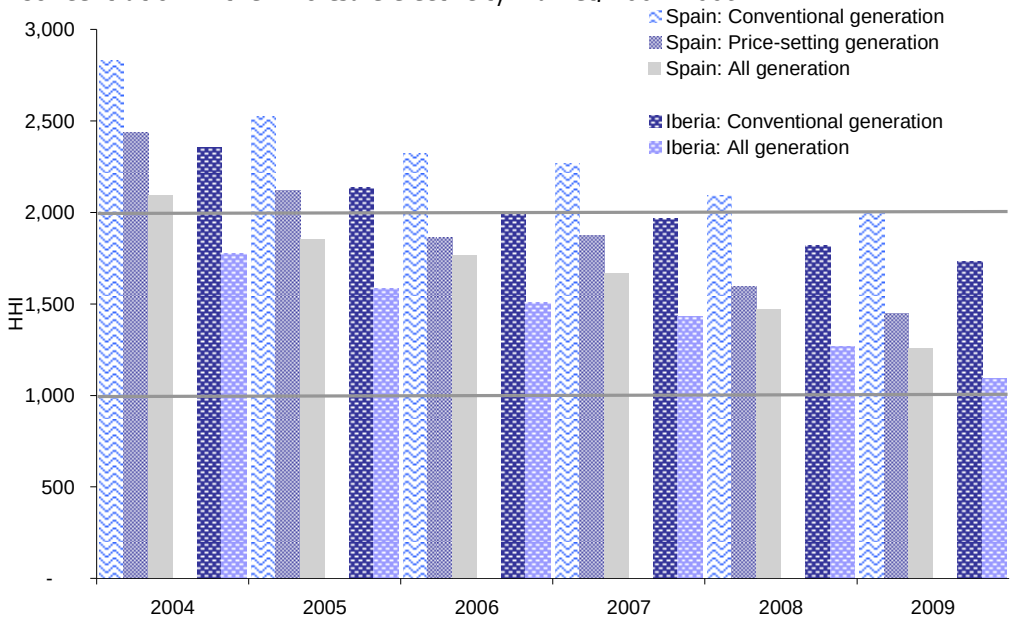


* Adjustment markets include intra-day, congestion relief and balancing markets.

Source: REE.

Figure 9

Concentration in the wholesale electricity market, 2004-2009

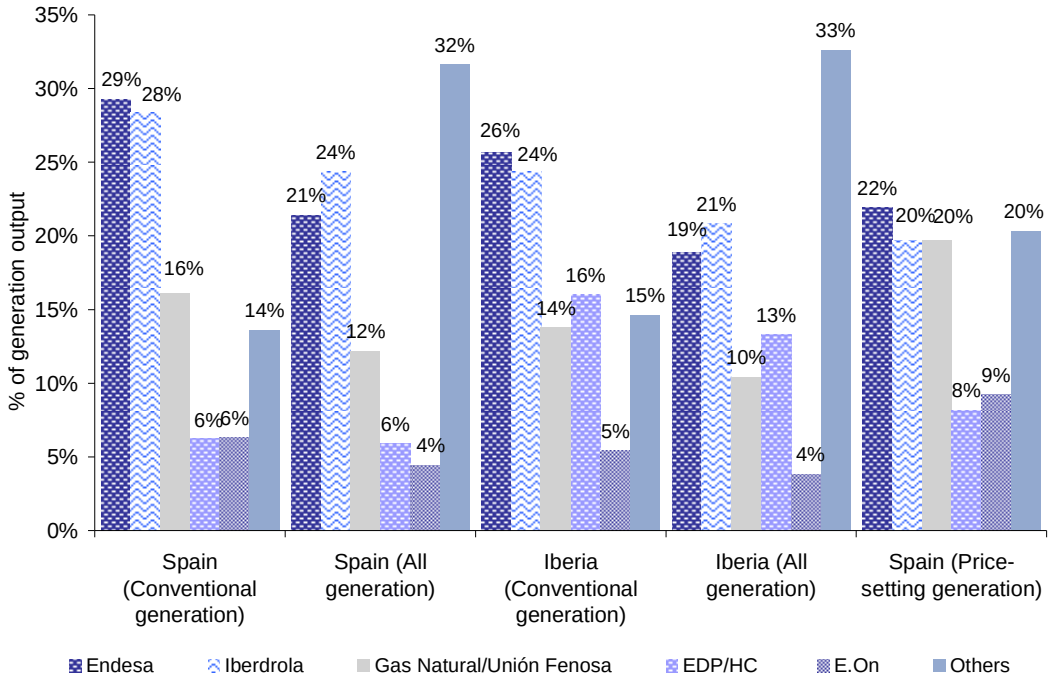


Source: REE; REN; company annual reports; own analysis.

