Security of Energy Considering its Uncertainty, Risks and Economic implications

Policy Recommendations

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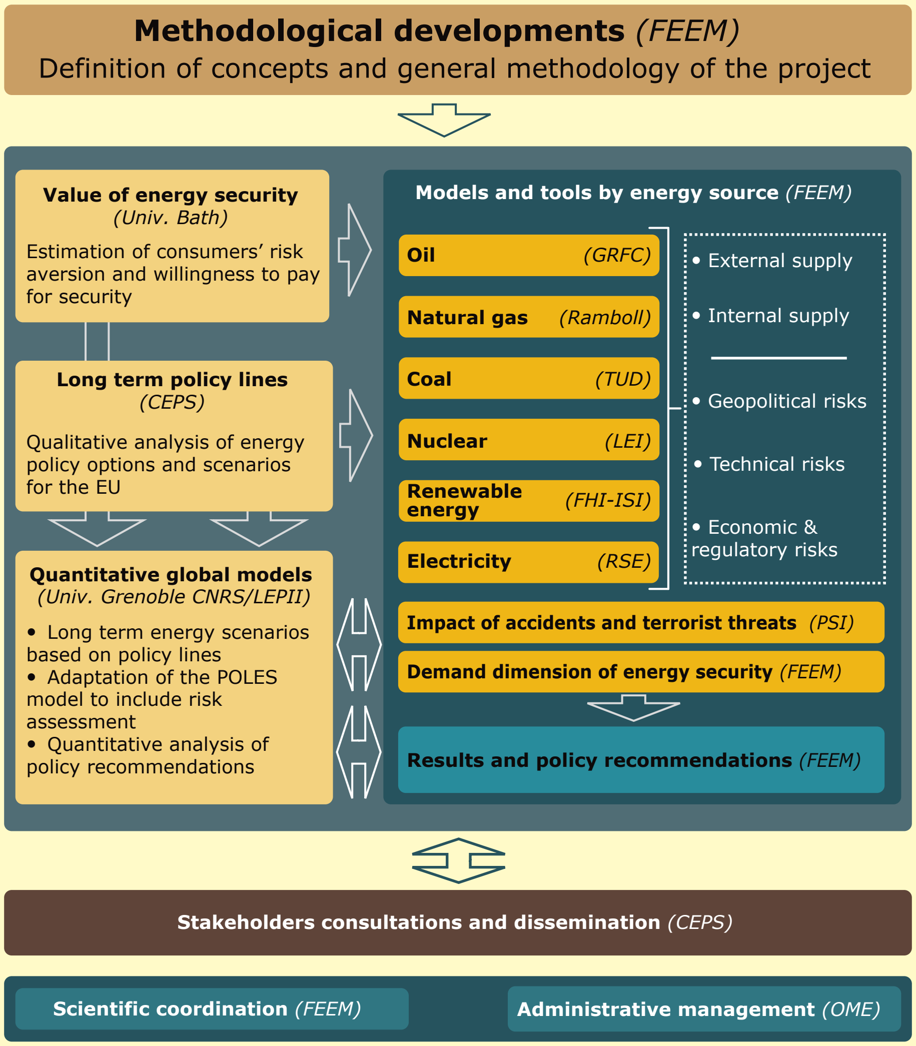
Introduction

SECURE (*Security of Energy Considering its Uncertainty, Risk and Economic implications*) is a research project funded by the European Commission under the Seventh Framework Programme.

This 3-year project, started in January 2008, is carried out by a consortium of 15 partners from 11 countries. Observatoire Méditerranéen de l'Energie is the project coordinator. Scientific coordinator is Fondazione Eni Enrico Mattei.

Structure of the SECURE project



The diagram illustrates the different modules of the SECURE project, their interactions, and the coordinating and responsible organization for each module.

The ambition of the SECURE project is to build a comprehensive framework that considers most of the issues related to the topic of security of supply, including geopolitics, price formation and the economic and technical design of energy markets inside and outside the EU.

The project develops tools, methods and models to evaluate the vulnerability of the EU to the different risks which affect energy supplies, in order to help optimize the Union's energy insecurity mitigation strategies. The project places equal emphasis on quantitative and qualitative approaches.

All major energy sources and technologies are addressed from upstream to downstream by means of both global and sectoral analysis of technical, economic/regulatory and geopolitical risks. The analysis is not limited to supply issues, but also integrates demand issues related to energy security.

Stakeholders' consultation has been an important element of the SECURE project. Several workshops have been organized both in Europe and in the main energy supplying regions for Europe (Russia, North Africa and Persian/Arabic Gulf) in order to discuss and test draft project results.

The SECURE project has been designed to provide the European Commission, as well as EU governments and regulators, with facts and methodologies to support their decision-making process towards the definition of energy policies and strategies. In particular the results of the project will be useful in order to achieve an energy mix that reconciles energy security and sustainability requirements; to develop stable relations with energy exporting countries and external partners; and to optimize the synergies between member states to improve security of supply.

There is no easy fix for ensuring long term as well as short term security of supply in the EU. Ensuring and improving security of supply is thus a combination of a number of policies and recommendations. This brochure summarises the main recommendations put forward by project partners at the end of their three years of joint research activities on these challenging issues.

/1/ SECURE's Energy Development Scenarios

Between now and 2050, mankind must face two intertwined problems: the growing scarcity of oil (and gas, but not coal) and the accumulation of greenhouse gasses (GHG) in the atmosphere.

These "bathtub problems" cannot be considered independently, as hydrocarbon scarcity paves the way to coal (and hence higher GHG emissions) while climate policies open the path to low carbon societies. "Smart" energy policies and associated international relations should combine the security, the sustainability as well as the competitiveness dimensions.

A family of scenarios have been developed in the SECURE project using the POLES model. They illustrate the complex interactions of climate policies and energy security issues:

1. The Muddling Through (MT) scenario describes the consequences of non-coordinated, low profile climate policies;
2. The Muddling Through & Europe plus scenario (MT E+) describes the consequences of non-coordinated, low profile climate policies but with some leadership from Europe;
3. The Europe Alone case (EA) represents the outcome of a scenario in which every country is free-riding except the EU;
4. The Global Regime (GR) explores a new world energy system, under strong emission constraint (EU-type). The two latter scenarios imply a new energy paradigm for the EU.

The scenario analysis performed using the POLES model was supported by a multi-criteria Decision Analysis (MCDA) to evaluate the various energy supply scenarios. The MCDA approach allows decision-makers and stakeholders to address simultaneously and in a structured manner the often conflicting economic, ecological and social criteria, account for the impact of subjective preferences and apply the necessary trade-offs. The associated process leads to increased understanding of the strengths and weaknesses of technologies and scenarios and identification of most robust options, and helps to guide the debate on controversial energy issues. The results obtained in the SECURE project point to policies that are most robust with respect to the balance between sustainability and security of supply.

