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**COMMUNICATION FROM THE COMMISSION TO THE COUNCIL, THE EUROPEAN PARLIAMENT, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS**

# A European Strategic Energy Technology Plan (SET-Plan)

## FULL IMPACT ASSESSMENT

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**COMMISSION STAFF WORKING DOCUMENT**

**Full impact assessment**

**for the European Strategic Energy Technology Plan**

## 1. INTRODUCTION

This Impact Assessment has been prepared in support of the forthcoming Commission Communication on the European Strategic Energy Technology Plan (SET-Plan). It is based upon:

- A two pronged stakeholder consultations with experts and open to the public via internet, as explained in section 1.2.

- A consultation process with the Advisory Group Energy for the Energy theme of the Seventh Framework Programme for Research.

- A preliminary analysis by the Commission services of the European research and innovation capacities in EU Member States, referred to as the 'Capacity Map'[1], also annexed to this Impact Assessment. This analysis aimed at providing a (non-exhaustive) overview on the energy research capacities both in the public and in the private sector in the EU Member States, and in Japan and the USA for comparison. Both analyses were undertaken inside the Commission by its Joint Research Centre.

- A preliminary analysis executed by the Commission services on the potential impact of energy technologies to achieve the energy policy objectives, i.e. reduction of greenhouse gas emissions, enhancement of the security of energy supply and improvement of the competitiveness of the European industry. This analysis is referred to as the 'Technology Map'[2] and is annexed to this Impact Assessment.

- The impact assessment takes the new binding policy directions for EU energy policy decided by the Heads of State in 8/9 March 2007at the European Council, as a guideline for technology development supporting these targets.

- Neither industry nor public entities involved today in Europe in research and innovation for energy are geared towards fully committing their efforts to achieving the policy goals. The mechanisms for supporting and creating innovation, technological leadership and market take-up for energy technologies in Europe lacks an overhaul and face several problems as described in section 2.

- This impact assessment report makes a qualitative review of the current structures of research and innovation in Europe and then proposes several options, largely building on

[1] The Capacities Map can be downloaded from: http://ec.europa.eu/energy/res/setplan/index_en.htm
[2] The Technology Map can be downloaded from: http://ec.europa.eu/energy/res/setplan/index_en.htm

already existing mechanisms and instruments, to boost energy technology development in Europe.

- The 'Capacities Map' and the 'Technology Map' provide a preliminary assessment of the resources available in Europe and of the potential of different technology avenues to contribute to our policy goals.

## 2. PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

### 2.1. Background to the development of the proposal

The main drivers for the Member States' call for an EU energy policy are the interrelated challenges of climate change, security of supply and competitiveness, within the overall context of sustainable development. The present energy situation within the EU is not sustainable. The challenge is complex and there are no quick fixes. We need an ambitious, integrated European strategy embracing all aspects in a coherent whole. This represents a unique opportunity for the EU to mobilise around a truly ambitious 'grand projet', a major European political undertaking.

On 10th January 2007 the European Commission proposed a comprehensive package of measures to establish a new energy policy for Europe. The fundamental policy targets were described in the EC Communications "An Energy Policy for Europe" COM(2007) 1 and "Limiting Global Climate Change to 2°C: The way ahead for the EU and the World for 2020 and beyond" COM (2007) 2. The three key objectives of this package are to simultaneously 1) fight against climate change, 2) improve the efficiency of EU energy market, and 3) guarantee a safe, reliable and sustainable supply of energy to EU consumers.

The Energy Policy for Europe agreed by the European Council on 8/9 March, sets out a number of strategic energy policy objectives for 2020: (i) reduction in greenhouse gas emissions by 20% compared to 1990 levels (30% if in the context of a global agreement); (ii) reducing primary energy use by 20% (through energy efficiency); (iii) increasing the level of renewable energy in the EU's overall mix to 20%; (iv) minimum target for biofuels of 10% of vehicle fuel. In addition, it is indicated that by 2050 global greenhouse gas emissions must be reduced by 50% compared to 1990 levels, implying reductions in industrialised countries of 60 to 80%.

To achieve these objectives means transforming Europe into a highly energy efficient and low CO2 energy economy, catalysing a new industrial revolution, accelerating the change to low carbon growth and, over a period of years, dramatically increasing the amount of local, low emission energy that we produce and use. The challenge is to do this in a way that maximises the potential competitiveness gains for Europe, and limits the potential costs. Energy technology holds the key to success. Without a sustained and increased effort, the targets will not be met.

Research and innovation has a vital role to play in breaking once and for all the link between economic development and environmental degradation. Europe must develop a world-class portfolio of affordable, clean, efficient and low-emission energy technologies and create stable and predictable conditions for industry, particularly SMEs, to ensure their widespread deployment in all sectors of the economy. Getting the policy mix right (targets, carbon pricing, incentives etc) is essential to rewarding the take-up of low-carbon technologies without harming economic competitiveness.

Accompanying the above-mentioned Energy Policy Package, the EC published the Communication "Towards a European Strategic Energy Technology Plan" COM (2006) 847. The motivation for such an initiative (referred to in the following as the SET-Plan) is the improvement of the European innovation system on energy technologies, first by creating the framework conditions and incentives for the development of new energy technologies and then by fostering the acceleration of the lab-to-market processes.

The Communication "Towards a Strategic Energy Technology Plan (SET-Plan) was endorsed by the 2007 spring Council who invited the Commission to propose such a Plan in 2007 to be considered by the Council no later than March 2008. The present impact assessment was produced in the context of preparation of the Commission Communication on the 2007 European Strategic Energy Technology Plan, which is included in the Commission Legislative and Work Programme 2007 as item 2007/TREN/006.

## 2.2. Procedure and stakeholder participation

The Impact Assessment was initiated in March 2007 and was completed in September 2007. The analysis for the impact assessment was performed internally by the Commission services, partly based on external sources of information. To this end, an Inter-Service Group (ISG), was established in November 2006 by Directorate General Energy and Transport (DG TREN) and Directorate General Research (DG RTD), with the participation from Secretariat General and DGs AGRI, BEPA, COMP, EAC, ECFIN, ENTR, ENV, INFSO, JRC, MARKT, REGIO, RELEX, RTD, TRADE, TREN. The ISG met in 10 November 2006, 7 February 2007 and 24 July 2007 to discuss about the scope of the Plan, the structure of the Communication and preliminary results.

Consultations with experts from key energy technology sectors in the form of dedicated workshops and hearings. To this end, 18 hearings and workshops were held between March and June 2007 dealing with the following subjects: wind energy, biofuels, photovoltaics, electricity networks, hydrogen and fuel cells, zero emission fossil fuel power plants, hydrogen and renewable energy, nuclear fusion, nuclear fission, concentrated solar power, solar thermal heating, cogeneration of heat and power, energy efficiency in buildings, geothermal energy, oil and gas, basic sciences, and, international cooperation. These consultations highlighted the consented view of the technology experts that there is still significant potential available for energy technologies which can be realised when a number of key barriers are lifted, such as development of key R&D infrastructure, capacity building, etc. During this phase of the consultation process, technology-specific information was also collected that was further evaluated for the formulation of the 'Technology Map'. Similarly, key barriers were identified and measures that should be undertaken at a European level to improve energy technology innovation were proposed by the experts. The reports of the workshops and hearings are available on the EUROPA SET Plan webpage3

The Commission has also involved the Energy Advisory Group during the hearings and workshops with the experts, as well as for feeding their expert opinion with recommendations on how to best improve energy technology innovation in the context of the SET Plan.

Finally, the Commission conducted a public consultation to give every stakeholder the opportunity to provide his/her opinion and ideas on the role of technology in the European Energy Policy, via an online questionnaire which was open from 7 March to 13 May 2007.

[3] http://ec.europa.eu/energy/res/setplan/expert_consultation_en.htm

This consultation was designed as a questionnaire seeking stakeholders' opinions on the importance of technology policy, innovation instruments and action at EU or global level to help achieve sustainable energy goals. The public consultation received inputs from 604 respondents (321 from individuals and 283 from organisations). The questionnaire and summary report are published on the EUROPA SET Plan webpage1[4]. The key messages that emerged from this consultation can be summarised as follows:

- Collectively, the respondents have acknowledged the importance of energy technologies to achieve the EU policy goals of a future more sustainable energy system, featuring lower $CO_2$ emissions, increased reliance on renewable energy sources and improved energy efficiency.

- More than 95% of the respondents from all sectors consider that there is an added value in undertaking actions at the European level to promote energy technologies, and that taking the right actions to develop and introduce in the market new energy technologies now could lead to sustainable energy in the future. While 49% of the respondents believe that the European Union could reach the targets proposed in the Energy Policy for Europe with energy technologies currently available in the market, 91% stress that new (not yet fully developed) technologies could contribute to reach those targets.

