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Accompanying document to the

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

on Investing in the Development of Low Carbon Technologies (SET-Plan)

IMPACT ASSESSMENT

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COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT

for the Communication on Investing in the Development of Low Carbon Technologies (Set-Plan)

Disclaimer: This report commits only the Commission's services involved in its preparation and does not prejudge the final form of any decision to be taken by the Commission.

TABLE OF CONTENTS

1. PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

Lead DGs: TREN, ECFIN, RTD

Other involved services in the Interservice Group: JRC, ENV, ENTR, REGIO, SG, COMP, DEV, INFSO, TAXUD, RELEX, TRADE, AGRI

Agenda planning or WP reference: 2008/TREN+/050

1.1. Background to the development of the proposal

The context of this Impact Assessment is as follows:

– The EU Energy and Climate Policy sets out ambitious plans to simultaneously i) fight against climate change, ii) improve the efficiency of EU energy market, and iii) guarantee a safe, reliable and sustainable supply of energy to EU consumers.

– Technology lies at the heart of the transition to a low carbon economy. Current low carbon technologies are too costly, hence the need for an energy technology policy. Without a significant improvement in the currently available low carbon technologies, achieving our short term (2020) goals will be costly; in addition, without new technologies we will not achieve our long-term (2050) goals of cutting CO2 emissions by 80%. The European Strategic Energy Technology Plan (SET-Plan), adopted as part of the Energy and Climate Package, aims to accelerate the development of technologies to bring them to the market more quickly than would otherwise be the case.

– The SET-Plan announced the Commission's intention to present a *Communication on financing low carbon technologies*. The Communication will address resource needs and sources, examining all potential avenues to leverage private investment, including private equity and venture capital, enhance coordination between funding sources and raise additional funds. In its conclusions from 28 February 2008 the Council invited the Commission to prepare this Communication.

This Impact Assessment addresses the financing needs of the strategic energy technologies identified in the key challenges of the SET-Plan (see Annex I). It covers research, technological development and demonstration (RDD) needs. It also covers deployment measures to the extent that they contribute to overcoming barriers to the market take-up of new technologies. However, it does not address the costs of the actual market deployment of energy technologies or of the transition to a low carbon economy. Such costs are several orders of magnitude higher than the RDD needs. The question of financing all the investments necessary to meet the 2020 renewable energy target will be addressed in a Communication by the Commission in 2010.

The financing can essentially be considered as part of the overall cost envelope of the Energy and Climate Package. By increasing RDD funding now, the aim is to lower the final cost of meeting the EU policy objectives, in addition to enabling the transition to a low carbon economy. This will be achieved by accelerating technological change with its resulting efficiency gains arising from the development of low carbon technologies.

In its conclusions of 02 March 2009, the Council confirmed the need for a substantial increase of private and public energy-related RDD compared to current levels, working towards at least a doubling of global energy-related RDD by 2012 and increasing it to four times its current level by 2020.

The European Union, Japan and the United States are the main[1] players in energy-related RDD. Therefore, to at least double the global effort implicitly means that these main actors would at least double their investment. This impact assessment is fully consistent with this policy.

1.2. Organisation and consultation of interested parties

This impact assessment was prepared to support the forthcoming Communication on Investing in the Development of Low Carbon Technologies which is foreseen as part of the implementation of the European Strategic Energy Technology Plan (SET-Plan). It builds on the impact assessment, the Capacities and Technology Maps and the consultation for the development of the SET-Plan in 2007[2].

In the context of the SET-Plan implementation (e.g. European Industrial Initiatives, European Energy Research Alliance) the Commission has open dialogs with many stakeholders from industry and the research community (including energy-related Technology Platforms), and also with Member States in the European Community Steering Group on Strategic Energy Technologies.

In addition, this Impact Assessment is based upon:

(1) A consultation process with the Advisory Group Energy for the Energy theme of the Seventh Framework Programme for Research in 2008 and 2009;

(2) The report on 'financing low carbon energy' by an internal DG TREN Task Force which has worked with the support of the SET-Plan Inter-service Group, as well as with a selected number of stakeholders (EBRD, developers, financial agencies agents, industry) who have been informally consulted (several of the stakeholders were consulted *ad personam)*. The EIB has been duly associated throughout the process;

(3) An analysis of current corporate and public RDD investments towards low-carbon technologies by the Institute for Prospective Technological Studies (IPTS) of the Joint Research Centre of the European Commission. During the preparation of this work around 20 major companies active in the energy field and 10 industry associations or

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1 According to the International Energy Agency, public RDD expenditure in the EU, Japan and the US represents 87% of the total expenditure in OCDE countries.

2 Impact Assessment [SEC(2007)1508]
Capacity Map of Energy - Analysis of Energy Research Capacities in EU Member States [SEC(2007)1511],
A brief and comprehensive description of the current status and prospects of key energy technologies aiming to provide information for the identification of potential European initiatives that could be considered as part of SET-Plan [SEC(2007)1510]
Public consultation

technology platforms were contacted; a consultation process with Member States has been initiated and is on-going. The International Energy Agency (IEA) was contacted with regard to their database on RDD budgets; furthermore, members of the Advisory Group on Energy to the European Commission provided comments on the report;

(4) An assessment of projected RDD needs prepared by the Institute for Energy (IE) of the Commission's Joint Research Centre[3] based on the consultation and inputs from stakeholders and other Commission services received in the context of the definition of the European Industrial Initiatives.

(5) A 2007 preliminary analysis by the Commission services of the European research and innovation capacities in EU Member States, referred to as the 'Capacity Map' along with an analysis of the potential impact of energy technologies to achieve the energy policy objectives referred to as the 'Technology Map'. The Capacities Map aims to prove 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. The Technology Map[4] assesses the reduction of greenhouse gas emissions, the enhancement of the security of energy supply and the improvement of the competitiveness of the European industry. Both analyses were undertaken within the Commission by its Joint Research Centre.

(6) A memo on Opportunities and Challenges of Innovation in the Energy Sector prepared by the European Commission's Joint Research Centre.

(7) During the SET-Plan consultation process, from March to June 2007, the Commission conducted an Expert Consultation with established advisory and stakeholder groups, such as the FP7 Advisory Groups, relevant European Technology Platforms and other sectors. A series of hearings and workshops were convened to feed into the development of the SET-Plan.

(8) In parallel, a public consultation offered the opportunity to all interested stakeholders to express their views by means of an on-line questionnaire, which was published on 7 March 2007 and was open for public response until 13 May 2007. The reports of the SET-Plan consultations can be found at the following link: http://ec.europa.eu/energy/technology/set_plan/expert_consultation_en.htm

(9) The inter-service group that was established for the SET-Plan was mandated to follow both the implementation of the SET-Plan and the Communication on Financing Low Carbon Technologies. It has met twice in 2008 and once in 2009.