Note: Price-setting generation is defined as all generation except nuclear, special regime and run-of-river hydro (estimated at an average hourly output level of 1.3 GW). The HHI estimates incorporate the impact of the Gas Natural/Unión Fenosa merger (and associated remedies) from January 2009, and the sales of assets from Endesa to Acciona from July 2009 (as reflected in Endesa's 2009 Annual Report). The HHI is computed on the basis of the market shares of the six largest firms in terms of conventional output.

Figure 10

Generation market shares by firm, 2009

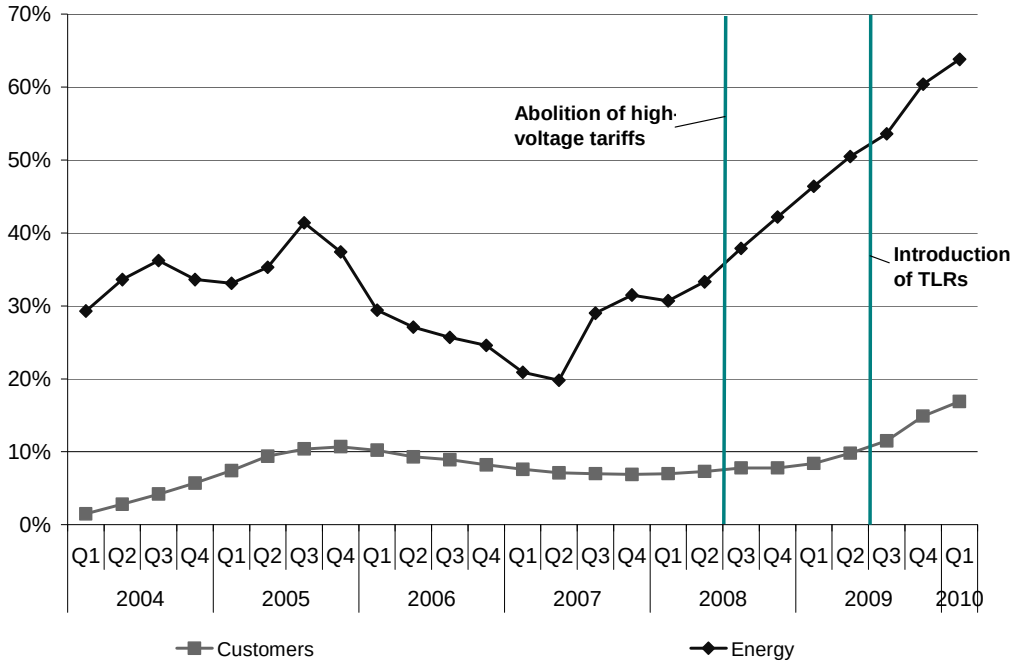


Source: REE; REN; company annual reports; own analysis.

Note: price-setting generation defined as all generation except nuclear, special regime and run-of-river hydro (estimated at an average hourly output level of 1.3GW). Shares incorporate the impact of the Gas Natural/Unión Fenosa merger (and associated remedies) from January 2009, and the sales of assets from Endesa to Acciona from July 2009 (as reflected in Endesa's 2009 Annual Report).

Figure 11

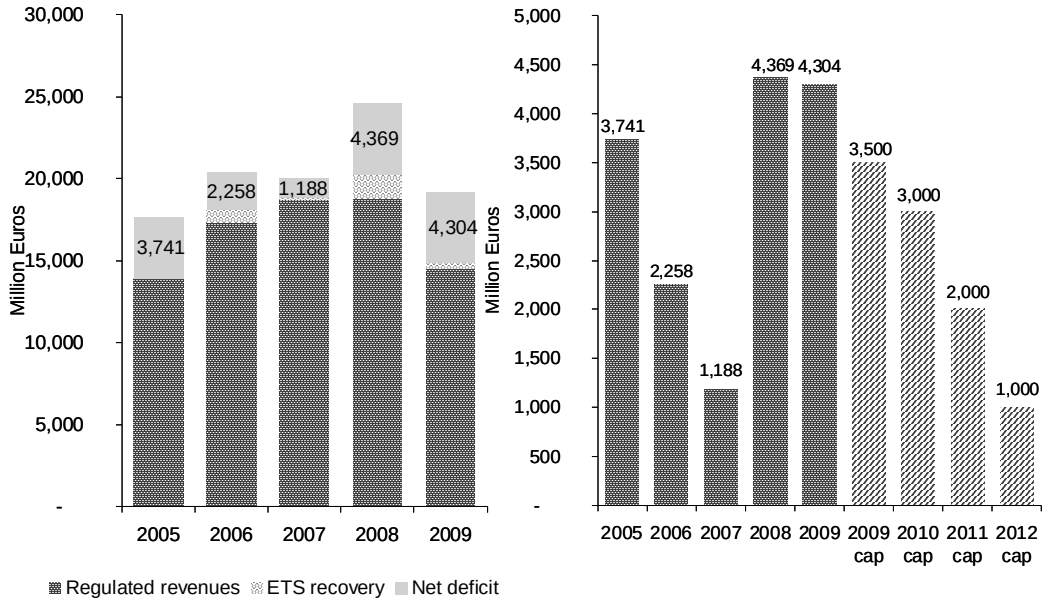
Share of the retail electricity market on market-determined prices



