



## Topic 3

# Transition Towards a Low Carbon Energy System by 2050: What Role for the EU?

Final Report  
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- The first milestone was the THINK expert hearing, where the robustness of the preliminary results were tested (Annex 5). This meeting was held on the 15<sup>th</sup> of March 2011 in Brussels, chaired by Ronnie Belmans. The authors benefited from comments by the meeting participants, including Cecilia Bladh, Christophe Bonnery, Norela Constantinescu, Amine Dalibey, Edouard de Quatrebarbes, Emmanuel De Jaeger, Erik Delarue, Jef Dermaut, William D'haeseleer, Floriane Fesquet, Martin Finkelmann, Serge Galant, Erik Ghekiere, Hubert Lemmens, Eric Momot, Mathias Normand, Luis Olmos, Pippo Ranci, Sophia Ruester, Jozef Sannen, Martina Sartori, Claudia Squeglia. The authors especially thank the expert panel of the hearing, consisting of Helen Donoghue, Adrian Gault and Peter Taylor.
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## Executive Summary

Following the European Council's target to reduce greenhouse gas emissions 80 to 95% below 1990 levels by 2050, the European Commission recently released a roadmap that already indicates what could be the relative contributions of the different sectors, which is setting the scene for new EU level policy actions. In the policy area of transport there is already a follow up roadmap with envisaged priority actions, and also in the area of energy such a policy roadmap will be released this year, 2011. This report gives recommendations for this 2050 energy roadmap.

**Chapter 1** introduces different studies in which stakeholders have presented visions of the low-carbon energy system they desire for 2050. We analyze the visions of the European electricity industry association, representatives of the European gas industry, the European Climate Foundation, the intergovernmental International Energy Agency and a non-governmental environmental organization in cooperation with an association of the renewable energy industry. The key policy challenges concerning the six main energy-related policy areas to achieve these visions are the following: 1/ energy efficiency - to achieve ambitious energy savings; 2/ greenhouse gas (GHG) emissions - to go towards a nearly zero-carbon electricity sector; 3/ renewable energy - to achieve an ambitious renewable energy technologies penetration level; 4/ energy infrastructure - to ensure electricity grid adequacy through the expansion and smartening of the grid; 5/ internal energy market - to ensure electricity supply security through timely investments and system flexibility; and 6/ technology innovation and R&D - to guarantee sufficient technology development for the achievement of the previous challenges.

**Chapter 2** is dedicated to the analysis of pioneering member states that have already started to address the

key 2050 policy challenges identified in the previous chapter. We analyze Denmark, Finland, France, Germany, Ireland and UK. Even though the status of the political process in these countries differs, the strategies that are emerging illustrate how the key 2050 policy challenges can be addressed. The analysis raises some concern on potential risk of policy fragmentation, but also finds opportunities for cooperation and EU added value.

**Chapter 3** focuses on the possible role for the EU in addressing the key 2050 policy challenges. We use an analytical framework with three types of EU involvement to derive promising EU interventions to deal with the challenges, which are summarized in Table 1. The first type of EU involvement corresponds to setting binding targets for member state actions. The second type of involvement is about harmonizing the actions taken by member states to achieve a certain target. The third type of EU involvement is to establish an EU-wide instrument in order to create a "level playing field". At the end of the chapter, we also discuss the need for an integrated policy package to assure a least cost implementation path. Such a package would need to take into account different energy policy interactions without forgetting the role of gas, but also the interactions of energy policy with other EU policy domains including external trade, regional policies and external relations, employment and social affairs, economic and monetary affairs, research and innovation as well as wealth distribution and public support.

The **main recommendations** are that it will be crucial to track progress during the transition to allow for policy adaptation, which implies close monitoring of investments and policy implementation, and the EU can also add value to member states' first steps on the road towards 2050. The ten priority EU interventions are: 1/ Make energy saving targets binding; 2/ Mobi-

lize cities towards a low-carbon future; 3/ Strengthen the carbon price signal; 4/ Integrate renewable energy technologies into the market; 5/ Create a level playing field for renewable energy cooperation with non-EU countries; 6/ Harmonize the regulation of

distribution and transmission grids; 7/ Design an EU infrastructure cost recovery instrument; 8/ Create an internal balancing market; 9/ Harmonize security of electricity supply mechanisms; 10/ Complement the Strategic Technology Plan (SET-Plan).

**Table 1** – Promising EU interventions in the 2050 context

	<b>FIRST</b> type of EU involvement <b>Effort sharing with binding targets:</b>	<b>SECOND</b> type of EU involvement <b>Harmonization with coherence requirements:</b>	<b>THIRD</b> type of EU involvement <b>Level playing field with EU-level instruments:</b>
<b>Energy efficiency</b>	<ul style="list-style-type: none"> <li>– Energy savings for 2020 and beyond</li> <li>– Overall and sector specific energy savings</li> </ul>	<ul style="list-style-type: none"> <li>– Measuring and reporting to facilitate spreading of good practices</li> </ul>	<ul style="list-style-type: none"> <li>– Good practice forum or register</li> <li>– Benchmarking of cities</li> </ul>
<b>GHG emissions</b>	<ul style="list-style-type: none"> <li>– Reduction of GHG emissions beyond 2020</li> <li>– More stringent and credible long term caps</li> </ul>	<ul style="list-style-type: none"> <li>– Carbon pricing with renewable energy targets</li> </ul>	<ul style="list-style-type: none"> <li>– Carbon market repository, platform, and authority for EU-ETS</li> <li>– Carbon tax, at least for non-EU-ETS sectors</li> </ul>
<b>Renewable energy</b>	<ul style="list-style-type: none"> <li>– Renewable energy beyond 2020</li> </ul>	<ul style="list-style-type: none"> <li>– Minimum market conformity requirements for national support schemes</li> </ul>	<ul style="list-style-type: none"> <li>– Support scheme</li> <li>– Decision bodies of Mediterranean regulators and transmission companies</li> <li>– Trade platform for the Mediterranean</li> </ul>
<b>Energy infrastructure</b>	<ul style="list-style-type: none"> <li>– Electricity grid adequacy</li> </ul>	<ul style="list-style-type: none"> <li>– Regulation of grids</li> </ul>	<ul style="list-style-type: none"> <li>– Grid operator and planner</li> <li>– Infrastructure cost recovery instrument</li> <li>– smart grid technology standards</li> </ul>
<b>Internal energy market</b>	<ul style="list-style-type: none"> <li>– Reservation of balancing services</li> </ul>	<ul style="list-style-type: none"> <li>– Balancing markets</li> <li>– Security of electricity supply mechanisms</li> </ul>	<ul style="list-style-type: none"> <li>– Balancing market codes</li> </ul>



## Introduction

We subsequently introduce the background and the scope of this report, as well as the analytical framework used in this report and its structure.

## Background to this report

Following the European Council's target to reduce greenhouse gas emissions 80 to 95% below 1990 levels by 2050 in order to keep climate change below 2°C<sup>1</sup>, the European Commission (DG<sup>2</sup> Climate) recently released a roadmap for a low carbon economy by 2050 (EC, 2011a). This DG Climate roadmap communicates what could be the most cost-effective pathway to reduce greenhouse gas (GHG) emissions by 80% by 2050 relative to 1990 levels, which would imply domestic emission reductions of 93-99% in the power sector, 54-67% in the transport sector, 88-91% in the residential & tertiary sector, 83-87% in the industry sector, 42-49% in agriculture, and 70-78% in other sectors (Figure 1).

The European Commission also started to think about the possible role of the EU in these sectors. DG Move already released a transport roadmap that proposes how the EU could guide the transition in the transport sector (EC, 2011h), and DG Energy has announced presenting its energy roadmap by the end of this year, 2011. These roadmaps are more policy-

oriented, while the DG Climate roadmap is mainly a modeling exercise. Note that the transport policy priorities highlighted in the transport roadmap (Annex 2) interact with the energy policies discussed in this report, which is especially the case for the envisaged urban mobility plans and smart pricing and taxation.

## Scope of this report

The role of the EU in the transition towards a low carbon energy future is increasingly debated (Jones and Glachant, 2010). This debate has been taking place in a context where various visions of the path to follow are presented by stakeholders, and several member states have already started implementing policies to guide the transition. The main contribution of this report is to first analyze this on-going process and then identify promising EU interventions in energy policy, based on the collected evidence. In the following we further detail the scope of our analysis.

## Visions

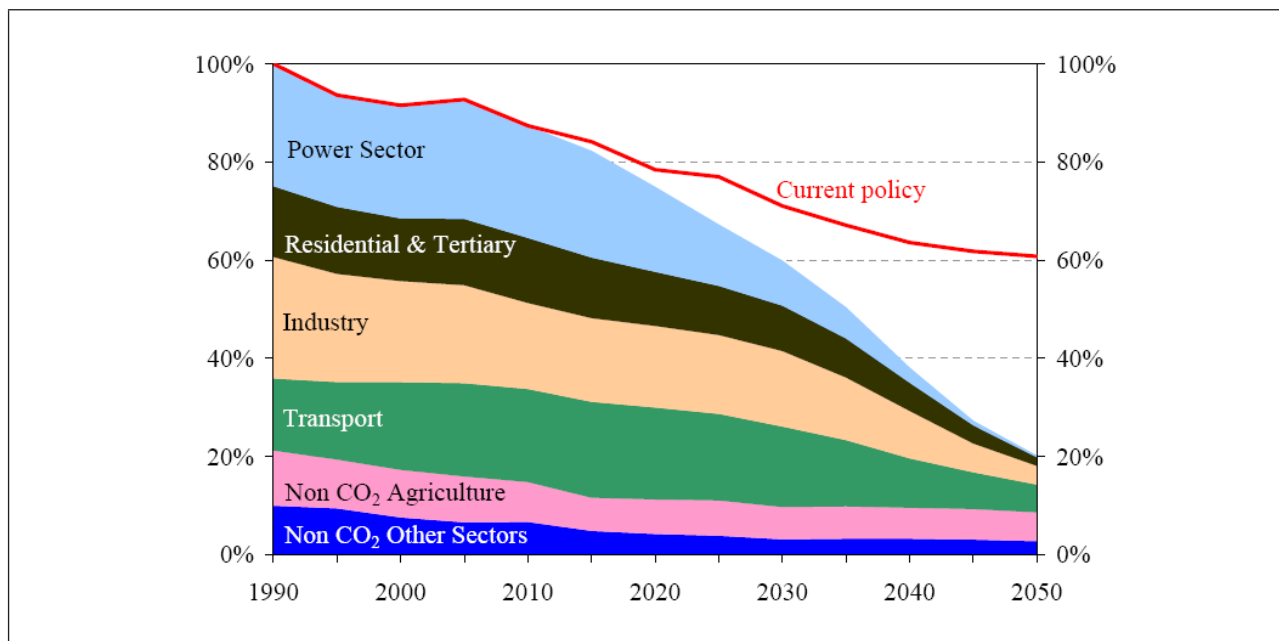
The visions analyzed within this report are recently released energy roadmaps that include a quantitative analysis for Europe<sup>3</sup>. They are from a diverse set of stakeholders: a European electricity industry association (Eurelectric, 2010a), representatives of the European gas industry (EGAF, 2011), the European Climate Foundation (ECF, 2010), the intergovernmental International Energy Agency (IEA, 2010) and a non-governmental environmental organization in cooperation with an association of the renewable energy industry (EREC/Greenpeace, 2010). We compare the visions of these stakeholders with the DG Climate roadmap (EC, 2011a), which presents the European Commission's vision of a low-carbon economy and the most cost-effective pathway to achieve the desired

1 Taking into account that total climate action from all countries will allow a global reduction of 50% in emissions by 2050. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) has concluded that a reduction of 50% to 85% in global GHG emission by 2050 compared to the 2000 level is needed to limit the global temperature rise to 2.0-2.4°C with respect to the temperature in pre-industrial times. According to more recent studies, a 50% GHG reduction may not be enough to avoid dangerous temperature increases (Allison et al, 2009). In this report we do not enter in the debate over whether 80-95% GHG reduction for the EU is too ambitious or not ambitious enough to reach this temperature limit, or if the 2°C target is enough to prevent climate disruption.

2 The European Commission is organized in several Directorate Generals, referred to as the DGs.

3 This explains why, for instance, WWF (2011) is not considered, since it does not present a quantitative analysis for Europe.

**Figure 1** – EU GHG emissions towards 80% domestic reduction (compared to 1990 levels) Source: EC, 2011a



goal.

## Strategies

For what concerns the member states' pioneering strategies, we include in the analysis those member states that have low carbon energy policies with specific 2050 targets in place, i.e. Denmark, France, Finland, Ireland, Germany and the UK (for the remainder of this report, we refer to them as the "pioneering member states").<sup>4</sup> By analyzing these selected visions and strategies, we identify the challenges that policy makers will need to address at member state and/or EU levels, and we also identify new risks of member states moving in different directions ("policy fragmentation") and new opportunities for member states' cooperation and European added value.

## EU

With this report, we are advising DG Energy in the preparation of their roadmap. We focus on the first

<sup>4</sup> Note that these are not necessarily today's pioneers. For instance, the UK during the last 10 years has only reached a share of renewable energy of around 3% (NREAP, 2010) in their gross consumption, while they need to reach 15% by 2020.

steps that should already be undertaken today at the EU level. As a result, the report also takes today's EU institutional boundary conditions as given. In other words, we are implicitly assuming that the EU is a multilateral agreement that is fixed. Even though it is out of the scope of this report, it is important to also further explore what could and should be a more ambitious approach to energy policy at the EU level.<sup>5</sup>

## Energy policy

We consider the following six main energy-related policy areas: energy efficiency, GHG emissions, renewable energy, energy infrastructure, internal energy market, and technology innovation and R&D. Within these areas, we focus on the electricity sector because, "electricity will play a central role in the low carbon economy" (EC, 2011a). Even though this report does not cover the other important sectors, such as the transport sector, included in the DG Climate

<sup>5</sup> Some have argued that energy policy cannot be efficient and effective if sovereignty on energy policy in Europe is kept at a national level Lévêque (2008). It has been advocated that in addition to an internal energy market, the EU should aim to create a common energy policy or, more audaciously, a European energy community (Notre Europe, 2010).

roadmap (Annex 1), it does briefly reflect on the interactions between the transformations in these sectors and the transformation of the power sector.

## Analytical framework applied in the report

We developed an analytical framework that distinguishes three different types of possible EU involvement (Figure 2).

- **The first type of EU involvement** corresponds to setting (binding) targets for member state actions. Member states still have total freedom to decide on how to achieve the targets. The EU creates added value by setting an objective for the EU as a whole, and by sharing the effort among member states, for instance, to ensure that every member state contributes to a European common interest.
- **The second type of EU involvement** is about framing the choice of measures taken by member states to achieve a certain objective. Member states still decide how to act or which instruments to use. The EU creates added value by harmonizing the approach taken by member states, for instance, by setting coherence

requirements that member states need to comply with when working towards their objectives.

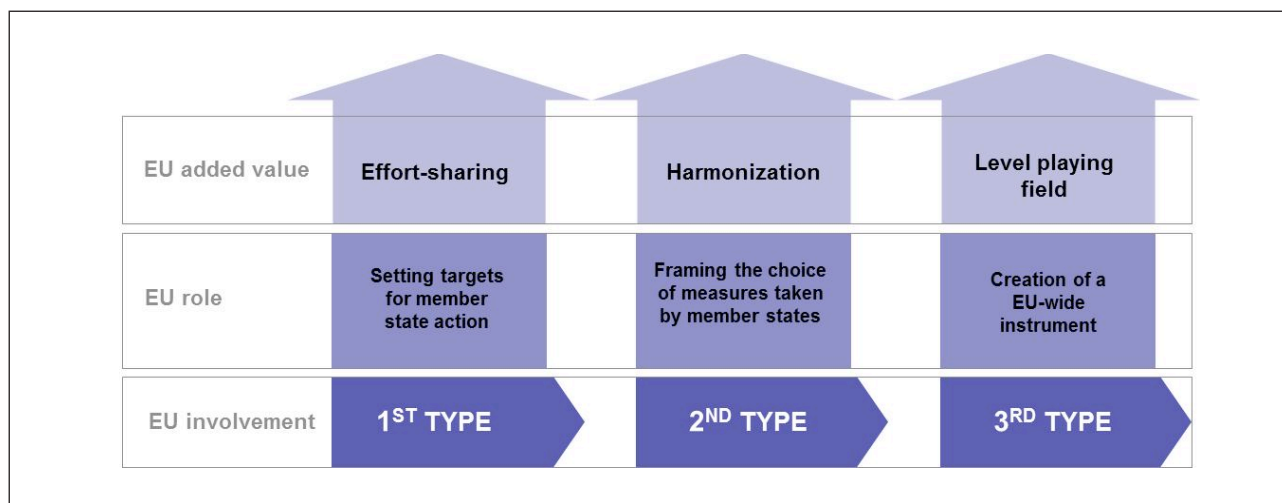
- **The third type of EU involvement** corresponds to the creation of an EU-wide instrument. Member states then rely on the performance of an EU instrument to amplify the individual measures taken at the member state level. The EU creates added value by creating a level playing field, for instance, by introducing a European Emission Trading Scheme (EU-ETS).

We use this analytical framework with three types of EU involvement to derive promising EU interventions to deal with the key 2050 policy challenges.