1.3. Impact Assessment Board

1.3.1. IAB recommendations

On the 1st of April 2009 the Impact Assessment Board received a preliminary draft of this Impact Assessment Report. The Board adopted its opinion on the 23rd of April 2009. The main recommendations were.

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3 IE, 2008

4 SEC(2007)1510

The potential for a further and more explicit prioritisation of technologies ought to be further analysed; indicating at what stage prioritisation of technologies ought to be made, how, and on what criteria. The IA should take account of recent policy developments and clarify the potential impact of the measures to be proposed on the mix of low carbon technologies modelled in that analysis.

The analysis of funding sources should be made more thorough and forward looking, it should analyse the drivers of mobilising or stimulating different types of funding with relation to the different technology groups and should be complemented by a review of the initiatives planned or underway in the framework of the response to the economic crisis. The IA should also discuss to what extent technologies belonging to the same group require different types of funding.

The problem definition needs to be further developed. In particular the IA should analyse in greater depth the shortcomings of current policy co-ordination and the drivers that underpin it. In this context the impact of measures which have already been agreed such as European Industrial Initiatives must be brought more fully into the analysis. The IA should be clearer about the political context of this initiative and include a presentation of the process of collecting and verifying investment needs for each technology.

The subsidiarity analysis should be strengthened, in particular the IA should explain the scope of EU action for each of the identified technology groups.

1.3.2. Actions taken in response to IAB recommendations

Section 2.2 has been amended and now includes the specific criteria under which the priority sectors were identified within the scope of the SET-Plan. The section also notes how the technologies will be assessed against those criteria, outlines the intra-sectoral prioritisation measures which will be taken, and explains why further detailed prioritisation measures would be undesirable.

Section 2.5 was made more specific in response to the critique of the funding mechanisms making specific links between the technology groups and the most appropriate funding source. Annex V was also added which goes into much greater detail on the drivers of the different funding types for each of the technology groups; meanwhile annex III now has a paragraph addressing the need to resolve the issues arising from the likelihood that different technologies from within the same group will require different types of funding.

Section 2.7 was amended and Annex VI added in order to provide further detail and content on co-ordination failures and their drivers (further detail can be found in the Capacities Map accompanying the SET-Plan Communication). Meanwhile annex V contributes significantly towards an explanation of the impact of the already agreed measures and existing instruments. The political context of the initiative is made clear in section 2.1; meanwhile the monitoring system regarding the needs of each technology is discussed in section 7.

The amendments mentioned above to section 2.7 serve to strengthen the subsidiarity analysis, as does the inclusion of annex VI which outlines the scope of EU action for each of the identified technology groups.

The new Annex VII provides an overview of recent initiatives in response to the financial crisis.

2. PROBLEM DEFINITION

2.1. Context and EU right to act

As outlined in the Impact Assessment of the SET-Plan[5] Europe lacks cost effective technological solutions to achieve the 2020 climate and energy targets. The acceleration of the development, demonstration and commercialisation of strategic energy technologies will require significantly higher investment, along with a greatly enhanced degree of coordination.

This is recognised and supported at the highest political level in the EU. Indeed, judging by the measures some Member States took in response to the current financial crisis one could argue that the crisis has, in itself, acted as an accelerator; as it allowed the low carbon technology sectors to emerge as a priority sector that can guarantee sustainable economic growth, in line with the Lisbon strategy. Nevertheless, investment remains insufficient to drive down energy sector CO_2 emissions[6]; 2020 emissions from energy are projected to rise to 4 253 Mt CO2 eq.

Both Council and Parliament have repeatedly reaffirmed their commitment to the SET plan originally approved by the Council in February 2008. In this context, in February 2009 the Council invited the Commission to *"Identify the necessary legislative and non-legislative actions and appropriate financial resources"* and to *"prepare a Sustainable Energy Financing Initiative as a joint Commission and European Investment Bank project to mobilise large-scale funding from capital markets for investments".* In March 2009 the Council stressed the importance of *"a substantial increase of private and public energy-related RD&D compared to current levels, working towards at least a doubling of global energy-related RD&D by 2012 and increasing it to four times its current level by 2020, with a significant shift in emphasis towards safe and sustainable low greenhouse-gas-emitting technologies, especially renewable energy".* The Parliament is in full agreement with this approach having stressed the "*need for resources to be deployed in partnership with industry, in order to leverage private sector investments in new low carbon technologies; stresses the need for a clear long-term vision and financial framework".*

All of this should be taken in the context of the 2007 Berlin Declaration on the future of the EU where Member States affirmed their intent to jointly lead the way in energy policy and climate protection. Furthermore, should the Lisbon Treaty enter into force 2010 Member States will be required to ensure security of energy supply in the Union and to promote measures at international level to combat climate change. Joining forces to finance strategic energy technologies could be a cost- effective way for Member States to comply with the potential requirements under the Lisbon Treaty. EU action is, therefore, called for to bring coordination and synergies so as to put existing instruments and efforts to optimum use.

5 SEC (2007) 1508
6 EEA Energy and Environment report 2008 and NEF Global Futures 2009

2.1.1. Competitiveness of EU business and EU citizens are affected

Should the needed investment happen, important 'first-mover advantages' could result for the EU-based industry[7] that could have positive spillover effects for the EU citizens. These may include:

– sustainable global market leadership for companies in the lead market,

– a substantial increase in exports,

– a high degree of competition and low prices for consumers,

– high skilled jobs due to an influx of marketing and RDD functions in the lead market,

– market attractiveness as an investment location for multinational firms which seek to become insiders in the lead market,

– the creation of a pool of knowledge that would benefit not only the industries active in the 'lead area' but also other industrial sectors.

– Other secondary impacts would include lower emissions, reduced dependency on energy imports and lower health bills due to the avoided health impacts of climate change.

In addition, the global race for a transition to a low-carbon economy is expected to result in "low-carbon" becoming a 'quality label' for energy technologies and energy itself. As climate change and energy security top political agendas across the world and bring about a wave of legislation, global demand for low-carbon energy technologies is expected to increase; exponentially so if an ambitious post-Kyoto deal to reduce emissions is struck in Copenhagen in 2009.

If there is no coordinated action at EU level, it is highly unlikely that the critical mass of investment and hence the necessary breakthrough RDD in low carbon technologies will be achieved. We would run the risk of allowing the market value for low carbon technologies to grow outside of the EU where global competitors do not face governance challenges.

