Decarbonizing the EU power sector: policy approaches in the light of current trends and long-term trajectories

Spencer, Thomas ; Marcey , Celine; Colombier , Michel and Guerin , Emmanuel
Institute for Sustainable Development and International Relations

15. November 2011

Online at http://mpra.ub.uni-muenchen.de/35009/
MPRA Paper No. 35009, posted 25. November 2011 / 16:24

WORKING PAPER
N°13/11 NOVEMBER 2011 | CLIMATE

Decarbonizing the EU Power Sector

Policy Approaches in the Light of Current Trends and Long-term Trajectories

Thomas Spencer, Céline Marcy,
Michel Colombier, Emmanuel Guérin (IDDRI)

ASSESSMENT
European climate policy is gradually shifting towards a long-term perspective. The electricity sector has a crucial role to play in the long-term decarbonization of the EU economy. It makes up a significant share of EU emissions and can contribute to the reduction of emissions in other sectors, particularly buildings and transport. The EU 2008 Climate and Energy Package (CEP) took a significant step towards a low-carbon future, initiating a very ambitious program of renewables expansion and strengthening the ETS. However, the omissions and internal inconsistencies of the CEP are becoming more and more evident. This relates in particular to the absence of long-term, comprehensive signals for decarbonization and the imbalance between the ETS, energy efficiency and renewables objectives. This risks delaying and distorting investment in low-carbon infrastructure and ideas, raising the ultimate cost of climate policy.

RECOMMENDATIONS
In view of the inertias within the electricity sector, it is imperative for the EU to set a long-term signal for the decarbonization of the sector by setting 2030 objectives for the ETS and complementary policies. The EU's decarbonization strategy needs to be robust against future uncertainties; strengthening a technology neutral instrument like the ETS can provide a key part of a comprehensive signal to develop the full range of decarbonization options. The instrument imbalance also needs to be addressed. Demand side policies should be the point of departure for supply side interventions: ETS caps should be set so as to achieve carbon scarcity after energy efficiency and RES objectives have been taken into account. A short-term adjustment of scarcity in the ETS may create some incentives for low-carbon investment. However, it would not address the fundamental concern, namely the lack of policy information regarding the post 2020 environment in which these investment will amortize.

www.iddri.org

Institut du développement durable
et des relations internationales
27, rue Saint-Guillaume
75337 Paris cedex 07 France

DISCLAIMER

This paper is part of the Project "Is there a case for the EU moving beyond 20% GHG emissions reduction target by 2020?" convened by Climate Strategies. Reports and presentations pertaining to this project are available at http://www.climatestrategies.org/research/our-reports/category/57.html

ABOUT CLIMATE STRATEGIES

Climate Strategies is an international organisation that convenes networks of leading academic experts around specific climate change policy challenges. From this it offers rigorous, independent research to governments and the full range of stakeholders, in Europe and beyond.

Climate Strategies c/o University of Cambridge
http://www.climatestrategies.org»www.climatestrategies.org

PUBLISHER
Publisher i.e. Climate Strategies 2011
For citation: Spencer, T., Colombier, M. and C. Marcy, "Decarbonizing the EU Power Sector - Policy Approaches in the Light of Current Trends and Long-term Trajectories", Paris: IDDRI and Climate Strategies, 2011.

☆☆☆

AUTHORS
For more information about this document, please contact the authors:
Thomas Spencer thomas.spencer@iddri.org
Céline Marcy celine.marcy@iddri.org
Michel Colombier michel.colombier@iddri.org
Emmanuel Guérin emmanuel.guerin@iddri.org

Decarbonizing the EU Power Sector
Policy Approaches in the Light of Current Trends and Long-term Trajectories

Thomas Spencer,
Céline Marcy, Michel Colombier,
Emmanuel Guérin (IDDRI)

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION AND CONTEXT

In October 2009, the EU agreed to a reduction of greenhouse gas emissions (GHGs) of 80-95% by 2050, against 1990 levels (European Council, 2009). Among EU Member States and internationally, the paradigm is gradually shifting away from marginal emissions reductions towards long-term, low-carbon development (THINK, 2011; Neuhoff, 2011). The EU's long-term objective therefore casts European climate and energy policy into a fundamentally new light. It is no longer sufficient to attain the EU's 2020 objectives; rather, policies for the short-term (2020) must place the EU on an economically feasible trajectory towards its 2050 objective.

A number of recent studies have analyzed the achievement of ambitious decarbonization objectives by 2050 within the EU (ECF, 2010; IEA, 2010; Eurelectric, 2011; EC, 2011). They all agree that such an objective is technically attainable under a variety of technology/policy scenarios. They also agree that a particularly significant role must be played by the electricity sector, due to its dominant share of EU emissions;[1] and the lower marginal abatement costs in this sector, which could allow it to adopt much of the effort of decarbonizing other sectors, notably transport and heating/cooling.

The electricity system requires synchronous balancing of supply and demand. Demand is relatively inelastic, especially in the short term, and therefore supply must follow demand.[2] Rigorous demand side policies will be required to allow the electricity sector to adopt much of the decarbonization effort in other sectors at manageable investment costs. However, both the scale and timing of electrification are uncertain, as are the adoption and ultimate effectiveness of demand reduction policies. Demand side policies interact in turn with supply related policies, such as the ETS and RES policies by impacting the scarcity and hence the price of carbon in an ETS. This interaction can place both upside and downside pressure on the carbon price, depending on the actual success of demand side policies and the *ex ante* calibration of the ETS and energy efficiency policies.

Demand scenarios therefore form the essential point of departure for policies related to the supply of low-carbon electricity. This paper therefore takes as a starting point the role of demand-side efforts in the decarbonization of the electricity sector. Its objective is to assess the coherence of the current policy framework in the electricity sector with the decarbonization agenda of the EU. It is structured as follows. Section 1 begins with the *status quo*: it examines recent investment trends in the EU electricity sector, and the key drivers for investment. Section 2 briefly describes key features common to the published studies on decarbonizing the EU power sector. Section 3 then examines in more detail the demand side of the decarbonization equation, in particular the role of demand reduction in the transition. On the basis thereof, section 4 examines the supply side of the equation, drawing out the policy implications of high inertias and uncertainties in the sector. Section 5 then zooms in on the policy context, focusing in particular on the transformational signals sent by the policy mix. Section 6 concludes with policy recommendations.

1.CURRENT INVESTMENT TRENDS AND GENERAL SECTORAL CONTEXT

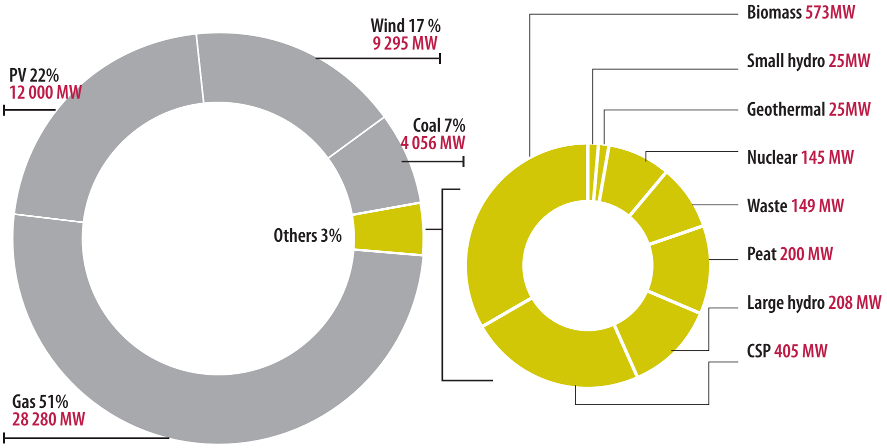
This section briefly gives the context for the following discussion of decarbonization in the electricity sector. It displays recent investment

---

[1] ~32% of EU27 CO2 emissions

[2] This could change in the long-term depending on the introduction of advanced demand side management.

Figure 1. Newly installed capacities in Europe in 2010



trends, and breaks down the scale and drivers of future BAU investment needs by decade (2010-2020 vs. 2020-2030) and region (Western vs. Eastern Europe).

1.1. Investment trends

Over the last two decades, investment in the EU power mix has been marked by two dominant trends. The first was a continual increase in total electricity demand, of roughly 75% between 1990 and 2008 (Eurelectric, 2010, pp. 10). The second has been a dramatic expansion in gas and RES in the electricity supply. Gas has seen the most dramatic growth, by roughly 420% between 1990 and 2008, from 167.5 TWh to 868.8 TWh in 2008 (IEA, 2011, pp. IV. 59).[3] This was driven by a feedback loop of technological breakthroughs allowing the construction of cheap, relatively small-scale gas units, while market liberalization introduced competition, creating economic conditions in which gas proved very attractive (cf. Winskel, 2002). Technology improvements and public support schemes have also driven an increase in renewables of 41% between 1990 and 2008 (IEA, 2011, pp. IV. 59). In particular biomass-and-waste and wind generation have grown dramatically, albeit from a low base. Nuclear, hydro and coal generation have remained roughly stable. In the decade 2000-2010, gas (49%), wind (28%) and solar (10%) made up the dominant capacity investments in Europe

Roughly 55 GW of new capacity were installed in Europe in 2010. These can be decomposed as follows:

A dash for gas: the majority of planned and under construction plants are combined cycle natural gas turbines (CCGT). In 2009, gas-fired capacity represented 19% of installed capacity. In 2010, the newly added capacities reached 28 280 MW. The wave of CCGT construction is particularly pronounced in Spain, Germany, the UK and France. Nevertheless, over 30GW of gas-fired projects have been put on hold, largely as a result of the impact of the crisis on projected electricity demand and the availability of financing. A number of factors have driven this dash for gas, including:

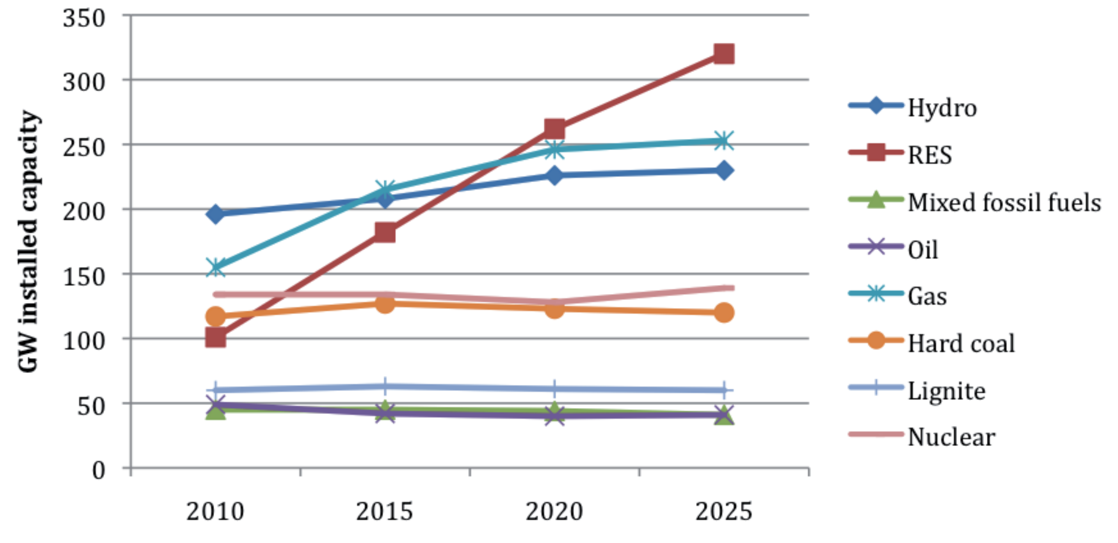
- a more attractive risk profile for private financing, due among other factors to lower capital costs and the ability of (marginal) gas plant to pass on fuel/carbon price fluctuations into electricity prices (cf. Hood, 2011). Thus electricity prices and gas prices tend to co-vary providing a hedge for gas-fired producers;
- relatively low gas/coal price ratios in recent years; and
- environmental and social opposition to other forms of thermal generation.

A dash for RES: wind and solar represented 17% and 22% of newly installed capacity in 2010, at 12 GW and 9.3 GW respectively (figure 1 above). New capacity investments in RES are driven largely by national support schemes, implemented for domestic energy security or green industrial policy objectives, or to meet the 20% RES objective in the 2008 EU climate and energy package. The dramatic success of such schemes in promoting capacity expansion has led to social cost concerns, as well as for the secure integration of RES into the grid. In addition, demand reduction as a result of the recession means more competition between different technologies. Recent retroactive adjustments to support schemes (e.g. Spain) highlight these tensions.

---

[3] NB. Figures for OECD Europe.

Figure 2. Projected installed capacities in Europe*



Source: ENTSO-E, 2010.

* Includes the EU27, and the Republic of Ireland, Norway, Bosnia-Herzegovina, Croatia, Former Yugoslav Republic of Macedonia, Montenegro, the Republic of Serbia, and Switzerland.

A shift away from coal: looking back over the last 3 years, around 23 GW of planned new coal capacity have either been suspended or cancelled. Nevertheless, the European Wind Energy Association states that in 2010 the EU power sector installed more coal than it decommissioned - 4 056 MW have been installed in 2010, while roughly 2 000 MW have been decommissioned over the same period (EWEA, 2011). Around 13 GW of coal power plants are under construction in Europe.

Hurdles in nuclear investments: the nuclear industry faces financing difficulties due to its high exposure to cost of capital risks (cf. Rothwell, 2006); exposure to electricity price risks (cf. Yang et al, 2008), as well as policy/social risks. Most nuclear projects have been delayed, particularly in UK and in Eastern Europe (Lithuania, Poland). Nuclear once again faces strong public oposition following the Fukushima disaster. Given planned retirements (UK) and nuclear phase outs (notably Germany), a significant investment program would be required just to maintain the share of nuclear in the EU electricity mix in the coming decades (cf. ENTSO-E, 2010). Concerns that the current policy framework is insufficiently robust to promote merchant-based nuclear investment have also motivated the proposed electricity market reform in the UK, for example.

1.2. Current drivers of investment and future trends

The EU power sector is approaching a major investment cycle driven by a number of factors. For further clarification, these can be usefully broken down into the two coming decades (2010-2020 and 2020-2030) and Western and Eastern Europe.

In the coming decade, the EU is expected to retire roughly 18% of existing capacity, or 150 GW compared to installed capacity of roughly 850 GW in 2009 (cf IEA, 2010b; Eurelectric, 2011). BAU electricity demand growth of roughly 1.5% for the decade (cf. ENTSO-E, 2010; EC, 2010) would lead to another 150 GW being installed, with a total capacity by 2020 of around 1000 GW. Therefore, total BAU capacity investments for the EU27 converge at a figure of around 300 GW of new investment by 2020.

In the decade following (2020-2030), both retirements and investments increase due *inter alia* to the aging fleet and the need for new, low-carbon capacities. Table 1 displays estimates of retirements, additions and investment needs in the OECD Europe power sector to 2035. Retirements are likely to accelerate somewhat in the latter decade, and investments will likely by dominated by high nameplate capacity, low capacity credit renewables.

Table 1. Additions, retirements, and investment needs in the OECD power sector to 2035[4]

2010-2020			2021-2035		
Additions (GW)	Retirements (GW)	Investment (USD2009 bln)	Additions (GW)	Retirements (GW)	Investments (USD2009 bln)
337	158	694	498	348	1 080

Source: IEA, 2010b

[4] N.B. figures for OECD Europe.

The drives for investment are somewhat more pronounced in Eastern Europe. In the CEE region, economic growth is expected to be higher in the coming decade, and electricity consumption per capita is currently lower, as a legacy of socialism.[5] Projected demand growth is therefore higher in the region (roughly 2% compared to 1.5% for the EU27) in the coming decade. In addition, the turbulent process of the post-socialist transition and the enormous "energy efficiency reserve" available in the region has led to a hiatus of investment over the past several decades. Therefore, rapidly aging capital stock will require significant investments in the region in the coming decade.

Bottom up BAU projections from European TSOs provide an insight into the trajectory of the electricity mix over the coming decade under existing policy frameworks. It should be noted that these are from the perspective of the *policy maker*, not the *private investor*; section 6 will discuss the implications of second-best policy effects on the decisions of investors. Nonetheless, these projections can generate useful insights. They are dominated by two marked trends: firstly, the dramatic expansion of installed RES capacity, which grows by 162% between 2010 and 2020, from 101 GW in 2010 to 262 GW in 2020; secondly, a similar jump in gas-fired capacity of some 60%, from 155 GW in 2010 to 246 GW in 2020. Other generation technologies roughly retain their absolute levels of installed capacity, although hydro, including pumped hydro, also experiences an increase, driven mainly by investments in Austria, Switzerland, Spain and Portugal. The projected evolution in the generation mix is shown in figure 2 above.

2. STUDIES OF EU POWER SECTOR DECARBONIZATION

This section briefly places the current trends discussed above in a longer-term perspective. From the published body of literature on the decarbonization of the EU economy and the electricity sector, several high level commonalities can be drawn (cf. RSCAS, 2011):

- The need for dramatic demand reduction relative to BAU levels, in order to reduce the investment challenge and partially offset the eventual electrification of buildings and transport.
- The need to roll out existing technologies, and develop and deploy new technologies and techno-institutional innovations (e.g. smart grids) in order to decarbonize the power sector at manageable cost.
- The need to expand and strengthen the internal EU energy market in order to enable the geographical hedging of intermittent renewable resources and the sharing of dispatchable back-up capacities.

This is not the place for a detailed review of these policy priorities for decarbonization. Rather, the following sections delve more deeply into the demand and supply sides of the decarbonization equation, in particular to identify potential inconsistencies between current trends and the trajectories implied by the literature on the decarbonization of the EU power sector. In particular, we focus below on the demand side of the equation as the essential point of departure for decarbonization policies in the sector.

3. THE DEMAND SIDE OF THE EQUATION

This section examines the role of the demand side in the decarbonization of the economy and the electricity sector. It underscores the role of the electricity sector in decarbonizing other final demand sectors (transport and buildings), and the need to undertake dramatic demand reduction policies in order to make this feasible.

All studies of decarbonization in the power sector agree that very significant improvements in energy efficiency compared to BAU are required i) to partially offset the projected demand increase from the electrification of stationary and mobile final consumption sectors, and ii) to keep the new capacity investment challenge manageable (cf. RSCAS, 2011; THINK, 2011). According to the Commission's decarbonization roadmap, by 2050 some 20% of final demand for heating and cooling would be electrified relative to less than 10% today (EC, 2011, pp. 76); for transport, this would reach 39% in the effective technology scenario, and still 13% in the delayed electrification scenario (EC, 2011, pp. 68).

Thus, generally speaking, decarbonization trajectories display significant reductions in electricity demand in the period 2010-2030, followed by an increased in demand 2030-2050 relative to BAU, as electrification of final demand begins in earnest (cf. Eurelectric, 2011; EC, 2011). This would place greater burdens on the power sector towards 2050, but is cost efficient from an economy wide perspective due to the lower marginal abatement costs in the electricity sector. **However, massive energy efficiency improvements are necessary**

---

[5] Socialist societies are sometimes called "frozen consumption" societies, due to the much lower levels of private consumption. During the process of catch-up to Western European levels of welfare, this legacy will erode.

in the final consumption sectors to keep their eventual electrification manageable from an investment perspective. For example, Eurelectric models that under a no energy efficiency policy scenario, total cumulative energy costs would be 3552 billion Euro_{2005} higher than in the effective policy scenario, which includes additional measures in the final consumption sectors (Eurelectric, 2011, pp. 77). Likewise, modeling by CIRED shows the added value of complementary demand avoidance measures for example in the transport sector, in view of its eventual electrification (Guivarch and Rozenberg, 2011).