Compared to earlier MCDA-applications the criteria set covering the three dimensions of sustainability (environment, economy and social), was extended by explicit representation of security of supply.

Scenarios with limited and uncoordinated action for reducing GHGs emissions, such as *Muddling Through* imply only weak signals in terms of carbon price, but as they mobilize the cheap part of the Marginal Abatement Cost curves, they already change significantly the level of emissions through reduced demand, accelerated development of non fossil energy (both nuclear and renewables) and Carbon Capture and Storage.

However, these scenarios do not succeed in meeting the emission targets deemed desirable in the latest IPCC Assessment Report (2007) in order to limit average temperature increase to 2°C above pre-industrial levels.

Scenarios with strong climate policies, such as Global Regime, clearly allow reducing both emissions and the level of tension on international hydrocarbon markets, through lower oil and gas production. This is a double dividend situation, probably the most important one to be derived from ambitious climate policies.

Finally, scenarios with unilateral actions from Europe involving a change of paradigm for the European energy system (*Europe Alone*) do not meet the climate target as the impacts of important efforts in Europe are not sufficient to induce massive emission reductions at world level, nor do they limit the risk of energy shocks. However these scenarios have highly beneficial implications for Europe:

- imposing strong emission reduction domestically results in a thorough restructuring of the European energy system;
- in case of energy shocks, this restructuring will allow Europe to be largely protected by lower energy demand, higher contribution of domestic non-fossil fuels (renewable and nuclear) and a much lower level of fossil fuel imports.

Scenarios that involve no drastic change in Europe's energy system imply the development of the energy security strategy in a conventional setting: the main concern is to ensure that sufficient supply is available, particularly of oil and gas supply. The Energy Charter that currently provides the basis for this policy is just one of the possible options. The key issue is the possibility of a timely investment for the development of huge production and transport capacities. In that case the Energy Charter should at least be completed by other policies.

One of the permanent requests of exporting countries is for the importers to ensure the demand security that will guarantee the cost-effectiveness of the supply and transport investments. They also call for the possibility of downstream investment.

This type of policy framework would result in some upstream-downstream reintegration of the industries with cross investments in common projects or joint ventures. Based more on bilateral relationships this type of policy may, however, enter into contradiction with the liberalization and Energy Charter perspectives.

Scenarios that imply a deep restructuring of the European energy sector and energy demand change the market perspectives for the exporters. Demand, when impacted by strong environmental constraints in Europe will display very different dynamics, in particular after 2030.

If Europe is alone in its efforts to develop a new energy paradigm the effectiveness in terms of climate change mitigation policies and even the impact on global energy markets will be limited given the moderate weight of the EU on a global scale; however Europe will be less vulnerable to energy shocks.

If some kind of global climate regime is implemented, then energy will be more sustainable in the long term, but in the short term there is a risk of producing countries underinvesting because of the uncertainties created. This case would provide a very challenging setting for the development of cooperative relations between importer countries and their suppliers. New orientations may encompass economic collaborations on new low carbon technologies or reinforced economic cooperation in areas other than energy.

Scenarios with a new energy paradigm display a lower demand and higher share of non fossil domestic sources, whether renewable or nuclear. Primary energy demand for oil and coal drops, while gas demand is much less affected.

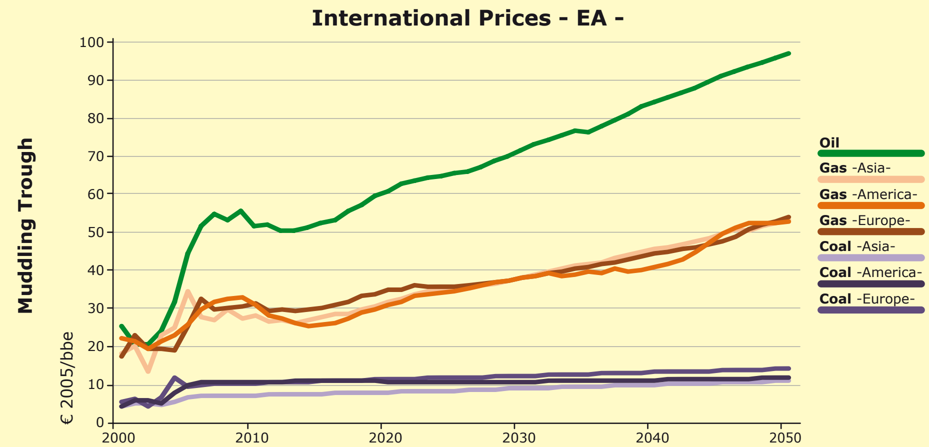
Total electricity production is almost unchanged in the new paradigm scenarios because electricity is the main carrier of decarbonisation. Moreover the role of renewable, nuclear and CCS increases with the strengthening of the carbon constraint. Wind and biomass play the major role in the increase of the renewable power plant capacity in Europe.

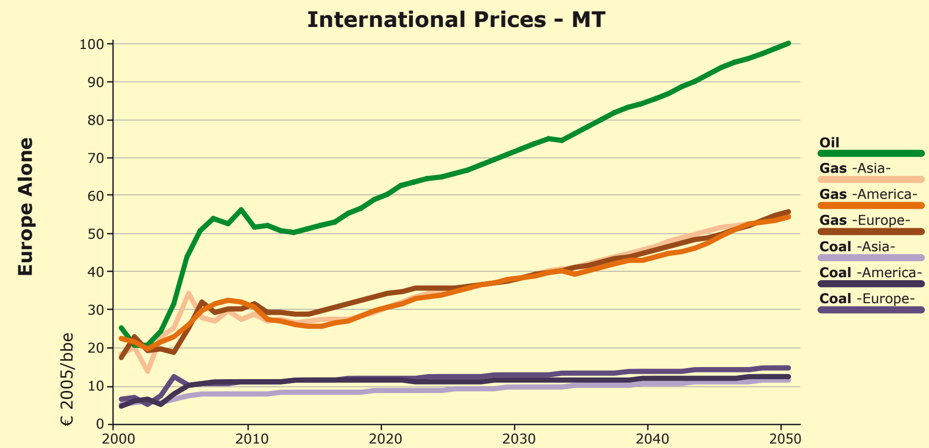
In the Global Regime scenario, climate policies bring about a significant double dividend in terms of reduced tensions on energy markets and in terms of increased environmental sustainability. However the Global Regime scenario is highly sensitive to shocks in form of a very severe nuclear accident and/or failure to implement carbon capture and storage on a large scale. This underlines the need of stringent application of high level safety standards for nuclear world-wide and intensification of efforts to develop and implement CCS-systems.