2.2. Technology gap of low carbon technologies

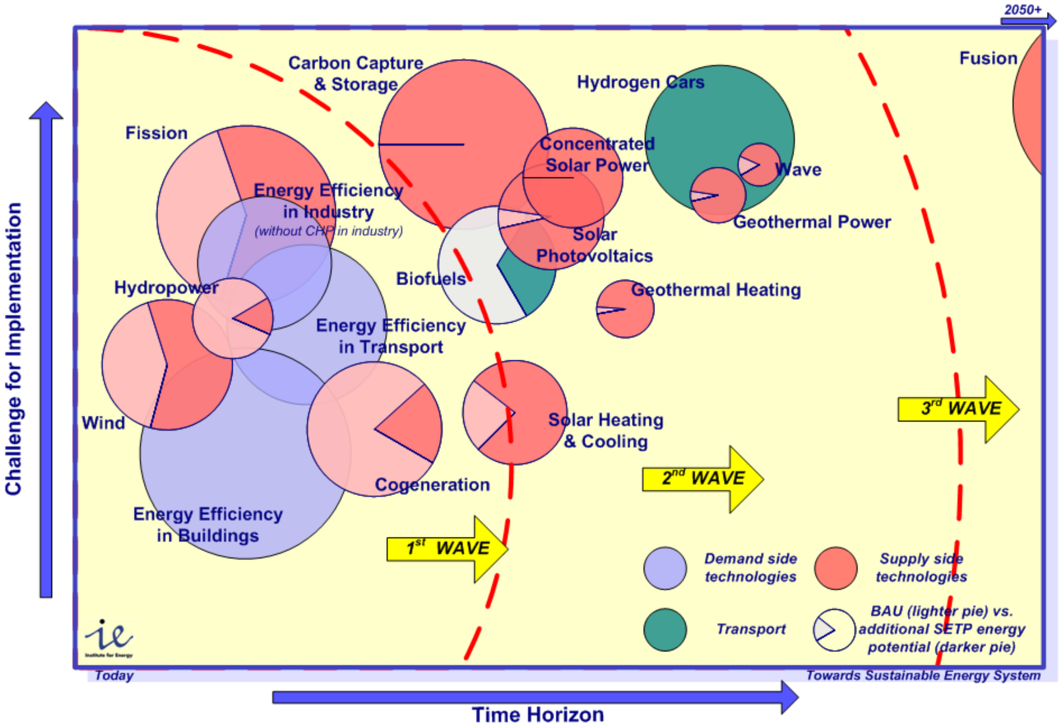
As stated in the Commission Communication *An Energy Policy for Europe*[8], the development and deployment of a diverse portfolio of low carbon energy technologies is one of the key elements for meeting the goals of the European energy policy. However, according to the *2nd Strategic European Energy Review*[9], Europe is not heading towards the renewal of its energy technology base. Under a business-as-usual (BAU) scenario, the EU energy system will continue to rely on conventional energy technologies rather than on low carbon ones.

The portfolio of low carbon technologies that could constitute a sustainable European energy system and its potential have already been estimated in recent studies, for example in the Technology Map of the SET-Plan[10] and the IEA ETP 2008 report. There is a significant

[7] See IPTS mimeo for a summary of challenges and opportunities of innovation in the energy sector.
[8] COM(2007)1
[9] COM(2008)0781
[10] SEC(2007)1510

potential awaiting to be exploited on which a sustainable energy system can be built. However, **additional RDD efforts are required to bridge the technology gap so that Europe, and the World, can benefit from its potential**.

The current understanding on the potential of low carbon technologies with respect to the EU energy policy goals is illustrated in the Figure below. More details about the construction of this graph are available in Annex II. In brief, it can be shown from the graph that several "waves" of technology deployment can be expected until 2050, each offering new opportunities in terms of the construction of a low carbon and sustainable energy system. A first wave, with a short-to-medium time horizon, is mainly composed of today's established and/or high penetrating technologies, with a prominent role for energy efficiency in buildings, transport and industry. A second wave, ranging from medium-to-long term, includes advanced technologies such as advanced solar, second generation biofuels, carbon capture and storage technologies, but also at later stage hydrogen and fuel cells in the transport sector, the next generation of renewable technologies such as ocean technologies and generation IV nuclear reactors. This will be complemented by fusion technologies beyond 2050.



Each low carbon technology faces its own unique challenges, which require dedicated research and innovation efforts. The above mentioned Technology Map of the SET-Plan describes all these in detail; however, there are commonalities between technologies. In the context of this Impact Assessment, these technologies have been grouped into three families based on their common positioning in the innovation cycle and their mutual requirements for advancement. These groups constitute a qualified simplification enabling analysis of the policy options, yet without jeopardising the quality of the assessment.

This characterisation of technologies is based in best available information, however it should be noted that technological breakthroughs or strong regulatory measures could significantly change the suggested grouping. Table 1 provides a brief overview of the technology groups; with a more in-depth analysis to be found in annex III.

Table 1: The main characteristics of the applied technology groups

	Group 1: Close to market competetiveness	***Group 2: Emerging technologies on the verge of mass market penetration***	***Group 3: New technologies***
Innovation status	Market for the technology exists exists with a maturing supply chain. Target is to improve performance and reduce costs through incremental innovation through market replication, and supporting RDD.	These are up-and-coming technologies in emerging markets. They require enhanced innovation schemes (frequently based on large scale demonstration) combined with further research.	These technologies are driven by RDD and hence require RDD based innovation schemes, pilot schemes and large scale demonstration projects in order to reach market
Technological maturity	High. Incorporates limited risk and a significant likelihood of market success due to the advanced stage of RDD. High attractiveness to industry.	Medium. The uncertainty regarding market success of RDD investments limits the attractiveness to private investments.	Low. The high risk and uncertainties associated with the technology and its market potential limits its attractiveness to industry investments.
Time horizon before return-on-investment	Short	Medium	Long
Upfront RDD investments	Medium. Further adaptation of existing infrastructure is required.	Relatively high. Further RDD efforts are required as well as additional adaptation/ reinforcement of existing infrastructure	Relatively high. Includes large RDD needs and significant adaptation of technology and supporting infrastructure
Composition	Energy efficiency technologies for buildings, transport and industry; on-shore wind, solar heating, solar photovoltaics (c-Si), electricity transmission, nuclear	Off-shore wind, solar photovoltaics (thin film), concentrated solar power generation, CCS, 2nd gen biofuels, electricity distribution	Nuclear fission (G IV), hydrogen and fuel cells, ocean energy, geothermal

	fission (GIII+), CHP.		