## Structure of the report

The report is organized in three chapters. Chapter 1 introduces the different stakeholders' visions and derives from them the main energy-related policy challenges. In Chapter 2, an overview is given on how pioneering member states are dealing with these key challenges and the risks of policy fragmentation; new opportunities for member state cooperation and European added value are also identified. Chapter 3 is

**Figure 2** – Different types of EU involvement



**Table 2** – Stakeholder visions

Stakeholder	Vision	GHG Target*	Fuel Prices	Technologies Development	
				CCTS **	RES ***
Eurelectric	Power Choices	75%	Medium-High	2025	Low
European Gas Advocacy Forum (EGAF)	Low gas price	80%	Medium-Low*****	2030	Medium
	High gas price	80%			
	Low gas price and constrained nuclear****	80%			
International Energy Agency (IEA)	BLUE Map	75%	Low	2015-2025	High
European Climate Forum (ECF)	Roadmap 40% RES	80%	Medium-Low	2020	Medium
	Roadmap 60% RES	80%			
	Roadmap 80% RES	80%			
EREC/ Greenpeace	Energy [R]evolution	80%	High	Not needed	Medium-High

\* GHG emission reductions relative to 1990 levels

\*\* Year when it is assumed to be commercially available

\*\*\* Learning rates (in qualitative terms)

\*\*\*\* Nuclear capacity constrained at 30GW by 2030

\*\*\*\*\* The fuel prices considered are the same as in the ECF report, except for gas, for which two different price scenarios (low and high) are considered. The high gas price scenario is the one corresponding to ECF values.

dedicated to the understanding of the possible role of the EU. Finally, the main recommendations deriving from the analysis are presented.

## 1. Stakeholder visions: what are the key 2050 policy challenges?

The stakeholders' visions on a low carbon energy system are introduced in this chapter. We report what the visions mention regarding the transition costs and benefits, and then continue with the identification of key policy challenges necessary to achieve them.

### 1.1 The transition cost and benefits

Stakeholders have presented alternative pathways towards a low carbon energy system in 2050 with slightly different geographic scopes<sup>6</sup> and GHG emis-

sions' reduction targets. In what follows, we discuss the differences in assumptions regarding: 1// fuel prices; and 2// technology development (Table 2).<sup>7</sup>

For the assumed fuel prices (Annex 3), IEA presents low fuel prices, based on the reference scenario of the IEA World Energy Outlook (WEO) (IEA, 2009a); it is assumed that fuel prices will decrease significantly towards 2050 as a result of the decreasing fuel consumption. ECF fuel prices are slightly higher, based on the low carbon scenario included in IEA WEO

Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Slovak Republic, Spain, Sweden and United Kingdom) plus Iceland, Norway, Switzerland and Turkey.

<sup>7</sup> Note that regarding economic growth, the stakeholders have assumption of a slow and stable economic growth after 2030 in common. Because the values used to report are not the same, it is not straightforward to compare assumptions. There is a difference in currency and different indicators are used to quantify growth; ECF and EGAF studies only present an average annual growth for the whole transition period, while the others present the expected value for GDP or GDP per capita.

<sup>6</sup> Eurelectric considers the EU 27, while both EGAF and ECF consider all the countries from the EU 27 plus Switzerland and Norway. The scope from IEA and EREC/Greenpeace reports is OECD Europe which consists of 19 EU member states (Austria,

(IEA, 2009a).<sup>8</sup> EGAF uses the same assumptions on fuel prices as ECF, except for gas where two scenarios are considered: a high gas price scenario with the same gas prices as ECF and a low gas price scenario which assumes that gas prices remain low up to 2050. The Eurelectric fuel prices, based on their own calculations using the Prometheus model, are higher than in the reports above. EREC/Greenpeace has the highest assumed fuel prices based on the high price sensitivity scenario in IEA WEO (IEA, 2009a).

Looking at the assumed technology developments, different stakeholders do not count on the same technologies, as they have different assumptions regarding the cost evolution of these technologies. For instance, IEA projects that Carbon Capture Transport and Storage (CCTS) will be available between 2015 and 2025, depending on the support that this technology will receive; ECF considers that CCTS technologies will be commercially available from 2020 on; Eurelectric considers these technologies from 2025 on, and EGAF from 2030. EREC/Greenpeace does not believe in CCTS technologies. For renewable energy technologies, stakeholders do not report the same indicators. For instance, Eurelectric presents levelized costs and EREC/Greenpeace the evolution of investment and operation and maintenance costs, while IEA, ECF and EGAF studies present the learning rates of the different technologies. Nonetheless, Table 2 gives an indication of how these technologies are projected to develop in the different visions.

Despite the differences in the assumptions among the different visions, their outcomes concerning the overall cost of the transition are considerably similar. The visions have in common that they report that the transition would increase the need for investments so

that capital costs increase, while fuel costs decrease. Note that the increase in capital costs depends on the assumed technology development, while the fuel cost savings depend on the assumed fuel prices.<sup>9</sup> In Eurelectric's vision, the fuel cost savings do not fully compensate the additional investment needed, compared to their baseline scenario. In the IEA's vision, the additional investments are lower than the cumulative fuel savings, compared to their baseline scenario. In ECF's vision, the cost of energy is reported to decline by 20-30% over the total period. EGAF however argues that the ECF pathways are costlier and riskier than accounted for.<sup>10</sup> The EREC/Greenpeace study reports an annual cost of electricity supply that is below that of their baseline scenario. In other words, the visions agree that investment goes up, and fuel costs go down, but they do not fully agree on what will be the net effect.

Some stakeholders have also argued that their findings are robust by showing that they also hold under different assumptions. For instance, Eurelectric performed four sensitivity analyses in order to study the impact of changing their main assumptions, including the delay on CCTS technologies development, the change in nuclear phase out policies, the tighter restrictions regarding on-shore wind installation and the inexistence of additional energy efficiency policies. The overall result is that in general there are no significant changes, neither on the target achieved nor in the overall costs of the transition.<sup>11</sup> IEA also

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<sup>9</sup> This is a simplification because, for instance, the development of technology also has an impact on the fuel costs as more efficient conversion technologies can save fuel.

<sup>10</sup> EGAF argues that a realistic and cost-efficient low carbon European strategy should take in consideration the considerable stranded costs that are likely to derive from the abandonment of gas distribution and storage infrastructures and the consequent economical and societal burdens connected with the natural gas industry.

<sup>11</sup> The inexistence of additional energy efficiency policies is the one with the highest impact both on the targets and on the costs, -7% and additional 3,552 billion Euros, respectively.

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<sup>8</sup> This low carbon scenario assumed the stabilization of the concentration of GHG in the atmosphere at 450 ppm CO<sub>2</sub>-eq, limiting the rise in global temperature by 20oC (IEA, 2009a).



performed some sensitivity analysis regarding assumptions in the different economic sectors (electricity, buildings, industry and transports) in order to guarantee the robustness of their conclusions. Within the ECF study there is a sensitivity analysis, but its main goal has been to show that the power system can sustain a high share of renewable energy sources, even when considering extreme weather conditions and/or reductions on interconnections (among other changes in the system).

The DG Climate roadmap confirms the need for additional investments in order to ensure the transition, which the roadmap considers to be about €270 billion<sup>12</sup> annually during the period 2010-2050 (corresponding to 1.5% of GDP). The roadmap also states that the net effect can be positive or negative depending on the fuel price developments, which are estimated to be about €175 to 320 billion annually during the same period.

Note that the stakeholder studies included here assess the policy costs mostly from an energy system analysis. Transformational policies such as those needed to achieve a low carbon economy are likely however to have impacts on various sectors of the economy and on the trading balance of the EU, which can be negative (e.g. reduced competitiveness of energy intensive industries) and/or positive (e.g. development of low carbon businesses). The DG Climate roadmap believes the net effect will be positive, considering the additional investments in the EU economy that will lead to an increase of competitiveness and jobs. Note also that the stakeholder studies compare the costs of the transition with a “business as usual” baseline scenario, which is actually not the correct way to discuss whether or not we should follow the decarbonisation

path, we should rather be comparing the costs of climate change with the costs of the transition to mitigate climate change.

## 1.2 Key 2050 policy challenges

In this section, we identify the key policy challenges concerning the achievement of the stakeholders’ visions. Throughout the identification, we demonstrate that these challenges are in policy areas where the EU is indeed already active in the 2020 context: 1// energy efficiency; 2// GHG emissions; 3// renewable energy; 4// energy infrastructure; 5// internal energy markets; and 6// technology innovation and R&D (Table 3).

First, in the policy area of **energy efficiency**, the key challenge reported by stakeholders is to achieve ambitious energy savings. The ambition desired is not always comparable among the different studies since they do not present the necessary energy efficiency improvements using the same indicators. Eurelectric and EREC/Greenpeace for instance report the primary energy savings that need to be achieved in their visions relative to a baseline, i.e. the reference scenario in IEA WEO (IEA, 2009a), while the others refer to the role of energy efficiency in terms of the GHG emissions’ reductions that are projected to be achieved with energy efficiency measures. The savings that need to be achieved in comparison with a baseline scenario are 20% in the case of Eurelectric, and 40% in the case of EREC/Greenpeace. In the IEA report, energy efficiency improvements reduce GHG emissions by 30%. ECF reports separate numbers for the building and the transport sectors, where 45% and 20% of GHG reductions are expected to be achieved through energy efficiency improvements, respectively. The visions are therefore difficult to compare, but require a significant increase in efforts in this area in comparison with previous years. The

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<sup>12</sup> The biggest share of this amount would be invested in the transport sector (€150 billion), followed by the built environment (€75 billion) and the power sector (€30 billion).

DG Climate Roadmap further emphasizes the importance of energy efficiency by considering it as the single most important contribution to the achievement of the objectives.

Second, in the policy area of **GHG emissions**, the key challenge reported by stakeholders is to achieve a nearly zero-carbon electricity sector.<sup>13</sup> The vision is to generate electricity mainly from low-carbon energy technologies, i.e. using renewable energy sources, nuclear and/or fossil fuels equipped with CCTS so that electricity can play an important role in decreasing also the emissions of the transport and heating sectors. Eurelectric considers the highest level of electrification for both sectors, followed by the ECF visions, while EREC/Greenpeace and IEA consider a higher direct use of renewable energy sources<sup>14</sup> and a lower use of electricity. In the EGAF vision, a major contribution could come shifting from coal power plants to gas with also an increased penetration of most efficient renewable technologies and the application of combined cycles to biomass electricity generation plants. Within the DG Climate Roadmap, electricity is considered to play a crucial role in the low carbon economy so that it also considers the decarbonisation of the electricity sector as a top priority.

Third, in the policy area of **renewable energy**, the key challenge reported by stakeholders is achieving the ambitious renewable energy targets. There is an agreement that the use of renewable energy sources needs to continue to increase, both directly and indirectly (through the use of electricity and heat and cooling generated from renewable energy sources). Concerning the use of renewable sources in electric-

ity generation, the share ranges from 30-34% (EGAF) up to almost 100% (EREC/Greenpeace) of electricity generation in 2050. ECF presents three different visions with different shares on the use of renewable sources within the electricity sector, ranging from 40% to 80%. IEA envisages that 50% of the electricity is produced from renewable energy sources. EGAF suggests postponing the main increase of renewables until after 2030.

Fourth, in the policy area of **energy infrastructure**, the key challenge reported by stakeholders is ensuring electricity grid adequacy. The importance of the electricity grid, and especially the expansion of transmission across borders, is emphasized in all visions. The expansion of interconnections that needs to be achieved in the different studies ranges from a 40% to more than 90% increase compared to today's capacities. Note however that the focus on electricity transmission expansion, as opposed to smarter grids (which apply to both transmission and distribution grids) with more demand flexibility and storage, can be partly explained by the fact that today's models are limited in how they represent smart grid technologies. Nonetheless, some of the visions already alert for the importance of not just expanding but also smartening the grid; for instance, ECF shows the potential benefits of using demand flexibility and EREC/Greenpeace refers to the need of a EU super-grid.<sup>15</sup> Moreover, the need to expand and smarten electricity grids is also highlighted in the DG Climate Roadmap.

Fifth, in the policy area of the internal **energy market**, the key challenge reported by almost all stakeholders

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<sup>13</sup> See also Delarue et al. (2011).

<sup>14</sup> Some of the most important indirect uses of renewable energy sources in these visions include solar thermal for domestic hot water; passive solar for space heating purposes and free cooling through the use of mechanical ventilation, cooling towers, etc.; use of biomass and geothermal for heating purposes.

<sup>15</sup> EREC/Greenpeace also released a more detailed study on the infrastructure needed to support the functioning of a European power sector almost 100% fuelled by renewable energy sources (EREC/Greenpeace, 2009) where they mention the need for a new political framework to implement the necessary infrastructure. This study has recently also been updated (Greenpeace, 2011).

is to ensure electricity supply security. Depending on the visions, the increase in generation capacity ranges from 50% (Eurelectric) to 164% (ECF 80% RES) of today's generation capacity. This raises concerns for timely investments, which is especially the case for investments in system flexibility. As emphasized by all the studies, matching supply and demand, i.e. balancing, will become increasingly challenging with the increased penetration of renewable energy sources. ECF for instance reports that, even if the electricity transmission grid is expanded to reduce the need for back-up, the back-up capacity needs to be significantly increased compared to today's values, i.e. between 170 to 270 GW of back-up capacity (equivalent to 22 and 35% of the today's installed capacity) in its visions with 40% up to 80% electricity generation based on renewable energy sources. EGAF reports a generation portfolio with more CCTS so that less back-up capacity is needed. As the amount of back-up capacity that will be needed is uncertain, depending on the generation mix and the electricity transmission grid expansion, there are concerns that the market will not deliver in time or will not provide enough system flexibility.

Sixth, within **technology innovation and R&D**, even

if there is not an explicit challenge mentioned in the different visions, all of them assume certain technology developments in order to allow the achievement of the intended goal. Indeed, technology innovation is a pre-condition for most of the challenges in the other policy areas: achievement of highly ambitious savings requires the use of technologies which are still not commercially available; the almost full decarbonisation of the electricity sector also relies on the increased efficiency of most renewable energy technologies for electricity generation and the development of CCTS technologies; and research on smart grids and super grids. Within the recently released roadmap, the EC also shows a concern about guaranteeing the necessary investment in R&D, demonstration and early deployment of different technologies to ensure their cost-effective and large-scale penetration later-on.

The key 2050 policy challenges identified in this chapter, as summarized in Table 3, are electricity focused. With the exception of the EGAF vision, the role of natural gas in the transition towards 2050 is not always fully clear, and not always explicitly discussed in the visions. We will come back to this issue in chapter 3.

**Table 3** – Key 2050 policy challenges

<b>Energy efficiency</b>
Ambitious energy savings
<b>GHG emissions</b>
Decarbonising the electricity sector
<b>Renewable energy</b>
Ambitious renewable energy penetration levels
<b>Energy infrastructure</b>
Electricity grid adequacy (expansion and smartening of the grid)
<b>Internal energy market</b>
Electricity supply security (timely investments and system flexibility)
<b>Technology innovation and R&amp;D</b>
Technology development is a precondition for most of the above challenges



## 2. Member state strategies: how are pioneers dealing with the key 2050 policy challenges?

In this chapter, we explore the low carbon energy policies with a view to 2050 that are emerging in pioneering EU member states. We do not assess the status of the member states policy towards the 2020 target, we only focus on the member states that have started actions with a longer term target. We first compare the status of the 2050 policy production process, and then compare what these member states are doing in order to identify new risks of policy fragmentation and new opportunities for member states' cooperation and EU added value.

### 2.1 Status of the political process

In what follows, we discuss the status of the political process of member states already mobilized towards a low-carbon energy future for 2050 in terms of 1// exploring policy options; 2// legal commitment; and 3// implementation (Table 4).

The first step corresponds to **exploring policy options**.

- The Danish government established the Commission on Climate Change Policy in 2008 to develop proposals to decarbonise and to become independent of fossil fuels. This commission, which consisted of 10 independent experts, published their recommendations in 2010 (DCCCP, 2010) and, based on these recommendations, the Danish government recently released a strategic roadmap to achieve independence from coal, oil and gas and to significantly reduce greenhouse gas emissions by 2050 (TDG, 2011).
- In Finland, the government approved the “Long-term Climate and Energy Strategy” (GOF, 2008) in

2008 with detailed proposals on climate and energy policy measures up to 2020, and suggestions up to 2050. In 2009, the government has published the “Foresight Report on Long-term Climate and Energy Policy” (PMO, 2009) to supplement the 2008 strategy, setting GHG targets up to 2050 and outlining longer-term climate policies; this report is based on a set of studies commissioned by the government to expert groups and on public consultations of stakeholders, experts and citizens.

- In France, the government initiated a debate with different stakeholders (including local authorities, trade unions, business, NGOs) on ecological and sustainable development in 2007, i.e. the “Grenelle de l’environnement”, which has resulted in a set of recommendations (Tuot, 2007).
- The German government has developed its low carbon energy policy, i.e. “Energiekonzept” (FMET, 2010) based on a study that models different scenarios on the future of the German energy sector (Prognos et al., 2010).
- In Ireland, the previous government released a Climate Change Bill in 2010 with the goal of legally establishing a target of 80% GHG reduction by 2050 (MEHLG, 2010). The bill also foresees the creation of an Expert Advisory Body that, with the support of the Irish Environmental Protection Agency, would give the Minister of the Environment the political, economic and technological advice necessary to define the specific policy measures to reach the target.
- In the UK, the climate policy with a 2050 target started with the previous government that established the Committee on Climate Change (CCC, 2008) and used its advice to develop a low carbon energy system transition plan (HMG, 2009).