- A vast majority of the respondents expressed their agreement with the statements cited in the communication "Towards a European Strategic Energy Technology Plan" regarding the role of technology and the need for action. More than 95% of the respondents agreed that technology has a vital role to play, recognised that 'business as usual' is not an option, and considered that the EU must act jointly and urgently. The need for stable and predictable framework and for developing a broad portfolio of technologies was acknowledged by as many as 93% of the respondents. Furthermore, 89% of the respondents recognised the need for transforming the European energy innovation system (from basic research to market take-up) in order to place the EU and global energy systems onto a sustainable path, to benefit from market opportunities and to achieve the ambitious targets set out in the Energy Policy for Europe.

### 2.3. The basis for EU action.

In March 2007, as part of the Energy Action Plan, the European Council invited the Commission to propose a European Strategic Energy Technology Plan in 2007 to be considered by the Council no later than March 2008.

### 2.4. Impact Assessment Board

On 5 October 2007, the Impact Assessment Board received a preliminary draft of this Impact Assessment Report. The Board adopted its Opinion on 25 October 2007. The main recommendations were:

The value added of the SET Action Plan should be further explained. The notion that the market will not deliver the necessary technologies, even when taking into account existing policies such as the Emission Treading Scheme, necessitates a thorough identification of unaddressed market and regulatory failures.

[4] http://ec.europa.eu/energy/res/setplan/public_consultation_en.htm

The comparison of the EU's R&D and innovation successes with the US and Japan should be more balanced and include the individual member states' performance, together with a more thorough explanation of the need for EU-level intervention.

The criteria for choosing the preferred option should not be biased against any one option. The rationale for the choice of criteria should be clarified and they should be aligned with the objectives. Some initial identification or at least the set of criteria for identifying benefiting technologies should be mentioned.

This revised Impact Assessment Report takes account some aspects of the Impact Assessment Board's opinion, in particular on the following points:

The problem definition has been further elaborated to explain the need for action, as well as the uncertainty associated to leaving the development of low carbon energy technologies only to the market, even with the introduction of the Emission Trading Scheme.

The available data do not permit a quantitative comparative assessment of the efficiency of the EU system against the US and Japan. In fact it is questionable to what extent we can talk about a EU RTD expenditure at all, when all these funds and actions, national and European, are decided and implemented in almost total isolation one from another. It would be more realistic to compare the US and Japanese system with that of individual Member States as suggested, but it goes beyond the scope of this impact assessment.

The objectives have been reformulated in a more structured way to improve the rational of the analysis. And, a brief outline of potential criteria for identifying benefiting technologies has been added in the section presenting the policy options.

## 3. PROBLEM DEFINITION

To meet the 2020 targets on greenhouse gas emissions, renewable energy and energy efficiency, we need to drive down the cost of existing technologies and bring about a step change in their market take-up. In the longer term, new generations of technologies have to be developed through breakthroughs in research if we are to meet the ambition of reducing our greenhouse gas emissions by 60-80% by 2050.

Hence, to achieve our policy goals technology will play a vital role. For this reason technology development is a key policy which forms an integral part of the Energy Policy for Europe adopted by the European Council on 9 March 2007.

***The problem is that today we are falling short – we are not in the pathway to meet our policy goals***

Current trends and their projections into the future are not encouraging; we are not on a pathway to meet our objectives. For decades, Europe has enjoyed inexpensive and plentiful energy supplies. The easy availability of resources, no carbon constraints and the cost imperative of market forces have not only left us dependent on fossil fuels, but have dulled the drive for innovation and investment in new energy technology.

Energy accounts for 80% of all greenhouse gas (GHG) emissions in the EU[1]; it is at the root of climate change and most air pollution. The EU is committed to addressing this - by reducing greenhouse gas emissions at a global level to a level that would limit the global temperature increase to 2°C compared to pre-industrial levels. However, current energy and transport trends would mean EU $CO_2$ emissions would increase by around 5% by 2030 and global emissions would rise by 55%. The corollary to this is that present energy policies within the EU are not sustainable.

Europe is becoming increasingly dependent on imported hydrocarbons. With "business as usual" the EU's energy import dependence will jump from 50% of total EU energy consumption today to 65% in 2030. Reliance on imports of gas is expected to increase from 57% to 84% by 2030, of oil from 82% to 93%.

The EU is becoming increasingly exposed to the effects of price volatility and price rises on international energy markets and the consequences of the progressive concentration of hydrocarbons reserves in few hands. The potential effects are significant: if, for example, the oil price rose to 100 $/barrel in 2030, the EU-27 energy total import bill would increase by around € 170 billion, an annual increase of €350 for every EU citizen[3]. Very little of this wealth transfer would result in additional jobs in the EU.

On top of this market trends, energy innovation is weak and has structural deficiencies leading to market failures.

Returns from energy efficiency improvements and switching to cheaper fuels normally pays back by themselves, but usually bring a high upfront investment which can be dissuasive. There is often an owner/tenant relationship issue that hampers market take-up – the owner won't invest if the tenant is the main beneficiary and vice-versa. The Energy Efficiency Action Plan, the Directives on Building, Eco-Labelling, CO2 from Cars, and Renewables address this question and proposes market mechanisms and incentives to overcome this upfront investment barrier.

The subject of the SET-Plan is low carbon technologies for which there is no market appetite (neither in the supply nor in the demand side) due to the commodity nature of energy. But, that are needed to reach the CO2 reduction targets in the short term and, even more, in the long term.

Investment in the development of these energy technologies in general has followed closely the same trends as oil prices over the last decades. Currently, higher oil prices are starting to have an effect on public side investment. We do not have information regarding the private side but it is most likely following the same trend.

However, what is not yet factored in, regarding the level of investment, are the new targets set by the European Council (e.g. they come a year after the adoption of FP7), the increased investment in other parts of the world, and the need to anticipate (precautionary principle) due to the long lead time to market and the irreversibility of high concentrations of CO2 in the atmosphere. The new carbon-constrained paradigm means that oil price signals no longer lead to an efficient level of investment. What worked in a market with no external constraints will not work in the future.

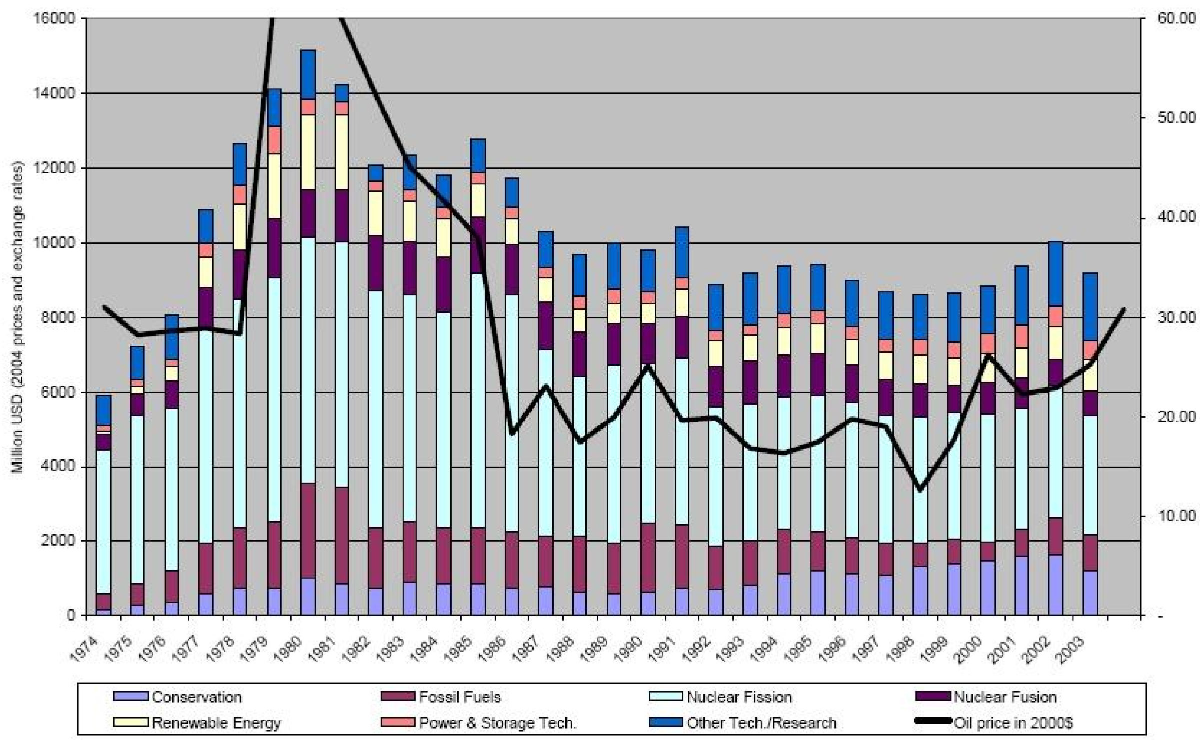
The main causes behind this problem are:

### *3.1.* Under investment

Energy research budgets (public and private) in the EU have declined substantially since peaking in the 1980s in response to earlier energy price shocks. This has led to an accumulated under-investment in energy research capacities and infrastructures. The levels of investment and innovation effort are now completely out of sync with the scale of the challenge faced.