Prioritisation of technologies

Given the significant scale of the public and private funding to be mobilised, it was necessary to differentiate between and prioritise the varying technologies. Whilst preparing the SET-Plan[11] an assessment was conducted in order to establish these priority technologies, which then took the form of the proposed European Industrial Initiatives. The most fundamental criteria applied were:

– the EU added value/additionality;

– the willingness of actors to join forces;

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

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

The key technologies/sectors identified were:

- Hydrogen and fuel cells;
- Wind;
- Solar (including photovoltaics and concentrated solar power);
- Biofuel;
- Smart grid;
- Carbon capture, transport and storage;
- Nuclear fusion;
- Sustainable nuclear fission (Generation IV).

Similar assessments of low carbon technologies and sectors will be conducted regularly by SETIS (SET-Plan information system) under the auspices of the Joint Research centre of the European Commission.

It is also necessary, however to establish intra-sectoral priorities at the level of technology advancement actions. In particular, the proposed European Industrial Initiatives encompass a broad range of actions to be undertaken by industry and the research community. They take the form of a criterion, using the above criteria to identify the most suitable financing source; public or private, national or community. The Technology Roadmaps 2010-2020 for the

[11] Impact Assessment for the European Strategic Energy Technology Plan (SET-Plan) -SEC(2007) 1508 from 22 November 2007

implementation of the European Industrial Initiatives [Staff working paper: 'A technology Roadmap' – SEC (2009) 1295] outline the result of this prioritisation exercise.

One final point would be with regards to the difficulties inherent within any further prioritisation. In particular, and given the wildly varying characteristics of the Member States economies, research set-up and regulatory frameworks, any further prioritisation we made would not be the most appropriate for each region, and could become more inappropriate over time. The proposed approach consisting of a menu of alternatives of strategic importance to the EU, and a criterion enabling the Member States to make informed choices between them, is the most appropriate mechanism under present circumstances.

2.3. The financial gap to effectively support the SET-Plan

The first step is to better understand the current level of public and private investment in research for the key sectors identified. This is difficult, however, as the statistical information available in this respect is too general[12], in some cases unreliable[13], and at times almost non-existent[14] .

The SET-Plan information system (SETIS) conducted an analysis [Staff working paper: 'R&D Investment in the priority technologies of the European Strategic Energy Technology Plan' - SEC (2009) 1296] resulting in the findings presented in Table 1. The total figures are indicative with an uncertainty of 25%, due to the methodology applied[15]. However, the order of magnitude of the results obtained with this approach is considered a reasonable benchmark for the estimation of future research needs in SET-Plan priority technologies.

Table 1: Current approximate investment in SET-Plan key technologies (2007)

Sector	**Corporate RDD investment** in 2007 (approximation in Mio Euros)	**Public EU** (FP6 + EURATOM; annual average, approximation in Mio Euros	**Public RD&D spending of EU Member States** in 2007 (approximation in Mio Euros)	**Yearly Total 2007** **(approximation in M€)**
H2/FC	380	70	170	620
Wind	290	11	80	380

12 e.g. not detailed by technology

13 e.g. double accounting of EU and national budgets

14 e.g. private sector investment

15 As data on corporate R&D investment are sketchy, a novel estimation-based approach was applied for assessing of corporate R&D investments, combining available data on R&D investment with other publicly available information and with expert judgment. Hence, the results only provide a rough estimation of research efforts and are subject to substantial uncertainties. Applying an overall uncertainty of not more than ± 30% associated with corporate R&D investments, ± 19% for public national investments and ± 5% for the EU funds, the cumulative error on the total R&D investment in SET-Plan priority technologies would not exceed ± 25% of the total. This uncertainty does not yet include the fact that the overall figures on corporate R&D efforts tend to be an underestimation whose extent cannot be quantified further. Nevertheless, the order of magnitude of the results shown above is also supported by a comparison with other sources both on the overall level and at the level of individual technologies and funders.

Solar (PV and CSP)	270	32	170	470
CCS	230	17	40	290
Biofuels	270	13	65	350
Smart Grids	210	14	50	270
SUM (non nuclear LC Techs)	*1650*	*157*	*570*	*2380*
Distribution by investor	*69%*	*7%*	*24%*	*100%*
Nuclear Fission	205	5	250	460
Distribution by investor	*45%*	*1%*	*54%*	*100%*
Nuclear Fusion	0	204	280	485
Distribution by investor	*0%*	*42%*	*58%*	*100%*
Total SET-Plan priority energy technologies	**1860**	**366**	**1100**	**3330**
Distribution by investor	*56%*	*11%*	*33%*	

The next step is to estimate the resources needed to accelerate developments across the varying sectors. To estimate the financial needs for the next ten years, we have made a cost analysis of the activities proposed in the European Industrial Initiatives (EIIs) of the SET-Plan. This estimation has been made in close consultation with stakeholders and specialists in the different fields, mainly from the European Technology Platforms and sector associations[16]. On this basis we have prepared a series of detailed Technology Roadmaps 2010-2020 for the implementation of the EIIs [Staff working paper 'A technology Roadmap' – SEC (2009) 1295]. It should be stressed however that the cost estimates are preliminary and may be subject to changes as we progress towards the actual implementation of the EIIs. (Refer to Annex IV for information about the implementation of the SET-Plan).

Table 2: Estimation of the financing needs for key technology and actions proposed in the SET-Plan

Sector	**Estimated investment needed for the next 10 years (B€)**	**Justification for the estimation**
H2/FC	5	Updated estimation of resources needed made by stakeholders – 'Implementation Plan' of the hydrogen and fuel cell technology platform (Study by the JRC)

16 TPWind, EWEA, Solar TP, EPIA, ESTELLA, BiofuelsTP, Zero Emission Power Plan TP, Sustainable Nuclear TP, Hydrogen and fuel cells TP

Wind	5.5	Estimation of resources needed made by stakeholders – Costing of the Wind Industrial Initiative
Solar	16	Estimation of resources needed made by stakeholders – Costing of the Solar Industrial Initiative
CCS	10.5 - 16.5	Estimation of resources needed made by stakeholders – Costing of the CCS EII (including the 7-12 B€ CCS demonstration projects - Study by McKinsey)
Bio-energy	8.5	Estimation of resources needed made by stakeholders– Costing of the Bio-fuels Industrial Initiative
Smart Grids	2	Estimation of resources needed made by stakeholders for transmission and by Commission for distribution – Costing of the Smart Grid Industrial Initiative
Nuclear Fission	5 - 10	Estimation of resources needed made by stakeholders – Costing of the Nuclear fission Industrial Initiative
Smart Cities	10 - 12	Estimation based on experience from CIVITAS and CONCERTO initiatives and reviewed by the JRC
European Energy Research Alliance (EERA)	5	Estimation of resources needed made by the Commission in consultation with EERA – Based on input from EERA assuming that 30% of their future activities are jointly planned and implemented.
Total	**67.5 - 80.5**	
Current investment contributing to these objectives	**14 - 20**	The Commission estimates that 50 to 70% of the current investment can be directed to these objectives.
Additional financial needs	**47.5 – 60.5**	

In conclusion, an estimated total investment[17] of 67.5 to 80.5 B€ is required over the next 10 years in order to effectively advance the actions proposed under the SET-Plan and thereby address the key technology challenges identified therein. Fortunately, as indicated in the table, 50 to 70% of the current investment can be regarded as contributing towards the SET-Plan objectives set out above, and therefore, the required additional investment will be in the region of 47.5 to 60.5 B€.