**Table 4** – Status of the political process of member states' climate policies for 2050

Member state	Exploring policy options	Legal commitment	Implementation
<b>Denmark</b>	<ul style="list-style-type: none"> <li>– Committee on Climate Change</li> <li>– Energy Strategy 2050 (TGD, 2011)</li> </ul>	/	/
<b>Finland</b>	<ul style="list-style-type: none"> <li>– Long-term Climate and Energy Strategy (GOF, 2008)</li> <li>– Foresight Report on Long-term Climate and Energy Policy (PMO, 2009)</li> </ul>	<ul style="list-style-type: none"> <li>– In 2009 the parliament endorsed the Long-term Climate and Energy Strategy</li> </ul>	<ul style="list-style-type: none"> <li>– Expected report by government</li> </ul>
<b>France</b>	<ul style="list-style-type: none"> <li>– Grenelle de l'environnement</li> </ul>	<ul style="list-style-type: none"> <li>– Grenelle law I 2009</li> <li>– Grenelle law II 2010</li> </ul>	<ul style="list-style-type: none"> <li>– 201 pending decrees</li> <li>– Annual status report by government</li> </ul>
<b>Germany</b>	<ul style="list-style-type: none"> <li>– Energieszenarien für ein Energiekonzept der Bundesregierung (Prognos et al., 2010)</li> </ul>	<ul style="list-style-type: none"> <li>– Energiekonzept law will not be voted on, as strategy changed</li> </ul>	<ul style="list-style-type: none"> <li>– Expected status report by government every 3 years</li> </ul>
<b>Ireland</b>	<ul style="list-style-type: none"> <li>– Expert Advisory Body*</li> </ul>	/	<ul style="list-style-type: none"> <li>– Annual report by the Expert Advisory Body</li> </ul>
<b>UK</b>	<ul style="list-style-type: none"> <li>– Committee on Climate Change</li> <li>– Electricity Market Reform Project (EMR, 2010)</li> </ul>	<ul style="list-style-type: none"> <li>– Climate Change Act 2008</li> <li>– Energy Act 2010</li> <li>– Additional legislation foreseen in 2011</li> </ul>	<ul style="list-style-type: none"> <li>– Annual Progress report by the Commission on Climate Change</li> <li>– Carbon budget update every 5 years</li> <li>– Annual status report by government</li> </ul>

\* Defined in the Climate Change Bill 2010, which has not yet been enacted (MEHLG, 2010).

Secondly, there is the need for a **legal commitment**. This step has not yet been achieved by all the member states referred to in this paper.

- In Denmark, the government will launch a review of current legislation in several areas such as electricity supply and regulation, energy efficiency, use of biogas, etc.

- In Finland, the “Long-term Climate and Energy Strategy 2008” was endorsed by the Parliament on June 2009 and the government is considering the possibility of supporting a Climate Change Act similar to the UK Act 2008 (UK, 2008).

- In France, the “Grenelle de l'environnement” initiative has already led to two legal commitments, i.e. “Grenelle I”, enacted in 2009, that sets the general policy without practical implementation or funding, and “Grenelle II”, released in 2010, which defines specific targets and actions.

- In Germany, the law corresponding to the “Ener-

giekonzept” was supposed to be voted on in 2011. After the recent events in Japan, Germany is however reconsidering its strategy.

- In Ireland, the Climate Change bill is still pending.<sup>16</sup>

- In the UK, a first legislative action has already been taken in 2008 with the Climate Change Act (UK, 2008), mandating to cut GHG emissions with 80% by 2050 relative to 1990 levels.<sup>17, 18</sup> Furthermore, an ad-

16 In Ireland, after the elections in February 2011, a new coalition leads the government, and it had not yet defined its climate policy at the time of our analysis, which is why Ireland is not discussed in the next section.

17 This act also officially established the Committee on Climate Change as an independent advisory body.

18 According to the Climate Act, the Committee on Climate Change recommends to the government the level of carbon budget (which is the maximum level of GHG allowed in the UK) in a five-year period. The government in turn must propose a budget before Parliament. In the first report in 2008 (CCC, 2008) the Committee on Climate Change recommended the level of the first three budgets, covering the period up to 2022 and the parliament subsequently legislated in line with its recommendations (HMG, 2011). In December 2010, the Committee on Climate Change published recommendations for the fourth budget (CCC,

ditional law, the Energy Act 2010 (HMG, 2010b), was voted on in April 2010 in order to implement part of the transition plan prepared by the government. New legislative proposals are expected in 2011.<sup>19</sup>

The third step is the **implementation** of the defined measures/policies.

- In Denmark, the roadmap by the government has only been released very recently so the envisaged initiatives for 2050 have not yet been implemented.
- In Finland, an initial report on the implementation of the new measures defined in the Foresight Report will be drawn up by the current government.
- In France, 201 decrees need to be implemented for the laws to become effective (CDD, 2010), which is foreseen for 2012. According to the Grenelle laws, the French government will need to report on the status of the implementation of this policy on a yearly basis.
- Similarly, in Germany this step has also not been accomplished but it is foreseen that the government will need to monitor and report on progress every three years.
- In Ireland, if the Climate Change Bill passes, the Expert Advisory Body shall prepare an annual report to the government on the progress towards the implementation of the low carbon policies.

2010b), covering the years 2023–27, based on which the government will propose further legislation in spring 2011.

<sup>19</sup> After the election in May 2010, the government changed, but the new conservative-liberal coalition also has a set of measures on its agenda to fulfill the ambitious low carbon targets put in place under the previous government. The measures seem to be largely in line with the policies of the previous government (HMG, 2010a), but there are also new elements. The new government has started a series of consultations for a wide reform of the electricity market in the context of climate change. See: <http://www.decc.gov.uk/en/content/cms/consultations/emr/emr.aspx>.

– In the UK, the Committee on Climate Change, in addition to the carbon budget recommendations, is realizing yearly progress reports and it has already published the first two (CCC, 2009; CCC, 2010a), advocating that even stronger measures need to be taken, such as the introduction of a carbon floor price. In addition, the Energy Act 2010 requires the government to present regular reports on the progress of decarbonisation policies.

## 2.2 Strategies to deal with the key 2050 policy challenges

We now analyze how member states deal with the policy challenges identified in the previous chapter: 1// achieving ambitious energy savings; 2// decarbonising the electricity sector; 3// achieving the ambitious renewable energy levels; 4// ensuring electricity grid adequacy; 5// ensuring electricity supply security; 6// technology innovation and R&D. Can we already identify in these climate policies new risks of policy fragmentation and new opportunities for member states' cooperation and European added value?

To achieve **ambitious energy savings** (i.e. key challenge identified in chapter 1 for the energy efficiency policy area), all countries consider the building sector to be the one with the highest potential for reductions, and they all propose important policy changes in order to lever the efficiency improvements in this sector. The Danish strategy focuses on renovation of buildings, which will be financed via grid tariffs. In Finland, after 2012, energy standards for new building will be amended to facilitate a gradual transition to passive houses. In France, the increase of building efficiency is considered as the measure with the highest potential, even when considering other policy areas. Indeed, the French target is to achieve a 38% reduction of the overall energy consumption within the building sector by 2020 and, in order to achieve

this, they intend to develop stricter building regulations for both new and refurbished buildings, defining minimum performance standards and minimum annual refurbishment rates. In Germany, the target is to reduce the overall energy consumption by 20% by 2020 and by 50% by 2050 relative to 2008 levels. This strategy relies on the establishment of a special fund to subsidize a wide range of measures for consumers, industries and local communities to increase energy efficiency, including in buildings. As in France, the intention in Germany is also to develop stricter building regulations for both new and existing buildings. Also in the UK, the priority regarding energy savings is to improve energy efficiency in homes, businesses and public buildings. The UK government has launched the “Green Deal”, a plan to provide up-front financing of energy efficiency improvements which the consumer pays back through their energy bills (DECC, 2010). In other words, we do see that the building sector<sup>20</sup> is strongly targeted by low-carbon energy policies at the member state level, but the approaches seem to diverge substantially.

Regarding **decarbonisation of the electricity sector** (i.e. key challenge identified in chapter 1 for the GHG emissions policy area), all the countries have in common that they only consider low-carbon electricity generation technologies for 2050. Nonetheless, the technology strategies are quite different from country to country. For instance, Denmark and Germany (after the Fukushima accident) do not consider nuclear as an option, while in France a large share of its electricity generation is still expected to come from nuclear power plants. The French electricity sector is expected to be already almost decarbonised by 2020,

assuming that it achieves the 20% national renewable energy target for 2020. Now that Germany decided to phase out nuclear by 2020, natural gas is likely to play a role as a bridging technology in Germany. In the case of the UK, the government wants to push CCTS and nuclear is also considered a valid low carbon option.<sup>21</sup> In the case of Finland, the government supports all low carbon technologies, including nuclear with the Olkiluoto Nuclear Power Plant currently under construction. In other words, there are diverging strategies in terms of the generation mix, which creates new risks for policy fragmentation. A first illustration of policy fragmentation is the decision of the UK government to introduce a carbon floor for electricity generation from 2013 on (HMT, 2011).

Concerning the achievement of the **ambitious renewable energy levels** (i.e. key challenge identified in chapter 1 for the renewable energy policy area), countries have different views of the strategic technologies they intend to develop by 2050, and renewable energy technologies are not the only strategic ones considered to be supported. In Denmark, biomass and wind-power are the ones that need to be pushed, and the government has planned to expand renewable energy continuing to levy costs on electricity consumers through the use of Public Service Obligations. In Germany, the original Energiekonzept strategy was to use renewable energy for 50% of the electricity consumed in 2030, going up to 65% in 2040, and 80% in 2050, but these numbers might change now that nuclear will not anymore be the bridging technology in Germany. In any case, the Germany strategy relies on the national support scheme to push its strategic

<sup>20</sup> Besides improving building efficiency, the member states analyzed also consider relevant the increase of energy efficiency in other sectors, such as transport. Germany has a target to reduce energy consumption in transportation of 10% by 2020 and of 50% by 2050. France wants to expand public transportation in order to reduce energy consumption within the sector.

<sup>21</sup> About nuclear, there has been a change of emphasis in UK policy. While the previous government supported nuclear technology, in the new government the Liberal Democrats have long opposed any new nuclear construction. According to the program of the new government new nuclear power plants will be possible but without public subsidy for construction (HMG, 2010a).

renewable energy technologies. Finland and the UK fully support renewable energy technologies but do not have long term targets for them because they are also open to developing other low carbon technologies, namely CCTS and nuclear. In other words, also regarding renewable energy policies, there are new risks of policy fragmentation.

Regarding **electricity grid adequacy** (i.e. key challenge identified in chapter 1 for the energy infrastructure policy area), important actions are foreseen in the different countries. The Danish strategy is based on further integration of its electricity grid into Europe and especially into the northern European grid. Also the German strategy is to take the initiative of developing an integrated Europe-wide grid. In addition to cross border infrastructure, the member states' climate policies recognize that it is fundamental to extend and develop the internal grid. The German government is developing a long-term plan for 2050 to develop and extend the national electricity network, especially focused to connect offshore wind farms, and it is creating the legal and financial conditions for a rapid expansion through easier licensing procedures and better investment mechanisms. The German government will also support the installation of smart meters. In the UK, in order to develop a national grid that can accommodate a large share of low-carbon technologies, the Energy Act 2010 (HMG, 2010b) redefines the role of the regulator who must now officially help the government to tackle climate change.<sup>22</sup> In Denmark the Commission on Cli-

mate Change recommends the government to define a specific plan for developing an intelligent energy network in collaboration with the national TSO and the electricity grid distribution companies. In other words, there are new opportunities to cooperation in the development of electricity grids, and pioneering member states seem to be willing to further integrate their electricity transmission grids to enable their low-carbon energy strategies.

To ensure **electricity supply security** (i.e. key challenge identified in chapter 1 for the internal energy market policy area), one of the strategies considered by member states is to further integrate the national electricity markets. The Danish policy is based on a further integration of its electricity market into Europe and especially into the northern European region. Also the German strategy is to support integration of the electricity (and gas) markets. In the UK low-carbon energy policies have triggered an electricity market reform process. The study that supports the ongoing public consultation (EMF, 2010) argues that an electricity generation capacity mechanism needs to be reintroduced in the UK to mitigate the security of supply risk. The study considers two options, i.e. a capacity payment for all, or a targeted capacity tender. Both would increase capacity margins and reduce risks to security of supply, but the study suggests that the tendering is the most appropriate option; one of the main reasons is that the alternative would imply a radical change that may create obstacles for the future integration of the UK market with the rest of Europe. Also in France, a market reform process is ongoing, and similar to the discussions in the UK, the intention is to introduce a generation capacity mechanism (Lévêque, 2011). The cases of France and the UK illustrate that generation capacity mechanisms are increasingly considered at the member state level, and because these mechanisms are currently national in scope, there is a new risk of electricity market frag-

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22 In 2010, the national regulatory authority for electricity and gas, OFGEM, defined a new regulatory framework designed to promote grid smartness, i.e. the so-called RIIO model, replacing the RPI-X model (OFGEM, 2010). OFGEM also allocated £500m over 5 years for the Low Carbon Networks Fund to support smart grid trials and, in collaboration with the Department of Energy and Climate Change, has established a new regulatory regime for offshore transmission networks to secure the connection of offshore wind. In addition to that, the UK government and OFGEM are collaborating to roll out smart meters in every home by 2019 (DECC, 2011).



mentation in Europe.

Regarding **technology development** (i.e. the key challenge identified in chapter 1 for the technology innovation and R&D policy area), pioneering member state envisage action at the national as well as the EU level.

– National level. In Germany, funding for R&D will be increased from 2011 onwards and an Energy Research Program will be defined before the end of this year with specific actions up to 2020 and an outline of central priorities for the period thereafter. It will mainly focus on RES, energy efficiency and energy storage. In the UK, the Department of Energy and Climate Change is supporting low carbon energy research, and it is funding demonstration and pre-commercial deployment projects through the Environmental Transformation Fund and the Low Carbon Investment Funding. Specific on CCTS, the Energy Act 2010 has introduced incentives to support the construction of four commercial-scale demonstration projects, and the new government wants to establish an emissions performance standard to build new coal-fired power plants equipped with sufficient CCTS to meet the emissions performance standard. Also in Finland, the government plans to develop and test CCTS. In Denmark, the R&D sector has a key role in the low carbon climate policy especially regarding wind power. In the context of the strategic roadmap for 2050, the Danish government will undertake a review of the public support for R&D in order to better coordinate all the government actions and to focus the efforts towards areas where support for research would have the greatest societal value. Moreover the Danish government wants to involve the business community more in this sector also entering into partnerships with private enterprises, and plans to actively support larger pilot tests like the wind turbine test centre at Østerild.

– EU level. The German government will support the implementation of the Strategic Energy Technology Plan (SET Plan) and in this context two CCTS demonstration projects eligible for EU funding are expected to be built by 2020; these tests will be important for the government to decide on future implementation of this technology. Denmark will support a doubling of the EU future funds for R&D up to 2020 in the energy and climate change areas. In France, public funding for the R&D in the energy sector has always been largely focused on nuclear energy. Following the Grenelle debate, the French government has decided to allocate more than a billion Euros up until 2012 in research for energy efficiency, for low carbon transportation and especially for renewable energy and CCTS, making the public support for these technologies comparable with the support for nuclear.

### 3. EU involvement: possible role of the EU in addressing the key 2050 policy challenges

In this chapter, we first discuss why the EU has a role to play in addressing the key 2050 policy challenges we have identified in the previous chapters (“Rationale for EU involvement”), to then use our analytical framework to derive policy options that are promising to address these challenges (“Three types of EU involvement”). Finally, the chapter illustrates the need for an integrated policy package.

#### 3.1 Rationale for EU involvement

In 2006, the European Commission published the Green Paper “A European Strategy for Sustainable, Competitive and Secure Energy” that calls for a common European energy policy. This then led to the “third energy liberalisation package”<sup>23</sup> to complete

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<sup>23</sup> The third package (EU, 2009f) consists of five legislative texts: (1) a Directive revisiting the internal market for elec-

the liberalization process in Europe, and the “climate and energy package”<sup>24</sup> with the so-called “20-20-20” targets for 2020:

- 20% reduction in primary energy use compared to projected levels for 2020, to be achieved by improving energy efficiency;
- 20% reduction in EU GHG emission below 1990 levels;
- 20% of final EU energy consumption from renewable resources.

From the legal point of view (Lisbon Treaty), environment and energy are among the areas where there is a shared competence between the EU and member states (Conference, 2007). From the economic point of view, the rationale for the EU involvement is about 1// assuring commitment; 2// internalizing externalities; and 3// reducing costs.

First issue is assuring commitment. The transition requires massive investments, while the path towards a low carbon energy system in 2050 is long and full of uncertainties. This implies that a political commitment is needed to give the necessary confidence to investors. For instance, within the 2020 climate and energy package, member states have legally committed to reduce GHG emission and increase renewable energy through binding targets defined at the EU

level. The targets have been fixed according to the wealth and existing mitigation opportunities of each country.

Second issue is internalizing externalities. National measures often have implications for other member states, which can be both positive and/or negative. The EU involvement can then also be justified by potential externalities resulting from member state actions as well as by fairness and equity issues. As internal energy markets and grids will be increasingly interdependent in the transition towards a low carbon future, the EU has an important role to play in addressing these externalities (e.g. grid adequacy, electricity supply security, etc).

Third issue is reducing costs. Some actions can be more effective if they are defined and organized at the EU level. This is the case for the EU ETS scheme for example, which is a successful instrument that works well on the European scale, which would probably not have worked on the national scale.

In other words, the EU has a role to play in addressing the key 2050 policy challenges we have identified in the previous chapters. The economic rationale for EU involvement in energy policy today, i.e. assuring commitment, internalizing externalities and reducing costs, is becoming even more important in the 2050 context.

### **3.2 Three possible types of EU involvement**

In this section, we use our analytical framework to derive policy options that are promising to address the key 2050 policy challenges in the six main energy policy areas. We first discuss this with a case-by-case approach, to then apply the approach to the six policy areas.

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tricity; (2) a Directive revisiting the internal market for natural gas; (3) a Regulation on conditions for access to the natural gas transmission networks; (4) a Regulation revisiting the conditions for access to the network for cross-border exchanges in electricity; (5) a Regulation establishing an Agency for the Cooperation of Energy Regulators.