The following chart shows RTD expenditure over the last decades in all OCDE countries:

Figure B: R&D expenditure in IEA countries and oil price 1974 - 2004




(*) OCDE report, June 2006

An analysis of the evolution in the European Union shows that the intensity of the effort has been ever-declining since the 80's. For this we only need to calculate the amount that government budget appropriations and outlays dedicated to energy R&D would be if the share dedicated to energy RTD remained the same as in the past, e.g. in 1981, 1990, 1991, 1995 and 2000.

| **2005 theoretical energy GBAORD (in Mio EUR)** | **calculations relative to total GBAORD (Mio EUR)** | **calculations relative to total GBAORD minus expenses for defense** |
|---|---|---|
| real reported data | 2139 | 2139 |
| if similar share as 1981 | 8479 | 9509 |
| if similar share as 1985 | 7440 | 8231 |
| if similar share as 1990 | 3564 | 3912 |
| if similar share as 1991 | 3198 | 3528 |
| if similar share as 1995 | 2490 | 2537 |

| | | |
|---|---|---|
| if similar share as 2000 | 2553 | 2536 |

* Calculations based on the Eurostat databases GBOARD.

The investment in energy R&D of the private sector[5] shows a somewhat similar pattern as the public energy R&D funding. The energy R&D expenditure of the business sector also concentrates in few Member States (France, Germany, Sweden and Italy account for three quarters of the EU total) with a limited contribution of the new Member States. Overall, the business sector's investment in energy R&D remains limited, not even reaching 5% of its total R&D expenditure. It is interesting to observe that a much higher R&D importance is awarded to related sectors such as the manufacturing of motor vehicles and electrical machinery. Transport-related R&D has a share of almost 25% in the total R&D expenditure by the business sector as an EU-average.

Also on a company level another trend is apparent: the R&D intensity[6] (i.e. R&D investment over net sales) in the manufacture of automobiles reaches an average value of 4.5% for the top investing 44 EU companies, compared to less than 1% for companies in the energy sectors with the exception of oil equipment and electrical components.

### 3.2. The energy technology innovation process is weak

The energy technology innovation process also has structural weaknesses. The complexity of the energy innovation process is characterised by long lead times to mass market (often decades) due to the inertia inherent in existing energy systems, locked-in infrastructure investments, dominant, often natural monopoly, actors, diverse market incentives and network connection challenges.

The market take-up of new energy technologies is additionally hampered by the nature of the technologies themselves. They are generally more expensive than the technologies they replace whilst not providing a better energy service. The benefits tend to accrue to society at large rather than the buyer and often require additional integration costs to fit into the existing energy system. In short, there is no natural market appetite for such technologies.

This is recognised as major market failure because energy is not internalising external costs that are eventually a liability to society. The establishment of the European GHG emission trading system (ETS) has put a price to carbon, and is likely to be the basis for broader emission markets that will include more sectors and countries. As a consequence of this, the incentives for adopting energy (and carbon) saving technologies are progressively permeating the choice of many companies, which are becoming increasingly active players in the energy sectors. It is expected that the ETS will become a major driver for innovation.

But, while the ETS is only European, the market for energy technologies is global. Therefore, ETS is as much a driver for innovation for European companies as for non-European companies that sell their products in Europe.

[5] This is described by the BERD – Business and enterprise sector expenditure on R&D – database.

[6] This data comes from R EU Industrial R&D Investment Scoreboard, which provides information on the top 1000 R&D investing companies inside the EU (of which 73 operate in energy and energy-related sectors with the latter including the manufacture of electronic equipment) and the top 1000 companies outside the EU.

Also outside Europe, other global agents have identified this opportunity of bringing new technologies into the market and are focusing their efforts on developing low carbon technologies. The undesired outcome of this could be a European Union carbon constrained market depending on imported technologies, despite the fact that the demand is created domestically.

It is important that the public sector paves the way for research, development and investment in new energy technologies. This implies that governments should guarantee an attractive R&D environment for both the private and public sector. In addition to promoting energy-related research ('technology push'), governments need to create favourable conditions for deploying new energy technologies ('demand/market pull'). In particular, public research initiatives (e.g. R&D funding) become necessary where the actions by the private sector are insufficient due to market failures.

Available data indicate that government support is therefore strongly needed in energy R&D as companies in the energy sector show a relatively low R&D intensity[7]. This is particularly true for electricity and gas supply companies, probably due to the fact that they produce a homogenous good (electricity) with price competition being the main competition success criterion. Moreover, the recent liberalization of the power sector may have reduced the "monopolistic rents", and therefore the company's' resources for investment in R&D. Finally, innovation in the energy sector often is not carried out at the level of the utility itself but at the level of component suppliers with a considerably higher investment in R&D (which may form part of the "electrical components" sector). The energy sector might be classified as a 'supplier-dominated sector', following the classification of Pavitt [8].

The role and support of EU Member States is therefore essential in energy research. However, both the institutional infrastructure as well as energy R&D programmes, spending and priorities vary substantially among EU Member States, making it difficult to exploit synergies. The sources of inefficiencies are described below.

### 3.3. The risk to future prosperity – fragmentation – global competition

Member States working alone will have difficulty in creating the conditions necessary to allow industry to compete in global markets. The main global players, the United States and Japan, but also now emerging economies such as China, India and Brazil, are facing the same challenges, and they are multiplying their efforts to bring about new energy technologies. Their market size, investment and research capacities far exceed those of most Member States. This is compounded by the fragmentation, non-aligned research strategies and sub-critical capacities that remain a prevailing characteristic of the EU research base.

Currently the European Union is not using the full potential for innovation of the internal market for exploring synergies between Member States in the development and deployment of new energy technologies. The variety of national regulations and technical specifications fragment the market and inhibit industry investments in risky technologies. Throughout the consultation with different stakeholders this inability to use the power of the internal market

[7] The R&D intensity is defined as the ratio of energy R&D expenditure and net sales. Underlying data are taken from the EU Industrial R&D Investment Scoreboard (see footnote 3).

[8] Pavitt, K. (1984). Sectoral patterns of technological change: towards a taxonomy and a theory. Research Policy Vol. 13, pp. 343-373.

to overcome intrinsic barriers to innovation of energy technologies was underlined as a lost opportunity to address this problem.

In addition, uncoordinated and unstable market incentives and support schemes add to the map of incoherence and, in certain circumstances, act as innovation deterrents. It is highly unlikely that Member States working in isolation will be able to develop this broad portfolio and compete for the low carbon energy markets with global competitors. These global competitors invest more, in a more coherent research and innovation system, and they have larger domestic markets.

There is heterogeneity in public energy R&D policy among EU Member States leading to fragmentation, overlapping, lack of coordination and coherence for target setting in EU energy R&D. And this with the background of strongly focussed and coordinated energy technology policies in the US through the Department of Energy (DoE) and Japan through the Ministry for Economy, Trade and Industry (METI).

Firstly, the ministries involved in setting up national energy research priorities vary strongly. Secondly, the implementation of energy R&D is rather heterogeneous, comprising dedicated energy agencies as well as technology agencies, the main national research organisations or directly the ministries themselves. Thirdly, there are large discrepancies for energy technology priorities and thus R&D spending (see Figure 2) overall and by technology across Member States

The merits of centralised and fragmented systems can be argued in favour of one or the other. However, taking into account the nature of energy research, the investments needed and the urgency to bring about change, it seems to be self evident that Member States working in isolation will be unable to finance the programmes and create the incentives necessary that would generate the necessary breakthrough new technologies and market innovation. In this case fragmentation is a key problem that requires action.