This conclusion is in line with recent reports (Stern, Intergovernmental Panel on Climate Change, International Energy Agency[18]) which recognise the need to increase current efforts by between a factor of 2 and 10. It is also in line with the Council conclusions from 2 March 2009, which confirmed the need for a substantial increase of private and public energy-related RDD compared to current levels. Specifically they targeted (at least) a doubling of global

17 This additional investment includes both private and public (Member States and Community). Note that for simplification, the estimated R,D&D needs (table 2) have been compared with the approximate current R&D levels (table 1). This approach does not yet account for methodological problems that are explained in more detail in Annex XX.

18 Energy Technology Perspectives, 2008

energy-related RDD by 2012 and a quadrupling of the current effort by 2020. Translating[19] this political guidance into monetary terms would represent an additional annual investment effort of about 60 B€ for the next ten years, which is in line with the needs presented here.

This financial gap is already beginning to be filled. The European Energy Recovery Plan has allocated 1.5 b€ to CCS demonstration projects and off-shore wind innovation activities. In addition, within the Emission Trading System 300 million allowances have been allocated to large-scale demonstration projects for CCS and innovative renewables. At the current market price of CO2 (approx. 15€/ton) this would represent 4.5B€. This means that approximately 6 B€ would be available to fill in the gap identified in the next ten years.

Annex VIII provides an overview of recent initiatives in the context of the financial crisis, which will contribute in the short term, but are not of such great relevance to the long term vision of this Impact Assessment.

2.4. The underlying drivers of the financing gap

The underlying drivers of the financing gap relate to the specificities of the energy technologies sector and a wide variety of other factors.

2.4.1. Spill-over effects

Due to positive spill-overs, the overall economic value to society of a research effort often exceeds the economic benefits enjoyed by the innovating firm. Three relevant distinct flows of spill-overs justifying public intervention can be distinguished:

(1) Spill-overs occur because the working of the market for an innovative good creates benefits for consumers and other non-innovating firms (market spill-overs).

(2) Spill-overs occur because knowledge created by one firm is typically not contained within that firm, and thereby creates value for other firms and their customers (knowledge spill-overs).

(3) The performance of interrelated technologies may also depend on each other, and as a result each firm improving one of these related technologies would create economic benefits for other firms and their customers (networks spill-overs).

The overall result is that the innovation efforts undertaken in the private sector will be smaller than the benefit created for the society as a whole.

Basic research has especially high spill-over rates meaning that private actors will autonomously conduct less basic research than what is needed overall. Similarly, the spill-over effect is especially strong for low-carbon technologies. This is due to the strong social preference for a rapid and global diffusion of breakthrough low-carbon technologies, itself resulting from the uncertainties of non-linear climate change damage and its probable damage to the interests of future generations.

[19] Taking the approximately 3.3 B€ invested in 2007 as a reference level of spending in low carbon technologies (see previous section)

Optimising the benefit of innovation to society by complementing private RDD through public RDD is the justification of public research efforts[20]. Governments should invest in projects that are likely to have a high social rate of return. On the other hand, the absence of government support would lead to a deficit on the public benefit side of the balance.[21]

2.4.2. Environmental externalities

The EU Emissions Trading Scheme puts a price on carbon emissions in the covered sectors, i.e. energy-intensive sectors in industry and power generation. Thus, it provides a market incentive for higher penetration of low-carbon technologies. The ETS thereby internalises the negative externality of carbon emissions by monetising them. Other instruments, in particular carbon taxes or in some cases standards, can be applied in sectors that are not in the EU ETS (e.g. in households, transport and services) to create similar cost-efficient incentives.

The ETS as well as energy or carbon taxes are cost efficient instruments. This means that they create the incentives to introduce the cheapest and most efficient abatement technologies first, i.e. the technologies with lowest costs. In terms of technology development, this is equivalent to the technologies closest to the market. Thus, market based policy instruments create a powerful stimulus for the introduction of these technologies. At the same time, these instruments also create incentives and accelerate the market uptake of more immature technologies by improving the expected long term rate of return of new technologies.

Market based instruments alone may, on the other hand, prove insufficient to provide incentives to develop those recently developed technologies which remain further from the market in the short term and at a sufficient pace. Additional support measures may therefore be required to foster RDD in less mature low-carbon technologies.

The energy technologies identified by the SET-Plan become competitive at a much higher carbon price than the current of €12/tn CO2 (e.g. offshore wind over €35/tn CO2, CCS over €70-90/tn CO2). The third phase of the ETS due to start in 2013 is expected to bring about more visibility to the price of carbon - particularly against a backdrop of an ambitious post-Kyoto international agreement for further emissions reductions - and is likely to be the basis for broader emission markets that will include more sectors and countries. Policy simulations of future climate policy scenarios point towards the need for higher global carbon prices in the long term. Limiting the global warming to 2 degrees has been estimated to correspond to a carbon price of €37/tn CO2 by 2020 and by €64/ tn CO2 by 2030[22]. In this context, it is expected that the ETS will establish itself as a major driver for technology market uptake in the EU in the covered sectors over the medium and long term. For those sectors to which the EU ETS will not be applied due to high transaction costs, CO2 related taxation would be the best alternative.

2.4.3. Uncertainty and risk aversion

One underlying problem for the introduction of new technologies is the risk aversion vis-à-vis new technologies shown by private investors, particularly in the context of the present

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[20] NCEP, 2004

[21] In addition, the enforcement of private property rights through e.g. patenting is a way of limiting spillovers for the innovator (Stern, 2006). Following this logic, the EU Commissioner for Industry proposed an accelerated patent application procedure for green technologies on 06. May 2008.