24 The climate and energy package consists of four legislative texts: (1) a Directive revising the EU ETS; (2) an “effort-sharing” Decision setting binding national targets for emissions from sectors not covered by the EU ETS; (3) a Directive setting binding national targets for increasing the share of renewable energy sources in the energy mix; and (4) a Directive creating a legal framework for the safe and environmentally sound use of carbon capture and storage technologies.

### 3.2.1 Case-by-case approach

A case-by-case approach is necessary because the framework only suggests the different types of EU involvement to consider in each policy area. In some policy areas, a combination of the three types of EU involvement can be promising, while in other policy areas it can be more appropriate to have only one or no type of EU involvement (Figure 2).

- The first type of EU involvement (“effort sharing” by setting binding targets for member state action) can create EU added value when there is a common European interest that will not be pursued or that will be achieved too slowly/costly if not all member states contribute.
- The second type of EU involvement (“harmonization” by framing the choice of measures taken by member states) can create EU added value when there is policy fragmentation and this situation is costly due to incoherence.
- The third type of EU involvement (“level playing field” by creating an EU-wide instrument) can create EU added value when a harmonized approach is beneficial, and there is strong enough agreement among member states on what the most appropriate instrument to be applied is.

Note also that some policies are simply better addressed at the member state level because, for instance, this allows for policy experimentation in an area where it is unclear what the target should be and what the most appropriate policy instrument to use to achieve the target is.

### 3.2.2 Energy efficiency

In what follows, we identify promising interventions

to address the key energy efficiency policy challenge in the 2050 context, i.e. to achieve ambitious energy savings.

#### **First type of EU involvement: “effort sharing”**

Binding energy savings targets for 2020 and beyond, i.e. overall targets as well as sector specific targets.

This is a promising EU intervention because of three main reasons: 1// affordability of the transition; 2// history of indicative energy saving targets not being achieved; 3// increased risk of locking-in into energy inefficient technologies and assets with a long lifetime.

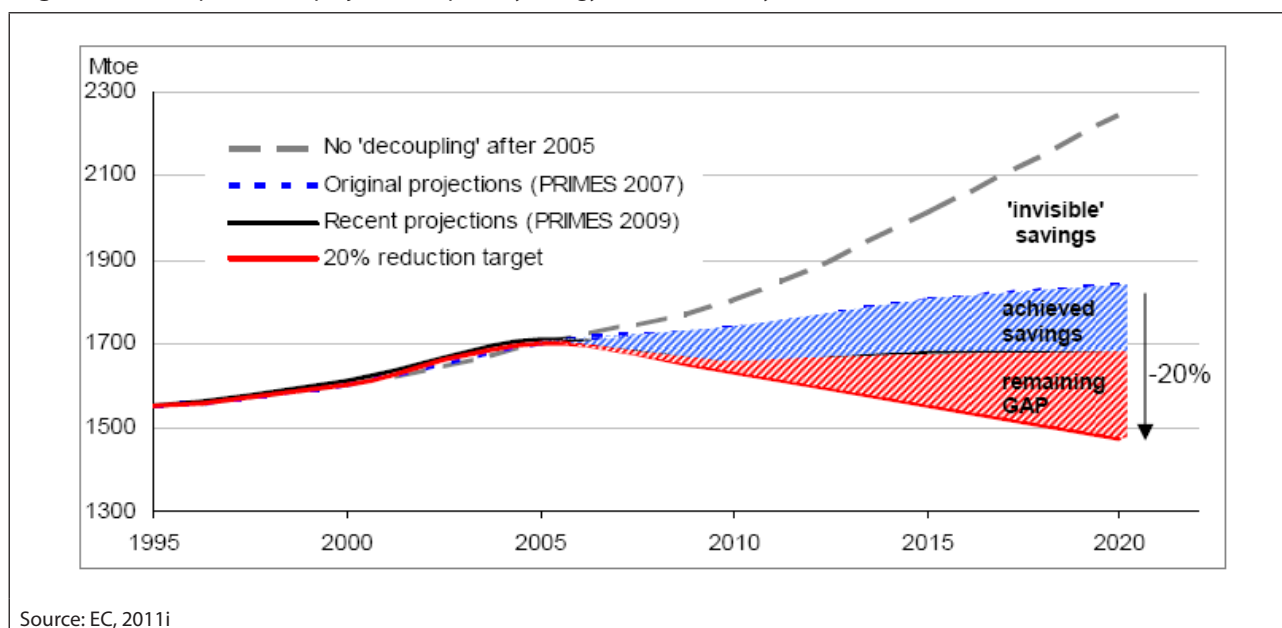
First reason is the affordability of the transition. The visions discussed in chapter 1 indeed indicate that the transition cost is sensitive to achievement of energy saving ambitions so that not achieving these ambitions can endanger the affordability of the transition.

Second reason is the history of indicative energy saving targets not being achieved. The current (and previous) lack of progress towards indicative targets suggests that binding national targets are needed for 2020 (Ecofys and Fraunhofer, 2010). The target of 20% reduction of the EU primary energy consumption in 2020 compared to a baseline scenario will indeed not be met with the existing policy (Figure 3) (EC, 2011b).

Third reason is the increased risk of locking-in into energy inefficient technologies and assets with a long lifetime. This is especially the case for buildings and transport infrastructures. The existing proposal to require public authorities to refurbish at least 3% of their buildings each year (EC, 2011b) would already be a step in this direction, but the member state strategies discussed in chapter 2 indicate that even more ambitious targets may be needed for buildings in the 2050 context.



**Figure 3** – Development and projection of primary energy use for the EU by 2020



### Second type of EU involvement: “harmonization”

Coherence requirements for measuring and reporting tools for energy saving measures

This is a promising EU intervention because of two main reasons: 1// local character of many energy saving measures; 2// reporting failure.

First reason is the local character of many energy saving measures. Local characteristics can be cultural and social (mobility patterns, average dwelling size, etc.), natural (climate, local topography, etc.) and/or economic (average income per household, main local economic activities, etc.). Because of these local characteristics, it is not necessarily opportune to harmonize member state approaches, but measuring and reporting tools will need to be harmonized anyway to facilitate the spreading of the good practices.

Second reason is reporting failure. The previous THINK report on “Smart cities: fostering a quick transition towards sustainable local energy systems” (THINK, 2011b) identified the reporting failure that

currently exists at the city level (Box 1), and argued that it needs to be addressed at the EU level with a harmonization of measuring and reporting tools for energy saving measures.

The EU has already been successful in voluntarily committing city authorities to reduce their CO<sub>2</sub> emissions with at least 20% by 2020 (Covenant of Mayors). In the context of the Covenant, a methodological framework has been developed to help signatories to elaborate their baseline emissions inventory and their so-called Sustainable Energy Action Plans (SEAP). It is also mandatory for Covenant signatories to produce a report every second year to monitor progress.

The SEAP template already requires city authorities to set targets, and list a set of actions to reach the targets, with the built environment, the local energy networks, and the urban transport systems integrated in one plan. Cities however often use different approaches in defining what sectors to include in their reporting, in establishing the geographic boundaries

### Box 1. City level “reporting failure” (THINK, 2011b)

The EU has already been successful in voluntarily committing city authorities to reduce their CO<sub>2</sub> emissions with at least 20% by 2020 (Covenant of Mayors). In the context of the Covenant, a methodological framework has been developed to help signatories to elaborate their baseline emissions inventory and their so-called Sustainable Energy Action Plans (SEAP). It is also mandatory for Covenant signatories to produce a report every second year to monitor progress.

The SEAP template already requires city authorities to set targets, and list a set of actions to reach the targets, with the built environment, the local energy networks, and the urban transport systems integrated in one plan. Cities however often use different approaches in defining what sectors to include in their reporting, in establishing the geographic boundaries of the area included (i.e. what is a “city”), as well as in aggregating data (Crocì et al., 2010; OECD, 2010; CEPS, 2010), and the Covenant also allows cities to use different accounting methodologies, for both CO<sub>2</sub> emissions and energy consumption. It is therefore necessary to evolve towards a more uniform methodological framework for smart cities. Alternatively, the inter-

operability between the existing methods could be improved so that cities can be compared even if they do not use the same reporting methodology (CEPS, 2010).

The framework could also account for a context to improve comparison between groups of cities. It is for instance important to measure the effect of the plans against a “likely future without a plan” rather than against the present. This issue is particularly relevant to filter out the on-going changes at the higher policy levels that have an impact on the performance of the local level, such national policies that impact the generation mix in a certain country and therefore the emissions associated with consuming electricity on the local level.

The reporting and monitoring framework should also enter into the project level, while the Covenant stays at a more aggregated level. Cities could for instance be asked to present a curve with the abatement costs of all proposed measures, allowing a better understanding of the cost-effectiveness of the different options (CEPS, 2010).

of the area included (i.e. what is a “city”), as well as in aggregating data (Crocì et al., 2010; OECD, 2010; CEPS, 2010), and the Covenant also allows cities to use different accounting methodologies, for both CO<sub>2</sub> emissions and energy consumption. It is therefore necessary to evolve towards a more uniform methodological framework for smart cities. Alternatively, the interoperability between the existing methods could be improved so that cities can be compared even if they do not use the same reporting methodology (CEPS, 2010).

The framework could also account for a context to improve comparison between groups of cities. It is for instance important to measure the effect of the plans against a “likely future without a plan” rather than against the present. This issue is particularly relevant to filter out the on-going changes at the higher policy levels that have an impact on the performance of the local level, such national policies that impact the generation mix in a certain country and therefore the emissions associated with consuming electricity on the local level.

**Table 6** – Promising interventions in the energy efficiency policy area

First type of EU involvement “effort sharing”	Second type of EU involvement “harmonization”	Third type of EU involvement “level playing field”
<b>Binding targets for</b> <ul style="list-style-type: none"> <li>– Energy savings beyond 2020</li> <li>– Overall and sector specific energy savings</li> </ul>	<b>Coherence requirements for</b> <ul style="list-style-type: none"> <li>– Measuring and reporting to facilitate spreading of good practices</li> </ul>	<b>EU</b> <ul style="list-style-type: none"> <li>– Good practice forum or register</li> <li>– Benchmarking of cities</li> </ul>

The reporting and monitoring framework should also enter into the project level, while the Covenant stays at a more aggregated level. Cities could for instance be asked to present a curve with the abatement costs of all proposed measures, allowing a better understanding of the cost-effectiveness of the different options (CEPS, 2010).

**Third type of EU involvement: “level playing field”**  
EU good practice forum or register

This is a promising EU intervention because it would support the spreading of good practices. The harmonization of measuring and reporting tools for energy saving measures (second type of EU involvement) will have a bigger impact if supported by an EU-instrument (third type of EU involvement) that registers the proven records and actively disseminates them.

**Third type of EU involvement:**  
**“EU level playing field”**  
EU benchmarking of cities

This is a promising EU intervention because it could mobilize cities towards a low carbon future. Cities are home to about 80% of Europeans and are responsible for about the same share of total primary energy use and carbon dioxide emissions (Eurostat, 2009). A global solution for climate change, even if achievable, would rely on the willingness of these citizens to cooperate so it is essential to have policies at multiple levels, including at the city level (Ostrom, 2009). A

promising intervention would be to require cities to report about their progress or lack of progress. This information could then be used to do an EU level benchmark report to better identify cities that have the capacity to act with the potential for a significant impact, but are not yet moving towards a local sustainable energy system (THINK, 2011b).

To sum up, Table 6 lists the most promising interventions in the energy efficiency policy area. Note that the recent Energy Efficiency Action Plan<sup>25</sup> is already a step in the right direction.

### 3.2.3 Greenhouse gas emissions

In what follows, we identify promising interventions to address the key greenhouse gas emissions policy challenge in the 2050 context, i.e. to decarbonize the electricity sector.

**First type of EU involvement: “effort sharing”**  
Binding GHG reduction targets beyond 2020, i.e. more stringent and credible long term caps.

This is a promising EU intervention because the transition to 2050 requires a long term steep decarbonisation, which requires a credible long term carbon price signal. In the 2009 revision of the EU ETS, it was

<sup>25</sup> The plan EC (2011b) is focused on reinforcing the existing Directives by proposing more stringent standards (for the industry sector e.g., through energy efficiency requirements for industrial equipment) and pushing energy efficiency to be a priority within the different sectors (e.g. it promotes the exemplary role of the public sector, by increasing the refurbishment rate of public buildings and introducing energy efficiency criteria in public spending).

agreed to introduce an EU-wide cap from 2013 on for the EU ETS sectors,<sup>26</sup> replacing the existing national caps. The EU-cap will decrease yearly by 1.74% of the average annual total quantity of allowances issued by the member states in years 2008-2012. As a result, the number of allowances available to EU ETS sectors in 2020 will be 21% below the 2005 level (EC 2010a, EC 2010b), which is in line with the binding 2020 target.

Note also that this linear path to decrease the EU-cap does not stop in 2020, implying that the EU already started defining emission caps beyond 2020 (EU, 2009c), but it could be important to launch a stronger signal to the investors that the EU is committed to continue its climate policy beyond 2020, that these caps are reliable and that they will become stronger in time.

#### **Second type of EU involvement: "harmonization"**

Coherence between carbon pricing and renewable energy targets

The approach of member states to reducing the GHG emissions of the electricity sector is already harmonized. Indeed, there is the EU-ETS to trade allowances, and from 2013 the initial allocation of allowances will also be harmonized with the introduction of auctioning<sup>27</sup> as the default method for the electricity sector.<sup>28, 29</sup>

26 The EU ETS is one of the pillars of the EU policy to combat climate change in the context of the 2020 package. It is the largest multinational emissions trading scheme in the world, it covers around 40% of the GHG emissions in the EU, including sectors as power generation, iron and steel, glass, cement, pottery and bricks.

27 Starting in 2013, the share of auctioning will gradually increase. Particularly in the electricity sector, free allocations have led to wind-fall profits (EC, 2008b; Keppler and Cruciani, 2010; Lévêque et al., 2009). Due to risk of carbon leakage, certain energy-intensive sectors can however continue to get all their allowances for free.

28 The Directive 2009/29/EC (EU, 2009c) allows an exception to this rule that is available to 10 member states: Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland and Romania. They may allocate a limited number of free allowances to the electricity sector but only for a transitional period.

29 Note also that the auctioning of the carbon emissions

The "harmonization" of carbon pricing with the renewable energy targets is a promising additional EU intervention because it would be about addressing the concern that renewable energy policies are depressing the carbon price. Experts have indeed pointed out that carbon prices are low due to a lack of coordination between the renewable policy and the GHG emissions policy.<sup>30</sup> The EU renewable target for 2020 is indeed pushing low carbon energy in the market, independently from the EU ETS, and the support schemes for renewables are much stronger incentives to invest in low-carbon technologies than the carbon price (Newbery, 2011; Traber and Kemfert, 2009; Morthorst, 2003).

#### **Third type of EU involvement: "level playing field"**

EU carbon market repository, platform, and authority for EU-ETS

With the EU-ETS, the EU succeeded in establishing a well-functioning carbon market that poses a cap on the total European carbon emissions (Ellerman et al., 2010). A voluntary EU- auction platform has now also been created that provides a centralized auctioning process with standardized electronic contracts (EU, 2010b). Except Germany, Poland and the UK, all the other member states have opted for participating in the common platform (Delbeke, 2011), and in reaction to security concerns regarding the national registers, the EU will also offer an EU-register that member states can voluntarily subscribe to.

An additional EU intervention to introduce a carbon market authority is promising because it would introduce independent oversight (de Perthuis, 2011).

will become a source of revenue for member states that can be used to finance low carbon policies in other sectors.

30 The low carbon prices of today could also be explained by the recent economic downturn that reduced demand for energy; that would imply that the price may go up along with the recovery of the economy and especially after 2013 when a stricter cap will be applied (Mercuri and Clô, 2010).

**Table 7** – Promising interventions in the GHG policy area

First type of EU involvement “effort sharing”	Second type of EU involvement “harmonization”	Third type of EU involvement “level playing field”
<b>Binding targets for</b> <ul style="list-style-type: none"> <li>- Reduction of GHG emissions beyond 2020</li> <li>- More stringent and credible long term caps</li> </ul>	<b>Coherence requirement</b> <ul style="list-style-type: none"> <li>- Carbon pricing with renewable energy targets</li> </ul>	<b>EU</b> <ul style="list-style-type: none"> <li>- Carbon market repository, platform, and authority for EU-ETS</li> <li>- Carbon tax, at least for non-EU-ETS sectors</li> </ul>

It could help to address the concern that the carbon price is not high enough.<sup>31</sup> This authority could then have the power to assess the carbon price when the price would be considered inadequate to support the EU climate and energy policy.

**Third type of EU involvement: “level playing field”**

EU carbon tax, at least for non-EU-ETS sectors

To guide the transition process, what matters is to have a carbon price that is a strong signal for investment, which can also come from a carbon tax. In fact, several economists have argued in favour of tax, also for EU-ETS sectors (Notre Europe, 2009). Such a tax could at least be considered as a promising EU intervention for non EU-ETS sectors. The European Commission has already taken a first step in this direction by proposing a new directive (EC, 2011j) to amend the 2003 directive on fossil fuel taxation (EU, 2003d). The proposal includes a minimum energy taxation based on CO<sub>2</sub> content to tax GHG emissions to non-ETS sectors, as a complement to the EU-ETS.

To sum up, Table 7 lists the most promising interventions in the GHG policy area.

### 3.2.4 Renewable energy

In what follows, we identify promising interventions to address the key renewable energy policy challenge in the 2050 context, i.e. to achieve renewable energy

penetration levels that are much more ambitious than the current objectives.