By 2050, electricity savings in the order of ~1150 TWh would need to be achieved in stationary final consumption sectors, relative to baseline levels, in order to partially offset the electrification of transport and buildings (Eurelectric, 2011, pp. 52; ECF, 2010, pp. 48). Deviations from BAU power consumption need to start almost immediately, due to the i) long lead-time for energy savings policies to be implemented and take effect, and ii) the large share of energy savings that needs to be achieved in highly inert existing capital stock, especially buildings and transport infrastructures. For example, Eurelectric models a reduction vs. baseline of 168 TWh and 468 TWh in the stationary sectors by 2020 and 2030 respectively, or ~5 and ~12% of projected net generation in the baseline (Eurelectric, 2011). **Eurelectric acknowledges that potentials for greater savings also exist.**

Significant uncertainties exist regarding demand evolution. Both the scale and timing of the electrification of further final consumption sectors is uncertain, as are the adoption and ultimate effectiveness of energy saving policies. Expectations of economic growth are likewise subject to very high uncertainties, especially when viewed over the short-term. However, electricity demand defines scarcity and price of emissions allowances in the ETS, and the level of effort necessary to reach emissions reduction objectives and particular penetrations of clean generation technologies. This implies that **a much clearer focus should be placed on the demand side when designing and implementing climate policies.**

From an economy wide perspective, electrification of final demand in transport and buildings is cost efficient. However, from a sectoral perspective, this places an additional investment burden on the power sector, particularly in the period 2030-2050. In order to keep this to a manageable level, in the period 2010-2030 it is necessary to undertake significant policy efforts to improve the energy efficiency of these sectors. It is also necessary to take into account interactions between sectors (buildings, transport and power generation) and instruments (ETS and energy efficiency); these issues are the subject of section 6. **Demand trajectories should therefore form the cornerstone of decarbonization policy in the electricity sector, and the point of departure for supply side policies.**

4. THE SUPPLY SIDE OF THE EQUATION

4.1. Inertias and technology and portfolio options

4.1.1. Inertias in the power sector

The power sector is characterized by very strong inertias. Long lead-in times for investment and very long infrastructure lifetimes mean that, firstly, any significant shift of investment will take time; and secondly, investment decisions will have a legacy effect of 20 to at least 40 years under "normal" conditions.[6] Policy makers and firms are faced by significant uncertainties related in particular to the technical/social feasibility of future abatement options (i.e. CCS); the learning curve for current commercially immature technologies, and the delivery of enabling infrastructures such as electricity grids and CO_2 transport and injection infrastructures.

4.1.2. Technology characteristics

Renewable energy technologies. The level of penetration and of development of renewable energy technologies depends mainly on the level of technological and economic maturity, and the policy framework. While some technologies, notably onshore wind, are close to achieving competitiveness with conventional generation, other renewable energy technologies are less mature and still need R&D and deployment support. Among promising RES technologies, offshore wind is likely to see rapid learning, driven also by ambitious deployment programs. Some coastal European countries will rely on this technology for achieving their 2020 targets, e.g. Germany and the United-Kingdom (with respectively roughly 7700 MW planned or approved projects in Germany to be on line by 2015 and 6700 MW planned, approved, applied or proposed projects in the United-Kingdom). As this technology is still immature in terms of costs, a high level of remuneration is required in support schemes.

The support scheme and related policies imply an important social cost that needs to be

---

[6] i.e. without the early decommissioning of capacities.

monitored and controlled. The economic crisis and the dramatic success of some schemes in rolling out capacities has led to concern in some countries regarding costs and system security (e.g. Netherlands, Czech Republic). However, all renewable energy technologies are capital-intensive investments, with the major part of the costs being investment costs. Costs of capital for RES are high due to general liquidity constraints in European economies, and specific policy/technical risks.

At larger-scale penetrations, the intermittency of some RES technologies begins to matter for system security. As the major expected increases in RES capacity will come from intermittent RES (off/onshore wind, PV), innovations in system coordination will be required to evolve concurrently (e.g. back-up capacity, interconnectors, storage, and advanced demand-side management). This will increase the system-wide investment costs. The coordination externalities attending the long-term transformation of the existing socio-technical complex are a major barrier to significant RES expansion (cf. Unruh, 2002).

Nuclear. Currently, the lead-in time for building a nuclear generating capacity with a proven technology is at least 10 years in Europe. The Fukushima disaster will slow down potential investments in new nuclear capacity. Several dimensions need to be taken into account when considering the role of nuclear:

- Nuclear power is especially exposed to risk in terms of costs of capital. There are significant project management risks, due to the expense and complexity of implementing construction projects, especially with the new generation 3 reactors. As a price taker in a liberalized market, it is also exposed to carbon, fuel and electricity price risks (for a breakdown of risk factors see e.g. Rothwell, 2006).
- The relative competitiveness of nuclear plant is closely linked to the gas and carbon price (NEA, 2011). If gas and carbon prices remain low in coming years, as at present, this will decrease incentives to invest in merchant based nuclear.
- Therefore, investment in new nuclear plant would likely necessitate the involvement of the government to lower project risks and the cost of capital, either in the form of government loan guarantees or support instruments (e.g. the Electricity Market Reform in the UK).
- Harnessing nuclear power depends especially on the institutional environment surrounding the upstream (building the facility), the operation and the downstream (decommissioning and waste management) of the entire program, and particularly in countries that are not yet involved in nuclear assets (e.g. Poland).
- The institutional environment must ensure the safety of the nuclear asset operation. Safety regimes require specialized high-level engineering training as well as the reinforcement of the waste management procedures. Developing these capacities will take time in countries with no prior experience of managing nuclear plant.
- Lastly, nuclear faces public acceptance issues. Overcoming them would require that concerns be addressed as to the safety of the whole nuclear program in those countries considering new capacities.

Assuming that risk issues can be solved and public acceptance gained, developing a secure institutional environment and constructing new plant both require long lead-in times, limiting anyway the contribution of new nuclear in the coming two decades.

Gas. Gas has been the preferred investment option for several years. Gas units are small, rapid to build and do not require high amount of capital, making them attractive to private investors. In the near future, new dynamics – positive and negative – are likely to come into play:

- As the penetration of intermittent renewables increases, more gas-fired capacity will potentially be required for system balancing (with other options like storage and advanced demand side management likely to take longer to come to scale). However, in systems with high RES penetrations, capacity factors for back-up plant will be low (this is currently deterring investment already in Germany). This would require a sufficient level of remuneration at peak times (through high spot prices or potentially capacity mechanisms) to attract investment.
- Environmental/climate policies can induce to coal-to-gas investment substitution. Policies on local air pollution and the ETS have changed the relative costs of gas and coal technologies somewhat, as have low gas prices over recent years. In addition, climate policy uncertainty may incentivize gas investment, as its profitability is more secure against both upside and downside carbon price uncertainties due to its lower sunk costs; ability to set the price as the marginal plant, and lower emissions (see section 6 below).

Coal Investments in coal are much more complex. In some CEE Member States (e.g. Poland), coal technology costs and the easy access to primary resources tend to encourage investment. However, if new coal-fired power plants are commissioned in coming years, they will lock-in capital stock for at least 40 years. If CCS fails to be deployed at a significant scale (including retro-fits), the 2050 objectives will never be achieved without draconian action (i.e. the premature shutdown of all coal-fired power plants by 2050).

- However, CCS faces a suite of challenges on the path to commercialization and large-scale deployment. These include technical hurdles (demonstration of large-scale, integrated plant); social acceptance hurdles with regard to onshore storage; coordination hurdles with regard to the construction of a large-scale CO_2 transport infrastructure, and financial hurdles with regard to public subsidies for demonstration and eventual acceptability by ratepayers of higher electricity prices. Relative to unabated plant, the IEA estimates an increase in the levelized-costs of electricity from CCS plant of 55-64% for coal[7] depending on the capture route, and 33% for gas. Avoided CO_2 costs range from 39-44 $Euro_{2010}$/ton for coal, to 60 $Euro_{2010}$/ton for gas (Finkenrath, 2011).[8] According to analysis by the Commission, carbon prices – assuming the achievement of RES and non-ETS objectives – will not be high enough to incentivize merchant-based CCS post 2020 (EC, 2010); this modeling also does not include the impact of the proposed energy efficiency directive, discussed below.

4.1.3. Portfolio considerations

The analysis of available electricity-generating technologies should also focus on the energy technology portfolio as the electricity system currently relies on a reasonably diversified portfolio of technologies (apart from in a small number of outlier countries, notably France and Poland). The perspective of the technology portfolio alters the picture for policy-makers and investors:

- Large-scale development of nuclear or coal CCS could inhibit the development of currently available renewable energy technology (i.e. wind power plants). For system management, the coexistence of large-scale, inflexible plants and intermittent renewable energy technologies makes balancing the electricity system difficult.
- The large-scale development of intermittent RES requires the implementation of back-up gas-fuelled capacities,[9] and advanced demand supply management and interconnectors. However, the large-scale deployment of RES will also reduce the load factor of conventional plant, decreasing its attractiveness without additional policy measures to ensure an adequate capacity margin.
- Countries with a highly carbon intensive electricity sector (notably Poland with coal and Estonia with shale oil) face strategic decisions on the mix, in order to reduce their exposure to increasing carbon constraints. However, such systems exhibit significant path dependencies and inertias, as new technologies require changes in the existing social-technical complex and face market prices and conditions defined by the incumbent technologies.
- Short-term (2020) carbon targets can be met with existing technologies. However, meeting longer-term objectives cost effectively will require the deployment of new technologies throughout the electricity supply chain, from generation, to transmission (e.g. HVDC lines), to distribution and consumption (e.g. smart-grids) (cf. Linares and Pérez-Arriaga, 2009). **Inertias in existing physical/regulatory systems and the need to guide private investment and R&D necessitate the swift establishment of a longer-term vision and regulatory framework.** The power sector should adapt to new technologies that will emerge in the future and leave room for their development and commercialization.

4.1.4. Summary

The electricity sector is characterized by high inertias due to long lead times and plant lifetimes. Concerning the ramp up of low-carbon generation, individual technologies are also characterized by strong inertias, albeit to different degrees and for different reasons. For RES, inertia is due to the remaining cost gaps to commercialization,[10] and especially to the system transformations required to integrate large-scale intermittent RES. For nuclear, inertia is due to the very long lead-time for nuclear projects, and financial, technical and social constraints to rapid expansion. CCS is a pre-demonstration technology, and large-scale deployment is not foreseen before 2025-2030. Equally, the phase-out of high carbon assets is constrained by the feasibility/costs of alternative technologies, and the long commercial lifetimes of existing plants or new investments in unabated plants. As we saw in section 2.1.2 above, accelerating investments will be needed after 2020, which will be planned in this decade. **This implies the need to swiftly set a long-term regulatory framework to shape investment decisions for the next generation of plant post 2020.**

---

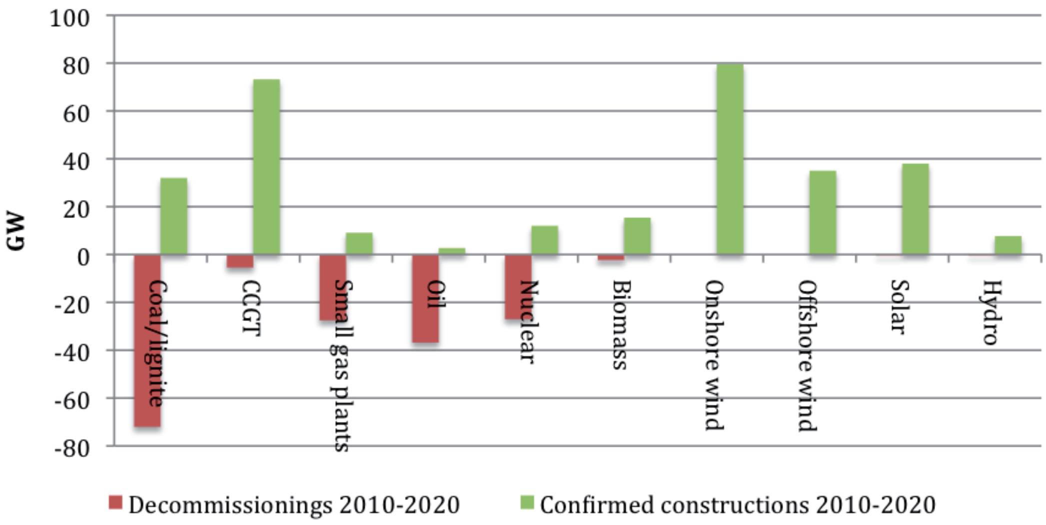
[7] These figures are relative to conventional coal technology, not IGCC.