**Figure 2: Public energy R&D expenditure in selected EU Member States, Japan and USA by thematic area in 2005 (source: IEA)**

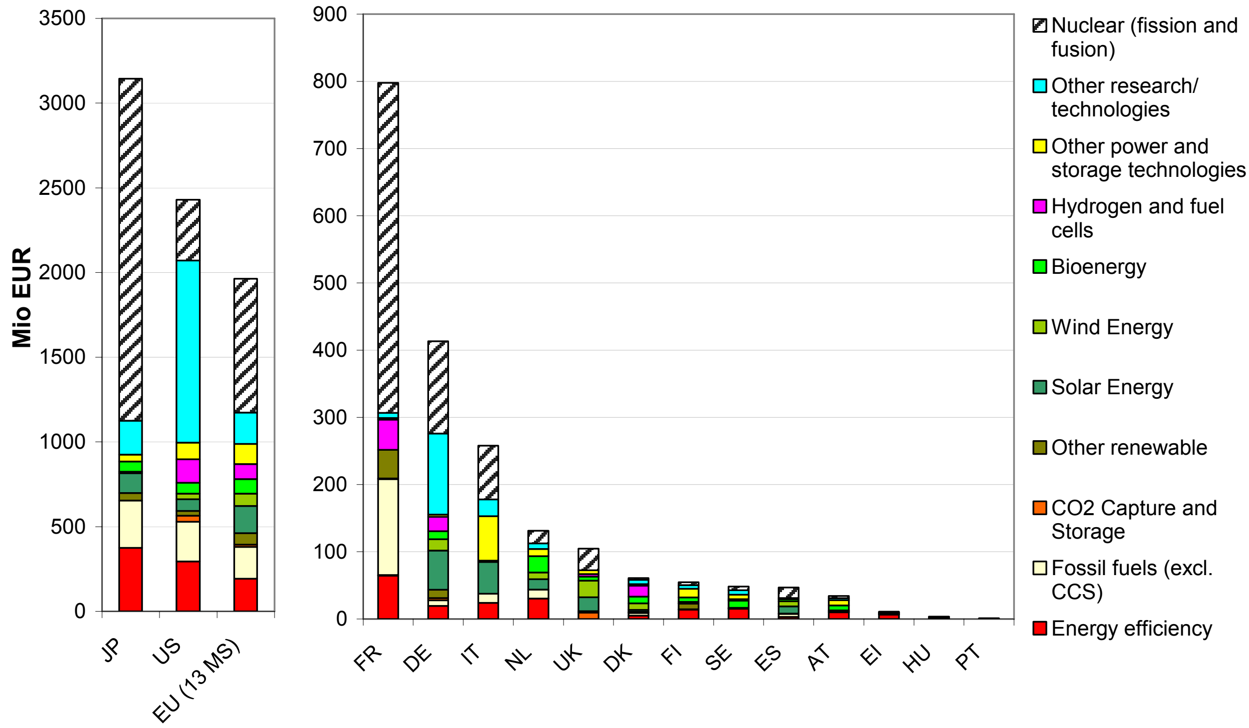



Figure 2 illustrates the different effort that the EU, the US and Japan are putting lately into the development of energy technologies. It also shows the fragmentation of the European effort, consisting on almost as many programmes as Member States.

The EU energy R&D expenditure is even falling behind Japan's in nominal terms, as Japanese funds increased over the same period. Moreover, the aggregated budget appropriations for energy R&D in the EU 27 Member States (excluding EU funding) was on average a share of 2.8% of the overall public R&D budgets by 2004, compared to 17% in Japan. This compares to a relative share of around 10% in the early 1980s, and 3.5-4% in the early 1990s (in the EU-15). These trends illustrate the low importance given to energy research in the EU, yet concealing large variances among the individual Member States.

### 3.4. Weak coordination and cooperation between the Member States and the Community Framework Programmes for Research and for Innovation

Despite the daunting technological challenges and investments needed, coordination and cooperation between National programmes and the Community programmes is weak. In nuclear fusion by working together the EU has gained global leadership in the international arena (ITER project). This is the exception.

The Community programme is executed as one more programme. Certainly, it fosters subjects with a clear European added value and with full respect of the subsidiarity principle. But, it is also clear that there are cases where the programme actions have a lot in common with National actions.

Despite sharing objectives and facing common challenges, programmes are conceived and implemented in isolation. No linking mechanism, such as common monitoring and reporting system, exist, and there are no institutional mechanisms mandated to open such a dialogue.

### 3.5. Time is of the essence

The transition to a low carbon economy will take decades and touch every sector of the economy, but we cannot afford to delay action. Decisions taken over the next 10-15 years will have profound consequences for energy security, for climate change, for growth and jobs in Europe. The cost of action will be high, but the price of inactivity much higher.

### 3.6. A broad portfolio of technologies

In a carbon constrained world, the mastery of technology, of a broad portfolio of technologies (fossil fuels, renewables and nuclear), will increasingly determine prosperity and competitiveness. If we fall behind in the rapidly intensifying global race to win low carbon technology markets, we risk becoming dependant on imported technologies to meet our targets, giving a whole new, and unwelcome, aspect to external energy dependency. The cost in terms of lost commercial opportunities, growth and jobs would be severe.

It will take decades to progressively transform the energy system, but we must start now. It is a process that requires strategic action at European level, pro-active planning and a comprehensive policy framework. To meet the challenge, we must develop a world-class portfolio of affordable, competitive, clean, efficient and low-carbon technologies and create stable and predictable conditions for industry, particularly SMEs, to ensure their widespread deployment in all sectors of the economy.

The broad technology portfolio approach spreads risk and avoids locking-in to technologies that may not provide the best solution in the long run. The portfolio includes existing technologies that can be deployed immediately, technologies where incremental improvements are needed, technologies where breakthroughs are required, transition technologies and technologies which necessitate major changes to existing infrastructures and supply chains. All of these technologies face different challenges and barriers and are likely to be brought to commercialisation within different time horizons.

However, among the many technology choices we need to be selective to choose the right support instruments and to decide on the adequate level of action.

Understanding the evolving characteristics, economics and performances, and barriers for market penetration of such a broad portfolio is a problem that needs to be addressed in developing an energy technology policy. The information is dispersed and multifaceted. In many occasions it is either inaccurate or the source has a vested interest.

In particular, we need to investigate the potential of the different technology avenues, to analyse what can be expected from each. On this basis we can then calculate the expected impacts regarding our policy goals (greenhouse gas emission, security of supply and competitiveness) derived from realising this potential.

### 3.7. Data and information availability

Systematic and consistent reporting of information on R&D spending, programmes and priorities is a pre-requisite for a better coordination of energy R&D programmes among EU Member States. Currently available information does not allow for a comprehensive

and consistent overview of the R&D infrastructure and expenditures in public and private energy R&D.

Overall, research efforts need to be better synchronized in order to provide the technologies that will allow the energy sector to meet its long term challenges. This requires as first step transparent information on energy and transport R&D efforts among Member States, comprising both quantitative information and information on policies, programmes and responsibilities.

The Capacities Map report reveals that information on energy- related R&D is fragmented. This applies both to data on public as well as on private spending, with the latter usually being sketchier. Furthermore, available data sources are not easily comparable due to differences in methodology, coverage etc. In some cases, such as for the trends in energy-related public funding, even contradictory trends emerge between various data sets. Data availability for public energy-related research is much less comprehensive than data on transport-related research.

Compared to quantitative data, information on the institutional structure, programmes and policies is even sketchier. Except for a number of studies that are not regularly updated, there is little regular and structured information available on the institutional energy R&D infrastructure. ERAWATCH[9] is an important data source for providing such structured information on research policies, but energy and transport R&D policies and programmes as such are currently not explicitly addressed.

On the EU level, the exchange of information between the Member States and among different national actors could be facilitated by providing a database containing a standardized set of information regarding energy R&D funding, programmes, priorities, responsibilities and structures. Yet, the success of such a measure depends on the completeness of the respective database, which may argue in favour of either a compulsory reporting by Member States or an expert-based scheme with secure multi-annual funding.

With respect to quantitative data on energy and transport-related R&D funding and expenditure, the Eurostat GBAORD, GERD and BERD databases may be a good starting point but currently contain too little information on the sector level or on different technologies. As they rely on reporting to Eurostat we fail to capture more comprehensively the funding trends in energy- and transport-related sectors. The IEA R&D statistics are also recognised as a reliable database on energy R&D expenditure, yet following a different sectoral breakdown. Furthermore, not all EU Member States are members of the IEA.

## 4. OBJECTIVES

The Energy Policy for Europe agreed by the European Council on 8/9 March 2007, sets out a number of strategic energy policy objectives for 2020: (i) reduction in greenhouse gas emissions by 20% compared to 1990 levels (30% if in the context of a global agreement); (ii) reducing global primary energy use by 20% (through energy efficiency); (iii) increasing the level of renewable energy in the EU's overall mix to 20%; (iv) minimum target for biofuels of 10% of vehicle fuel. In addition, it is indicated that by 2050 global greenhouse gas emissions

[9] ERAWATCH is a European web-based service that presents information on national and regional research policies, actors, organisations and programmes. It is funded through the European Community's Research Framework Programme and jointly run by the European Commission's Directorates-General for Research and the Joint Research Centre - Institute for Prospective Technological Studies (IPTS). The online service is provided through CORDIS (http://cordis.europa.eu/erawatch/)

must be reduced by 50% compared to 1990 levels, implying reductions in industrialised countries of 60 to 80%.

Technology has a vital role to play in achieving these strategic objectives. But, European energy and innovation system is falling short; it is not delivering on time the required low carbon technologies. This is a multifaceted problem that requires public intervention, as described in the previous section.

**The strategic objective pursued is to accelerate the development and market take up of low carbon energy technologies.**

Meeting the targets in 2020 and the vision for 2050 is a significant challenge that can only be faced as a collective endeavour. Member States, the Community, industry and the research community all have different roles to play, but they must be harnessed in an effective way to optimise the overall effort.