Source: CNE.

Figure 12

Evolution of the annual electricity tariff deficit 2005-2009, and deficit caps for 2009-2012.

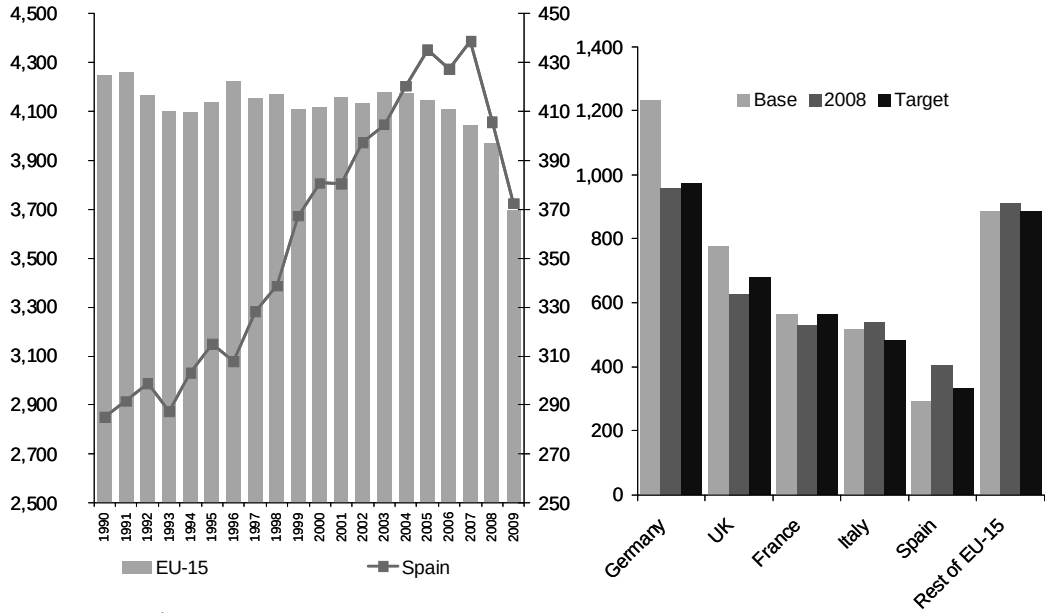


Source: CNE.

Note: annual deficits include the costs associated with annuity payments on past deficits. "Emission Trading System (ETS) recovery" refers to the expected revenues from collecting the windfall gains associated with the introduction of carbon pricing and free emission allowances, as set out by Spanish legislation applicable until June 2009. Estimated deficit for 2009 to be reduced to approximately € 3,800 million, in light of the adjustments computed by the CNE.