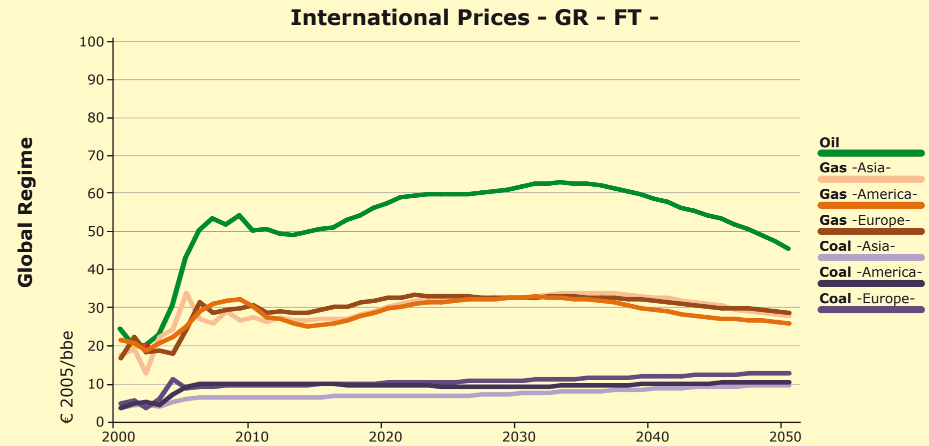
Overall it can nevertheless be said that there are clear synergies between protection of climate and security of supply, as meeting ambitious GHG-emission reduction goals by means of successful decarbonisation of the energy supply system through expansion of renewables, nuclear and CCS, combined with very extensive efficiency improvements is also highly beneficial for security of supply.

Fossil fuel prices are lower in presence of strong commitment to climate change mitigation policies

International energy prices in alternative POLES scenarios:



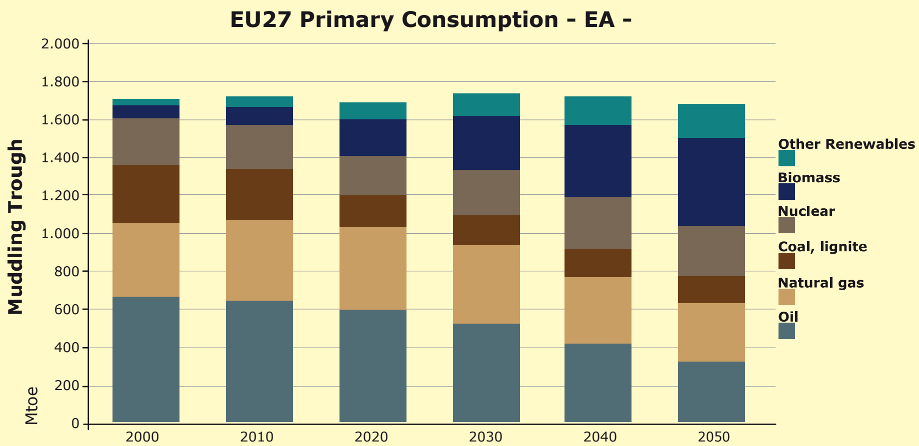


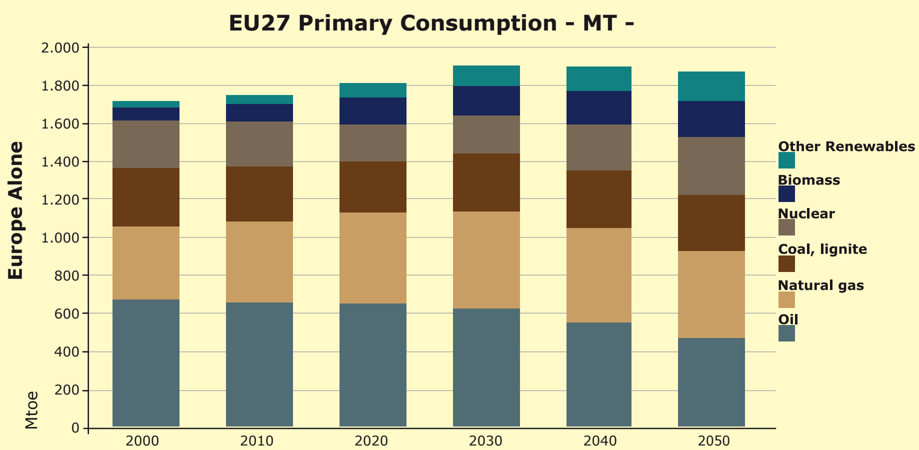


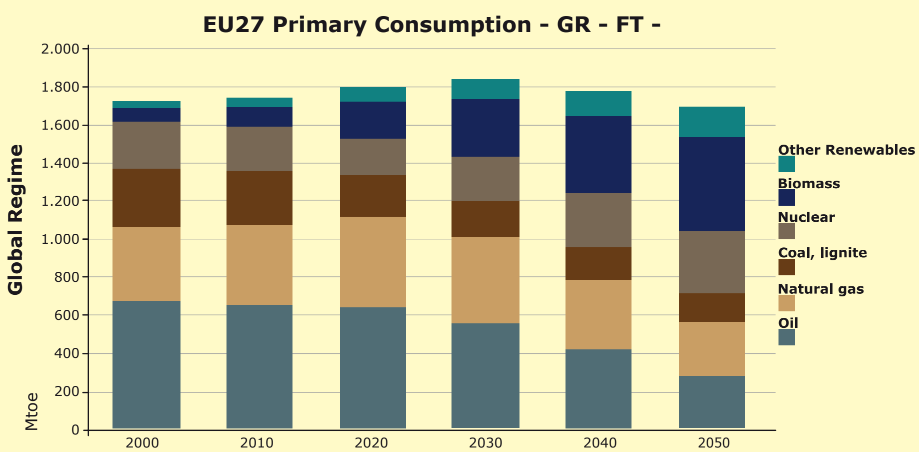
Prices in constant (2005) US dollars, per barrel of oil equivalent

A strong carbon constraint induces more nuclear and renewables, and substitution away from fossil fuels

Composition of energy primary consumption in the EU in alternative POLES scenarios:



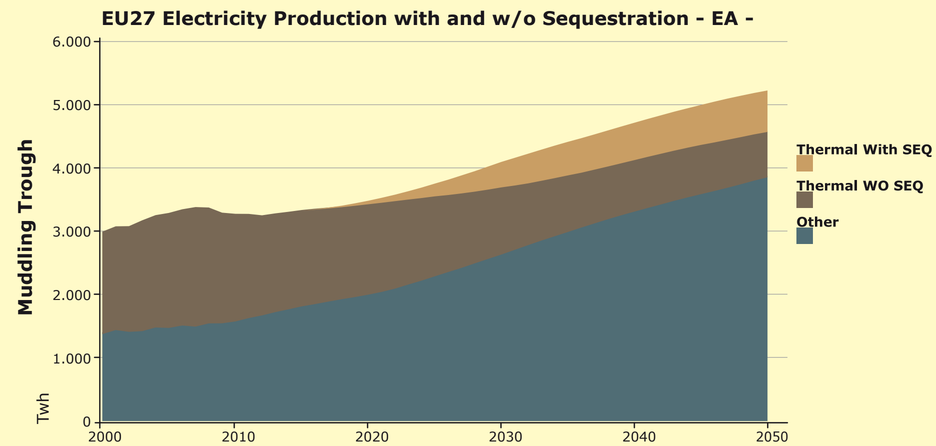


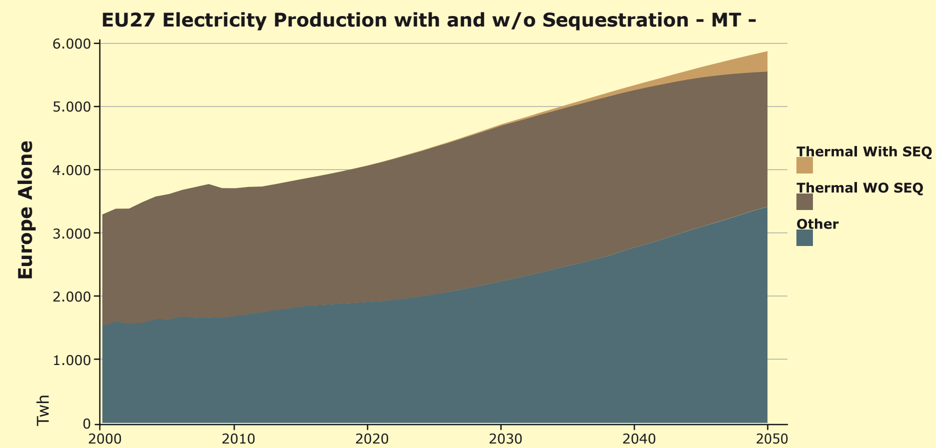


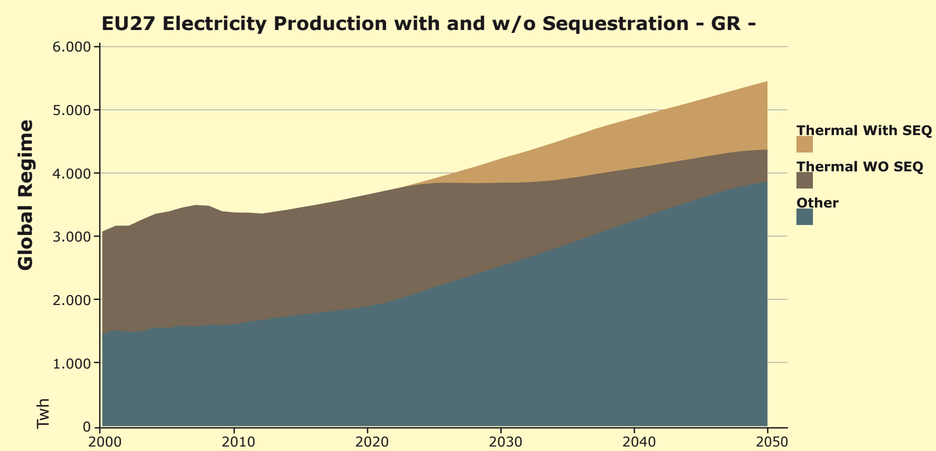
Millions of tons of oil equivalent

Stringent climate change mitigation policies accelerates the decarbonisation of electricity production

Electricity generation in the EU by technology, with and without Carbon Capture Sequestration, in alternative POLES scenarios:







/2/ Oil

There is no easy and immediate connection between **resource nationalism** or political instability and global supply of oil and gas. This does not mean that political developments are irrelevant to oil and gas supplies, but simply that the effect of these tendencies is highly variable and unpredictable.

Therefore, political considerations should not be counted as the primary determinants of the oil and gas markets but should be one of the factors that political leaders take into account when they look at those industries.

The existence of conditions of financial stability and growth is crucially important in determining the attitude of producing countries towards the desirable level of production and exports.

Financial instability, negative returns on financial assets and protectionism against the oil producing countries' industrial exports all contribute to support the exporters' view that it is best to keep resources in the ground.

Similarly, expectations about the future price levels also influence political attitudes towards production and exports. Aggressive policies aimed at decarbonisation and energy efficiency may have an ambivalent effect: there may be a negative announcement effect, because producers will fear demand destruction and invest less in expanding or maintaining capacity; and a positive market effect, when demand is effectively reduced. Hence the policy indication is not to entertain policy objectives which cannot realistically be reached, but to emphasise cooperation and pragmatism.

Restrictions of Passage
The most dramatic situation for word oil supply would be the closure of the Strait of Hormuz. The SECURE project's analysis has shown that closing the Strait is not easily accomplished, a good part of the Gulf production could be sent from other ports of the region and the shortage of crude oil could be made up thanks to strategic stocks under the IEA framework.

The recommendation is to maintain readiness to reorient oil flows as required. The burden of this task falls primarily on the oil producing countries. At the same time it is necessary to maintain the capability to reopen the Strait of Hormuz, in the unlikely event that it might actually be closed.

The European Union should aim at mitigating the danger of closure of other critical sea lanes which might be caused by navigation accidents through congested passages, the most critical situation being that of the Turkish Straits. An option would be to seek a revision of the Montreux Convention of 1936, to allow for the imposition of size limitations and passage charges on tankers, to discourage free riding and create conditions for the commercial development of pipeline by-passes. The EU should aim at facilitating investment in infrastructure adapted to reduce the danger of accidents and vulnerability, by offering financial incentives and promoting even more stringent regulations for oil and chemical tankers.

Functioning of the International Oil Markets
The unsatisfactory functioning of the international oil markets and the resulting uncertainty and volatility in oil prices is the main security threat for future oil supplies. Price volatility and unpredictability is at the heart of the insecurity that is felt by European citizens and governments, while in fact physical availability, especially for oil, has never been in question.

Price volatility and unpredictability discourages investment at all stages of the industry and increases the danger of supply interruptions.

The root cause of price volatility is the rigidity of demand and supply in the short term. These are impossible to change and can only be alleviated through encouraging the accumulation of larger stocks. Increasing the relative weight of trading in real ("wet") oil barrels rather than future paper contracts and their multiple derivatives would improve the situation. This hinges on the will and initiative of major oil producing countries, but the EU should engage in a dialogue to encourage the adoption of better price discovery methods.