[8] 2010 UDD/Euro exchange rate of 1.3261 from the US Federal Reserve.

[9] Given the limitations on the expansion of hydro exploitation.

[10] This differs by technology, and is due both to the immaturity of the technologies themselves, and the imperative to internalize the externality of GHGs from conventional generation.

Figure 3. Decommissionings and planned constructions 2010-2020



Source: Eurelectric, 2011.

4.2. Decarbonization scenario mixes for Europe

4.2.1. Decarbonization mixes – a little bit of everything?

A number of studies have modeled the evolution of the generation mix under strong decarbonization. They tend to converge around a generation mix balanced between RES; coal and gas with CCS, and nuclear. However, several studies have also explored sensitivity scenarios involving higher shares of specific technology groups (e.g. the ECF, 2010, 80% and 100% RES scenarios) or delay of a given technology (CCS delay scenarios in Eurelectric, 2011, and EC, 2011). These sensitivity analyses indicate that decarbonization objectives could still be met, albeit at higher cost, e.g. an additional 164 billion Euro_{2005} in the Eurelectric delayed CCS scenario or an additional investment cost of 225 billion Euro in the ECF 100% RES scenario, compared to the 80% RES scenario.

However, the general analytical convergence towards a vision of a balanced decarbonization mix is actually indicative of the uncertainty attending each option. These risks relate to technology development, system integration, environmental issues, social acceptance and cost, and were detailed briefly in section 5.1 above. Clearly, no decarbonization pathway is risk-free, and policy-makers will need to assess and balance delivery risks against multiple criteria and dimensions. More research at the interface of social science and technology policy is clearly needed. However, at this stage several implications can be drawn:

- Clearly, each technology option should be pursued with a balanced combination of push and pull development strategies as appropriate, taking into account its individual characteristics (see below).
- However, the overall decarbonization strategy should be robust against the widest possible range of eventualities with regard to future technology deployment and carbon/fuel price evolutions. Technologies with "optionality", i.e. the ability to operate in multiple future worlds, should be preferred. **This places an even greater premium on energy efficiency so as to avoid new capacity investments under current uncertainties.**
- **A longer-term policy framework would be desirable so that investments can take place in the presence of the fullest possible information regarding the longer-term evolution of the sector**. It would allow companies to better manage technology risks, and potentially reduce those risks by stimulating private investment in R&D (for the impact of the ETS on private R&D in the electricity sector, see e.g. Rogge et al, 2011). The policy framework should include not just longer-term pricing signals, but also facilitate the enabling conditions for new technologies to enter the market, e.g. regulatory provisions for new entrants; grid investment for RES, or CO_2 transport for CCS.

4.2.2. Are there risks in current trends?

As noted in section 2 above, the current decarbonization trend in the power sector is maintained by, firstly, the significant expansion of currently mature RES capacities, with also a growing share of emerging RES such as offshore wind; and secondly, the rapid expansion of gas-fired generation. This section discusses the risks that may attend the current approach.

*Carbon lock-in***.** According to the bottom-up projections of EU TSOs, by 2025 current investment trends would leave a legacy of roughly 430 GW of unabated fossil fuel capacity, at about 250 GW of gas capacity, and 180 GW of coal (ENTSO-E, 2010). According to Eurelectric's bottom-up analysis of investment plans for the coming decade, the dominant new capacities will be onshore wind (79.5 GW), CCGT (73.2 GW), offshore wind (35 GW) and new coal (32 GW). These figures, and planned decommissionings for the decade, are shown in Figure 3 above.

The projected investment in new fossil-fuel capacities, particularly in CCGT technology but also new coal, needs to be weighed carefully against a number of considerations:

- Of currently mature baseload technologies, gas represents a lower regret investment, due to its low capital intensity, low CO_2 emissions and flexibility to back-up large shares of intermittent generation. The option value to deploy gas generation as back up for RES, or baseload with CCS, can be purchased at lower sunk cost compared to other baseload technologies, notably coal. Security of supply concerns may also diminish over time, as European gas import capacities diversify (LNG and expanded intra-EU infrastructure) and shale-gas potentially comes online. However, even with unconventional gas, it appears unlikely that European production will increase above current levels (cf. Gény, 2010)
- However, fossil fuel investments will lock-in significant capital infrastructure in gas and coal generation, and in gas import and distribution.[11] The reliance on a pre-demonstration abatement technology (CCS) brings back-end delivery risks, although these will be somewhat reduced for gas compared to coal. Risks of carbon lock-in and stranded assets cannot be excluded, particularly with regard to new coal investments, as it is still uncertain what role CCS will play in the decarbonized mix in the EU. **However, lengthening the carbon scarcity signal under the ETS would allow firms to better manage such technology risks surrounding CCS, and potentially reduce those risks as firms increase investment in R&D.** In the current context of short-term regulation, firms are likely to make suboptimal capital investments (e.g. potential over-commitment to unabated fossil fuels) and lower levels of private R&D (cf. Bosetti and Victor, 2011). This may eventually transfer risks to the public sector, in the form of public commitment to R&D or even compensation for early retirement of high-carbon capacity (Guivarch and Hood, 2011).[12] **At the least, investment decisions in fossil fuel capacity should be made in the presence of credible information regarding the longer-term regulatory environment.**

Focus on currently mature RES. The massive expansion in RES is often justified by the need to ensure learning-by-doing to accelerate cost reductions in RES technologies – there is evidence that this has indeed been successful. However, cost reductions are, broadly speaking, the result of two processes: firstly, the expansion of capacity and usage (learning-by-doing), and secondly, investment in R&D (learning-by-researching). The ratio of learning-by-doing to learning-by-researching depends on a number of factors, including the level of maturity of the technology and the importance of economies of scale in the manufacturing process (Wiesenthal, 2010). It can be argued that the EU's current technology development strategy for RES is weighted towards learning-by-doing. R&D investments in the Strategic Energy Technology Plan (SET Plan) technologies[13] amounted to just €2.38 billion Euro in 2007 (Wiesenthal, 2009). As a comparison, net support costs for renewable electricity amounted to €7 billion in the same year (Ecofys, 2011).

However, some 70% of R&D financing into SET plan technologies comes from private corporations (Wiesenthal, 2009). **This underscores the importance of a clear policy framework, including market pull policies, to direct private R&D into low-carbon technologies. In this regard, the EU's RES objective is justified.** However, there may be several concerns with the current policy balance:

- A focus of short-term (2020) deployment without complementary R&D policies and longer-term carbon scarcity signals may lead to suboptimal investment in currently mature technologies. This may be detrimental to the dynamic efficiency of the EU's decarbonization

---

[11] For example, the EC's low-carbon roadmap projects gas import requirements under the to be some 36-42% below baseline levels by 2050, at roughly 250 bcm of imports by 2050 (EC, 2011). This compares to projected BAU pipeline imports capacities of some 400 bcm by 2020 (ENTSO-G).

[12] A situation similar to that in Australia, where the government is intending to negotiate the premature closure of the dirtiest coal-fired plant is not inconceivable.

[13] Excluding nuclear.

Table 2. Investment costs in the power sector

Study	Power sector emissions objective by 2050	Investment costs
EC, 2011	93-99% below 1990 levels	Cumulatively €2.2 – 2.6 trillion for generation plant, compared to 1.7 trillion in the reference scenario Cumulatively €1.6 – 2 trillion for grid investment, compared to 1.3 trillion in the reference scenario
ECF, 2010	At least 95% below 1990 levels	€55-70 billion per year between 2020 and 2035 for generation, compared to €25-30 billion per year over the last decade. Cumulatively, 1.3 trillion over the next 15 years.
Eurelectric, 2011	Economy-wide at least 75% below 1990 levels, emissions from the power sector of ca. 25 kg/MWh	Cumulatively €05 1.75 trillion by 2050 for generation plant, 12% higher than the baseline Cumulatively €05 1.5 trillion in for grid investment, 35% higher than the baseline.

Source: as indicated in text.

path in the electricity sector, which will depend on the development and roll-out of technologies across the whole learning curve. **The imperative of a decarbonization strategy robust against future uncertainty implies the implementation of long-term carbon scarcity signals in order to leverage technological innovation across supply options and throughout the innovation curve.**

- There is a risk that current subsidy schemes will not be socially sustainable. Already several countries have wound back support schemes (Czech Republic, Spain). In addition, the reliance on support schemes for low-carbon generation shifts the economic burden to ratepayers, while reducing the carbon price signal for other economic actors. This leads to economic distortions and potential inequities. There is the risk that such distortions could reduce the price incentives to invest in other lower carbon technologies. **This is not to say that a mix of instruments is unnecessary, but rather that the balance between instruments should be as finely tuned as possible given the objectives and market failures they are designed to address. Clearly, mature RES technologies such as onshore wind and some biomass should enter the portfolio of investment on an economic basis (driven by the carbon price, not support schemes) by the end of the decade.**

4.2.3. Summary

This section has surveyed the characteristics of low-carbon technology options in the electricity sector. It has noted the very high inertias in the sector, due to the lead in times for large capital investments and long lifetimes of assets once built. **This implies the need to immediately set a long-term regulatory framework to shape investment decisions for the next generation of plant (post 2020).** It further argued that the risks attendant on each technology option should not be obfuscated. In this uncertain context, the overall decarbonization strategy should be robust against the widest possible range of eventualities with regard to future technology deployment and carbon/fuel price evolutions. **Therefore a longer-term policy framework would be desirable so that investments can take place in the presence of the fullest possible information regarding the longer-term evolution of the sector**. This would allow companies to better manage technology risks, and potentially reduce those risks by stimulating private investment in R&D. The following section assess the impact of second-best policy effects (such as short-termism) on private actors' investment decisions.