Figure 13

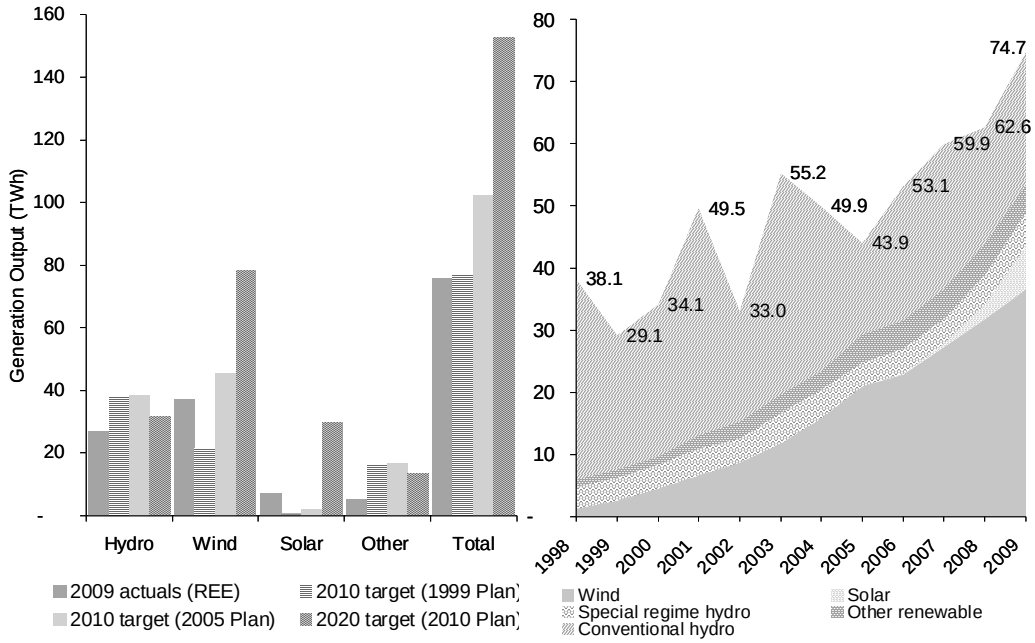
European performance under the Kyoto targets, 1990-2009 (million tonnes of CO_2-eq.)



Source: EEA; ETC/ACC; Ministerio de Medio Ambiente.

Figure 14

Renewable generation levels and targets, 2009, 2010 and 2020 (left-hand panel); and the evolution of renewable generation in mainland Spain, 1998-2009 (right-hand panel) (TWh).

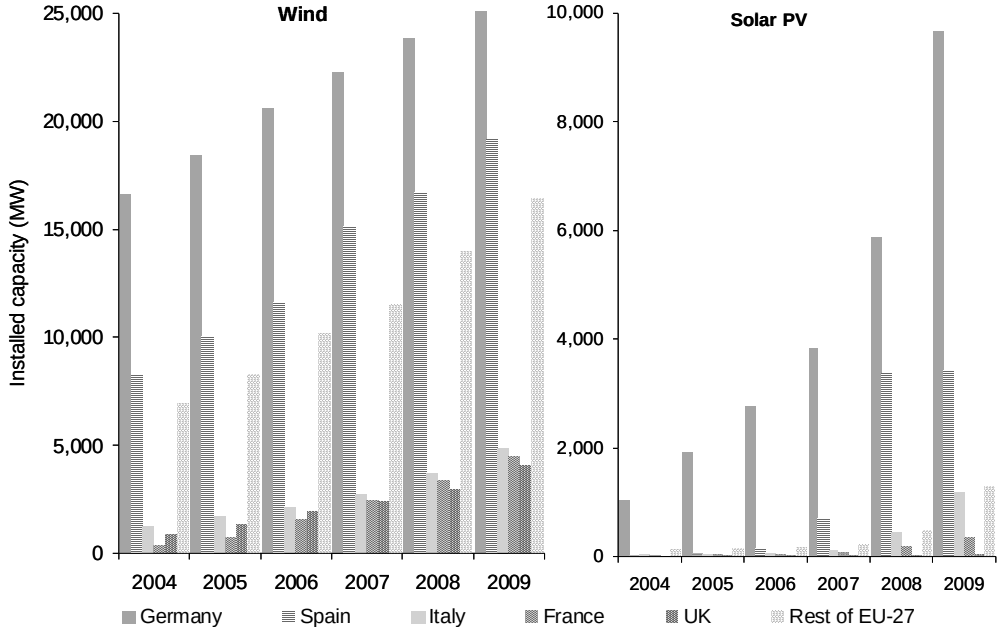


Source: PFER 1999, PFER 2005, PANER 2010, REE.

Note: conventional hydroelectric energy excludes an estimate for pumped storage generation (set at 70% of pumped storage consumption).