The EU can also move in the direction of shifting the emphasis of price discovery from spot to forward pricing (normally less volatile) by imposing a time lag between the announcement and the implementation of price changes at the retail oil products level. The possibility of a flexible and adjustable price band should also be studied, to avoid price bubbles and/or spikes.

The EU should establish a public agency to invest in larger storage facilities to be offered for use to oil producers (be they national or international oil companies) at low cost. The agency should be empowered to issue certificates convertible in physical barrels: oil deposited into the storage would be exchanged for such certificates, and certificates could be used to withdraw oil from storage. Stored oil certificates should be designed and regulated in such a way that they will be accepted as collateral by financial institutions. The availability of an "oil bank" of this kind would encourage investment in capacity additions in anticipation of demand, thus contributing to more comfortable supply conditions. In this perspective, the role of strategic stocks (which are rarely used and have not prevented or helped in containing major price oscillations) should also be redesigned. Their importance should be revisited in favor of a more flexible policy of encouragement to the accumulation of industry stocks.

Vertical integration and reciprocity could also help. Specifically, the national oil companies of major producing countries should be allowed to invest downstream in the European markets establishing their own distribution networks, so as to acquire direct access to the final consumer, in the same way as European firms should have the same possibility in producing countries.

/3/ Natural Gas

Recent times have seen considerable dynamism in the gas market in Europe. Concurrently, there have been a major Ukraine-Russia gas crisis, a collapse in the spot price of natural gas, new European natural gas security of supply regulation, an unprecedented increase in global Liquefied Natural Gas (LNG) supply and finally the mass production of natural gas from unconventional sources in the US as a result of technological advancements which had a huge impact on world gas markets.

Security of demand and security of supply are complementary issues in ensuring an overall balance in the security of natural gas supply in the EU. Security of demand requires the EU to provide clearer signals regarding future gas demand in Europe to facilitate investment both internally and externally.

Underinvestment may threaten the adequate provision of new supplies by exporters or in the development of necessary new infrastructure due to contradictory estimates in gas demand.

The present lack of clarity within the EU and underinvestment would lead to serious security of supply issues in natural gas that could not be solved in the short or medium terms. Therefore, the EU should develop a gas demand forecast which is based on the amalgamation of energy policies and individual national plans.

National and regional differences imply that security of supply levels and mitigation tools will necessarily differ between countries and regions. The Baltic countries and parts of the South East of the EU have significantly lower levels of security of supply and are subject to regional and country-specific circumstances, which call for an overall EU security of supply policy that will allow for adjustment of measures and policies to specific regional circumstances. The model applied in the Baltic Energy Market Interconnection Plan (BEMIP) could be applied for this regional focus, allowing for action with resolve in a certain region.

The process of gas market development and the continued liberalization of the EU's markets are not yet fully realized, and there is a pressing need to go ahead with these measures to ensure long-term security in gas supply. Market structures on the national scale in the EU remain highly concentrated, interconnection projects must be realized, and regulation should be clear and facilitate the market in investments. Furthermore, gas prices in the EU should reflect supply and demand of gas in the long run. Legislation should continuously be reviewed and the goal of creating a fully functioning gas market should be a priority for legislators both national and in the EU.

EU gas market operators have been shown to invest in markets and not necessarily in security of supply. This means that markets alone will not solve the current issues of low security of supply in some countries, especially where markets are poorly if at all developed, as in the case of Baltic countries. Thus increasing security of gas supply in these regions is likely to be dependent on government intervention and/or EU regulation.

Further diversification for areas with a current low level of suppliers and routes can be ensured by reverse flow and interconnection as well as new supply routes, both pipelines and LNG. Demand flexibility should be studied further regarding its ability to mitigate security of supply issues in the EU.

The development and strengthening of early warning and crisis prevention mechanisms at the EU level as well as the implementation of regional emergency plans should be encouraged.

Regarding gas transit across Ukraine, the possibility of an independent transmissions operator in the Ukraine composed of Ukrainian, EU, and Russian operators should be seriously evaluated. Such cooperation would significantly enhance security of supply reducing the chances of bilateral disputes affecting gas supply, and additionally ensuring the much needed investment in the Ukraine transmission infrastructure.

Although production of unconventional gas in the United States has already had the indirect effect of increasing redirected LNG supply to Europe, the potential of unconventional gas in Europe to significantly impact security of supply is presently unclear, and such resources should only be considered to have a potential impact in the medium to long term. Nevertheless, legislation regarding unconventional gas production should be streamlined and reviewed in order to accompany any potential unconventional gas' development and to make sure that any lacuna regarding the law of its production is addressed.

Additionally an accurate survey of its potential production in Europe should be generated in order to evaluate its potential impact and provide a degree of clarification about recoverable resources.

With the relevance of traditional suppliers such as Norway and Algeria posed to decline in the medium term, there is a need for Europe to have a robust policy with Russia, but also with the Caspian and Middle East regions, that shows pragmatism, partnership and commitment to their development as gas export partners with Europe as they are expected to play a more important role in European gas supply after 2030.

/4/ Coal and Carbon Capture, Transport and Storage (CCTS)

The real issue in European steam coal supply security is not resource availability, but rather the absence of an economically and politically sustainable use of coal due to obstacles in the implementation of CCTS. Given the availability of coal, the continuing public financial support to the sector becomes harder and harder to justify.

On the resource side, virtually all major exporters can be considered as reliable countries in geopolitical terms and no sudden supply disruption on political grounds can reasonably be expected. Short-term supply disruptions may occur due to a variety of events, such as social tensions, which may lead to strikes. Yet, efficient supply management with stockpiling and supply diversification can reduce the short-term risk of disruption for European import countries. Therefore, we suggest that:

- Market monitoring should continue, particularly for developments in specific regions (China);
- Competition authorities should continue to monitor international coal markets, particularly mergers and acquisitions of large coal and mining companies.

On the utilization side, there is an implicit supply security threat, i.e. that coal will no longer be an essential element of European energy supply, because the CCTS roll-out will be delayed or never carried out. There is justified concern that the ambitious development plans in CCTS demonstration as outlined in the IEA Technology Roadmap over the next decade will not be met.

This is based on a lack of determination on the part of public authorities to overcome the significant obstacles inherent in the complexity of the CCTS chain, and the difficulties of the power sector in embracing a technology that challenges the business model of coal electrification. In Europe the economic use of coal in the power sector and in industry could be threatened. Coal substitution in industrial processes could pose even larger challenges than in electricity production.

Recent estimates found a significant decline in European storage potential and transport infrastructure. Further, increased public opposition to onshore storage will most likely necessitate offshore solutions. This will raise the costs and the technical complexity of the CCTS chain, questioning the role of CCTS as a cornerstone of a strategy to decarbonise European energy systems. The SECURE project therefore recommends that:

- The potential contribution of CCTS to a decarbonised European electricity sector should be reconsidered given new data available on CCTS costs, a better understanding of the complexity of the process chain and the lowered CO_2 storage potential.