[22] IA to the Communication Limiting Global Climate Change to 2 degrees Celsius, SEC 2007(7)

economic downturn. The final result of the research and innovative effort is genuinely uncertain, as not all projects generate marketable results. Thus, unproven technologies entail large risks and high learning investments, i.e. high *technology risks*. The private actors are not able to incorporate the positive benefits on the society as a whole by bringing these low carbon technologies to the market. The overall result is too little investment in the development of these types of technologies or too little diversification of technology options compared to what is needed to retain the flexibility to achieve more stringent emission reductions in the future.

The energy technologies identified by the SET-Plan involve high upfront learning investments, and long lead times. Particularly in the present global financial and economic downturn, debt financiers show a pronounced reluctance to provide funds for as yet unproved technologies. The uncertainty about the technologies also has a bearing on the cost estimates for the demonstration plants. There is a need for demonstration projects to help gain knowledge, and thus drive cost reductions and commercial competitiveness in the industries involved. The technological risk warrants support to cover the costs arising from accelerated and large-scale investment in these unproved technologies.

The fact that the demand for low-carbon energy technologies is partially policy driven exposes the sector to high *regulatory risks*. Key legislation, in particular the climate change and energy package, is now in place and provides a stable policy framework within the EU. This is expected to act as a driver for the quick implementation of the SET-Plan. However, the effectiveness of EU legislation in this area largely depends on the development of climate policy, post- Kyoto. The stability of the regulatory system remains an important factor in this regard for the consolidation of investor confidence.

Continued uncertainty also exists within other policy areas, e.g. trade policy. The liberalisation of trade in environmental and energy services and goods and hence the protection of intellectual property rights and other barriers to technology and know-how transfer remains an important issue for the development of new low carbon technologies.

A range of other market factors will also have an impact on the risks and uncertainties facing the development of new low carbon technologies. One of the most important factors in this respect is the development of future oil and energy prices, as they influence the rate of return on the investment in alternative energy sources. The last year has showed that these price developments can be very uncertain and volatile. The crude oil price peaked close to $150 per barrel in July 2008, reflecting a more than a quadrupling of the price since 2003. At present, crude oil is around a third of the price at the peak.

2.4.4. Various other market failures and the specificity of the energy sector

The inherently high upfront learning investments in the energy sector (e.g. full-scale CCS about €1 billion) combined with the long life cycles of existing plants (e.g. 40 years for a coal-fired plant, 25 years for a CCG plant[23]) and infrastructure and network investments create a lock-in effect- that favours established technologies and thus impedes innovation of new technologies in the energy sector. Established technologies have undergone a long path along the experience curve, enabling them to attain low production costs and economics of scale. Hence, large investments in both innovation and deployment are required for new

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23 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SEC:2008:2872:FIN:EN:PDF

energy technologies in order to become competitive. In addition, the existence of high initial (transaction) costs to enter the market due to the need of distribution and grid system is another difficulty for new technologies to enter the market. Hence, these different features of the energy system constitute barriers to entry for new technologies. The difficulties to reach the market with new technologies also act as a disincentive for innovation in the energy sector.

Furthermore, the regulatory framework for new infrastructure deployment might still be too fragmented to enable sound competition between emerging technologies options envisaged to serve new demands. This concerns for example undefined legal framework about who should bear the costs of building "carbon grids" to connect large scale CCS to carbon producers.

The problems with competition on the European electricity and gas markets reduce the pressure on the incumbent companies to develop new technologies and to reduce costs. Barriers to entry, both in terms of access to the grid/network and the competitive situation on the wholesale markets, limits the possibilities for companies that apply new technologies to enter the market. The 3rd legislative internal energy market package due to be adopted in 2009 aims to address and improve this situation.

To overcome these various market failures and specific features of the energy sector, public funding could make a difference through providing support for the high initial research and development costs, but also by supporting the early deployment stage of some low carbon technologies. This can be done by various financial instruments, with different leveraging potentials for public funds.

2.5. Current financing instruments and their gaps

At present available financing instruments include RTD Programmes (national and EU), innovation programmes, debt based financing, Venture Capital Funds, Infrastructure Funds and market- based instruments (see Annex V). The matrix below gives an indication of the applicability of each of the available instruments for the specific technology groups and also highlights any particular needs those instruments may have with regards to a given technology group.

Table 2: Overview of the existing investment vehicles and applicability to the technology groups.

Investment vehicles	Group 1: Technologies close to market competitiveness	Group 2 : Emerging technologies on the verge of mass market penetration	Group 3: New technologies
RTD programmes (EU/ MSs)		Applicable, but further resources and coordination required.	Applicable, but further resources and coordination required.
Innovation programmes (EU/ MSs)	Applicable, but further resources and coordination required.	Applicable, but further resources and coordination required.	
Debt Based financing (EIB / national) incl. RSFF	Applicable.	Applicable, but further resources [and coordination] required.	Applicable, but further resources required.
Venture capital funds (private / public-private)	Applicable, but further resources desirable.	Limited applicability, further resources desirable.	
Infrastructure funds (EIB / national)	Applicable, but further resources required.	Applicable, but further resources and coordination desirable.	
Market-based instruments	Applicable.	Limited Applicability	

Market based instruments, the last category in the table above, have a very important role in supporting the last step to commercialisation and market deployment of new low carbon technologies. However, the design of targeted market based instruments such as feed-in tariffs or green certificates remains the competence of the Member States; work on taxation instruments is on-going within the Commission; and the EU Emissions Trading Scheme has just been reviewed. These mechanisms are therefore left outside the scope of the policy options considered in this impact analysis.Based on the table above, the following specific needs have been identified:

- A need for both further resources and co-ordination across the RTD and Innovation programmes.

- A need for further resources and co-ordination of all instruments with regards to Group 2 technologies, and particularly large scale demonstration projects.

- A general need for further resources, and in some cases enhanced co-ordination with regards to Group 1 technologies.

- Clear benefits could also be gained from increased resources to venture capital instruments.

See Annex V for further discussion of the individual instruments and their drivers.

2.6. Effect of financial crisis on the financing of low carbon technologies

The financial crisis has transformed into disrupted trade flows and stagnating or contracting domestic private demand in most EU Member States, leading to an economic crisis. These trends fuel uncertainty about the profitability of a number of investment projects. Actually, bank lending to the private sector is declining (the *Public-Private Infrastructure Advisory Facility* has already registered trends in increased costs, delays and cancellations, which are expected to continue[24]). With public finances weakened by recession, governments may also come under increasing pressure to cut spending on investment. If the current crisis lasts for a longer period of time, there is a risk that governments and businesses may not only postpone closing the RDD investment gap necessary to support the EU long-term growth potential, but even reduce their current research and innovation effort. There are clear evidences that cuts in investment, if spread on a significant scale, could create disproportionate reduction in EU economy productive capacity with long-lasting effects[25]. In this context, it is all the more important the ensure that scarce public and private capital resources are directed to investments with the highest economic rates of return[26], taking into account long-term social benefits.