We need to create a long-term EU framework for energy technology development (an EU energy technology policy) to address all the facets of the problem we are facing. Such a framework would be characterised by:

- National and Community actions decided and implemented in a more coordinated manner to strengthen their coherence and overall impact;

- The underinvestment accumulated over the last decades, both public and private, is radically reversed; human resources are progressively developed to cope with the research work as well as with a transformational market reality;

- The potential of the Internal Market and the European Research Area is fully exploited, to enable European industry to embark on ambitious programmes and investments, overcome the innovation weakness of the sector and gain leadership in global markets;

- The most promising technologies, within the broad portfolio approach, are supported by joining efforts in effective and targeted programmes;the most appropriate instruments, whether 'technology push' or 'market pull', are used to accelerate their development and market introduction;

- Information and data being collected through structured and analytical process, and made available to all stakeholders.

We should therefore pursue the following **operation objectives**:

- The transformation of the **governance** of the energy research and innovation system through the engagement and the commitment of all stakeholders in a coherent programme that addresses the European energy priorities on the short, medium and longer terms and encompasses all the elements of the future energy system (technologies, infrastructures, human capacities, etc.)

- A strategic **planning** that orients the research and innovation efforts towards technologies and measures with the greatest potential, to deliver the European energy policy targets.

- A more **effective implementation**, execution and management of all activities across the whole innovation process including an active and dynamic monitoring of the activities which will allow adjustments and reorientations of efforts when required
- A cost-effective and results-oriented allocation and increase of means (private and the public **investment**, human resources, research infrastructures), combining efforts of interested industrial parties, national and regional parties in a coherent framework to maximise synergies and cross-fertilisation and act as a catalyst for increasing Europe's innovation capacity, dealing with the complex challenge of facilitating and streamlining resources allocation from multiple origins at the service of a coherent pan-European endeavour.

## 5. POLICY OPTIONS

Following the analysis of the problems, the finding in the 'Technology Map' and the 'Capacities Map', the results of the consultation with experts from different sectors, the consultation with the Energy Advisory Group and the public consultation, the policy options considered in this impact assessment concern the following dimensions:

- Technology - To achieve our 2020 and 2050 energy policy ambitions, which mix of technologies should Europe pursue, taking into account the inherent uncertainties of the development process? How can Europe make best use of its knowledge base and reinforce it? What measures can be taken to link the knowledge base and the market?
- Resources - An accelerated development process depends on addition resources, both financial and human, but, what are the options to reinforce the resources dedicated to energy technology development and market introduction?
- Management - How can available resources be used in more effective manner – new instruments, new management practices? What would be the right balance between cooperation and competition of National resources to overcome the current fragmentation?
- Governance – How would Europe organise and steer this collective endeavour? Which institutional structures would optimise the collective effort most effectively?

The combination of different options for the above four policy dimensions would in theory lead to many different policy options. However, not all of them are equally relevant or likely. In addition, analysing all the potential impacts of each option within each policy dimension and composing global impacts would not be representative because of the many other variables involved (e.g. market prices, geo-political developments, actual evolution of climate change, etc…).

The number of possible policy options exceeds by far what can be analysed within an Impact Assessment because the system involved is complex and multifaceted, despite simplicity in the formulation of the problem ([we are not achieving our energy policy targets) and the establishment of the objective (we need to accelerate the development and market take up of low carbon energy technologies). To make the Impact Assessment feasible and meaningful a simplified approach has been followed.

Based on the detailed work done in the preparation of the 'Technology Map' and the 'Capacities Map', and on the broad and thorough consultation, preliminary conclusions/proposals are drawn to address the options regarding technologies, resources and management. These preliminary conclusions/proposals will be subject to dedicated Impact Assessments at a later stage, if eventually a proposal is made by the Commission that may have regulatory or budgetary consequences.

Although the thematic priorities have been identified in the Communication, a detailed research and implementation plan for each proposed European Industrial Initiative will be required. This however, should be elaborated with the industry and the academic/research community after the endorsement of the SET-Plan by the Council. It is likely, that the path followed by the fuel cells and hydrogen European Technology Platform, working its way towards the proposed Joint Technology Initiative Regulation (i.e. the formulation of a detailed implementation plan within a technology forum), may serve as a guideline for other initiatives.

In assessing the need for European Initiatives, the most fundamental criteria to apply would be:

– the EU added value/additionality;

– the willingness of actors to join forces (MSs and/or industry);

– the potential market penetration of the technology in different time horizons;

– the potential contribution to CO2 reduction, security of energy supply, and competitiveness.

This Impact Assessment therefore focuses on the analysis of different options relating to the organisation of the underlying research and innovation system in the EU. The policy options considered are:

**Policy Option 1 (PO1): Loose coordination - Continuity**

One possibility is to continue with the current energy technology innovation process, which, although aiming at a common goal, the sustainability of the European energy system, is mainly based on individual programmes, with their own priority setting mechanisms, governance and funding, implemented at different levels: EU, national, regional, corporate, etc. Furthermore, these programmes differ in scope and scale of allocated resources, as reflected on the intensity of efforts dedicated to specific technologies. This approach has been effective in supporting the European energy system so far, while several Member States are already pursuing ambitious strategies on next generation energy technologies indicating the importance to invest now in this field. However it is recognised that overall, the current innovation pace will not enable Europe to address its future short and long term needs and imperatives for sustainability. To improve the level of coordination between programmes to create the optimal critical mass and raise the necessary additional funding to address the challenges facing the energy sector, some efforts are currently undertaken through trans-national agreements (ERA, bilateral agreements), the establishment of memoranda of understanding (e.g. COST, EUREKA, EU framework programmes), etc. Nevertheless, the intensity and nature of coordination that has been achieved so far is loose, yet to fully contribute to the Lisbon strategy. Overall, the achieved coordination has not been able to translate words into action.

**Policy Option 2 (PO2): Strategic coordination**

Another possibility is to establish a new innovation structure and process at the EU level, embedded in a single, coherent and flexible strategic coordination framework, coupled with a shared vision and a dynamic strategy on energy technologies and making the most of and expanding the current European energy technology innovation base. Ultimately, the new process pursues a more effective use of resources – from ideas to markets, while revitalising, increasing and more effectively utilising, public and private investment. More specifically, a **Committee for the Coordination of Energy Research and Innovation**, populated by Member State representatives with authority on budget and chaired by the European Commission, which reports directly to the European Council, is established(e.g. under an appropriate legal basis or under the Open method of Coordination). Ad-hoc advisory or consultative groups are set-up as required to serve the governance. The **Coordination Committee** defines and supervises a multi-annual strategy for enhancing innovation on energy technologies, in line with the energy-related short, medium and long term policy objectives. It also steers a results-oriented Action Plan which is revised on a regular basis. Open-access information and knowledge management systems, including technology watch and capacities mapping are created in support of the **Coordination Committee** on strategy and implementation. The Action Plan is implemented through a number of European Actions, which include several European Initiatives; is executed by 'sharing-in-doing', i.e. the engagement and commitment of resources at the Action level; and is monitored periodically through a common assessment framework. In this context, variable geometry initiatives are developed on a volunteering basis, originating from coalitions of Member States, industry, the European Commission, the Research Community, etc. The means for undertaking each Action (financial, human resources, infrastructure) are provided by each party that contributes to it, under specific instruments for joint execution, such as Art. 169, Art. 171, bi- or multi-lateral agreements, etc. Finally, an annual EU Energy Technology Conference brings together all stakeholders in the entire innovation system.

**Policy Option 3 (PO3): A centralised structure for energy innovation**

Another possibility is to set up an structure with the remit of devising and implementing a strategy on energy innovation at the EU level in line with the EU policy objectives. This structure is established through a regulation with its own governing board. The Governing Board sets, endorses and reviews a multi-annual strategy and a detailed work plan that is managed and monitored by its own management structure. Funding is provided to the institution by the Member States, the European Commission and the industry either on a case by case basis or through fixed grants, and is allocated by the Governing Board through its work plan. The actions to be funded are selected through calls for proposals, open to all European stakeholders. In essence, the main differences with the previous policy option (PO2)are: (i) the creation of a European dedicated structure having as a mandate to define a multi-annual innovation strategy and to manage at the European level Community and Member States efforts; doing so however requires funding from national and Community levels; (ii) the decision-making framework is based on a top-down approach, and, (iii) R&D&D funding is channelled through the organisation on a competitive basis.

**Policy Option 4 (PO4): A market-driven approach**

The market-driven approach relies on distinctive roles of public forces and private entities. The public authorities set binding targets on carbon emissions and put in place the required enabling market instruments creating a fertile ground for the uptake of technologies. In turn, the leadership of technology development is borne solely by the market forces. In practice, a set of binding targets for CO2 emissions are enacted at the EU level, accompanied with a strong carbon pricing mechanism (possibly via ETS).The main differences with the three previous options are (i) the lack of coordination and planning on technology innovation at the EU level, and, (ii) there are not a priori established joint operational efforts between public and private sectors to enhance innovation, but may be formed on demand.