**First type of EU involvement: “effort sharing”**

Binding renewable energy targets beyond 2020

This is a promising EU intervention because such binding targets have been a successful way to organize effort-sharing among member states to develop renewable energy technologies. The 2020 climate and energy package includes the target to use renewable energy sources for 20% of energy consumption encompassing the three main energy consuming sectors, i.e. electricity, transport, and heating and cooling (EU, 2009e).<sup>32</sup> EU member states share the burden to achieve this overall target with binding national targets that have been set at EU level. Beyond this general target, there is a specific target for transportation: in each country at least 10% of transport fuel in 2020 must come from bio fuels or other renewable energy sources.<sup>33</sup>

Projections show that renewable energy in all member states will grow faster than in the past years. EU countries are underway to reach their 2020 targets

<sup>32</sup> Targets for renewable energy were first defined at the EU level by the Directive 2001/77/EC (EU, 2001) with the aim to increase the share of RES to 21% in the electricity sector and to 5.57% in transportation by 2010. But these targets were not binding and only a few member states were expected to achieve them by 2010. The failure to reach the agreed targets and the need for all member states to support renewable energy led to the new RES policy defined by the Renewable Energy Directive in 2009 (EU, 2009e).

<sup>33</sup> The biofuels must be produced in a sustainable way, do not undermine food production or lead to deforestation or biodiversity loss (EU, 2009e).

<sup>31</sup> The UK government has for instance announced that it will introduce a carbon floor price for the power sector from 2013 (HMT, 2011).



and almost half of the counties are planning to exceed their binding quota. If all member states implement the National Renewable Energy Action Plans they have recently submitted to the European Commission (EC, 2011d), the EU will exceed the 20% target in 2020. EU energy consumption in 2020 is projected to be 95% of the 2005 level and energy from renewable energy source is expected to more than double from 103 Mtoe in 2005 to 217 Mtoe in 2020. The electricity sector will account for 45% of this increase (especially wind power will significantly increase in importance, see Figure 4), heating 37% and transport 18%.

Continuing the targets beyond 2020 is a promising intervention because the costs of these technologies are not expected to reach competitive cost levels by 2020 (EU, 2009e), with perhaps a few exceptions, while the transition towards a low carbon future heavily relies on the development of these technologies.

#### **Second type of EU involvement: "harmonization"**

Market conformity requirements for national support schemes

This is a promising EU intervention as member states will continue their policies to push renewable energy technologies into the market with national support schemes. This massive deployment of renewable energy will have a major impact on the electricity market, also due to the fact that this market will be more and more European.

As renewable energy technologies reach significant penetration levels, it will be important to integrate them into the market (Egenhofer and Jansen, 2006; Hiroux and Saguan, 2010). A harmonization of national support schemes for renewable energy could therefore include the requirement that these technologies participate in the wholesale and balancing electricity markets, so that at least part of their profits

depend on their performance in these markets. This could be done by introducing "market conformity" requirements for these national support schemes.

#### **Third type of EU involvement: "level playing field"**

EU support scheme

This is a promising EU intervention because today most member states continue to focus on national renewable energy resources to achieve their 2020 target (EC, 2011d), while the European Commission has estimated that up to 10 billion Euro could be saved if the existing cooperation mechanisms were used inside the EU.<sup>34</sup>

An important exception is given to Sweden and Norway as have recently announced to create a joint green certificate support scheme that will start in 2012. Note that the European Commission tried to introduce a tradable green certificate scheme, which has been unsuccessful (Box 2), but a promising EU intervention would be to promote the voluntary participation of other member states to this type of member state cooperation initiatives.

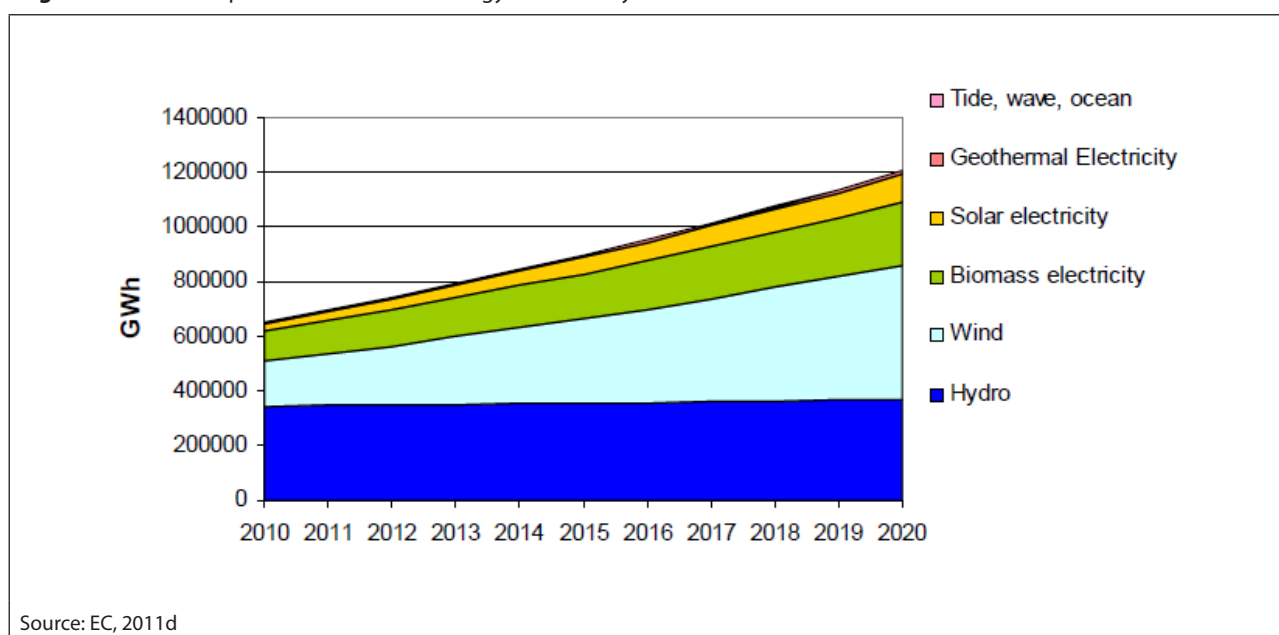
#### **Third type of EU involvement: "level playing field"**

EU decision bodies of Mediterranean regulators and transmission companies; and EU trade platform for the Mediterranean

This is a promising EU intervention because the massive renewable energy sources just outside EU borders in the Mediterranean area are attractive to develop in

<sup>34</sup> Note that renewable energy directive established three different mechanisms by which member states can work together to develop renewable energy: with "statistical transfers" a member state can transfer a virtual quantity of renewable energy produced to another member state for target compliance purposes; a "joint project" is a project that is financed by several member states; and in "joint support schemes" two or more member states can join or coordinate their national support schemes (Klessmann et al. (2010) and Ahner (2011)).

**Figure 4** – EU development of renewable energy in electricity



**Table 8** – Promising interventions in the renewable energy policy area

First type of EU involvement "effort sharing"	Second type of EU involvement "harmonization"	Third type of EU involvement "level playing field"
<b>Binding targets for</b> <ul style="list-style-type: none"> <li>Renewable energy beyond 2020</li> </ul>	<b>Coherence requirement</b> <ul style="list-style-type: none"> <li>Market conformity requirements for national support schemes</li> </ul>	<b>EU</b> <ul style="list-style-type: none"> <li>Support scheme</li> <li>Decision bodies of Mediterranean regulators and transmission companies</li> <li>Trade platform for the Mediterranean</li> </ul>

the 2050 context.<sup>35</sup> Creating a level playing field for cooperation with these non-EU countries would help progress these multilateral projects.

The Mediterranean Solar Plan initiative can already be part of the solution. The EU launched this initiative in 2008 as one of the main projects of the Union for the Mediterranean and aims to develop 20 GW of renewable electricity capacity on the South Shore of the Mediterranean. Note that there is also an industry-led initiative called DESERTEC that has the ambition to

have concentrated solar power systems, photovoltaic systems and wind parks in the Sahara desert. A super grid would then connect this electricity production with consumers in European and African countries.

EU-instruments that can help create a level playing field could include adapting EU-decision bodies, such as ACER, ENTSO-E and ERGEG to Mediterranean countries, or to create their Mediterranean counterparts. It could also be opportune to create a trading platform (e.g. "power exchange") for the Mediterranean (Glachant, 2011).

To sum up, Table 8 lists the most promising interventions in the renewable energy policy area.

<sup>35</sup> Note however that only the EREC/Greenpeace vision relies on 60 GW of renewable energy to be developed outside the EU. The other visions in chapter 1 assume that the development will only take place inside the EU.

### Box 2. Unsuccessful proposal for an EU tradable green certificate scheme

The European Commission tried to introduce an EU tradable green certificate scheme because it was considered to be more in line with the integration of the EU electricity market (EC, 2005b). Member states did not want it for two main reasons.

First, the alternative scheme, referred to as feed-in tariffs/premiums, has proven to be successful in member states such as Denmark, Germany and Spain, where it supported an impressive growth of renewable energy generation. In the European context, it is considered by many to be the most efficient and effective mechanism, but there is no consensus on what would be the best EU-scheme, as some continue to argue that

a certificate scheme would be successful at the EU level. For an overview of this debate, see for instance EC (2008f), Fouquet and Johansson (2008), Frondel et al. (2010), Haas et al. (2011a and 2011b), IEA (2009b), Johansson and Turkenburg (2004), Klessmann et al. (2008), Re-Shaping (2011) and Verbruggen and Lauber (2009).

Second, member states tend to prefer developing renewable resources with national support schemes, also at higher costs, because it allows them to capture local benefits such as green jobs and renewable technology industry development (del Río, 2005; Lund, 2009; Wiser et al., 2007; Yin and Powers, 2010).

### 3.2.5 Energy infrastructure

In what follows, we identify promising interventions to address the key energy infrastructure challenge in the 2050 context, i.e. to ensure electricity grid adequacy, which includes expanding the transmission grid across borders and also the smartening of transmission and distribution grids.

#### First type of EU involvement: “effort sharing”

Binding targets for electricity grid adequacy

This is a promising EU intervention because there is a history of not achieving indicative targets. The heads of government agreed at the Barcelona Council in 2002 (EC, 2002b). Following these Barcelona targets, each member state should have had enough interconnections to allow the import of at least 10% of its installed generation capacity by 2005. As indicated in red in Figure 5, several countries are not complying with these targets (indicated in red in Figure 5).

In the 2050 context, binding targets could therefore

ensure that every member state contributes to the development of a European grid. Ambitious binding targets would however need to be more sophisticated than the indicative Barcelona targets, for instance, because “import capacity” is difficult to define and measure.

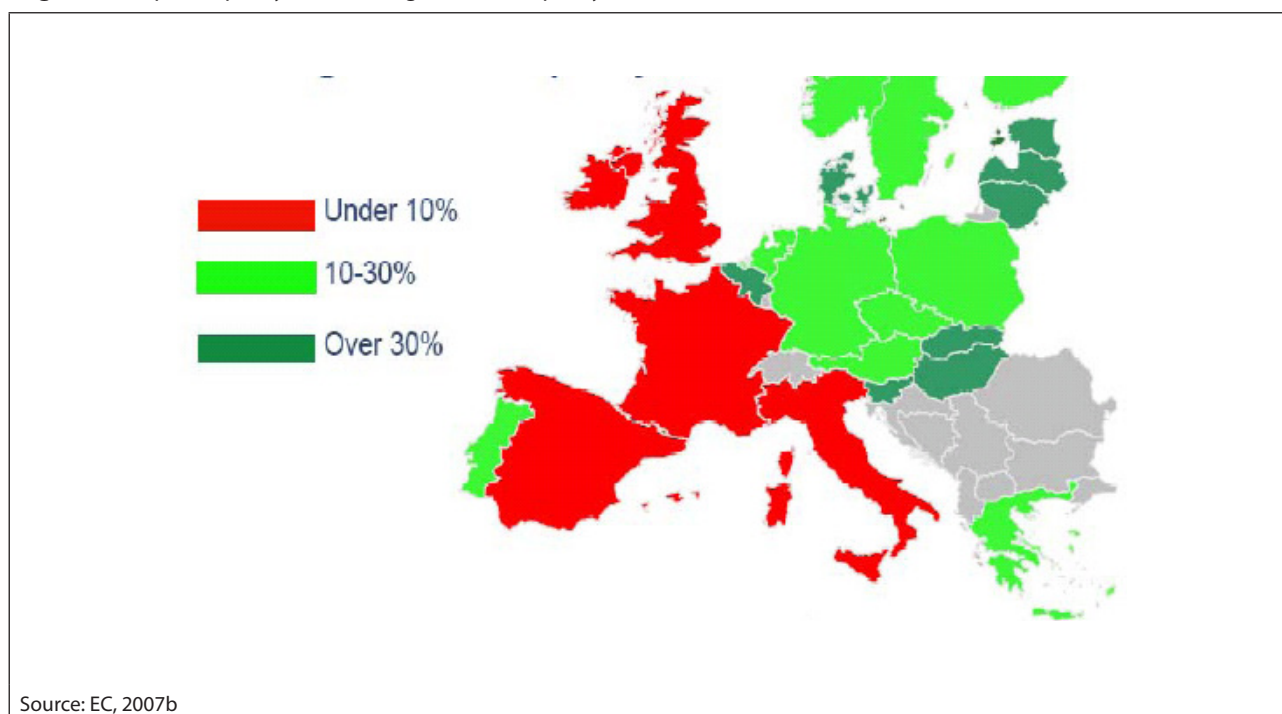
#### Second type of EU involvement: “harmonization”

Coherence requirements for the regulation of distribution and transmission grids

This is a promising EU intervention because smart grids need smart regulation (Bauknecht et al., 2007; Connor and Mitchell, 2002; Meeus et al, 2010; Meeus and Saguan, 2011; Pérez-Arriaga, 2010). The conventional regulatory framework that has been successful at incentivizing grid companies to provide value for money grid services in the liberalization context, has its shortcomings in the current context where grid innovation is needed to allow Europe to achieve its ambitious energy policy targets. The main shortcomings of the conventional regulatory framework are that grid companies



**Figure 5** – Import capacity % installed generation capacity



have disincentives to innovate, and if they do innovate, they are confronted with grid users that have disincentives to participate in the ongoing innovation.

The harmonization of regulation of distribution and transmission grids could introduce coherence requirements for the economic regulation of grids. Regulators could also be mandated to enable the transition (e.g. supporting the innovation an Europeanization process) rather than being only responsible for improving the cost efficiency of grids.

Note that smart markets are also an essential part of smart grids (CPI, 2011). There is still room to make better use of existing infrastructure by further integrating electricity markets (ERGEG, 2010). Progress has been made by coupling markets at the day-ahead stage, but this has not yet been done on all borders.<sup>36</sup>

<sup>36</sup> Meeus (2011): “Cross-border capacities have been underpriced (Newbery and McDaniel, 2002; Neuhoff, 2003; Purchala et al., 2004), underused, and even frequently misused increasing price spreads instead of reducing them (Creti et al.,

Several borders are still closed one day before delivery so that intra-day and real time trade is only national in the countries concerned. This is an ongoing process (ERGEG, 2010), and the third package includes several opportunities to make further progress, for instance via the introduction of market codes and grid code.

**Third type of EU involvement: “level playing field”**  
EU grid operator and planner

This is a promising EU intervention because of two main reasons: 1// development of off-shore grids; 2// grid operation in a system with high penetration of variable renewable energy.

First reason is the development of off-shore grids. As illustrated in the case of Kriegers Flak (Box 3), tap-

2010; CRE, 2009; Frontier economics and Consentec, 2004; Kristiansen, 2007; and Turvey, 2006), resulting in a lack of day-ahead hourly price convergence in Europe (Zachmann, 2008).” Furthermore, as evidenced by the experience on the Kontek Cable, it is not enough to implement market coupling, it has to be implemented properly (Meeus, 2011).

### Box 3. Kriegers Flak

Kriegers Flak is a project that envisions the development of three wind farms (for a total capacity of 1.6 GW), within German, Swedish and Danish waters, linked by a combined offshore grid connection which would also serve as an interconnection between the three countries (Energinet.dk, 2009). Three different TSOs are involved (50-Hertz, Energinet.dk and Svenska Kraftnätt), as well as two market systems and two synchronous zones, posing a huge challenge regarding regulation of cross-border infrastructure. The feasibility study, published in a joint report of the three TSOs, concluded that the combined solution would generate positive net benefits compared to the separate solution.

Despite the recognition of benefits for the whole region and the priority attributed to this project from the Commission, the stakeholders in this project are subjected to national regulatory regimes that are not aligned. This can partly explain that the Swedish TSO left the project (note however that the technology used allows them to anyway step into the join solution at a later stage), the German TSO could not wait to pursue a separate solution for one of its wind farms, and the ambitions of the Danish TSO have been reduced as the Danish wind developer downscaled its project (Meeus and Sagan, 2011).

ping into large scale renewable energy sources requires coordination between national transmission companies, renewable energy developers, and technology providers, which could be partly internalized by an EU grid operator and planner.

Second reason is grid operation in a system with high penetration of variable renewable energy. In the 2050 context, coordination between TSOs will be increasingly important for the operation of transmission grids that will be increasingly interdependent with increasing penetration of variable renewable energy. Note that in November 2006, 15 million people lost their electricity supply due to a lack of coordination between TSOs inside Germany. This has already led to a regional initiative called Coreso, which currently includes Belgium (Elia), France (RTE), part of Germany (50Hertz), Italy (Terna), and the UK (National Grid) and the aim is to help European TSOs enhance the level of security of supply by giving them a common analysis of electricity flows complementary to their national analysis.