- Europe has an important role to play in keeping the technology options open and avoiding premature intellectual property appropriation. The EU co-funded projects should make new knowledge widely available, and a competition between projects should be promoted that yields the highest chances of achieving technical progress.
- The huge and readily available funds for CCTS should be rapidly deployed. Where industry does not respond, the legal and regulatory framework should be readjusted and the level of incentives should be raised. In the absence of a credible CO_2 price path, forcing utilities into a capture ready option will raise the costs of the standard plants but will not incentivize CCTS investment.
- The strong focus on the implementation of CCTS in the power sector observed in the past should be extended to industry, which can be highly vulnerable to an abandonment of coal. Due to a larger number of small emissions sources, this poses higher challenges to network development.
- Early planning of transport routes is of paramount importance should large-scale CCTS deployment ever become reality. At least in this phase, the state will be needed as a major provider in the development of transportation infrastructure, including planning and siting.
- Construction and operation can be tendered to the private sector, or carried out by state-owned network firms. Routing pipelines along existing networks can lower costs and public rejection. Thus, synergies with other energy network infrastructure (gas, electricity) should be considered.
- Future regulation should specify the allocation and financing principles as well as access for third parties. Sufficient incentives for the private sector to manage the network development are unlikely, given the political, regulatory, technical, and economic uncertainties.
- If Europe fails to fill its role as CCTS pioneer, new strategies for the global roll-out of CCTS are needed. The inclusion of CCTS under the Clean Development Mechanism could help to bring the technology to the markets. However, this would also imply the outsourcing of potential risks associated with the technology.

/5/ Nuclear

Current nuclear energy operating under conditions prevailing in most industrialized countries exhibits good economic and environmental performance. Within the western world it also has a positive safety record thanks to extensive improvements implemented after the TMI-accident in 1979. This is reflected in very low estimates of expected risks. The sensitive issues for nuclear energy include risk aversion towards hypothetical accidents with very severe consequences, the necessity to assure safe storage of relatively small volumes of radioactive wastes over extremely long period of time and the possibility of nuclear proliferation. These aspects strongly influence the public opinion and consequently also the social acceptability of nuclear power.

Nuclear energy offers opportunities for diversifying energy supply and ensuring long-term security. The main advantages of nuclear energy in this regard are the limited importance of raw material – natural uranium – in the total cost of producing nuclear electricity, the geopolitical distribution of uranium resources and production capabilities, and the easiness for users to maintain strategic stockpiles of fuel.

Natural uranium is widely available in the world including in many countries where the geopolitical risk is limited. Its cost represents only a few percent of the total cost of generating nuclear electricity. Furthermore, maintaining strategic stockpiles representing several years of consumption, is physically easy and does not represent a significant financial burden for users.

In order to fulfill climate policy goals, nuclear energy may have to play a major role in worldwide and EU long term energy balances. However, according to some IEA and European Commission energy scenarios, the EU nuclear share may halve between now and 2030. As nuclear is presently providing two thirds of all low carbon electricity in the EU, this will create an even larger strain on fulfilling CO_2 targets.

In fact, the often announced nuclear renaissance is having a difficult birth. With 148 aging reactors in operation in 15 member states, there are presently just four reactors under construction in the EU (one in Finland, one in France, two in Bulgaria).

Reasons for the stalling renaissance of nuclear energy are:

- limited social acceptability (political opposition) for a technology which is perceived as dangerous and for which the final long-lived waste disposal facilities are still not available;
- lack of human capacity (Europe's industrial capacity of building nuclear power plants is said to be currently limited to maximum four per year, other regions seem to have the same problem of aging workforce); this problem could even worsen over the next years as specialists retire, although nuclear education programs at European universities and elsewhere have been reinitiated;

- while earlier built nuclear power plants are today mostly fully competitive (in spite of sometimes troublesome developments involving high costs of backfitting to satisfy much extended safety requirements) there has been an escalation in investment costs for the new plants belonging to the third generation; this is largely due to: industrial experience deficit, costly mistakes, rush to build without being fully prepared, first-of-its-kind plants, changing regulatory requirements during construction and capacity problems in manufacturing critical components;

- the difficulty to finance hugely capital intensive plants in a market environment and in particular after the financial crises;

- the increasing uncertainty on construction costs raise some doubts on the ability of nuclear power to foster a decrease in prices; however, experience from Asia, where nuclear power has been intensely developing during the last two decades as opposed to stagnation in Europe and US, shows that these uncertainties can be overcome and the above mentioned difficulties can be avoided, leading to smooth expansion of nuclear energy.

In this context government action is essential to:

- promote public debates on nuclear safety, energy security of supply and climate change issues thus providing a balanced perspective on nuclear and other energy supply options;

- assure that legal, regulatory conditions for nuclear energy are clear and stable;

- promote human capital building;

- implement the planned waste repositories to demonstrate practically their feasibility;

- explore regional centers for high level waste disposal;

- create a level playing field for low carbon technologies via an effective EU-wide emission trading system and/or carbon tax.

As member states retain sovereignity over energy mixes, local political/public consent and support is vital.

The same high safety standards as for nuclear reactors must be applied to all elements of the associated infrastructure: conversion, enrichment, fuel fabrication, spent fuel storage and reprocessing. Accumulated knowledge and experience both upstream and downstream are reflected in existing safety rules. They must be strictly applied in any country using nuclear energy. The EU should put all its geopolitical weight to make sure that these rules are respected everywhere and to promote non-proliferation. In fact, a major nuclear accident anywhere in the world could have dramatic consequences also on the European nuclear development.

/6/ Renewable energy sources (RES)

In order to decrease import dependency and promote decarbonisation of the European energy system, the increased use of RES should be supported in the electricity, heat and transport sector by means of renewable support policies.

A high share of renewable energies in the mid- to long-term cannot be reached without strong increases in all three sectors: renewable electricity (RES-E), heat (RES-H) and biofuels. The current policy framework in the individual member states does include an extensive set of supporting mechanisms for RES-E and to some extent for biofuels, but the current limited and dispersed support for RES-H needs to be addressed in the future. Concerning biofuels, efforts should be directed to develop second generation biofuels which are posed to be less troublesome in terms of land competition with food crops and competing use of the feedstocks.

The general approach should be to keep a level playing field among different technologies, so that most efficient solutions can emerge from market forces, rather than being selected by policy makers.