In particular, currently falling demand in OECD countries translated in abrupt fall in oil and carbon prices. This trend fuel expectation of further demand reductions in the short-term and weakens incentives to invest in the rapid market deployment of the most mature low-carbon technologies. Nonetheless, global demand for energy can only be expected to rebound once the economic situation improves, especially as demand growth from emerging markets is likely to be sustained. Achieving the legally-binding EU targets to increase the share of renewable energies and to reduce emissions of greenhouse gases by 2020 will reduce our exposure to future energy price shocks. Besides, when the upturn starts, low carbon technologies will be among the lead markets. Hence, the economic slowdown is not a reason to slow the shift to low-carbon energy-efficient production and consumption patterns, wherever it can bring productive efficiency gains.

Under the assumptions of a stable favourable framework for low-carbon energy technologies, it is likely that cuts in corporate RDD activities could be less severe for low-carbon technologies than in other sectors. Indeed, some companies may see the crisis also as an opportunity for carrying out those structural shifts, which have been considered as necessary over the past years, in a radical way. RDD is widely acknowledged for being central for ensuring such a shift.

However, the crisis may induce a tendency to shift corporate investments from more basic research to RDD activities that are considered less risky and provide a faster return on

24 Public-Private Infrastructure Advisory Facility: "Financial crisis affecting new private infrastructure projects", article to be downloaded from http://www.ppiaf.org.

25 For example, Servén, L. (2007): "Fiscal discipline, public investment and growth". In: Perry, G., Servén, L., Suescun, R. (eds): "Fiscal Policy, Stabilization and Growth". World Bank Publications. Also IMF (International Monetary Fund) (2003): "Fiscal adjustment in IMF-supported programs". Washington DC: IMF.

26 For example, Japan in the 1990s undertook massive public infrastructure projects that arguably resulted in waste of resources, created a large debt burden for Japan, while were not successful to counter the recession and failed to have a long term impact on the supply side.

investment. At the same time, the financial crisis makes merger and acquisition deals less likely, but there seems to be a qualitative shift from debt financed to equity financed deals, making deals in technologically challenging activities such as offshore wind energy more probable, which could possibly lead to a higher concentration of RDD investments.

Currently, no common business strategy in response to the current crisis can be observed. In fact, a non-exhaustive review of press releases shows cuts in workforce, whilst RDD budgets likewise have announced constant, and even rising figures. Given the combination of uncertainty and the societal need for developing low-carbon technologies, it becomes even more important for the public sector to ensure favourable incentives and market conditions in order to trigger corporate RDD investments in these technologies.

In these circumstances, the EU and many MS recovery plans very appropriately comprise actions targeting low-carbon technologies. The bulk of national measures are frontloading of the ongoing or planned projects[27] . However, it is worth noting that some MS have embarked in designing new measures thus creating an additional impetus towards the completion of the EU climate and energy objectives. A good example of this is Finland which has established a strong participation in risk capital funds to sustain private investments in low-carbon innovation, meanwhile Denmark has established a new major 12.5 bn EUR investment plan over 2009-2020 to upgrade its transport infrastructure to higher economic and energy efficiency levels. Similarly, Germany, Luxembourg, France and Ireland have set up actions aiming at demonstrating low-carbon energy-efficient buildings, which is a way to realise important economies of scale to mainstream low carbon technologies in this sector, with accompanying positive spill-over effects throughout the EU.

2.7. Added value of further EU action

As outlined above the transition to a low carbon economy is both necessary and beneficial for the Community. Yet, taking into account the nature of energy research, the investments needed and the urgency to bring about change, it seems to be evident that very few Member States have the capacity to individually finance the programmes and create the incentives necessary to generate the necessary technologies and market innovations. The main global players, the United States and Japan, but also emerging economies such as China, India and Brazil all face the same challenges, and are multiplying their efforts to bring about low carbon technologies.

In particular, it should be noted that, at present the EU is not making full use of the potential for innovation of the internal market to exploit the synergies which exist between Member States with regards to the development and deployment of new energy technologies. Action to make full use of the available synergies could only be taken at EU level, is necessary and would have substantial benefits.

Furthermore, it should especially be borne in mind that the market alone cannot be relied upon to finance the required transformation. Although cost efficient, it lacks a long term strategic outlook, is risk averse, and suffers from the market failures outlined above which prevent it from being the sole agent of transformation. Again therefore, the transformation

[27] Estonia has confirmed the funding for its support programme developing low carbon biomass technologies and Austria its programmes to support RDD and Innovation in climate change mitigation technologies; Portugal has frontloaded 145 million EUR investment as exceptional support to fasten the market replication of wind and solar technologies, etc

will require public and EU level effort in order to bridge the financial gap and address the market failures outlined in earlier sections; as well as compensating for the coordination failures set out below which prevent European industry from achieving its full potential.

2.7.1. Co-ordination Failures

Worryingly, at present, and unlike the strongly focussed and coordinated energy technology policies in e.g. Japan and the US[28] no single European programme currently exists. With the exception of fusion, pan-European co-operation is limited, and possible synergies underused.

In the EU, there are many such coordination failures which prevent European industry from achieving its full potential. They range from engineering and technical failures to strategy and planning failures and, perhaps most importantly, implementation failures.

– Engineering and technical coordination failures:

  – New technologies have to be compatible with exiting energy systems if they are to spread widely. For example, the lack of compatibility with electricity networks can hold back the market take-up of low carbon electricity generation technologies.

  – The variety of national regulations and technical specifications fragment the market and inhibit industry investments in high risk technologies.

– Strategy and planning coordination failures

  – Multiple, uncoordinated individual programmes lead to a tendency to over-focus on the most attractive short term technology options, whilst starving promising, but further from the market technologies, of sufficient support.

  – Uncoordinated and unstable market incentives and support schemes add to the map of incoherence and, in certain circumstances, act as innovation deterrents.

– Implementation coordination failures:

  – Fragmentation of effort and resources leads to duplication and sub-critical mass, leading to underperformance with respect to other regions, even if the overall R&D spend is similar.

  – Transnational co-operation in low carbon energy RDD concentrates on those MS with the highest spending, and a high potential for co-operation remains unexploited[29].

  – In addition, there are a number of other sources of funding (from financial institutions e.g., EBRD, WB and/or national support programmes) which could provide valuable additional synergies alongside EU resources.