Promising, but institutionally difficult to establish, would be to have an EU Independent System Operator (EU-ISO) to operate and plan the European layer of grid.<sup>37</sup> This EU-ISO could then develop EU planning tools to complement the EU planning procedures that have been introduced in the third package (Ten Year Network Development Plan).<sup>38</sup> An alternative could be to push the integration of grid operation and planning on a regional basis by supporting initiatives such as Coreso.

37 Friends of the Supergrid, which is a group of companies and organizations with a mutual interest in promoting the policy agenda for a European supergrid, have recently released a position paper where a possible policy and regulatory framework for the supergrid is presented, which includes: a single planner, a single grid code and a single European regulator. According to them, "ENTSO-E should also commence considering establishing an ISO (Independent System Operator) among the TSOs of the North Sea region involved. This ISO would then enlarge its operational powers to involve the other TSOs while the Supergrid enlarges to the rest of the EU" (FOSG, 2010).

38 Note that these EU planning procedures are a bottom-up approach to make a top-down plan. Indeed, these TYNDPs will be made by ENTSO-E in interaction with ACER, which are the EU-level decision bodies consisting of national transmission companies (TSOs) and regulators (NRAs) that have been created by the third package (EU, 2009f).

**Third type of EU involvement: “level playing field”**

EU infrastructure cost recovery instrument

This is a promising EU intervention because the existing cost recovery instruments are inadequate (Glachant and Kalfallah, 2011), they are: 1// nationally regulated tariffs and congestion revenues; 2// Inter-TSO Compensation (ITC); 3// EU funding.

First type of instrument is nationally regulatory tariffs and congestion revenues. Due to lumpiness of infrastructure investments, the allocation of cross-border capacities will not generate enough revenue to pay for adequate grids (Pérez-Arriaga et al., 1995). Nationally regulated tariffs are appropriate tools for increasing projects of national interest, but they do not give incentives for efficient cross-border infrastructure projects. There is a fundamental problem that countries expected to expand their transmission grids do not necessarily benefit from it, while third countries can be important beneficiaries.

Second type of instrument is the Inter-TSO Compensation (ITC). ITC mechanism defines the compensation rules between TSOs whose grid users cause transits and TSOs that incur costs due to transits (FSR, 2005; Olmos, 2007). The compensation however only covers operation costs of existing infrastructure, such as losses, and the compensation is ex-post based on the actual usage of the infrastructure. In other words, it has not been designed to incentivize investment in new infrastructure.

Third type of instrument is EU funding. Examples of EU funding are the Trans-European Network program (EU, 2003b; EU, 2004b; EU, 2009f), the European Economic Recovery Program (EC, 2008e) and the European Investment Bank. EU funding has been used to finance feasibility studies for project of com-

mon European interest and has also given limited support to the construction of these projects, but this support is marginal in comparison with the scale of the investments that are needed.

Promising, but institutionally difficult to implement, would be to have an EU regulated asset base paid by an EU tariff component. An alternative could be to implement an EU infrastructure investment cost compensation scheme. Contrary to the inter-TSO compensation mechanism, this investment cost compensation scheme would however need to be an ex-ante scheme because it is about incentivizing new infrastructure. The experience with the inter-TSO scheme also suggests that this investment cost compensation scheme will need to be set at the EU level because as it is too difficult for European stakeholders to find a consensus among them.

**Third type of EU involvement:  
“level playing field”**

EU smart grid technology standards

This is a promising EU intervention to ensure interoperability in the electricity grid. The EU already started playing a key role in setting standards for smart grid technologies. In line with the Directive 2004/22/EC (EU, 2004c) and the Directive 2006/32/EC (EU, 2006c), the Commission for instance issued a mandate to the European Standardization Organizations (ESOs) in 2009 to define EU standards for smart utility meters. In March 2011, the Commission issued an additional mandate to ESOs to develop standards to facilitate the implementation of smart grid (EC, 2009c).

To sum up, Table 9 lists the most promising interventions in the energy infrastructure area. Note that the announced infrastructure package can already be part of the solution. The intention is to create regional cooperation platforms, following the example of the

**Table 9** – Promising interventions in the energy infrastructure policy area

First type of EU involvement "effort sharing"	Second type of EU involvement "harmonization"	Third type of EU involvement "level playing field"
<b>Binding targets for</b> - Electricity grid adequacy	<b>Coherence requirements for</b> - Regulation of grids	<b>EU</b> - Grid operator and planner - Infrastructure cost recovery instrument - Smart grid technology standards

Baltic Energy Interconnection Plan and the North Seas Countries Offshore Grid Initiative; better and faster permit granting procedures; guidelines or a legislative proposal to address cost allocation for cross-border projects (EC, 2010c).

### 3.2.6 Internal energy market

In what follows, we identify promising interventions to address the key energy market challenge in the 2050 context, i.e. to ensure electricity supply security, which includes making sure that there are timely investments, especially concerning system flexibility.

#### First, second and third type of EU involvement

Creation of an internal balancing market with binding targets for reservation of balancing services, harmonization of national balancing markets, and an EU balancing market codes

This is a promising EU intervention because of three main reasons: 1// system flexibility is addressed in balancing markets; 2// today's balancing markets are mainly national; 3// visions assume an internal balancing market.

First reason is that system flexibility is addressed in balancing markets. The experience in countries with a large penetration of renewable energy technologies is indeed increasingly evidencing that the reliability of the system will depend on having enough flexibility to balance wind and solar power (IEA, 2011; Gottstein,

2011; Pérez-Arriaga, 2011). The problem of system flexibility is addressed in balancing markets in which TSOs are the single buyers of balancing services. TSOs are also responsible for allocating the costs of these services to the parties that are responsible for the system imbalances, and for reserving capacity to ensure the availability of balancing services (Frun, 2011; Vandezande et al., 2010; Vandezande, 2011).

Second reason is that today's balancing markets are mainly national. These markets are organized very differently in most countries, including: how the services are defined, the contractual arrangements, time of procurement, and the allocation of costs.<sup>39</sup> This was already a concern from the internal market point of view (EC, 2007b), but the new element is that the reliability of the system will now also increasingly depend on the functioning of balancing markets and the availability of balancing services.

Third reason is that the 2050 visions assume an internal balancing market. Indeed, the visions in chapter 1 have in common that they project ambitious grid expansions across borders, which reduces the need for back-up capacity.

A first step towards an internal balancing market

<sup>39</sup> Exceptions include Nordic countries that have an integrated balancing market. Other exceptions are arrangements that are specific to the synchronous system a country belongs to, such as the UCTE solidarity mechanism for dealing with the first reaction to a system disturbances (Tractebel Engineering and Katholieke Universiteit Leuven, 2009).

**Table 10** – Promising interventions in the internal energy market policy area

First type of EU involvement “effort sharing”	Second type of EU involvement “harmonization”	Third type of EU involvement “level playing field”
<b>Binding targets for</b> – Reservation of balancing services	<b>Harmonization of</b> – Balancing markets – Security of electricity supply mechanisms	<b>EU</b> – Balancing market codes

could be regional balancing markets, which has been a relatively successful approach to integrate wholesale markets (Everis and Mercados, 2010). The EU involvement in balancing markets could lead eventually to EU balancing market codes to create a level playing field by defining EU-balancing services. In such an internal balancing market, the reservation costs of these services will also need to be shared, which could be organized as a burden sharing with binding national reservation targets.

**Second type of EU involvement: “harmonization”**

Harmonization of security of electricity supply mechanisms

This is a promising intervention to avoid that these mechanisms work against the decarbonisation process. The vision of the liberalization process has been that market opening<sup>40</sup> and the creation of an internal wholesale market leads to timely investments, but member states have been given a lot of freedom in the market by the security of supply directive (EU, 2006b).<sup>41</sup> Regulators have already expressed concerns that these measures are

still mainly national in scope and therefore possible external effects on neighbouring countries and markets are often not considered (CEER, 2009).

There is also an on going debate on whether or not such interventions are necessary, and on what the best way to intervene is (Box 5). Fact is, that the conventional long-term security of supply mechanisms used to intervene have been designed to generate additional revenue for power plants that can be available during peak hours when the reliability of the system is at stake, while the new challenge in the 2050 context is system flexibility. Furthermore, these conventional mechanisms can also extend the lifetime of high carbon power plants and, if not properly designed, they also tend to favour generation side solutions.

The few experiences with long term security of supply mechanisms that also foster demand side participation, have been positive (Gottstein and Schwartz, 2010). Harmonization could therefore, for instance, include the requirement that demand resources be able to participate in these mechanisms on equal footing with generation.

To sum up, Table 10 lists the most promising interventions in the energy infrastructure area. The recent European Council decision can already be part of the solution (EC, 2011f): “The internal market should be completed by 2014 so as to allow gas and electricity to flow freely. This requires in particular that in cooperation with ACER national regulators and transmission system operators step up their work on market

<sup>40</sup> The EU involvement in the energy market policy area started in 1985 with the objective of creating an EU internal market by 1992. The opening of the energy sector was achieved much later than in other sectors and the final step was to require member states to open their household markets by July 2007 (EU, 2003c).

<sup>41</sup> The intervention can be explicit or implicit. Explicit means that there is a generation capacity mechanism (e.g. capacity markets or capacity payments), which is for instance the case in Ireland, Italy, Spain and Greece. Implicit interventions are for instance long-term contracting of energy and/or reserves by the regulator or the system operator, which is for instance the case with “strategic reserves” in the Nordic countries.



### Box 5. Long-term security of supply mechanisms

Battle and Rodilla (2010): *"Since the very beginning of the power systems reform process, one of the key questions posed has been whether the market, of its own accord, is able to provide satisfactory security of supply at the power generation level, see for instance Perez-Arriaga (2001), Stoft (2002), Hogan (2005), Joskow (2007) or Finon and Pignon (2008), or if some additional regulatory mechanism needs to be introduced, and in the latter case, which is the most suitable approach to tackle the problem. The previous authors have contributed to this debate by claiming that, in a number of different contexts, and for a variety of reasons, there is a market failure. This market failure poses the regulatory need to provide the incentives the market is not providing so as to ensure an efficient security of supply level. This translates in practice into providing generators with an extra income and/or hedge instruments in exchange for a product (e.g. installed capacity or long-term energy contracts) aimed to enhance security of supply."*

In the 2050 context, the main concern is policy uncertainty. Only part of the investment will respond to market prices, and this part is very unsure. It is for instance unclear how strong and fast other sec-

tors will electrify (demand side uncertainty) or low carbon technologies will be pushed (supply side uncertainty). As discussed in chapter 2, the UK and France have recently started a market reform process motivated by increasing electricity supply security concerns.

Battle and Rodilla (2010) observe a certain convergence in long-term security of supply mechanisms design criteria worldwide, but conclude that we are still far from obtaining a definite consensus on the subject. They find that the reason is that each market's particularities make it difficult to export a successful design. Joskow (2008) reports about the deficiencies of the original capacity payment mechanisms that have been used in the US and argues in favour of a forward capacity obligation in combination with a centralized auction for capacity. Similarly designed capacity markets are discussed and proposed, for instance in Cramton and Stoft (2008) and Finon and Pignon (2008). Battle and Pérez-Arriaga (2008) also reviewed the main criteria to be taken into consideration in the design of a regulatory mechanism of this nature.

coupling and guidelines on network codes applicable across European networks."

### 3.2.7 Technology innovation and R&D

Improving currently known technologies and developing new ones is a crucial energy and climate objective. Several studies have argued that an ambitious clean energy R&D program is both effective and efficient, but that it would require an increase of R&D

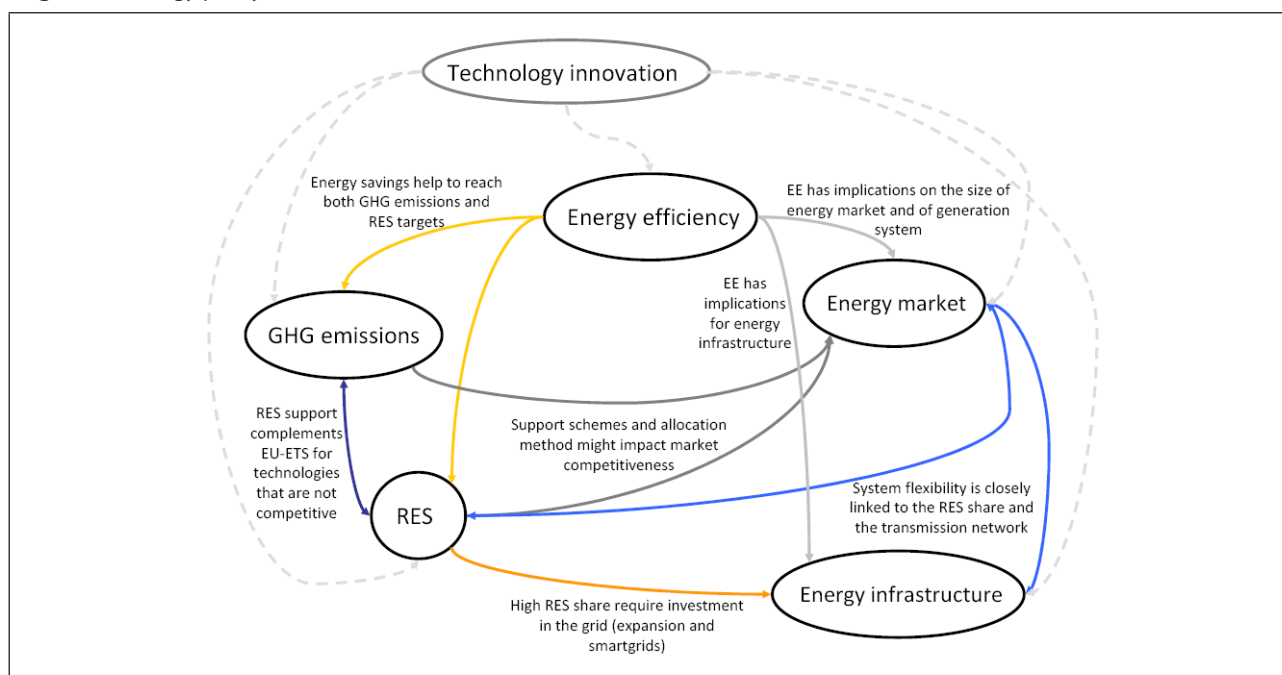
expenditures to several times the recent levels (Bosetti et. Al, 2009; EC, 2009a; IEA, 2010).

#### Third type of EU involvement: "level playing field

Complement the Strategic Energy Technology Plan (SET-Plan).

The policy area of technology innovation and R&D has been covered in the previous THINK report on "Public support for the financing of RD&D activities

**Figure 6 – Energy policy interactions**



in new clean energy technologies” (THINK, 2011a). This THINK report identified the Strategic Energy Technology Plan (SET-Plan) as the state-of-the-art instrument used at the EU level to prioritize innovation projects in low carbon technologies (EC, 2009a).

The report concluded that this EU instrument could be improved to ensure that public support will go to a balanced portfolio of innovation projects. Currently, the SET-Plan is industry focused and bottom up, which needs to be complemented by a more top down approach that can prioritize projects proposed by different industries and also improves the balance between early innovation to create new options and later stage innovation to push the most promising options into market (i.e. third type of EU involvement).

### 3.3 The need for an integrated policy package

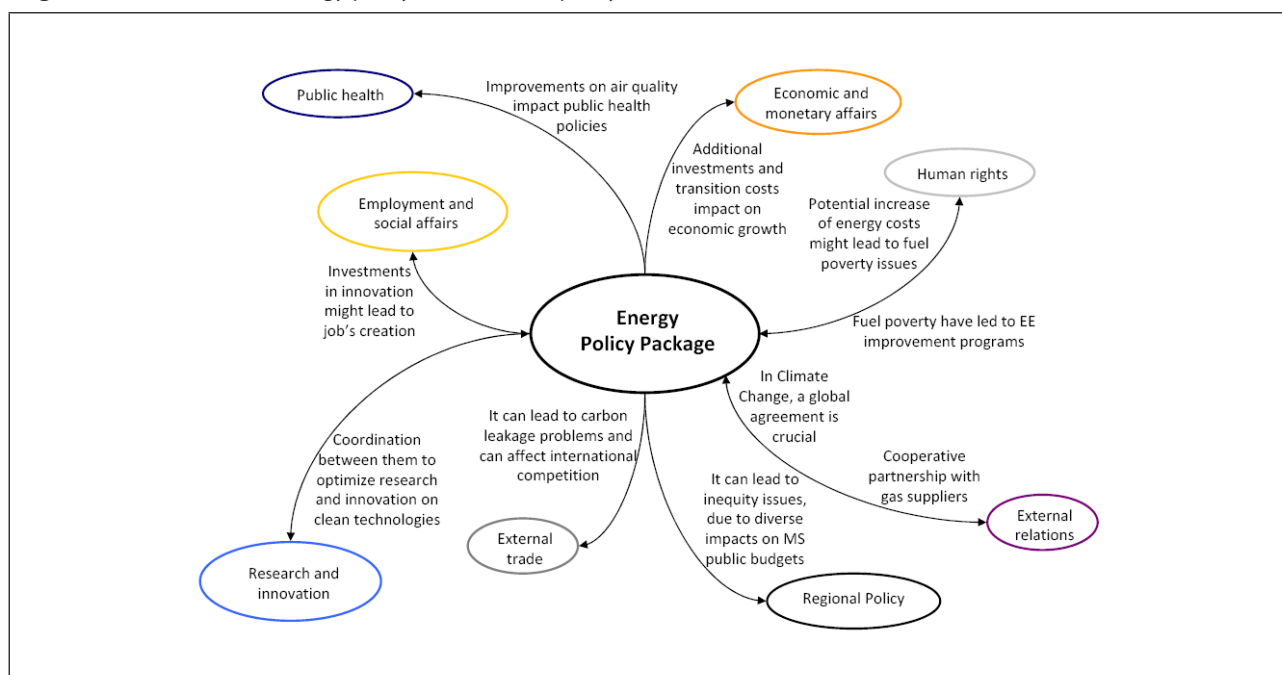
The need for an integrated policy package comes from the many interactions between the six energy

policy areas that we have discussed individually in the previous sections. It also comes from wider interactions between these energy policy areas with other EU policy domains in the 2050 context.