5. THE POLICY CONTEXT

Having begun with the concrete issues of demand and supply trends and scenarios, this section now turns to the policy context and its coherence with the climate objectives of the EU. It surveys first the investment needs for the transition and the investment impacts of second-best regulation, in order to underscore the imperative for a robust policy framework to attract and direct investment. Then it briefly discusses the role of the ETS within a balanced policy mix. Finally, it assesses the transformational signal sent by the ETS and the current balance of policy instruments.

5.1. Investment needs and implications for policy

A very significant ramp-up of investment rates is necessary for the EU to meet its decarbonization objectives in the power sector. Table 2 above displays estimated investment costs of the low-carbon transition in the EU power sector relative to baseline scenarios. These indicate that, firstly, roughly a doubling of investment intensity is required relative to recent historical investment rates (cf. Eurelectric, 2011, pp. 72; ECF, 2010, pp. 70).[14] Secondly, incremental investments in the order of 12-30% for power generation, and 35-40% for grids, are required, relative to baseline levels (EC, 2011; Eurelectric, 2011). Thirdly, across the scenarios, average levelized costs of electricity may emerge roughly equal across the decarbonization and baseline scenarios in the period to 2050, although this depends heavily on the modeled fossil fuel prices and learning rates of low-carbon technologies.

Generally speaking, low-carbon investments in the power sector are characterized by high capital intensity, and high dependence on the policy framework to ensure competitiveness relative to conventional technologies. These investments will need to be made in an environment in which, currently:

- government commitment to policy objectives and instruments remains ambiguous;
- costs of debt are high due to general liquidity constraints in the financial sector, and technological uncertainties and novel business models for most low-carbon generation technologies;
- as a result of financial crisis, utilities have scaled back capital expenditure programs and undertaken balance sheet consolidation (see Eurelectric, 2010b on the impact of the financial crisis on utilities);

In addition, it is clear that, given the scale of the investment challenge, traditional modes of financing in the electricity sector, i.e. balance sheet borrowing and project finance, will not suffice (ECF, 2011; Accenture and Barclays, 2011). There is the need to attract new institutional investors to the low-carbon energy sector, in order to broaden the pool of available capital and accelerate capital recycling in the sector. **These considerations underscore the imperative of a robust policy framework to attract and direct scaled up capital from new sources to the sector.**

5.2. Investment under uncertainty in the electricity sector

A large literature exists concerning the impact of climate policy uncertainty on the timing and content of investment decisions in the power sector. Different methods of assessment of investment under uncertainty are applied, including real options theory, scenario analysis, and the capital asset pricing model (for a summary of analytical methods, see e.g. Neuhoff, 2007). This is not the place for an exhaustive review of this literature, but several common conclusions from the literature on investment under uncertainty can be highlighted:

- Policy uncertainty can create incentives to delay investment decisions, in order to profit from learning-by-waiting. The incentive to delay is in inverse proportion to the expected timing of resolution of the policy uncertainty. In other words, the closer the expected resolution of uncertainty, the greater the incentive to delay investment (Yang et al, 2008). Given that any decision to revise the Phase III cap would need to be taken by the end of 2012, and that the post-2020 cap would have to be fixed by 2015-2016 at the latest, there is likely to be a strong incentive to delay investment to learn of future policy commitments. **This may present energy security concerns for countries facing large investment needs (e.g. UK, Poland or Germany).**
- Policy uncertainty can result in higher costs of capital and distorted investment decisions, increasing the costs of implementing climate policy (IEA, 2007). In particular, removing the (heroic) assumption of perfect policy foresight among economic actors, macro-economic costs of policy increase exponentially and inversely to the length of the credible policy commitment (cf. Bosetti and Victor, 2011). This is explained by suboptimal capital investments (lock-in) and also lower investment in low-carbon R&D (delayed innovation).
- Policy uncertainty can distort the content of capital investment decisions. In particular, policy related uncertainty could disadvantage high capex, low-carbon investments, as these i) suffer especially from higher risk-adjusted capital costs; ii) rely on the policy-framework to deliver profitability, i.e. the internalization of the economic externality of GHG emissions from fossil fuel combustion and the resulting long-term change in relative prices between energy technologies.
- Policy initiatives to reduce the long-term volatility of carbon prices through longer-term, credible commitments and potentially complementary policies, such as price caps/floors, can increase the propensity to invest in low carbon generation assets, and improve the environment for new entrants into the electricity sector (cf. Kettunen et al, 2011). **As noted above in section 6.3 above, the scale of the investment challenge necessitates the inclusion of new, and therefore likely risk-averse, investors.**

---

[14] Relative to historical rates, a significant increase in investment intensity is also necessary in the baseline scenarios.

5.3. What role for the ETS in a policy mix?

The coexistence of multiple market failures and multiple policy objectives implies the need for a mix of policy instruments. However, care must be taken to ensure that this mix is optimally balanced against its short and long-term objectives. The ETS currently forms, ostensibly at least, the centerpiece of the EU's decarbonization policy. In theory, an ETS can achieve efficient reductions of GHGs by changing the relative prices of high and low-carbon generation options, and between energy savings and energy consumption. It was noted in the introduction, however, that the EU's (and arguably, the world's) agenda is moving slowly away from a paradigm of tinkering at the margin towards long-term low-carbon development. In this context, the transformational aspects of the ETS as current designed need to be considered.

In economic theory, multiple policy instruments are justified by multiple market failures. Broadly speaking, alongside the externality of GHGs, three further market failures justify interventions:

- Coordination externalities: the private benefit of expanding a network is exceeded by the public benefit. As Bowen et al note, in such situations, "… [w]ithout public intervention, the market response is an underinvestment in expanding the network, as coordination between users and suppliers of the infrastructure can be hard to achieve" (2009, pp. 4). Such network effects can play a very significant role in retarding the transition to a low-carbon energy supply, e.g. in the case of smart grids or grid interconnectors.
- Information barriers and access to capital: consumers lack information and capital to make rational decisions. This applies particularly where consumers are disorganized (i.e. private individuals compared to firms) and decisions involve novel technologies. Policies to give consumers easier access to adequate technology and capital can be crucial to implement e.g. energy savings.
- Innovation spillovers: knowledge can be described as a public good, in so far as it can be difficult to exclude others from using it, the patent regime notwithstanding. As they are unable to appropriate the full benefits of innovation, private actors will under invest in R&D.

Alongside these economic considerations, some political economy factors need to be taken into account. The difficulty for new technologies to enter the electricity and energy sector more broadly has been well analyzed by Unruh (2002). Incumbent technologies operate within an existing techno-institutional framework, which can pose significant political economy and systemic barriers to the penetration of new technologies. In addition, where very high carbon prices are required to change the relative prices of high and low-carbon technologies, the political feasibility of imposing such prices may be low, particularly in the absence of a robust international agreement and the presence of powerful, organized stakeholders covered by an ETS (see e.g. Victor, 2011). In such instances, targeted push and pull instruments may be desirable to facilitate the commercialization of new technologies beyond the effect of a second-best ETS, an example being feed in tariffs or premiums for low-carbon generation.

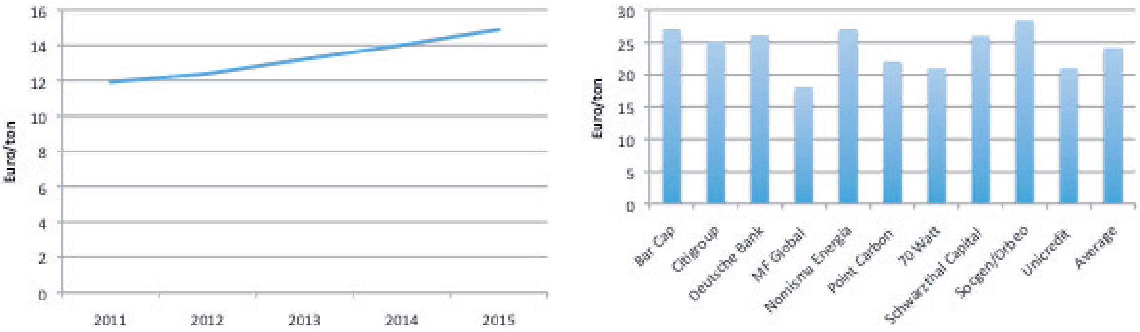
These considerations notwithstanding, the ETS still has a vital role to play. Carbon pricing is the only instrument that can efficiently coordinate economic decisions across the millions of consumers and producers who must ultimately change their economic behavior. In this regard, carbon pricing provides the broadest and most credible signal to economic actors on the development of markets, including those not covered by the ETS. Robust carbon pricing is necessary, but not sufficient. Indeed, in directing private investment and providing public revenues, there is a clear complementarity between carbon pricing and supplementary public policies for innovation and efficiency (see e.g. Alfsen et al, 2010).

A more robust, longer-term carbon price could expedite the transition to a more efficient and harmonized system of support for decarbonization. Indeed it is the absence of this - due to government hesitation and slow progress internationally – that is leading to the multiplication and fragmentation of support schemes in the EU (the UK Electricity Market Reform is a case in point). Such fragmentation risks distortions and inefficiencies at the EU level, and potentially threatens the long-term incompatibility between EU regulatory regimes and energy systems. **The ETS therefore also plays a crucial role in coordinating the action of EU Member States**. In light of this introduction, the following section assesses the achievements and deficiencies of the ETS as currently designed, with particular focus on its transformational aspects.

5.4. The signal sent by the EU ETS

The EU ETS is the central instrument for achieving "reductions of greenhouse gas emissions in a cost effective and economically efficient manner… so as to contribute to the levels of reductions that are considered scientifically necessary to avoid dangerous climate change" (Directive, 2009/29/EC, §1). Its implementation represents a significant policy success for the EU. It has delivered a price on carbon emissions, and ensures the achievement

Figure 4. EUA futures prices 2011-2015, left panel; financial intermediaries' projections for EUA prices Phase III, right panel



Source: futures prices from EEX data; projections from Reuters survey, August 2011.

of quantity targets in the covered sectors. Research suggests that the EU ETS has brought the issue of carbon management into company boardrooms, and has influenced company RD&D strategies (Rogge et al, 2011). Although there are methodological difficulties with measuring policy-induced reductions against a counterfactual, it seems that the ETS has also induced emissions abatement in Phase I (Ellerman et al, 2010), and also in the start of Phase II, even when accounting for the impact of the recession (Egenhofer et al, 2010; Abrell et al, 2011). The revisions to the ETS brought about in the 2008 climate and energy package will likely improve its efficacy, particularly the shift to full auctioning[15] and the extension of the cap to 2020.