The key attributes of the Policy Options discussed above can be summarised as follows:

| | |
|---|---|
| • PO1 | • A variety of disconnected programmes addressing research and development, as well as deployment, at the international, European, national, regional, etc. levels.<br>• Programme management based on different governance models, but the management of projects prevails at the EU level<br>• Funding available but not sufficient<br>• Proven programme implementation mechanisms – success stories<br>• Loose level of coordination through intergovernmental schemes or Community instruments, such as ERA-Net, yet to fully contribute to the Lisbon strategy. |
| • PO2 | • Open innovation model based on a single framework for innovation linked to the EU policy agenda<br>• Shared European multi-annual strategy and action plan for energy technology innovation<br>• Reliance on and optimisation of existing programmes<br>• Governance structure that proposes for the alignment of efforts on energy technology innovation across the EU<br>• Open-access information and knowledge management systems that provide guidance for and supports strategy and implementation<br>• Facilitation of partnerships of variable geometry strengthened by an implementation at action level – revitalisation of public and private investment<br>• Framework for systematic use of existing joint undertaking and programming instruments<br>• Common monitoring mechanism and a dedicated strategic support |
| • PO3 | • Dedicated European structure on energy technology innovation - Mandated to transpose policy objectives into a single EU innovation programme<br>• Central governing board for strategic planning and steering<br>• Common implementation and monitoring framework<br>• Institutionalised budget |
| • PO4 | • Establishment of an enabling regulatory framework with binding targets on $CO_2$ reduction at the EU level and of market-pull instruments |

| | |
|---|---|
| | • Market-driven approach for innovation without direct public engagement and support<br>• No institutionalised framework for coordination of European activities<br>• Action management by the industry<br>• Resources through private investment |

## 6. ANALYSIS OF IMPACTS

### Introduction

The approach followed for assessing the impacts of the considered policy options focuses only on the innovation process that needs to be developed to deliver both the technology and the capacities (R&D infrastructure, human capital, etc.) to ensure that the policy goals and targets are met within the specified timeline, and does not assess the individual European Actions that could be undertaken. As mentioned in section 4, implementing each action will be embodied through dedicated programmes and projects, which will further entail consultation and commitment among all interested parties. When implying legislative or budgetary intervention of the Community, if appropriate, the technology programmes and/or projects will be subject to detailed impact assessments as already performed for example, for the Fuel Cell and Hydrogen Joint Technology Initiative proposal to be adopted by the Commission in October 2007.

It is assumed that the restructuring of the European energy technology innovation base will directly impact on:

- **Energy research and knowledge management**, in view of a better coordination of research activities, enhanced mobilisation of stakeholders for the creation of optimal critical mass, focused prioritisation aligned to policy goals, results-oriented and cost effective implementation of programmes, fostering of partnerships, available and accessible research infrastructure, etc.
- **Competitiveness and other economic issues**, such as ensuring the availability and adequacy of investment flows for innovation, the further development of human capital and industrial capacity, promoting international trade of technologies, etc.

For the purpose of this assessment, these impacts have been grouped into three main indicators, namely, ‘leadership’, ‘implementation’ and ‘resources’, which are used to identify and subsequently measure the strength and weakness of each policy option. The grouping of impacts per indicator presented in the Table below:

| Leadership | Implementation | Resources (financial, human, research infrastructure) |
|---|---|---|
| • Establishment of decision-making partnerships for the development of optimal critical mass<br>• Coordination of efforts<br>• Prioritisation and capacities building | • Results-oriented<br>• Flexibility<br>• Cost-effectiveness<br>• Partnership | • Revitalisation of investment<br>• Enabling the development of human resources<br>• Ensuring development of world leader research |

| | | |
|---|---|---|
| | facilitation | infrastructure |

Environmental and social impacts, expected to derive from the implementation of the proposed policy options, do not differ between options, and in any case they are not expected to be significant. There they are not part of the analysis.

## 6.1. Policy Option 1: Loose coordination - Continuity

### *6.1.1. Leadership*

*Main Strengths*

- Mobilisation and commitment of stakeholders into results-oriented projects through well established instruments.
- Several Member States are already pursuing ambitious strategies on next generation and new energy technologies.
- Capitalisation on regional strengths and resources via a diversity of programs with different scales of implementation.

*Main Weaknesses*

- There is a lack of consideration of the systemic nature of innovation in European programmes.
- Duplication of efforts and sub-optimal use of research capital due to the absence of a common European strategy on innovation for energy technologies or a holistic structural mechanism for the alignment of priorities of individual programmes across the EU, despite the ongoing efforts with ERA-Net schemes to enhance cooperation.
- Insufficient recognition of and support for the development of critical mass at the right scale on key technologies and future options on which Europe should invest to meet its own challenges and compete on the global scene.
- Limited consideration of dissemination of results across the EU, with concomitant effects on technology roll-out and hence partial exploitation of the benefits offered by the European internal market.

### *6.1.2. Implementation*

*Main Strengths*

- Many success stories both at the European and national level that have significantly contributed to strengthening the European industry and the research base resulting from good management and implementation practices.

*Main weaknesses*

- Limitations for the establishment of optimal critical mass, the launch of capital- and research-intensive programmes and the exchange of information, due to diverse administrative rules and procedures.
- Ineffective knowledge sharing as a result of non harmonised IPR issues.

*6.1.3. Resources*

*Main Strengths*

- Funding is already available, although Europe is under-spending on energy technology innovation compared to its main competitors.
- Some resources available for training schemes on cutting-edge technologies.

*Main weaknesses*

- Difficulty in raising funds for new very large European projects, as funding programmes have limited amounts of additional resources and usually apply cumbersome instruments that are not attractive to business.
- Insufficient investment for trans- and inter-disciplinary research and education at the European scale.

## 6.2. Policy Option 2: Strategic coordination – Coordination Committee

*6.2.1. Leadership*

*Main Strengths*

- It is a first-of-a-kind initiative putting innovation on energy technologies at the heart of the European energy policy agenda.
- The Coordination Committee can take decisions for a coherent, integrated and flexible multi-annual strategy for technology development and capacity building, as well as a detailed Action Plan to be followed by European, national, regional programmes.
- Engagement and commitment of all European stakeholders in a single framework.
- The coherency, stability and empowerment of the governance are ascertained through the Coordination Committee.
- The ability to form the optimal critical mass is facilitated through focused, flexible and visible prioritisation of programmes.
- All stakeholders can have a key role since projects are decided and committed at Action level. An annual Energy Technology Forum ensures a strong mobilisation of industry and research community and fosters experience sharing among all stakeholders across the energy innovation system.
- Capitalisation on and optimisation of existing programmes.
- A continuous effort on basic research, socio-economic tools and international cooperation in support of the main priorities in the short term and for opening up new opportunities in the long term is a core element of this option.
- Having a common European framework for innovation promotes projects with a European dimension, and offers a single voice to global cooperation initiatives, advertising European excellence to the international scene which can foster further cooperation on a global scale.
- This open method of cooperation can act as a new European model for improving innovation in sectors beyond energy.

*Main Weaknesses*

- Compromises may have to be made for the agreement of areas of common interest and action and resources.

### 6.2.2. *Implementation*

*Main Strengths*

- The 'sharing-in-doing' implementation approach proposed, which is an engagement and commitment of resources at the Action level, strengthens a results-oriented management as it allows for the quick adjustment of resources and priorities to the evolving needs without having to amend a budget allocation as would had been necessary with a multi-annual programme that couples priorities and budget appropriations.
- This option provides and facilitates the systematic use of a set of specific instruments to carry out integrated actions as well as Actions on energy innovation as a whole.
- It facilitates the formation of partnerships for priorities that concern mainly a coalition of stakeholders in Member States.
- A common monitoring mechanism covering the whole energy technology innovation process (i) enables the benchmarking of the progress of the actions of a portfolio of technologies, (ii) stimulates feedback between basic research, R&D, demonstration and business support within an Action, and, (iii) promotes synergies between technology options.
- Implementation at the Action level is supported by a coherent, stable and empowered leadership, with the possibility of legally binding decisions.
- The alignment of existing efforts is stimulated and guided by the presence of governance structure.
- The continuous flow of strategic analysis of the output of the initiatives to the coordination committee is ensured by the establishment of open-access information and knowledge management systems.

*Main Weaknesses*

- Possible discrepancies between the overall strategy and the long term commitment of the stakeholders to carry out the action plan may emerge since funding is decided and committed at the action level.
- There are may be difficulties to agree on the timely contribution of existing programmes to new joint Actions at the European level.