#### 3.3.1 The interactions between the six energy policy areas

The DG Climate roadmap (EC, 2011a) indicates that by achieving the energy efficiency target in 2020, the GHG emission reduction target would be overachieved. It is just one of many examples of how energy policy areas interact. These interactions as well as the resulting need to make an integrated policy package have also been one of reasons to call for an integrated climate and energy policy package for 2020 (Capros et al., 2008).

Figure 6 illustrates these interactions, i.e. they include technology innovation that is a precondition for most of the challenges in the other areas, the interaction between GHG emission targets and RES targets, en-

**Figure 7** – Interactions of energy policy with other EU policy domains

energy savings that have implications for the size of the internal energy market and infrastructure, renewable energy development that will drive the need for electricity transmission grid expansion and distribution grid smartening, etc.

In the 2050 context, the above interactions are extremely important, and together with the European ambitions, the importance of these interactions is also increasing. There are also new interactions to consider, including 1// the possible impact of the decarbonisation of the transport and heating and cooling sectors on the electricity load profile, and 2// the likely impact of the decarbonisation policies on the role of natural gas infrastructure and the natural gas market.

First is the impact of the decarbonisation of the transport and heating and cooling sectors on the electricity load profile. In the 2050 context, the size of the electricity system will depend on how quick and to what extent there will be a high level of electrification in

the transport and heating and cooling sectors. This is a challenge, but also an opportunity for the electricity sector (Ekman, 2011; Lund and Kempton, 2008; Kempton and Tomić, 2005). For instance, a massive penetration of electric vehicles would be a challenge because it would significantly change the load curve, while electric vehicles could also help to manage the variable output of renewable energy sources. It is therefore important to ensure consistency between the initiatives proposed in the transport roadmap and what should be included in the energy roadmap. It could therefore be opportune to have an integrated “energy and transport” policy package.

Second is the impact of the decarbonisation policies on the role of natural gas infrastructure and the natural gas market. Gas could be the bridging fuel of the first part of the 21st century, while R&D work to find efficient and effective solutions to climate change. Gas, indeed, is an option immediately available to reduce GHG emissions, by displacing coal and oil in power generation and other sectors until renewables



can compete on a large scale and CCS has passed its test period and is commercially viable. Most decarbonisation pathways assume a decreasing gas demand, but gas continues to play a key role in the balancing of the energy system. Note also that even if gas might no longer be the fuel of choice, it could become the fuel of consequence anyway in case some other options do not materialise in the timeframe planned (e.g. the recent events with nuclear or the growing cost of subsidizing solar). Moreover, gas could be a no-regret option. Firstly, CCGTs have a considerably lower capital costs compared to coal, nuclear and renewables. Secondly, gas power plants can provide the system flexibility that is needed to deal with massive penetration of variable renewable energy. However, there is uncertainty regarding the role of natural gas, which may lead to underinvestment both inside and outside the EU, which may also lead to security of supply issues (SECURE, 2010).<sup>42</sup> Even though it is out of the scope of this report, it is important to revisit the role of the EU regarding natural gas in the 2050 context.

### **3.3.2 Interactions of energy policy with other EU policy domains**

Figure 7 illustrates some of the many interactions of energy policies with other EU policy domains in the 2050 context. The “other EU policy domains” in the illustration follow the terminology used by the EU when dividing policy into domains.

The above EU policy domains can be grouped into 1// international issues (regional policy and external

relations); 2// economic issues (employment and social affairs, economic and monetary affairs, research and innovation, external trade); 3// and social issues (public health and human rights). Below we highlight a few of these interactions because addressing these issues will be crucial to gain public support for the transition towards a low carbon energy system.

First are international issues. Without a coordinated global action, the EU policy alone will not avoid climate change by 2050 and EU should keep incentivizing other countries to develop low carbon energy policies. The EU ETS can play an important role. First, as the largest carbon price scheme, it set an important example that could be followed; second it could be extended to non-EU countries that are interested to join it.<sup>43</sup> Furthermore, the EU also needs to pursue its transition to a low carbon economy in a cooperative partnership with its main fossil fuel suppliers, especially gas suppliers (SECURE, 2010). Finally, the EU has also made an effort to lift people out of poverty, which includes the increase of people’s access to energy. Universal access can go hand in hand with fighting climate change, but only if sustainable growth is promoted based on the development of a sustainable energy system (EC, 2010d).

Second are economic issues. The transition to a low-carbon economy for 2050 requires massive investments. As highlighted by the DG Climate Roadmap, this could spur economic growth in the manufacturing sectors and environmental services in Europe with potentially opportunities of new business and jobs (EC, 2011a). There is however also a concern that low carbon energy policies could also lead to the loss of competitiveness of energy-intensive industrial activities. This is something that should be considered by the EU when designing its energy policy, since there is the

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<sup>42</sup> Furthermore, despite the possibility of no longer being the fuel of choice, natural gas can become the fuel of consequence anyway in case some other options do not materialize in the timeframe planned (e.g. the recent events with nuclear). For instance, after the recent events in Japan, Germany decided to quit the option of using nuclear as a bridging technology which might lead to a larger use of natural gas than the one predicted.

<sup>43</sup> The EU ETS is already extended to non-member states: Norway, Iceland, and Liechtenstein joined the scheme in 2007.

need to promote measures that help these industries to mitigate the transition. This so-called carbon leakage issue has to be addressed in a cooperative approach with other major economic blocks using for instance sector approaches. Another important aspect to consider is the impact that the climate policy will have on public budgets of the member states. THINK has also been asked by DG Energy to make a report on the impact of climate and energy policies on member state budgets. This report will be finalized by the end of May 2011, together with this report.

Third are social issues. Low carbon energy policies will have an impact on the distribution of wealth because it includes radical changes within the economy and for the society in general and comprehends a significant cost for the society (at least in the short-term). The EU recognized fuel poverty as a relevant issue in the third energy market liberalisation package,<sup>44</sup> but

it will also be important to anticipate possible redistribution effects; for instance, when designing energy efficiency and renewable energy support schemes it is important to avoid or remedy that poor people pay for the support via higher grid tariffs, but do not benefit from it as they are not able to afford the upfront investment that is anyway required (so-called “reverse Robin-hood effect”). Furthermore, it is fundamental that people are aware of the importance of low carbon energy policies. For instance, because many new infrastructures will be needed in the next future and local resistance to these projects could constitute a serious barrier to their achievement (Wüstenhagen et al, 2007; Zoellner et al., 2008; Create Acceptance, 2007), but also because all EU citizens are called to change their behaviour as energy users and this will inevitably enter into their everyday life.

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44 From the Directive 2009/72/EC for the internal market in electricity and the Directive 2009/73/EC for the internal market in natural gas (EU, 2009f): “Member States should ensure the necessary energy supply for vulnerable customers”.

## Recommendations for the DG Energy roadmap

### Track progress

The path towards 2050 is long and full of uncertainties with strong and complex interactions. It will therefore be crucial to track progress during the transition to allow for many policy adaptations, with 2030 and 2040 as important milestones. This implies close monitorization of investments and choices made by private actors, as well as policy implementation by policy makers, as several pioneering member states already started doing at the national level.

### Ten priority EU-interventions to add value to member states' first steps on the road towards 2050

#### Energy efficiency

- 1) **Make energy saving targets binding.** We cannot afford not reaching our energy savings ambitions, and locking ourselves into energy inefficient technologies and assets, such as energy consuming buildings and transport infrastructures.
- 2) **Mobilize cities towards a low carbon future.** It implies going beyond the Covenant of Mayors, which is a successful voluntary initiative that should be complemented by an organized mapping of cities with an EU reporting methodology to allow good practices to be identified and spread.

#### Greenhouse gas emissions

- 3) **Strengthen the carbon price signal.** This could be done with a more ambitious emission reduction targets and credible longer term cap for the EU-ETS and/or the introduction of a carbon tax.

#### Renewable energy

- 4) **Integrate renewable energy technologies into the market.** Renewable energy technologies need to be pushed into the market as long as necessary, but they should also be integrated into the market, for instance, by requiring them to participate in wholesale and balancing electricity markets.
- 5) **Create a level playing field for renewable energy cooperation with non-EU countries.** This implies adapting EU-instruments, such as ACER, ERGEG, ENTSO-E to Mediterranean countries, or to create their Mediterranean counterparts.

#### Energy infrastructure

- 6) **Harmonize the regulation of distribution and transmission grids.** Smart grids need smart regulation. Harmonization of the economic regulation of distribution and transmission grids is needed to ensure that grid regulation will not hamper the smartening of grids.
- 7) **Design an EU infrastructure cost recovery instrument.** The existing cost recovery instruments for infrastructure are inadequate to support the European grid expansion that will enable the transition towards a low carbon energy system.

#### Internal energy market

- 8) **Create an internal balancing market.** Market integration has to be completed and extended to the real time. System flexibility is crucial to keep the lights on in a low carbon electricity system. It requires the creation of an internal balancing market with regional balancing markets as a possible intermediate step. This implies to organize a burden sharing for the reservation costs of balancing services.
- 9) **Harmonize electricity supply security mechanisms.** These mechanisms can be justified by na-

tional system specificities, but they should at least comply with minimum requirements to avoid that they work against the decarbonisation process.

### **Technology innovation and R&D**

10) **Complement the Strategic Energy Technology Plan (SET-Plan).** The SET-Plan is industry focused

and bottom up, which should be complemented by a more top down approach that can prioritize projects proposed by different industries and that improves the balance between early innovation to create new options and later stage innovation to push the most promising options into the market.

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## Annexes

### Annex 1: Sector-specific objectives and GHG emissions reductions

**Table A.1** – Sector-specific objectives and GHG emission reductions within the DG Climate Roadmap

Sector	GHG emissions' reduction	Sector-specific objectives
<b>Power</b>	93 to 99%	<p><b>Almost fully decarbonised by 2050</b></p> <p>Electricity might partially replace fossil fuels in transport and heating; however, electricity demand continues to increase at historic growth rates, due to continuous improvements in efficiency</p> <p>The share of low-carbon technologies is estimated to increase from 45% today to around 60% in 2020, to between 75 and 80% by 2030, and nearly 100% in 2050</p>
<b>Transport</b>	54 to 67%	<p>Technological innovation can help in the transition to a more efficient and sustainable energy system, through:</p> <ol style="list-style-type: none"> <li>1 increase of vehicle efficiency (new engines, material and design)</li> <li>2 cleaner energy use (new fuels and propulsion systems)</li> <li>3 better use of networks and safer and more secure operation (ICT)</li> </ol>
<b>Residential and services</b>	88 to 91%	<p>This sector provides low-cost and short-term opportunities to reduce emissions (mainly through the improvement of energy performance of buildings)</p> <p>The refurbishment of the existing building stock is the greatest challenge within the sector</p>
<b>Industry</b>	83 to 87%	<p>The deployment of carbon capture and storage technologies at a larger scale might be necessary after 2035</p>
<b>Agriculture</b>	42 to 49%	<p>Improved agricultural and forestry practices can increase the capacity of the sector to preserve and sequester carbon in soils and forests</p>
<b>Other</b>	70 to 78%	-

## Annex 2: DG Move transport roadmap

**Table A.2** – Highlights of what needs to be done according to this roadmap

<b>An efficient and integrated mobility system</b>
<b>1. A single European transport area</b> A true internal market for rail services; Completion of the single European sky; Capacity and quality of airports; A maritime “Blue Belt” and market access to ports; A suitable framework for inland navigation; Road freight; Multimodal transport of goods: e-Freight
<b>2. Promoting quality jobs and working conditions</b> Social code for mobile road transport workers; A social agenda for maritime transport; A socially responsible aviation sector; An evaluation of the EU approach to jobs and working conditions across transport modes
<b>3. Secure transport</b> Cargo security; High levels of passenger security with minimum hassle; Land transport security; “End-to-end” security
<b>4. Acting on transport safety: saving thousands of lives</b> Towards a “zero-vision” on road safety; A European strategy for civil aviation safety; Safer shipping; Rail safety; Transport of dangerous goods
<b>5. Service quality and reliability</b> Passenger’s rights; Seamless door-to-door mobility; Mobility continuity plans
<b>Innovating for the future: technology and behaviour</b>
<b>1. A European Transport Research and Innovation policy</b> A technology roadmap; An innovation and deployment strategy; A regulatory framework for innovative transport
<b>2. Promoting more sustainable behaviour</b> Travel information; Vehicle labelling for CO <sub>2</sub> emissions and fuel efficiency; Carbon footprint calculators; Eco-driving and speed limits
<b>3. Integrated urban mobility</b> Urban mobility plans; An EU framework for urban road user charging; A strategy for near “zero-emission urban logistics”2030
<b>Modern infrastructure and smart funding</b>
<b>1. Transport infrastructure: territorial cohesion and economic growth</b> A core network of strategic European infrastructure – A European mobility network; Multimodal freight corridors for sustainable transport networks; Ex-ante project evaluation criteria
<b>2. A coherent funding framework</b> A new funding framework for transport infrastructure; Private sector engagement
<b>3. Getting prices right and avoiding distortions</b> Smart pricing and taxation
<b>The external dimension</b>
Transport in the World: the external dimension

## Annex 3: Assumed fuel prices

**Table A.2** – Assumptions regarding fuel prices from the different stakeholders' visions (US\$ 2008)

	EGAF Low Gas Price Scen. *		IEA-WEO Reference Scen.		Eurelectric Power Choices		IEA-ETP BLUE Map		ECF Low Carbon Scen.		Greenpeace E[R]	
	Year	Price	Year	Price	Year	Price	Year	Price	Year	Price	Year	Price
Oil (US\$/bbl)	2009	59	2008	97.2	2010	71.9	2008	97	2009	59	2015	110.6
	2015	87	2020	100	2020	88.4	2020	-	2015	87	2020	130
	2030	115	2030	115	2030	105.9	2030	90	2030	115	2030	150
	2040	115	2040	-	2040	116.2	2040	-	2040	115	2040	150
	2050	115	2050	-	2050	126.8	2050	70	2050	115	2050	150
Gas (US\$/GJ)	2010	7.9	2008	10.3	2010	8.12	2008	10.9	2009	9.39	2010	11.0
	2015	7.9	2020	12.1	2020	10.7	2020	-	2015	11.1	2020	16.6
	2030	7.9	2030	14.2	2030	13.2	2030	11.6	2030	15.0	2030	19.3
	2040	7.9	2040	-	2040	14.96	2040	-	2040	15.0	2040	22
	2050	7.9	2050	-	2050	16.94	2050	9.1	2050	15.0	2050	26.0
Coal (US\$/ton)	2009	70	2010	120.6	2010	95.5	2008	121	2009	70	2010	120.6
	2015	91	2020	104.2	2020	129.8	2020	-	2015	91	2020	135.4
	2030	109	2030	109.0	2030	141.8	2030	65	2030	109	2030	142.7
	2040	109	2040	-	2040	141.2	2040	-	2040	109	2040	160
	2050	109	2050	-	2050	146.1	2050	58	2050	109	2050	172.3

\*For the high gas price scenario, the gas prices are the same than in ECF

## Annex 4: List of Abbreviations

CCTS	Carbon capture transport and storage
DG	Director General
ECCP	European Climate Change Programme
ECF	European Climate Foundation
EGAF	European Gas Advocacy Forum
EREC	European Renewable Energy Council
EU	European Union
EU ETS	European Union Emission Trading Scheme
GHG	Greenhouse gas
IEA	International Energy Agency
ISO	Independent system operator
RES	Renewable energy sources
SET-Plan	Strategic Energy Technology Plan
TSO	Transmission system operators
TYNDP	Ten Year Network Development Plan
WEO	World Energy Outlook

## **Annex 5: industrial council meeting – summary of the discussion on the robustness of the preliminary project results in March**

Responsible: **Serge GALANT**, Technofi  
Submission date: **March 2011**

### **The question to be answered**

What role for the EU in the design and implementation of 2050 low carbon energy policies?

### **The tentative answer**

– There are several options available for the EU, which may cover standardizing technologies, regulating markets, harmonizing coordination between network operators, pricing network tariffs to account for their progressive reengineering, enforcing existing or future Directives more stringently, etc...

– At any rate, there is a prerequisite for future low carbon energy policies: all member states will have to go for more interdependence in order to send and reach the future 2050 orientations.

### **Clarity improvements proposed for the report next version**

– Indicate right up front the role of the THINK report at EC level, given an already complex background in the energy sector (FP7, FP8, FP9...), the role of the SET Plan. In other words, the report ambition should be properly tuned.

– Emphasize, within a dedicated section, the paradoxical situation where Europe will be more and more

- there are drivers for more interdependence (for instance TSOs have initiated CORESO and TSC for regional coordination of operations)
- there are drivers for more fragmentation (for

instance regional renewable policies)

- and attempt to list the drivers that support either one of the opposite attitudes.

– Recall, in the introductory section the changes of mind set, which are needed to address 2050 orientations and 2030 targets<sup>45</sup>.

– The three pillars of European policy must be revisited, thanks to changes in mind set. For instance, which are the right market designs that lead to the proper capacity investment able to support an improved security of supply?

– Detail the future expected market failures which will require public support: this will help in getting public acceptance on such public support schemes, both as energy consumers and energy savers.

– The harmonizing orientation should be further digged into, providing new clues beyond what has been or is being done.

– Be careful about the interpretation of IEA roadmaps in the future report. They do not recommend what the EU role could or should be in moving forward according to 2050 orientations. Rather, they provide quantitative scenarios to position EU within a world perspective, leaving EU players the only ones responsible for the choice of 2050 orientations and the action plan implementation to move forward according to such orientations.