However, it can be questioned to what extent, in its current form, the ETS actually creates an investment framework consistent with the long-term decarbonization of the power sector. Empirical research by Rogge *et al* (2011b) finds that utilities' longer-term expectations regarding the future carbon price are a key factor determining the investment relevance of the ETS. In the current context, they find that the ETS currently plays a small role in shaping power sector investment decisions, relative to other factors such as fuel and electricity prices and technology specific measures such as feed-in tariffs (see below). However, power utilities are currently highly uncertain of the level of future carbon prices, i.e. in 2020 and beyond (Rogge et al, 2011b). Criticisms of the transformational aspects of the ETS can take four forms.

5.4.1. The absence of a consistent long-term signal

The revised ETS directive establishes an automatic annual cap reduction by 1.74% in the average total quantity of allowances issued by Member States during Phase II. The linear reduction factor continues after 2020, but should be reviewed by 2025 at the latest (Directive, 2009/29/EC, §9). Thus, ostensibly the ETS sends a long-term scarcity signal to economic actors in the covered sectors. However, it is clear that, firstly, this reduction rate is not consistent with the long-term decarbonization of the electricity sector. Under the current rate of cap decline, it is estimated that the ETS sector would reduce emissions by ~50% by 2050, relative to 2005 levels; this compares with a reduction of 88-92% by covered sectors under an economy wide reduction of 77-81% by 2050 (EC, 2011, p. 54).

Given the mandatory review by 2025 and the acknowledged inconsistency between the current ETS trajectory and the EU's long-term objective, it appears that stakeholders discount post-2020 carbon scarcity. For example, a Norton-Rose survey of investors finds that less than 10% consider that the EU ETS has provided a strong enough price incentive to switch from high to low-carbon investments; not a single respondent considered that the EU had provided *long-term* price certainty to incentivize low-carbon investment (IIGCC, 2011). For power generators, this is confirmed by a survey conducted by Rogge et al (2011b), which finds that some 38.7% of survey participants considered themselves "very unsure" of 2020 carbon prices; 30.6% considered themselves "unsure"; and just 6.5% and 1.6% described themselves as "confident" or "very confident". Clearly, the difficult macro-economic condition plays a role in this uncertainty; however, policy uncertainty is also a significant contributing factor, as the two following sections below discuss.

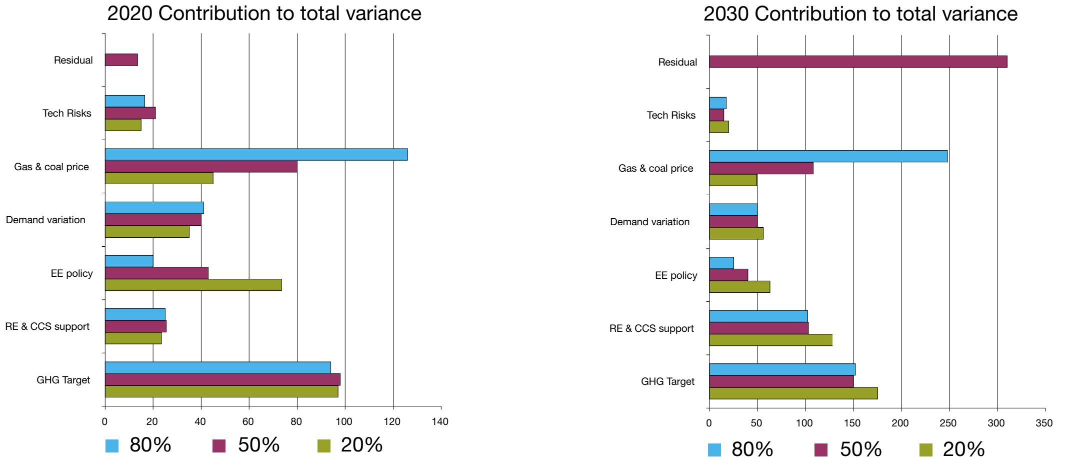
5.4.2. The long-term uncertainty of the carbon price signal

Despite the longer-term annual cap reduction inscribed in the directive, economic actors appear to discount post-2020 carbon scarcity in setting the

---

[15] With a transitional derogation for highly coal dependent, poorer Member States.

Figure 5. Sources of marginal cost uncertainty in the ETS, 2020 and 2030



Source: Blyth and Dunn, 2011.

current market price. Currently traded EUA futures prices reach around 15 Euro by 2015, while Phase III projections from the major financial intermediaries average around 24 Euro (Figure 5 above). It can be questioned whether such levels incorporate scarcity in future periods, given that, in theory at least, the cap should decline indefinitely by 1.74%. Power sector investors are motivated by existing legislated policies and futures prices; less legally precise policies, such as the commitment to post-2020 scarcity in the ETS, seem to be discounted from pricing decisions.

This point can be underscored by an analysis of future carbon price uncertainties. In general, price fluctuations based on changes in fundamentals, e.g. fuel prices, should not necessarily be the concern of policy-makers (cf. Fuss et al, 2008). These are investment risks that the private sector should reasonably adopt. Of more concern, however, is the case where policy-driven risks contribute significantly to carbon price uncertainty. Policy driven uncertainty in the ETS derives from a number of factors, including i) the level of the 2020 cap given the ongoing debate about the move to 30% emissions reductions; ii) the delivery of complementary policies, such as energy efficiency and renewables objectives to 2020; iii) the uncertain trajectory of the post-2020 cap.

Blyth and Bunn (2011) construct a model combining stochastic market-based and policy-related uncertainties to build a picture of the marginal price uncertainty in the ETS to 2020 and 2030. The paper finds that policy related risks, in particular the uncertain cap trajectory, are very significant on the 2020 timeframe, and dominate on the 2030 timeframe. The central results of the paper are shown in figure 6 below. In addition, in lower policy commitment scenarios, ETS prices are significantly driven by policy-related uncertainties such as the delivery of complementary policies in energy efficiency or RES (see also below). By contrast, in scenarios with tighter caps, ETS price fluctuations are largely driven by market fundamentals. The absence of a more stringent and long-term price signal under the ETS, coupled with significant public (fiscal) commitment to complementary policies, may suggest an imbalance of policy instruments and a suboptimal allocation of risk between the public and private sectors.

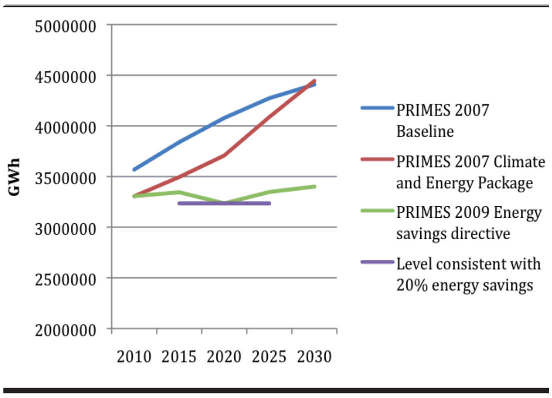
5.4.3. Consistency of policy instruments

ETS and Energy Efficiency

The analysis cited above underscores the importance of carefully balancing instruments within the policy mix. These instruments interact in highly complex ways. Broadly speaking, the overlap of RES and energy efficiency instruments with an ETS will impact the scarcity and price within the ETS, as some of the abatement demand will be delivered outside of the carbon price. It should be stressed again that this does not mean that an instrument mix is unjustified, but rather that instruments should be balanced as far as possible given their objectives.

It is debatable whether the EU's 20/20/20 by 2020 objectives were internally coherent, even before the economic crisis. Pre-crisis modeling by the Commission for the impact assessment of the 2008 climate and energy package indicates a reduction in primary energy consumption of just 6.2% in the Climate and Energy package scenario with CDM and JI trading verses the baseline scenario (Capros et al, 2008). This compares with the agreed objective of a 20% primary energy saving against

Figure 6. Projections of gross electricity generation, 2010-2030



Source: Capros et al, 2008; EC, 2011c.

the pre-crisis baseline projection of the Commission by 2020. Thus already before the crisis, the EU's policy instruments were not calibrated in a manner consistent with the 20% energy savings objective.

The economic crisis has led to a dramatic reduction in energy demand, with consequent impacts on the ETS price. In addition, the EU is preparing further energy efficiency measures, necessary to meet the energy savings objective (EC, 2011c).[16] The Commission's impact assessment estimates that the proposed energy efficiency directive would reduce primary energy consumption in the EU by 19.7 to 20.1% by 2020, relative to the PRIMES 2007 Baseline scenario (EC, 2011c). This would bring the EU in line with its 20% energy savings target. Furthermore, the impact assessment projects significant reductions in electricity demand relative to the PRIMES 2009 Baseline. Under the Baseline scenario, gross annual electricity generation is projected to be 3795.4 TWh in 2020, while in 2030 it reaches 4191.9 TWh (EU, 2010, pp. 67). By contrast, in the PRIMES 20% energy savings scenario of the Commission's impact assessment, gross annual electricity generation reaches 3234.695 TWh in 2020 and 3400.449 TWh in 2030.

Figure 7 shows the progression in electricity demand projections from the pre-crisis BAU scenario (Capros et al, 2008), to the climate and energy package (Capros et al, 2008), and the post-crisis impact assessment of the 2011 energy efficiency directive (EC, 2011c). **This underscores again that the ETS was not configured *ex ante* in a manner consistent with the 20% energy savings target.**

In this regard, two points should be considered.