### 6.2.3. *Resources*

*Main Strengths*

- Additional private investment and industrial involvement across the overall portfolio of energy technologies is triggered by the facilitation of a systematic use of specific instruments such as Joint Technology Initiatives.
- Financial resources are expected to be more effectively used since funding is decided and allocated at the Action level.
- Allocation of resources from multiple –Community, National, Industrial etc. - origins is facilitated by a coherent European Framework and Action Plan.
- The availability of resources for training and building research infrastructure is increased in a systemic approach to innovation.

*Main Weaknesses*

- The long term availability of funding needed to carry out a multi annual strategy is not guaranteed by the commitment of funding at the Action level.

- Difficulties can emerge for the long term viability of individual actions since the contribution of the different supporting programmes is on a volunteer basis, although the empowerment of the governance can reduce this risk.
- A non-unified source of funding can result in conflict of interest between funding parties at the expense of a common EU dimension.
- Possible lack of funding for actions with long lead times due to the reluctance of industry to contribute.

- Additional cost for the Commission and Member States to manage and participate respectively in the coordination committee. These additional cost might be off set if this new committee would replace two existing committees (research framework programme and competitive and innovation).

## 6.3. Policy Option 3: Centralised structure

### *6.3.1. Leadership*

*Main Strengths*

- Direct transposition of policy objectives into a visible strategy and action plan through a dedicated European structure ensures the coherence between policy objectives, technology and capacities development.
- The engagement and commitment of all stakeholders is embedded into the governing board of the organisation, which accelerates the decision making process. This is especially important for undertaking large scale actions at the European level.
- Duplication of effort is reduced by a central leadership, planning and monitoring.
- The achievement of priorities of a common European interest is better ensured by the structure which can act for the build-up of critical mass on key technologies and catalyse the alignment of existing efforts.
- The recognised systemic approach, as a working principle of the organisation, guarantees the continuous effort on basic research, socio-economic tools and models and international cooperation in support of the main priorities in the short term and for opening up new opportunities in the long term.
- The continuation of efforts both in terms of technology development, human capital and large scale research infrastructure over a long term horizon is ensured by the organisation.
- A large scale entity fosters cooperation with major European and international stakeholders, strengthening the European industry and the research base.
- The organisation can act as a new model for improving innovation in sectors beyond energy in Europe.

*Main Weaknesses*

- Subsidiarity concerns may limit the scope of action of the organisation, as research and innovation is a shared competency between the Member States and the European Union.
- Fast adjustments to new priorities of the multi-annual strategy and Action plan resulting from the analysis of ongoing actions, market and science developments may be inhibited by rigidity over time, associated with any established monolithic structure.
- There is a possible risk of non considering fully the priorities of small and medium-sized partners unless interest groups are formed to represent them in the governing board.

*6.3.2. Implementation*

*Main Strengths*

- The organisation develops its own operational procedures, hence offering a common framework for implementation of the actions.
- The implementation of priorities across Europe is secured by the allocation of budget to the organisation over a certain period, both for operational purposes and for funding of the individual actions.
- The visibility of the European efforts to the international scene is raised by the presence of a single European organisation, hence attracting best scientists and stimulating international cooperation and investment in Europe.
- Feedback from the projects that could lead the re-alignment of the efforts are facilitated by the presence of an integrated framework for implementation and monitoring.

*Main Weaknesses*

- The option implies the establishment of an additional structure that carries additional administrative costs (mainly facilities and staff). This cost would be higher than for PO2, for which only a new committee is foreseen.
- Unless the interfacing and integration with existing programmes is established via the statute of the newly formed organisation, there is a risk of the latter becoming an additional organisational layer with no clear impact on the optimisation of the current innovation process.
- Like in most established organisations, there are increasing risks over time of: (i) bureaucratisation, (ii) operational inflexibility, and, (iii) locked-in infrastructure, which may hinder the capacity of the organisation to adjust its priorities as required.

*6.3.3. Resources*

*Main Strengths*

- A minimum level of stability to support a balanced portfolio of short term and long term technologies is guaranteed by an institutionalised budget.
- The financial resources required for large scale projects may be easier to raise with a dedicated central organisation.

The availability of resources for training and building research infrastructure is *increased in an organisation that promotes a systemic approach to innovation.*

*Main Weaknesses*

- The funds necessary for the organisation to execute its work plan may be limited due to competition for resources with existing programmes, if the establishment of the organisation is not accompanied by a restructuring of the innovation process.

## 6.4. Policy option 4: Market-driven

*6.4.1. Leadership*

*Main Strengths*

- Driven by optimisation of resources and customer needs, this approach ensures the rapid engagement and the commitment of stakeholders.
- Private investment is attracted and secured by the stable market environment provided by the setting of targets and the establishment of enabling regulatory frameworks by the policy makers.
- The priorities are adjustable based on the foresight of the market players.
- The market-driven approach conveys and ensures realistic, results-oriented, cost-effective short term priorities.

*Main Weaknesses*

- There is no overall structured coordination among the European stakeholders.
- A market-driven approach based on carbon constraints does not necessarily ensure innovation in capacity building in Europe or the achievement of other competing policy goals.
- A market driven approach can impose a short term technology planning at the detriment of a long term strategy, locking in sub-optimal technology options.
- Equally, it can be expected that effort focuses on a limited number of options associated with the least market risk (crowd-in effect). Consequently, the necessary efforts required overtime for building additional large scale infrastructure to open up new technology pathways is under-prioritised.
- The market does not fully consider social and environmental issues that do not have a market value.
- Long term solutions entailing large risk and upfront capital investment are likely not to materialise without long term binding targets and risk-sharing schemes.
- Small and medium-sized players with shortage of equity and research capacities will find difficult to participate, resulting in a situation dominated by the major industrial players and depriving Europe of the innovative potential of SMEs.
- Competitive issues may inhibit cooperation between stakeholders as well as the formation of the optimal critical mass.

### *6.4.2. Implementation*

*Main Strengths*

- A quick response time to mobilise capacities and capital, hence shortening the time between product conception and market roll-out.
- Adjustable results-oriented priorities to market needs.
- Well established project implementation procedures based on industrial know-how and expertise.

*Main Weaknesses*

- The means to achieve the policy targets could be realised either using non-European technology or technology developed by European companies outside Europe.
- The importance of the academia and research institutes as the main provider of basic research and human capital is undermined at the expense of applied R&D and technology validation.

### *6.4.3. Resources*

*Main Strengths*

- The allocation of resources is decided and made at the project level ensuring its effective utilisation.
- The market-driven approach ensures the raising of the necessary private investment with less pressure on public resources that can be re-oriented to other priorities.

*Main Weaknesses*

- The investment in human capital and basic research as carried out by European universities will fall under a technology roll-out objective with, however, mismatching time lines.

The key strengths and weaknesses of the four policy options are summarised below:

**STRENGTHS**

| | Leadership | Implementation | Resources |
|---|---|---|---|
| • PO1 | • Mechanisms already in place for the coordination of efforts and mobilisation of stakeholders<br>• Capitalises on existing resources and means | • Proven results-oriented management of individual programmes – success stories | • Funding available but not sufficient<br>• Some training schemes available |
| • PO2 | • Enhanced coordination and strategic alignment of efforts to EU policy goals through a single framework.<br>• Focused and visible prioritisation on policy objectives via a multi-annual strategy and action plan shared across the EU<br>• Coherent, stable and empowered governance<br>• Strong mobilisation and engagement of the industry and research community<br>• Capitalises on optimal use of existing resources and means | • Systemic and open approach to innovation<br>• Strengthened results-oriented management at action level<br>• Dedicated service for strategy and implementation support<br>• Flexibility for adjusting resources and priorities, supported by an integrated monitoring mechanism<br>• Systematic use of existing joint undertaking and programming instruments<br>• Focus on partnerships of variable geometry | • Stimulation of additional private investment and industrial involvement<br>• Results-oriented and focused funding that maximises return on investment<br>• Integrated approach for training and building-up R&D,D infrastructure<br>• Reduction of administrative costs if the proposed governance structure replaces two existing |

| | | | |
|---|---|---|---|
| | | | committees |
| • PO3 | • Direct transposition of policy objectives into a visible strategy and action plan through a dedicated European structure<br>• Accelerated decision-making process<br>• Encouragement for the alignment of capacities across the EU and streamlining of efforts<br>• Ensured continuation of initiatives in the longer term<br>• Facilitation of large scale actions | • Efficient implementation and monitoring based on a single framework<br>• Secured multi-annual implementation through budget appropriations<br>• Promotion of international partnerships dues to the high visibility of European efforts | • Ensured institutionalised budget coupled with additional private investment<br>• Results-oriented and focused funding that maximises return on investment<br>• Integrated approach for training and build-up of R&D,D infrastructure |
| • PO4 | • Enhanced mobilisation and engagement of private stakeholders through a stable market environment<br>• Realistic, results-oriented cost-effective short term priorities | • Quick response time to mobilise capacities and capital.<br>• Adjustable results-oriented priorities to market needs | • Market driven utilisation of resources<br>• Less pressure on public resources |