Figure 15

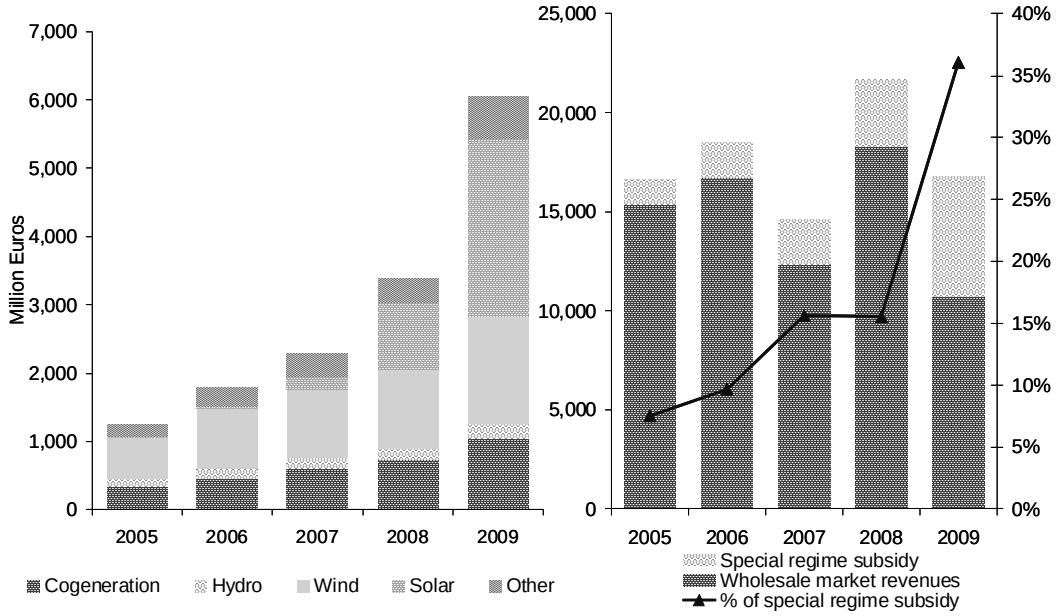
Evolution of wind and solar PV capacity in Spain and other EU-27 countries, 2004-2009.



Source: EWEA for wind data; BP Statistical Review of World Energy for solar PV data.

Figure 16

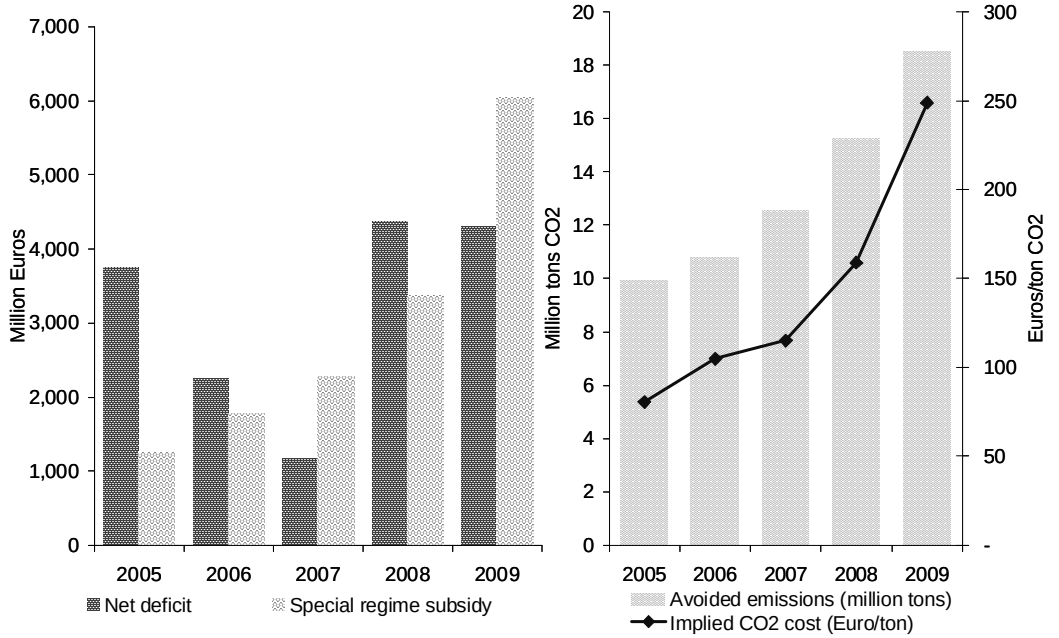
Evolution of the subsidy to special regime generation, 2005-2009



Source: CNE

Figure 17

Size of the special regime subsidy, in relation to (a) tariff deficit; and (b) avoided CO2 emissions



Source: CNE; own calculations.

Note: assumes that emissions avoided through renewable special regime correspond to avoided CCGT generation, with an emission factor of 365 g CO_2/kWh. Computes the cost of CO_2 abatement through renewable support based on the renewable subsidy levels.