- **The overlap of instruments leads to significant price risks in the ETS**, as it is by no means assured that energy efficiency objectives will actually be delivered (Blyth and Bunn, 2011). On the flip side, the presence of complementary efficiency policies reduces upside risks of socially unacceptably high carbon prices to deliver quantity targets. Optimal policy entails a balancing act of short-term static efficiency taking into account market failures across the abatement curve, and long-term dynamic efficiency (see below).
- In its impact assessment for the proposed energy efficiency directive, the PRIMES modeling assumed perfect foresight among market actors and optimal banking until *2050* (EC, 2011c, pp. 75) – even in this case, the ETS price is reduced to 14.2 Euro/ton in 2020. However, these conditions clearly do not hold currently – market actors have neither perfect foresight nor even a credible regulatory commitment post-2020, let alone to 2050. **Therefore, the actual delivery of RES and efficiency objectives would likely significantly reduce the carbon price in the ETS, weakening its dynamic efficiency.**

It should be stressed: it is not an either/or question with regard to the ETS and energy efficiency. Both are necessary parts of the EU decarbonization policy mix, as was argued regarding energy savings in section 4 above. However, in designing overlapping instruments **it is necessary *ex ante* to calibrate the ETS to generate carbon scarcity after energy efficiency policies have been factored in.**

ETS and RES policies

The ETS and RES policies interact in so far as RES policies deliver abatement outside of the ETS and hence reduce the carbon scarcity within the system. The overlap of instruments may be justified from the perspective of multiple goals, such as industrial policy or energy security. In addition, given long lead times in physical systems and the need for rapid innovation in low-carbon technologies, "starting early" with high cost abatement options can indeed be justified from the perspective of dynamic efficiency (Vogt-Schilb and Hallegatte, 2011).

There is evidence that RES policies are currently the dominant driver of decarbonization in European electricity systems. For example, the Australian Productivity Commission calculated total implicit abatement subsidies in the electricity systems of

---

[16] The proposed package of measures includes: an EU-wide energy savings obligation on utilities; refurbishment obligations for public buildings; improved information in consumer energy bills; mandatory energy audits, and requirements to equip new generation capacity and high-heat-demand industry installations with heat recovery

the UK and Germany of 52.5-138.6 Euro/ton and 95.9 – 122.5 Euro/ton respectively, compared to a carbon price of 14 Euro/ton in the study year (APC, 2011, pp. xxvii). According to the same study, non-ETS policies delivered up to 98% (!) of power sector abatement in the study year. Calculating "effective" carbon prices and abatement from non-carbon pricing policies is fraught with methodological difficulties. However, this does provide some analytical support for Rogge et al's (2011, 2011b) and the IIGCC (2011) interviews with power and financial sector actors, which concluded that the ETS played a relatively insignificant role in driving abatement and investment currently.

Careful conclusions

Policy-makers are faced with a conflict of interest between static and dynamic efficiency in carbon pricing instruments (cf. del Río González, 2008). In the short-term, the objective of static efficiency[17] implies seeking the lowest carbon price to reach a given objective. In the longer-term perspective, dynamic efficiency implies maintaining (the credible expectation of) a sufficiently high carbon price to create incentives for innovation and deployment of low-carbon technologies, in order to reach longer-term objectives at lowest cost. However, in the context of second-best political economy considerations it may be difficult to implement sufficiently high carbon prices across organized, powerful constituencies (such as industry), and more targeted pull instruments may provide a solution. In addition, dynamic efficiency considerations can justify "starting early" on high cost abatement options.

However, two consideration need to be made:

- It was emphasized in section 5.2.1 that decarbonization policies need to be robust against multiple future scenarios. This implies pursuing all abatement options in the short and long-term. **Technology neutral instruments, such as the ETS, have the advantage of providing efficient economic signals across the suite of supply-side technologies and demand-side abatement options. In addition, the ETS plays a crucial role in coordinating Member State actions on abatement and ensuring a level playing field in the EU.**
- The social cost of policies needs to be monitored and controlled. If complementary policies distort price signals and partially shift the abatement burden to diffuse and politically disorganized constituencies (ratepayers), there is the risk that they may be neither equitable nor sustainable in the long run. **Given the scale of investments required and the need (especially in the current climate) to sustain public and political acceptance for climate policy, efficiency is at a premium.**

Once again it is not a question of either/or with regard to RES, energy efficiency and ETS policies. Rather, it is a question of the balance of short and long-term signals within and between abatement options. It can be questioned whether the current balance is optimal.

5.4.4. Potential over-allocation of the ETS as a result of the crisis

The economic crisis led to a decline in economic activity of the covered sectors. As a result, emissions have also fallen, by some 11.3% between 2008 and 2009 (EC, 2011b). According to the post-crisis PRIMES 2009 Baseline and Reference scenarios, between 2008 and 2012 a buffer of ~2.3 Gt will accrue due to emissions being lower than the cap. In the Baseline scenario, which assumes weaker implementation of the non-ETS and RES objectives, 1.6 Gt of unused permits remain in 2020. In the Reference scenario, which assumes full implementation of the non-ETS and RES targets, unused credits in 2020 are higher, at 2.4 Gt in 2020 (figures from EC, 2010b, pp. 30-34). In other words, the 2020 ETS cap may not send sufficiently strong transformational signals during and beyond the current period due to the build-up of a significant buffer of allowances (cf. also Galharret and Guérin, 2011).

If the ETS sent scarcity signals via a longer-term cap consistent with long-term objectives, combined with certainty regarding the banking of allowances, this apparent oversupply would be of lesser concern. In theory, firms would arbitrage between periods, bringing forward some reductions on the prospects of higher carbon prices in future periods. In addition, longer cap horizons coupled with banking would reduce current price volatility, as price formation would take into account price factors averaged out over longer time periods (Fankhauser and Hepburn, 2010). However, it was noted above that the level of the post 2020 caps is currently unclear to market participants. Moreover, if policy is incredible or if imperfect foresight among market participants is considered, over-allocation could have significant implications on banking behavior and hence permit price formation (Paltsev, 2009). For example, 70Watt estimates that permit prices could drop significantly in the ETS if industrial actors cashed their surpluses due to preferences for cash rather than permits, or un-credible policy after 2020 (70Watt, 2011).

---

[17] i.e. equal marginal abatement costs across economic actors and sectors.

5.4.5. Summary

With regard to the impact of climate policy, utility investment decisions are largely driven by the existing policy framework, and in particular, expectations regarding future carbon prices. While the ETS has provided a post-2020 scarcity signal, this is i) not consistent with the EU's long-term objectives and is subject to possible revision by 2025 at the latest; ii) is highly uncertain due to outstanding decisions in the current policy framework; iii) potentially weakened by the suboptimal interaction of climate policy instruments, and by the accrual of a significant surplus of allowances and the absence of a long-term framework with banking. This risks delaying or distorting investments to the determent of the efficiency and potential feasibility of the EU's decarbonization pathway.

6. CONCLUSIONS: POLICY RECOMMENDATIONS

The focus of the EU's climate policy is increasingly shifting from short-term emissions reductions at the margin to long-term, low-carbon development. This places the EU's 2020 objectives in a new light: it is no longer sufficient that they are achieved, rather they must be designed to place the EU on a feasible trajectory to large-scale decarbonization by 2050. This paper has examined the role of the electricity sector in the transition. Its focus has been placed on the *status quo*, i.e. an examination of current investment and demand trends as they are shaped, among other factors, by the existing policy mix. In this manner, it aimed to highlight potential inconsistencies with current trends and policies and the trajectories implied by the 2050 decarbonization of the sector.

Ambitious gains in energy efficiency were highlighted as a key condition for the decarbonization of the sector, and to facilitate its contribution to the decarbonization of final consumption sectors. According to modeling released by the Commission, the proposed energy efficiency directive would have significant impacts on electricity demand to 2020 and 2030. This would be positive in terms of preparing the sector for the longer-term electrification of final demand. However, the analysis in this paper highlighted serious concerns with the impacts of the measures on the dynamic efficiency of the ETS. This does not mean that they should not be undertaken. **Rather demand side policies should be the point of departure for supply side interventions: ETS caps should be set so as to achieve carbon scarcity after energy efficiency and RES objectives have been taken into account.** Ideally, such caps would be long-term, i.e. beyond 2020, to reduce the volatility of prices by averaging out fluctuations in price factors (electricity demand, fuel prices, progress with implementing complementary polices etc) over longer periods.

Turning to the demand side, the study highlighted the high uncertainties and inertias in the electricity sector. These should not be obfuscated. Rather, they **imply the need to immediately set a long-term regulatory framework to shape investment decisions for the next generation of plant (post 2020).** In the context of uncertain technology developments, the overall decarbonization strategy should be robust against the widest possible range of eventualities. **This implies that a longer-term policy framework would be desirable so that investments can take place in the presence of the fullest possible information regarding the longer-term evolution of the sector**. The absence of this risks distortions in capital allocations, which could jeopardize the cost-effective achievement of the EU's long-term objectives.

With regard to the policy framework, the study emphasized the need for a balanced mix of policy instruments. Within this, however, the ETS is crucial, as it can efficiently guide the economic decisions of numerous economic actors across the value chain, and actions across Member States. The ETS, as currently designed, faces two major flaws: firstly, it does **not send a credible longer-term signal to shape post 2020 investments**. Given the sectoral inertias identified, it is vital that this is put in place as soon as possible. Secondly, the transformational signal of the ETS is **weakened by the imbalanced of policy instruments**, i.e. RES and energy efficiency, exacerbated by the crisis.

In the light of this policy analysis, several recommendations can be drawn. **Firstly, the EU should begin the – likely drawn out – policy process of establishing post 2020 emissions caps**. Secondly, a short-term adjustment of scarcity in the ETS may create some incentives for low-carbon investment (see e.g. Kettunen et al, 2011, for analysis on the timing of policy shocks to stimulate low-carbon investment). However, it would not address the fundamental concern, namely the lack of policy information regarding the post 2020 environment in which these investments will amortize. **A discrete policy intervention to balance supply in the ETS is clearly second-best from this perspective, and if mismanaged could deter rather than promote investment.** Thirdly, it is necessary for the EU to continually monitor the balance of policy instruments, and to coordinate future interventions across the instruments in order to avoid repeating the mistakes of the 2008 climate and energy package. Fourthly, the EU's technology support policy can be improved. Alongside market pull interventions, basic R&D and a stronger carbon price also have a clear role to play in the delivery of RES and efficiency objectives. The absence thereof could shift delivery risks to the public sector, and lead to economic distortions and inequities in the distributions of burdens among economic actors.

With the 2008 climate and energy package, the EU has taken significant steps towards a low-carbon economy and electricity sector. However, conditions have significantly changed since the package's adoptions, and internal inconsistencies and omissions in the package are becoming more evident. The analysis in this paper has highlighted some of these. Interventions to lengthen and strengthen the carbon price signal and improve the balance of policy instruments can consolidate the steps the EU has already taken, avoiding potentially greater costs and delivery risks from the current trajectory.