### **Completeness improvements proposed for the report next version**

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45 See for instance the work performed in France on 2050 targets

- Feuille de route « Electricité photovoltaïque», Version finale, Juin 2010
- Feuille de route « Solaire Thermodynamique», Version finale, Juin 2010



- Beyond policy marking is policy implementation. One can learn from the 2020 targets, analyzing possible shifts in implementation, which are allowed by the Treaty. For instance, new policies could be implemented by a subset of pioneer players like in the recent European patent example.
- When addressing the challenges that underpin the choice of policy orientations, it is needed to detail
  - challenge areas where there is consensus (which does not mean that everybody is right!)
  - challenge areas where there is dissent (and where there is a higher probability of innovative ideas to be implemented)
- When addressing the energy sectors, the full coverage of all activities must be provided (electricity, residential, tertiary, industry, transport)
- Going toward less and less carbon releases will cost more and more, unless interdependences are more and more implemented. Higher investment costs might mean higher difficulties in raising the interest of investors (including non energy investors). This will require stable and robust returns on investments, which are easier for regulated monopoly players (network operators), than for free market players which are undergoing strong competition at generation and retail level. Only innovative business models will help, but with rate of returns that can be hampered by the inherent more risky position of the innovative business players.
- Underline the still existing risks of CCTS (where T stands for transport): the performance of CCTS cannot be taken for granted on the long term and requires long term knowledge acquisition to ascertain the final CO<sub>2</sub> capture performance (technical and economical). As a matter of fact, the coupling of CCTS with industrial activities must be underlined as a possible route which has not been to be studied so far.
- Complete the good lessons learnt from policy implementation in the mentioned targeted countries (France, Germany, UK) for 2020 and beyond policies. For instance, in the UK:
  - legislative budget to make the transition happen,
  - annual report to the Parliament with indications able to pinpoint critical under or over achievement,
  - investment monitoring to make sure that the financial market can respond to the investment needs
- Implement a section on the gas market and gas vector impacts onto the 2050 policy orientations, in view of the recent Japanese accident that could lead to a shift back to more carbonated fuels.
- In the major Member States where energy policy shifts were implemented in the past, a strong connection between energy policy and industrial policy was the basis for arbitrations between several optional routes. One of the roles of the EU would be to do the same, especially for better addressing the challenges of interdependence (for instance new technologies for electric transmission networks).

#### **Coherence improvements proposed for the report next version**

- Whereas final prices are quoted as a critical parameter to support or to inhibit the transition, much less is said about the impact of CO<sub>2</sub> pricing on the tentative routes. Please expand on this parameter too.
- There is no clear assumption about the cross relationships between a strong/weak Euro and 2050 policy choices. What is the optimal Euro profile to

support the future investments to implement the transition according to the 2050 orientations?

– As a consequence, can the EU be also in a position to structure capital markets, which would ease the above investments making them more attractive than the ones addressing similar low carbon issues in the USA, China or India?

– Can a section be introduced to address the impacts of the possible routes towards 2050 on trade within and outside EU27?

– Does it make sense to address the robustness of this policy recommendation using a “what/if” approach in a final section?

## Annex 6: comments by project advisors on preliminary version of the report in April

Project Advisor: **Pantelis CAPROS**,

Professor at NTUA – E3MLab/ICCS

Submission date: **April 2011**

The report is a very good effort to make a synthesis on a difficult topic. Good ideas about the EU role. Remarks for improvement:

### List of stakeholders visions

Probably there is now time to include the Roadmap 2050 published recently by DG CLIMA. This would be important.

### Levels of EU involvement

The report proposes three roles for the EU: setting targets, harmonization regarding measures to be chosen by MS, ensuring level playing field by introducing EU-wide instrument.

These are valid roles for the EU, but there should be probably two additional roles: a) making effective the building of common infrastructure which will facilitate sharing of resources to be employed towards decarbonisation (e.g. highway and other interconnections for sharing RES, common balancing for electricity at multiple countries level, common balancing for gas and arrangements to ensure flexibility in gas use and affordability as gas has a major reliability role to play in the future structure of power generation, common CO<sub>2</sub> transport system for sharing storage areas, etc.); b) setting common standards for new technologies (appliances, equipment, car battery recharging infrastructure, etc.) in order to maximize interoperability in the EU and increase efficiency through economies of scale in technology manufacturing at the EU level.

Probably the second role could be added to harmonization role. But the first role should be shown separately as it is important and cannot be categorized in the other roles.

Although the report mentions an EU-wide instrument, such an instrument is not identified and is not discussed further.

### Energy efficiency: challenge of achieving ambitious energy savings and setting of binding national targets

There is agreement on the great contribution of energy efficiency improvement in the emission cuts. For this purpose, the European Union has set up a long series of Directives and Regulations. The main problem however is the weakness of endorsement mechanisms in the European legislation, especially in the domain of Buildings, Energy Service Companies and obligations of energy utilities to show energy saving performance at the level of their customers. The enforcement mechanisms have to be concrete, direct, flexible and efficient, so as to need limited recourse to European Court procedures. Introducing binding national targets may help but the usual approach of setting binding targets without true (and market-based) enforcement mechanisms is very inefficient. It would be better to have binding targets specifically for the buildings sector and market-based mechanisms for ESCOs and energy utility obligations. An example is the white certificate system which could become the equivalent of ETS for the energy efficiency domain.

Based on this, I recommend that the report puts emphasis on endorsement mechanisms and the establishment of market-based instruments for delivering the energy efficiency objectives, rather than on the setting of (vague) national binding targets. By the way, imposing the 20% as binding target for 2020 is a controversial issue, because it would be very ambi-

tious to achieve and monitoring would be questionable. Many of the regulations for energy efficiency are still pending.

### Remarks for the EURELECTRIC study

In the main scenario, the assumption taken for CCS is that it would be mature by 2025 (not 2030 as stated) but technology learning curve will continue after that date.

In this study, the total cost of decarbonisation is similar to the reference scenario (which is strong in policies such as ETS but does not deliver the decarbonisation). Costs are significantly higher than a baseline (business as usual). The report states lower costs relative to a baseline, which is not correct.

### On carbon prices

It is not true that Eurelectric study recommends applying a uniform carbon price to all sectors as the only means driving decarbonisation. The modeling of the scenarios has used uniform carbon prices applying on all sectors and countries (as cost-efficiency would suggest), but its interpretation from a policy perspective is not that carbon prices (taxes or ETS type of pricing) should be introduced to non ETS sectors. The carbon price for the non ETS is just a shadow price inciting decarbonisation without being a tax or auction payment (no direct income reducing effect). Exactly the same approach was taken in the DG CLIMA Roadmap 2050.

The shadow price of carbon (applicable to non ETS) is a proxy of the marginal cost of a great variety of bottom-up measures (not identified explicitly a priori, but only their effects on consumption as resulted from the model simulations) that would be employed for decarbonisation purposes in the non ETS sectors. For example a shadow carbon price would incite energy efficiency but in reality this would be the result

of specific energy efficiency measures. Similarly, the carbon shadow price would motivate electro-mobility but this would be in reality the result of for example strict CO2 car regulation measures. Also, it is not true that the carbon pricing is proposed by Eurelectric as the only driver. It will be the ultimate driver on top of a large series of bottom up measures in all sectors.

Anyway it would be important to expand on the role of carbon prices as an instrument beyond EU ETS (or expand EU ETS to other sectors). Carbon taxes are an option? This will be a major EU role which fits in the category about an EU-wide instrument, which is not sufficiently expanded in the report.

### Transport sector

A major omission of the report is about decarbonisation in the transport sector and especially the electrification in road transportation and the extensive use of biofuels. Transport is a very inflexible sector from a decarbonisation perspective, if the structure and fuel mix was to remain similar to present situation. Change of fuel-technology paradigm is necessary (all studies show this). Zero emissions in power generation allows for such a change in paradigm, but this is not enough, and important transportation sectors can only have recourse to biofuels to decarbonise (aviation, maritime, trucks). There are differences in the studies about the biofuels (e.g. high biofuels in German studies, much lower in others).

Electrification in road transportation (at a massive scale) is a challenge for EU policies and a great opportunity for car manufacturing. The EU should ensure common and harmonized development of recharging infrastructure in a timely manner, and common standards for the entire chain. Smart metering and common market rules should ensure charging at base-load hours and keeping a level playing field regarding competition in the new market segment. Many other

common transport policies should be identified, as for example for rail freight, etc. (see Whiter paper on transports just released by DG MOVE).

### Renewables

Harmonizing the RES supporting policies is not sufficiently expanded in the report. Abandoning current system of subsidies is discussed everywhere in Europe, but the replacement of this system is not identified and in any case it should be harmonized at EU wide level and compatible with market competition especially in future conditions with stochastic RES contributing by more than 40% in power generation. This is a great EU role to play.

Also for RES, the least common denominator of all studies is the importance of RES facilitation policies: grids, interconnections, building codes and other measures (incl. smart grids) for high development of very small scale RES, back-up, storage, common balancing, licensing and easiness of access to new sites (incl. remote offshore areas). EU contribution should be identified and mentioned for this policy area.

### Affordability

The EU can play a role in addressing adverse effects of decarbonisation costs (and higher requirements for investment) regarding poverty and affordability, by shaping harmonized rules for more extended public service obligations (beyond electricity). This topic should be also mentioned.

### Gas market

Area to be mentioned with emphasis on great EU role as gas will have a strategic contribution and a key role in balancing: common EU market, flexibility, security of supply, affordability for small players, etc.

Project Advisor: **Christian von HIRSCHHAUSEN**,  
Professor at TU Berlin, DIW Berlin

Submission date: **June 2011**

As one of the scientific advisors to Think on the report „Transition towards a low carbon energy system by 2050: what role for the EU“ I have participated both in the experts meeting and in the Scientific Committee. In the following I summarize the issues raised live at these meetings

The objective of the report is “to structure the debate on the role of the EU to guide the transition towards a low-carbon energy system by 2050, based on visions presented by different stakeholders and existing Member States’ strategies to achieve the transition” (p. 1). The report consists of two parts:

- Descriptive “tale” of stakeholder/Member States’ approach to 2050
- Discussion about “possible role of the EU” (“y penser toujours, en parler jamais”)

The latter is later highlighted in 5 fields of action. In general, one senses a very significant competence on two of the “really important” issues: 4/ infrastructure, and 5/ energy market, whereas the others are dealt with in more general terms. The paper also derives some suggestions and recommendations have been given by the stakeholders, but it is less clear what could or should be the role of the EU.

My basic point is that the objective of 2050, i.e. a 80-95% reduction of CO<sub>2</sub> with respect to 1990, should guide the question “what needs to be done (at European level) to attain this goal IN EACH SECTOR”. We are mostly energy/electricity people, but this question can not be answered without looking at the transportation sector, and the industrial sector (off course the household sector as well). Consequently, we should organize a competence in these sectors, if we want to

be compatible with the 3 2050 roadmaps that are upcoming (ENER, MOVE, CLIM).

I think by just comparing studies that tackle the issue from today's perspective, with a focus on the energy/electricity sector, we are missing important issues, and my two favorites are:

a) Decarbonizing the transportation sector, with a particular focus on biofuels (I would love to believe in the scenarios on electromobility, but it is one scenario amongst many, and not a very realistic one); here I think a serious discussion of BIOFUELS, in connection with BIOMASS in general, is crucial. We have so far avoided detailed analysis of the sector, but need to engage into it.

b) The industry sector is a major CO<sub>2</sub> emitter, both from energy uses, and process heat uses; the latter are sometimes not avoidable, as in metal/steel, cement/klinker, ammoniak, hydrogen, petrochemicals, etc. Unless processes that are "cleaner" are found, there is no way to maintain these sectors in the European

industrial landscape, and meet the targets.

I would therefore have liked to see an in-depth treatment of these issues, and a focus of one (or two?) researchers in these fields that we are usually not very interested in... With respect to energy efficiency, the report may have included an analytical discussion what the "market failure" is all about, and how it can be remedied. Also, I have the impression that energy efficiency policies need to be different, and to a certain degree decentralized, e.g. to distinguish policies in Spain vs. Estonia.

Section 3.3: suggests to treat CCTS (carbon capture, transportation, and storage) as a "bridging technology". I think this is unrealistic in the European energy sector. In particular I do not see any reason to treat CCTS as a substitute for renewables. No other technology has received such focused support, and not yet delivered; one also observes that the focus is moving from electricity to industrial applications (steel, cement).



## Annex 7: Conclusions of the public consultation based on a preliminary version of the report April - May<sup>46</sup>

Responsible: **Serge GALANT**, Technofi

Submission date: **June 2011**

### Giving sense to the “EU involvement” concept

The report should address very early the definition of the concept of “EU involvement”. Indeed, there might be confusion about the meaning of “EU”. Is it

- The Council with specific political initiatives approved at the majority of the Member States?
- The Parliament with specific measures?
- The European Commission with dedicated RD&D activities?
- All three like in the building of Directives?

It is proposed to recall the European Added Value of measures in the energy sector which were decided in the past to give a precise sense to what is understood as “EU involvement” in this report.

### Fighting against further national policy fragmentation

The report identifies a major fear in setting and reaching 2050 targets: the fragmentation of policy measures that make this goal unrealistic.

### The report proposal

The present report rightly addresses the issue of national policy fragmentation to cope with climate change challenges. It proposes routes in section 3.2 which raises even more issues than it could help solving as mentioned in the EWEA comments for electricity generation capacity mechanisms. A European

capacity payment mechanism has distortive effects. National experiences already show that design and implementation of such capacity payments is complex and may lead to investment distortions as it disincentivizes demand-side participation as well as investments in interconnections and storage capacity. As a matter of fact, capacity payments might be considered as a temporary regulatory tool to relieve occasional tightness in generation adequacy and ensure security of supply in weakly interconnected or isolated power systems. Yet, in an interconnected system like continental Europe, capacity payments should follow the foreseen improvements in current electricity markets, i.e. implementing European-wide market coupling by 2014 as targeted by the European Commission, establishing and integrating intra-day markets, enhancing market-based demand-side participation, increased transmission capacity, etc.

### Recommendations

The report should keep away from specifying dedicated measures to fight policy fragmentation but rather propose routes for policy improvements in view of meeting 2050 decarbonization goals (see below the interdependence theme).

### Future levels of EU involvement: avoid being technology prescriptive

There are two generic mistakes in this document which may lead to very strange conclusions in connection with CCS.

- CCS is not an energy source: it is an end-of-pipe technology. There is nothing in the renewables legislation that impacts the possible development of CCS.
- “Renewable energy technology” is not one single technology: it means 10 to 15 different technologies with no “dominant technology”, although wind and biomass are expected to make the largest contribu-

<sup>46</sup> With written comments either in the initial draft report or in a specific paper coming from Greenovate !Europe, GERG, EWEA. ENTSO-E was not in a position under such a short notice to propose an answer.

tions up to 2020, just as they did between 2000 and 2010. The EU policy approach has, so far, encouraged competition between all these renewable energy technologies which means that the lowest cost options - wind and biomass - will be the largest contributors to the targets.

Hence, the argument made in the report for CCS could just as easily be made for the majority of renewable energy sources, e.g. geothermal, tidal, wave, offshore wind energy, CSP etc. These are all being deployed due to national efforts, the Directive being technology neutral.

As a matter of fact, a technology-prescriptive effort at EU level for CCS would require addressing all the other - currently less competitive - technologies, which are not assisted under current EU renewables legislation.

#### **Towards a fourth level of EU involvement: stressing the needs for more interdependence to reach the 2050 goals**

One way of fighting the increased fragmentation of national energy policy is to give the EC a role in showing the impacts of more interdependence at regional, national and European level. A fourth level of involvement should be created in order to design public incentives that would correct for future fragmentation by encouraging for positive interdependence. Increasing interdependence between organizations has indeed both pros and cons:

- maximizing interdependence will lead to extra investment costs (for instance in networks interconnecting organizations) which can be recovered either by savings on the energy needs to run a business and/or by getting revenues from carbon credits, a tool which will be deployed at European level to drive a low carbon economy

- maximizing interdependence may lead to a lack of system reliability beyond a certain critical level: if one critical energy provider experiences an internal failure (for instance, lack of waste heat towards downstream end users due to a breakdown of its own industrial process), many other players may also face a loss of reliability which also could impact their business activities.

There are technical, legal, regulatory, social and economic challenges at promoting interdependence between energy players in Europe at all levels. It is believed that interdependence will become a generic driving factor to decarbonize our energy system in Europe. The involvement of EU players (Council, European Commission and Parliament) will be necessary to promote optimal levels of interdependence as a mean to reinforce the credibility of the upcoming 2050 decarbonization goals. The recent decision of the German Government to phase out of nuclear electricity production illustrates the role of interdependence in future EU 27 energy policies.

#### **The natural gas energy vector**

There is a major flaw in the work: the natural gas issue, with related comments on the hydrogen economy, should be included in the report. Natural gas will be very critical in a post Fukushima assessment of the 2050 decarbonization goals. The involvement of EU27 will go much beyond the Third Energy package where gas and electricity networks were at stake.



## THINK

THINK is a project funded by the 7<sup>th</sup> Framework Programme. It provides knowledge support to policy making by the European Commission in the context of the Strategic Energy Technology Plan. The project is organized around a multidisciplinary group of 23 experts from 14 countries covering five dimensions of energy policy: science and technology, market and network economics, regulation, law, and policy implementation. Each semester, the permanent research team based in Florence works on two reports, going through the quality process of the THINK Tank. This includes an Expert Hearing to test the robustness of the work, a discussion meeting with the Scientific Council of the THINK Tank, and a Public Consultation to test the public acceptance of different policy options by involving the broader community.

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