The present technological uncertainty suggests the need to maintain some public support to a wide range of technologies, at least until the relative merits of different solutions emerge on the basis of solid experience. Consequently, any future policy framework should consider providing technology-specific support to the various RES options. However, this policy should entail periodic reviews of the incentive schemes, in the light of a possible future phasing out.

Efforts to support RES are needed in all member states. The uneven distribution of RES potentials and costs emphasizes the need for intensified cooperation between member states, where suitable accompanying flexibility mechanisms can assist the achievement of national RES targets in an efficient and effective manner.

RES policies should be supported by a strong energy efficiency policy. Modelling results indicate that in the absence of strong energy efficiency policies energy demand is higher and more RES is required in order to achieve the targeted share of 20 percent by 2020. Consequently, more expensive renewable energy technologies have to be utilized and the average yearly policy costs are expected to increase largely.

To face the challenges resulting from an increased share of fluctuating wind electricity, several potential remedies may be applied:

- Forecasting tools and imbalances management should be improved. Wind power prediction tools enable energy suppliers to forecast the variations of the power outputs which are typical for wind power plants. The implementation of forecasting tools may increase the maximum amount of wind power that can be accommodated in the network.

- Trading at the intra-day market platform would imply a correction of all the imbalances whereas the imbalance payments only apply for the net system imbalances (that, in case of low wind penetration, could be only 50 percent of the total imbalances).
- Storage systems such as pumped-storage hydropower plants, hydro reservoirs, compressed air storage, flywheels or batteries may be used to contribute to managing the integration of fluctuating generation. However, some of the mentioned technological options are not yet competitive in economic terms.
- Smart grids providing intelligent services in addition to its initial purpose of delivering electricity to the consumers, may contribute to the operation of the electricity system. By enabling intelligent monitoring and an improved control of supply and demand, system reliability and the security of supply can be improved.
- Finally, the reinforcement and, if necessary, the extension of the electricity grid represents one main option of how large amounts of fluctuating electricity can be integrated into the electricity system.

Looking at the longer term, a beneficial political and regulatory framework promoting solar energy imports from North Africa should be created, including options for granting these projects priority status under EU infrastructure projects as well as promoting the development and operation of European and trans-Mediterranean super-grids. Such super-grids would need a high level of redundancy or resilience otherwise they may be very easy targets for a terrorist attack.

/7/ Electricity

One of the main barriers to long term investments in the electricity sector (that usually are quite capital intensive) is regulatory uncertainty: it is fundamental to guarantee investors with some basic key conditions under which they will have to operate, in order to let them correctly assess their risks.

Generation

Electricity generation has undergone a liberalization process, which has proven able to develop in a reasonable way without excessive state interference. However, a monitoring of the adequacy of capacity remains appropriate. To this end, Transmission System Operators (TSOs) should be given the task to determine how much new generation capacity of the different types (e.g. base load, mid-merit, peak) may be needed to meet the security standards, when and where (the location in the network is very important), having regard to the cost-effectiveness of the proposed solution.

In case public authorities were to identify significant security problems, they could set up incentive/obligation schemes (through instruments such as tendering procedures, capacity payments, capacity markets, etc.) to induce investors to pursue the "optimal" development of the generation set outlined by TSOs. Of course, it is desirable that all this process is coordinated and harmonized at the EU level (by ENTSO-E and ACER) to increase its effectiveness and to avoid market distortions.

Transmission

A significant increase of cross-border transmission capacity is highly desirable. To this aim (but also in case of development of intra-national transmission lines) it is necessary:

- to pursue a more stable and harmonized regulatory framework at the European level, under control of the Agency for the Cooperation of Energy Regulators (ACER);
- to pursue more harmonized, efficient and clear authorization procedures at all administrative levels, requiring thecompliance with general framework guidelines; such procedures should have a reasonable and mandatory time limit for their duration (e.g. three years);
- to gain social acceptance by clearly stating and quantifying the public benefits of the projects especially from the security of supply, from the sustainability (in particular when renewable energy flows are involved) and from the economic points of view. This latter issue is very important to gain consensus: people must know that the realization of the projects will reduce their electricity bills (either by imports of cheaper energy) or by direct compensations; moreover, the strategic importance that characterizes cross-border transmission projects must be highlighted with the support of the highest political decision-making levels.

Regulation should be designed to provide "locational signals", i.e. the spatial (zonal/nodal) differentiation of electricity prices (due to maximum transfer capability constraints and losses on the lines) and of transmission charges (calculated on the basis of how much each agent uses the network). The provision of such signals can lead to a more efficient system operation in the short-term and can promote a more optimized siting of new generators and loads in the long-term.

Distribution
As to the progressive transformation of distribution networks from "passive" to "active" and "smart" networks, cooperation among international, European and national standardization bodies, regulatory authorities, grid operators and manufacturers should be encouraged to further improve open communication protocols and standards for information management and data exchange, to achieve interoperability of smart grid devices and systems and to get rid of technical barriers to their deployment.

From a regulatory point of view a key issue is how to support distribution network companies in their investments in such innovative technologies in order to ensure that their deployment provides a cost-effective solution to the needs of network users. In this perspective, both incentive and minimum requirements regulation should be based on the quantification, through appropriate indicators, of the effects and benefits of such investments in "smartness".

/8/ Impacts of severe accidents and terrorist threat on energy security

The energy sector is both a key resource and a critical infrastructure for the economy that forms the backbone of today's society, its goods and services. Therefore, the comparative assessment of accident risks is a pivotal aspect in a comprehensive evaluation of energy security concerns.

Among centralized large-scale technologies in industrialized countries estimated expected accident risks are by far the lowest for hydro and nuclear power while fossil fuel chains exhibit the highest risks. On the other hand the maximum credible consequences of low frequency hypothetical severe accidents, which can be viewed as a measure of risk aversion, are by far highest for nuclear and hydro (given high population density downstream from the dam), in the middle range for fossil chains and very small for solar and wind. For nuclear, the maximum consequences are expected to be substantially reduced for fourth generation plants compared with third generation plants.

Severe accidents affecting energy infrastructure can be costly and can affect other critical infrastructure due to dependencies on energy supply. In most cases, the effects of severe accidents on security of supply are of short-term character due to infrastructure redundancies. Severe nuclear accidents could cause a long-term problem in electricity supply primarily due to potential secondary effects of such accidents, negatively affecting nuclear energy in general. Accidents in fossil chains are generally not expected to cause long-term supply disruptions; however they can have devastating consequences on local / regional ecology and economy (e.g. in the case of oil spills), lead to temporary production bans (e.g. for deep offshore production after the Deepwater Horizon accident) or the enactment of new regulations (e.g. after Exxon Valdez), to which industry has to adapt. There are also concerns for hydro, particularly in small countries with relatively few large dams and high dependence on their output.