**WEAKNESSES**

| • | • Leadership | • Implementation | • Resources |
|---|---|---|---|
| • PO1 | • No common European strategy on innovation and for joining efforts at the required scale<br>• Insufficient recognition of and support for the development of critical mass on key technologies and future options<br>• Limited consideration for dissemination and | • Limitations for establishing critical mass due to the diversity of existing programmes | • Difficulty in raising funds for very large actions<br>• Insufficient funding on trans- and inter-disciplinary research and education. |

| | | | |
|---|---|---|---|
| | exploitation of results across the EU. | | |
| • PO2 | • Difficulties in reconciling stakeholder interests | • Possible diversions in expected results due to discrepancies between strategy and stakeholder commitment at action level.<br><br>• Difficulties in re-orienting means of existing programmes | • No framework provision of funding for the long term<br><br>• Possible disagreement on funding allocation due to conflicts of interest<br><br>• Possible lack of funding for actions with long lead times due to reluctance of industry to contribute<br><br>• Additional management cost for the governance structure (MS group) if the proposed governance structure do not replace two existing committees |
| • PO3 | • Risk that strategy setting becomes rigid over time<br><br>• Possibility of non considering priorities for small and medium-sized stakeholders<br><br>• Possible subsidiarity concerns | • Additional administrative expenditure<br><br>• Risk of forming an additional organisational layer with no impact on restructuring the innovation system<br><br>• Risks of bureaucratisation and operational inflexibility | • Competition for resources with existing programmes may limit funding |
| • PO4 | • There is no overall structured coordination among the European stakeholders<br><br>• The implicit market-driven strategy | • European efforts may be directed outside Europe due to the lack of public support.<br><br>• Undermined role for the academia and | • Lack of long term paradigm shifting ideas from basic research<br><br>• |

| | | | |
|---|---|---|---|
| | emphasises on short term priorities and does not ensure the building of new European capacities<br><br>• Poses a risk of not achieving policy goals other than carbon mitigation<br><br>• Can lead to a technology crowd-in effect<br><br>• May not favour high risk and capital intensive projects and the emergence of small and medium stakeholders | research institutes<br>• | |

## 7. COMPARING THE OPTIONS

The strengths and weaknesses of each indicator for every policy option considered, as discussed in the previous section, are herein evaluated based on a common methodology. The aim is to identify the optimal policy option(s) that could help overcoming best the issues identified in Section 2.

### 7.1. Methodology

The evaluation of policy options relies on a qualitative grading of each indicator, on a scale from (-) to (++), based on a comparison to a baseline, which by definition is set to (0). More specifically:The **baseline** refers to the energy technology innovation process as it stands today, described in the *status-quo* policy option. This entails:

– *Governance*: There are individual programmes with their own well established leadership, however, the collective dimension necessary for the mobilisation of stakeholders, coordination of efforts and the focused build-up of capacities, required to meet Europe's future needs, is not yet in place, which makes the current innovation pace unsatisfactory.

– *Implementation*: Individual programmes have mostly established results-oriented, relatively flexible and cost effective implementation mechanisms, nevertheless there is still duplication and fragmentation of efforts due to unexplored synergies as well as unbalanced allocation of resources on specific energy technologies.

– *Resources*: Funding is available, although Europe is spending less than its main competitors. Furthermore, these resources are distributed to individual programmes and in many cases are not sufficient for the necessary investment required for developing and deploying new technologies.

(1) A (++) grade is granted when the indicator for a given policy option provides a significant improvement to the energy technology innovation process.
(2) A (+) grade is granted when the indicator for a given policy option provides satisfactory improvement compared to the baseline, in particular considering a moderate impact on the restructuring of the energy technology innovation process.
(3) A (0) grade is also granted when no decisive impact is made.
(4) A (-) grade indicates a possible deterioration of the effectiveness of the innovation process.

## 7.2. Grading

Leadership

**Policy Option 1** is granted (0) by definition, being the baseline.

The level of leadership achieved by **Policy Option 2** is reinforced both by the establishment of a single framework for innovation and a coordination committee, with the possibility to take decisions. Although some difficulties remain in terms of fully committing to new Actions, it is considered that this model of governance is suited for kick-starting a restructuring of the energy technology innovation process at the European scale, while maintaining existing capacities. As a consequence a grade of (++) is granted.

**Policy Option 3** is an alternative governance model which is widely used at various levels and has proven success records when the building of a critical mass is required. This model addresses the needs for accelerating the pace of innovation, although may not be the optimal instrument for embracing the development of a wide technology portfolio since this governance model cannot fully consider the needs of all actors needed to advance the European energy technology innovation. However, ensuring the effectiveness of this model requires some transfer of competencies from the Member States, raising some subsidiarity concerns. As a consequence, a grade of (+) is given.

**Policy option 4** does not have an institutionalised leadership to balance the short term vision of the market to the longer term sustainable goals of Europe. Hence, a grade of (-) is given.

Implementation

**Policy Option 1** is granted (0) by definition, being the baseline.

A key strength of **Policy Option** 2 is the provision of a single framework for the implementation of Actions, reinforced by a governance, on a broad portfolio of energy technologies that facilitates the systematic use of instruments for joint programming and execution, hence, the engagement and commitment of resources, made at the Action level, leads to results-oriented and coherent activities across the EU based on optimal use of resources and formation of strong tailored partnerships. A grade of (++) is granted.

The effectiveness of implementation of **Policy Option 3** is secured by a single and institutionalised framework supported by an organisation with its own budget and governance. This option however caries a risk of bureaucratisation and more importantly, of self transforming an additional organisational layer with no significant impact on innovation, unless it is a clearly interfaced and coupled with existing programmes in its statute. A grade of (++) is granted.

As implementation is driven by the market, **Policy Option 4** ensures a quick response time to mobilise stakeholders hence shortening the time between product conception, validation and market roll-out. The means to achieve the policy targets could also be realised using non-European technology or technology developed by Europeans abroad, hence seriously undermining the European energy technology innovation process. As a consequence, a grade of (+) is given.

<u>Resources</u>

**Policy Option 1** is granted (0) by definition, being the baseline.

The facilitation of a systematic use of specific instruments such as Joint Technology Initiatives in **Policy Option 2** catalyses the revitalisation of public and private investment, while ensuring that financial resources are allocated and used in a more focused and results-oriented manner. Furthermore, the availability of resources for training and building research infrastructure is increased. Although the long term availability for funding needed to support a multi-annual strategy is not guaranteed by the commitment of funding at the Action level, the participation of budget authorities in the empowered governance minimises any risk of critical lack of funding in the short and medium term. A grade of (++) is granted.

The institutionalised budget in **Policy Option 3** guarantees a minimum level of stability to support a balanced portfolio of short term and long term technologies. Furthermore, the financial resources required for large scale Actions are easier to secure. Nonetheless, the funds necessary for the structure to execute its work plan may be limited due to competition for resources with existing programmes. A grade of (++) is given.

The market-driven approach in **Policy Option 4** ensures an effective utilisation of resources and the necessary fund-rising from private investment, putting less pressure on public resources. It is however noted that the investment in human capital and basic research may not be optimal. A grade of (++) is granted.

The scores are summarised in the Table below.

| | **Leadership** | **Implementation** | **Resources** |
|---|---|---|---|
| **PO1** | **0** | **0** | **0** |
| **PO2** | ++ | ++ | ++ |
| **PO3** | + | ++ | ++ |
| **PO4** | **-** | + | ++ |

### 7.3. Recommendation

From the above discussion, the preferred option is Policy Option 2 'Strategic Coordination – Coordination Committee' as it combines the best features for leadership, implementation and resources. This seems to be the best option to evolve towards a reinforced energy resesrch and innovation system that would accelerate developments. In the longer run, the successful implementation of Policy Option 2 may lead to further apetitie for integration, making progressively Policy Option 3 more attractive than today.

## 8. MONITORING AND EVALUATION

The proposal for establishing a European Strategic Energy Technology Plan (SET-Plan) contains provisions for the periodic evaluation of its activities. The purpose is to ensure the highest quality of outcome and the most efficient use of resources.

European programmes or projects undertaken within the SET-Plan that would imply legislative or budgetary intervention of the Community, if appropriate, would be subject to detailed Impact Assessments, as already performed, for example with the Fuel Cells and Hydrogen Joint Technology Initiative.

The SET-Plan will be reviewed every two years, while the progress of individual European actions annually, in the context of the Conference. The review will cover the overall performance of the governing structure, and of the resource raising and allocation mechanism as well as the effectiveness of implementation.

To this end, the role of the open-access Information and Knowledge Management Systems with capabilities on technology watch, capacities watch, modelling tools etc, is pivotal for underpinning future reviews of the SET-Plan.