REFERENCES

Abrell, J. et al (2011), "Assessing the Impact of the EU ETS Using Firm-Level Data", Brussels: Bruegel.

Accenture and Barclays Capital (2011), "Carbon Capital: Financing the low-carbon economy".

Alfsen, K. (2010), "Technology change and the role of non-state actors", in Birmann et al (eds), "Global Climate Governance Beyond 2012: Architecture, Agency and Adaptation", Cambridge: CUP.

Australian Productivity Commission (2011), "Carbon Emission Policies in Key Economies", Melbourne: APC.

Blyth, W. and D. Bunn (2011), "Coevolution of policy, market and technical price risks in the EU ETS", *Energy Policy*, 39.

Bosetti, V. and D. Victor (2011), "Politics and Economics of Second-Best Regulation of Greenhouse Gases: The Importance of Regulatory Credibility", *The Energy Journal*, 32.

Bowen, A. et al. (2009), "Meeting the Climate Challenge: Using Public Funds to Leverage Private Investment in Developing Countries", Section 2 - Analytical framework: The case for public sector action, LSE Grantham Institute.

Capros, P. et al (2008), "Model-based Analysis of the 2008 EU Policy Package on Climate Change and Renewables", E3MLab/NTUA.

del Río González, P. (2008), "Policy implications of potential conflicts between short-term and long-term efficiency in CO_2 emissions abatement", *Ecological Economics*, 65.

Egenhofer, C. et al (2010), "The EU Emissions Trading System and Climate Policy towards 2050: Real incentives to reduce emissions and drive innovation?", Brussels: CEPS.

Ecofys, "Financing Renewable Energy in the European Energy Market", Utrecht: Ecofys.

Ellerman, D. et al (eds) (2010), "Pricing Carbon: The European Union Emissions Trading Scheme", Cambridge: CUP.

ENTSO-E (2010), "ENTSO-E Report System Adequacy Forecast 2010-2025", Brussels: ENTSO-E.

Eurelectric (2010), "Power Statistics: 2010 Edition Synopsis", Brussels: Eurelectric.

Eurelectric (2010b), "The Financial Situation of the Electricity Industry – A View to the Future Challenges", Brussels: Eurelectric.

Eurelectric (2011), "Power Choices: Pathways to Carbon Neutral Electricity in Europe by 2050", Brussels: Eurelectric.

European Council (2009), Brussels European Council 29/30 October 2009, Presidency Conclusions.

European Climate Foundation (2010), "Roadmap 2050: A Practical Guide to a Prosperous, Low-Carbon Europe", Brussels: ECF.

European Climate Foundation (2011), "Financing for a zero-carbon power sector in Europe: A financial sector's view on the decarbonisation of the European power sector", Brussels: ECF.

European Commission (2010), "EU Energy Trends to 2030 – 2009 Update", Brussels: EC.

European Commission (2010b), "Analysis of options to move beyond 20% greenhouse gas emission reductions and assessing the risk of carbon leakage" Commission Staff Working Document, Background information and analysis Part II, SEC(2010) 650

European Comission (2011), "A Roadmap for moving to a competitive low carbon economy in 2050", Impact Assessment, SEC(2011) 288 final, Brussels: EC.

European Commission (2011b), 2010 Compliance Data.

European Commission (2011c), "Commission Staff Working Paper, Annexes to the Impact Assessment Accompanying the Document Directive of the European Parliament and of the Council on Energy Efficiency and Ammending and Subsequently Repealing Directives 2004/8/EC and 2006/32/EC", Brussels: EC.

European Wind Energy Association (2011), "Pure Power: Wind energy targets for 2020 and 2030", Brussels: EWEA.

Fankhauser, S. and C. Hepburn (2010), "Designing carbon markets. Part I: Carbon markets in time", *Energy Policy*, 38.

Finkenrath, M. (2011), "Cost and Performance of Carbon Dioxide Capture from Power Generation", Paris: IEA.

Fuss, S. et al (2008), "Investment under market and climate policy uncertainty", *Applied Energy*, 85.

Galharret, S. and E. Guérin (2011), "The EU Climate and Energy Package: Elements to assess its current performance and suggestions on the way forward", Paris: Iddri.

Gény, F. (2010), "Can Unconventional Gas be a Game Changer in European Gas Markets?", Oxford: Oxford Institute for Energy Studies.

Guivarch, C. and C. Hood (2011), "Early retirement of coal-fired generation in the transition to low-carbon electricity systems", in IEA, "Climate and Electricity Annual", Paris: IEA.

Guivarch, C. and J. Rozenberg (2011), "Short-Term / Long-Term Coherence of Emissions Reduction Pathway", Cambridge: Climate Strategies.

Hood, C. (2011), "Electricity market design for decarbonisation", IEA, "Climate and Electricity Annual", Paris: IEA.

Institutional Investors Group on Climate Change (2011), "IIGCC (2010), "Shifting Private Capital to Low Carbon Investment: An IIGCC Position Paper on EU Energy and Climate Policy", London: IIGCC.

International Energy Agency (2007), "Climate Policy Uncertainty and Investment Risk", Paris: IEA.

International Energy Agency (2010), "Energy Technology Perspective 2010: Scenarios and Strategies to 2050", Paris: IEA.

International Energy Agency (2010b), "World Energy Outlook 2010", Paris: IEA.

International Energy Agency (2011), "Electricity Information 2011", Paris: IEA.

Kettunen, J. et al (2011), "Investment Propensities under Carbon Policy Uncertainty", *The Energy Journal*, 32.

Neuhoff, K. (2007), "Investment under Climate Policy Uncertainty", Cambridge: Climate Strategies.

Neuhoff, K. (2011), "Climate Policy After Copenhagen: The Role of Carbon Pricing", Cambridge: CUP.

Nuclear Energy Association (2011), "Carbon Pricing, Power Markets and the Competitiveness of Nuclear Power", Paris: NEA/OECD.

Organization for Economic Cooperation and Development (2011), "Projected Costs of Generating Electricity – 2010 Edition", Paris: OECD/IEA/NEA.

Paltsev. S.. J.M. Reilly, H.D. Jacoby and J.F. Morris (2009), The Cost of Climate Policy in the United States. Joint Program Report Series.

Linares, P. and I. Pérez-Arriaga (2009), "Promoting Investment in Low-Carbon Technologies", *European Review of Energy Markets*, 3.

Rogge, K. et al (2011), "The innovation impact of the EU Emission Trading System — Findings of company case studies in the German power sector", *Ecological Economics*, 70.

Rogge, K. et al (2011b), "Relative Importance of different Climate Policy Elements for Corporate Climate Innovation Activities: Findings for the Power Sector", Cambridge: Climate Strategies and CPI.

Rothwell, G. (2006), "A Real Options Approach to Evaluating New Nuclear Plants", *The Energy Journal*, 27.

Robert Schuman Centre for Advanced Studies/Florence School of Regulation (2011), "EU 2050 Low-Carbon Energy Future: Visiton and Strategies", Florence: RSCAS.

THINK (2011), "Transition Towards a Low Carbon Energy System by 2050: What Role for the EU?", THINK.

Victor, D. (2011), "Global Warming Gridlock: Creating More Effective Strategies for Protecting the Planet", Cambridge: CUP.

Vogt-Schilb, A. and S. Hallegatte, "When Starting with the Most Expensive Option Makes Sense: Use and Misuse of Marginal Abatement Cost Curves", Washington: the World Bank.

Unruh, G. (2002), "Escaping carbon lock-in", *Energy Policy*, 30.

Wiesenthal, T. et al (2009), "R&D Investment in the Priority Technologies of the European Strategic Energy Technology Plan", Seville: JRC.

Weisenthal, T et al (2010), "Quantitative Assessment of the Impact of the Strategic Energy Technology Plan on the European Power Sector", Seville: JRC.

Winskel, M. (2002), "When Systems are Overthrown : The 'Dash for Gas' in the British Electricity Supply Industry", *Social Studies of Science*, 32.

Yang, M. (2008), "Evaluating the power investment options with uncertainty in climate policy", *Energy Economics*, 30.

70Watt Consulting, *Carbon Quaterly*.

Decarbonizing the EU Power Sector

Policy Approaches in the Light of Current Trends and Long-term Trajectories

Thomas Spencer, Céline Marcy,
Michel Colombier, Emmanuel Guérin (IDDRI)

IDDRI
SciencesPo.

IDDRI'S PUBLICATIONS

- E. Guérin and T. Spencer (2011), "Strengthening the European Union Climate and Energy Package - To build a low carbon, competitive and energy secure European Union", IDDRI, *Studies*, n°4/11.
- (2011) *L'énergie en Allemagne et en France - Une comparaison instructive,* Les Cahiers de Global Chance n°30, Global Chance / IDDRI.
- S. Galharret and E. Guérin (2011), "The EU Climate and Energy Package: Elements to assess its current performance and suggestions on the way forward", IDDRI, *Idées pour le débat-Working Papers*, n°1/11.

www.iddri.org

The Institute for Sustainable Development and International Relations (IDDRI) is a Paris and Brussels based non-profit think tank. Its objective is to develop and share key knowledge and tools for analysing and shedding light on the strategic issues of sustainable development from a global perspective.

Given the rising stakes of the issues posed by climate change and biodiversity loss, IDDRI provides stakeholders with input for their reflection on global governance, and also participates in work on reframing development pathways. A special effort has been made to develop a partnership network with emerging countries to better understand and share various perspectives on sustainable development issues and governance.

For more effective action, IDDRI operates with a network of partners from the private sector, academia, civil society and the public sector, not only in France and Europe but also internationally. As an independent think tank, IDDRI mobilises resources and expertise to disseminate the most relevant scientific ideas and research ahead of negotiations and decision-making processes. It applies a crosscutting approach to its work, which focuses on five threads: global governance, climate change, biodiversity, urban fabric, and agriculture.

IDDRI issues a range of own publications. With its *Working Papers* collection, it quickly circulates texts which are the responsibility of their authors; *Policy Briefs* summarize the ideas of scientific debates or issues under discussion in international forums and examine controversies; *Studies* go deeper into a specific topic. IDDRI also develops scientific and editorial partnerships: among others, A *Planet for Life*. *Sustainable Development in Action* is the result of collaboration with the French Development Agency (AFD) and The Energy and Resources Institute (TERI), and editorial partnership with Armand Colin.

To learn more on IDDRI's publications and activities, visit www.iddri.org