Decentralized energy systems are less sensitive to severe accidents than the centralized ones. Supposedly, for some renewable technologies the most accident-prone stage is not the actual electricity generation, but rather upstream processes that can involve various hazardous substances, such as for the manufacturing of photovoltaic cells.

The overall accident risk for EU 27 (or a specific member country), is not only depending on domestic accidents, but additionally can be strongly affected by its total energy import share and actual composition of import countries, which is predominantly an issue for fossil energy chains. Risk reduction measures should aim to decrease import dependency, and to achieve a higher diversity among importing countries.

Allocating appropriate resources for maintaining high safety standards of nuclear power plants and hydro dams is of central importance also for security of supply. In the case of oil and natural gas primarily the exploration and production (E&P) sector as well as the major transportation routes by tankers and pipelines are concerned, in regard to ensure comfortable safety levels.

The first-of-its-kind analyses of the terrorist threat by means of scenario quantification for selected energy infrastructure facilities (e.g. oil refinery, LNG terminal, hydro dam, and nuclear power plant), were carried out by the SECURE project. For this purpose a tool was developed that allows for a quantification of risk, integrates uncertainty assessment, and provides estimates for several consequence categories using a Probabilistic Safety Assessment (PSA) approach. Analysis of uncertainties is of particular relevance because luckily there is no historical experience of extreme scenarios and access to terrorist databases is very limited.

In spite of large uncertainties the analysis indicates that the frequency of a successful terrorist attack with very large consequences is of the same order of magnitude as can be expected for a disastrous accident in the respective energy chain.

This is primarily due to the fact that centralized large energy installations are hard targets and relatively easy to protect, requiring sophisticated attack scenarios to cause significant damage and lasting impacts. Historically, terrorists prefer to attack soft targets that are more vulnerable and may cause a larger number of fatalities and do not require the mobilisation of large resources.

The methodology applied in the SECURE project provides a framework for the quantitative assessment of terrorist threats to specific energy infrastructures. However, a successful application should aim to integrate expert knowledge from a wide range of actors involving political sciences and intelligence information on the motivation of terrorists, military knowledge on scenario planning, and physical assessment of consequences. Such a comprehensive coverage could also contribute to reduce overall uncertainties in risk quantification.

/9/ The demand dimension of Energy Security

In general, the promotion of a greater end-use energy efficiency should hold the first place in any energy policy, since most actions in this field have a "negative" cost, therefore they are more economically efficient than actions to support RES development and to reduce CO_2 emissions (such as Carbon Capture and Storage technologies). Demand Response should be encouraged, with a rapid and extensive deployment of enabling technologies, such as smart metering. Moreover, Demand Response programs should be designed so as to provide strong (i.e. able to ensure a substantial economic convenience in case of response) signals, as well as be simple and easily understandable by consumers.

SECURE's analysis of the relationship between energy efficiency and energy security, has shown that energy efficiency policies in the EU do work, but there is no silver bullet able to successfully address different policy objectives such as energy security and energy efficiency, unless it is so general that naturally encompasses different sectors and energy uses.

What seem to work is the policy mix: the good news is that currently in Western Europe a policy menu is in place that has produced significant improvements in energy efficiency, has reduced the amount of carbon emissions generated by the economic system, and has contributed to a more secure energy supply for Europe. On the other hand, more fine-tuning and coordination among member states is required in order to reap the potential benefits of enhanced energy efficiency also in terms of energy security. In this sense, the 20-20-20 strategy and in general the proactive attitude of the EU in the field of climate change policy could be important opportunities.

This suggests that it would be advisable to continue EU Action Plans and make them binding wherever effective. In this process, differences in the responsiveness of energy consuming sectors to efficiency policies should be taken into account: SECURE's analysis has highlighted, for instance, that mandatory standards for electrical appliances seem to work better for the residential sector, whereas measures supporting information, education and training are more effective in the industrial sector.

Cross cutting measures, in particular those related to marked-based instruments, are those having the strongest influence both on energy security and energy efficiency. From this perspective, it is recommended to consider the development of white certificate market models at EU-level. Due account should be taken of successful deployment in some member states.

Demand Response (DR) is profitable only if electricity markets are structurally subject to variations, which can be absorbed by the flexibility offered by customers. There are no pre-defined solutions as these hinge on structural conditions. Market design is crucial as it should exploit all the potential of DR, restrictions in flexibility should be clearly analyzed and not discarded for the sake of simplicity.

Network regulation also has an important role, both at the transmission and the distribution level, and in particular where there is the interaction with the majority of customers and where a future large deployment of Distributed Generation is possible, which shares a very similar customer base with DR.

Metering, that is, the ability to control and give detailed measures of electricity flows, is the key driver for the implementation of DR.

The role of a public intervention aimed at curbing structural inefficiencies should be evaluated, not only in terms of financial support, but also in terms of creating a market with a clear and stable regulatory framework, in which Europe-wide standardization will reduce the costs of adaptation to national markets.

/10/ Conclusions

Security of supply should be addressed only within a wider, consistent approach that integrates the other two fundamental pillars of the EU energy policy: sustainability and competitiveness. "Smart" energy policies must combine these three dimensions without nevertheless neglecting the international relations context.

European climate policies bring a significant double dividend in terms of reduced vulnerability to energy shocks, even in a non-cooperative framework. However energy scenarios opening the path to low carbon energy systems require an improved framework and incentives for electricity investment (including renewables), a high degree of integration of the European electricity systems, a favorable institutional and regulatory framework for Carbon Capture Transport and Storage (CCTS) and no foreclosure towards nuclear development. In addition to supply policies, demand policies must be strongly pursued as well.

Since none of the requisites above are self-evident, and if low-carbon technologies fail to be available in time, the whole transition path to a low carbon economy is likely be at risk. Governments might thus be required to step in and provide the adequate support. The most efficient way for the EU to develop cost-effective low carbon energy use is to have a generalized and viable EU-wide emission trading system capable of delivering standardized carbon prices or an effective EU-wide carbon tax. This is an important example of an area where energy security of supply and market development converge.

Another area where the energy security of supply and the competitiveness dimensions converge is the internal market's development. Integration of markets by developing regulatory policies, which enhance interconnections in gas and electricity infrastructure and thus foster competition, would be a big step in the right direction for European security of supply.

The unsatisfactory functioning of the international oil markets and the resulting uncertainty and volatility in oil prices is seen as the main security threat for future oil supplies because it hinders investment. Measures to reduce this artificially increasing volatility should be envisaged.
Climate policies strongly influence the menu of policy solutions to energy security problems and illustrate the type of uncertainties that the EU and its energy suppliers will have to face in the next decades. Efforts are thus needed to combine institutional solutions with a dialogue with EU's partners on a medium term programming of investments in the energy sector, in a balanced perspective of mutual understanding.

Partners

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