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28 Wiesenthal et al, "R&D Investment in the priority technologies of the European Strategic Energy Technology Plan".

29 IPTS, 2009

Annex VI presents a further insight into EU policy coordination failures and Annex VII goes into further detail on the exact justification for EU action with regards to each of the Technology Groups.

3. OBJECTIVES

The EU's Strategic Energy Technology Plan (SET-Plan) is part of the Energy and Climate Change policy framework. It contributes to the overall policy objectives by proposing, developing and implementing an Energy Technology Policy for Europe. It complements EU policy in energy and climate change and can enable cost effective compliance with legally binding targets. These include the realisation of the internal market in electricity and gas; compliance with emissions' reductions and the revised and strengthened Emissions Trading Scheme; the increased contribution of renewables to the EU's electricity generation; the measures to enhance energy efficiency; the EU car emissions standards; the negotiation of a post-Kyoto international agreement; and the development of an external energy policy.

3.1. Strategic objectives

The subject of this impact assessment is the financing of low carbon technologies to achieve the objectives of the SET-Plan. The SET-Plan aims *'to focus, strengthen and give coherence to the overall effort in Europe, with the objective of accelerating innovation in cutting edge European low carbon technologies.'*

The strategic objective to be pursued within the framework of the SET-Plan is:

- to accelerate the development and facilitate the market take-up of low carbon technologies which have the potential to be competitive in the long-run;

The SET-Plan proposes a comprehensive set of actions at governance and implementation level to achieve this objective. Overall, these actions would lead to a better use of resources by focussing and bringing coherence to the overall effort in Europe, currently characterised by its fragmentation and general downward trend in public energy research and development expenditures over the last decades (which remain well below its levels from the mid-1980s despite the upturn in more recent years). To achieve this objective through the full and timely implementation of the SET-Plan, both the Council and Parliament call for an increase in resources.

3.2. Specific objectives

There is consensus that industry investment should be the main driver to achieve the SET-Plan objective in a cost-effective manner, with public research efforts playing a supporting role. However, despite all measures taken and policies proposed, the sector faces several market failures and in particular has accumulated a significant underinvestment (as explained in chapter 2).As things stand, industry is not investing with the intensity required by the agreed energy and climate policy targets and has no incentive to do so.

Hence, the specific objectives to be pursued are:

- to stimulate a substantial increase in private investment in research, technological development, demonstration, and market replication of SET-Plan technologies.

- to ensure the provision of sufficient, appropriate and efficient financial resources in support of the development of the low carbon technologies identified in the SET-Plan, so as to secure a level of innovation in line with EU policy goals.

3.3. Operational objectives

To achieve the specific objectives in relation to the SET-Plan, public policy should pursue, inter alia, the following operational objectives:

- to at least double financial resources to the research, development and demonstration of the low carbon technologies identified in the SET-Plan for the next ten years.

- to ensure a more flexible and effective use of currently existing instruments; and

- to modify or develop new flexible and effective instruments and/or institutional arrangements, as appropriate, and in cooperation with industry, the research community and Member States.

The SET-Plan information system (SETIS) provides a 'technology neutral' performance management framework to meaningfully monitor progress towards these objectives.

4. POLICY OPTIONS

To cover as much as possible the broad range of potential policy measures, the following four main policy options have been selected, to specifically illustrate and exemplify the alternatives available. These are:

(1) the continuation of the existing investment vehicles within the current institutional arrangements (BAU)

(2) increased funding channelled through the existing investment vehicles within the existing institutional arrangements (option 1)

(3) a strengthening of the existing investment vehicles within modified institutional arrangements (option 2)

(4) new investment vehicles, taking specific institutional arrangements, filling in gaps and removing recurring weaknesses of the existing portfolio of investment vehicles (option 3).

In this context, "investment vehicles" are defined as the specific means through which the emergence of a low carbon economy is furthered and promoted, and "institutional arrangements" represent the governance structure under which the investment vehicles are managed.

4.1. Business as usual (BAU)

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 research programmes, with their own priority setting mechanisms, governance and funding. These are implemented at different levels: EU, national, regional, corporate, etc and rely on non-aligned roadmaps that are influenced by fragmentation and developed to suit a ‘single client’; they also in vary in terms scope and scale of allocated resources. The SET-Plan proposed the creation of a European Community Steering Group on Strategic Energy Technologies to address this fragmented landscape. However, although the Group has been established, it will take time until its impact is significant.

These currently existing programmes would all continue under the Business As Usual scenario, and include mainly:

- Innovation efforts in energy under the CIP programme amounting to €730 million for 2007- 2013.

- National and EU level RDD funding, amounting to € 683 million in 2007 for non-nuclear RDD and € 700 million for nuclear fission.

- EIB Group activities including the EIB's typical infrastructural and corporate loans (EUR 20 bn for Energy related activities 2009/2010), the RSFF programme (EUR 2 bn-joint with the Commission), its Global loans for SMEs, investments in infrastructural funds, and the

EIF's venture capital and guarantee activity (particularly under the CIP mandate conferred on the EIF- € 550 million 2007-2013).

- Additional measures under the European Economic Recovery Plan, including both national and EU level measures. If approved by the Council and the Parliament, the European Energy Programme for Recovery adopted as part of the European Economic Recovery Plan could amount to an additional €3.5 billion to improve electricity and gas networks, kick-start the demonstration of CCS and stimulate the development of offshore wind technologies.

Some efforts are also currently undertaken through transnational agreements (EU framework programmes, ERA, bilateral agreements) the aim being 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.

4.2. Increased funding through the existing investment vehicles (option 1)

One option would be to generally increase the amount of funding and resources heading to these investment vehicles. In many cases the problems defined in the problem definition arise from a lack of adequate resourcing; and provision of such resourcing could have a significant impact in terms of encouraging the development of low carbon technologies. Specific measures here could include:

- Allocating further financial resources to the Energy Theme within the RTD Framework Programmes (EC and EURATOM) without changing the instruments used to finance projects. The EU could encourage Member States to similarly reinforce National RDD programmes, without changing their current implementation modalities. Under this option, the European Industrial Initiatives and the European Energy Research Alliance of the SET-Plan could be implemented as 'soft' partnerships, not involving legislative proposals to set up new institutional arrangements.

- Allocating further financial resources to the energy components within the CIP programme (which focus on non-technological barriers and seek to bridge the gap between the successful demonstration of innovative technologies and their effective broad market take-up) without changing the instruments used to finance projects. Particular emphasis might be placed on the Intelligent Energy-Europe segment of CIP within which prominence is given to energy efficiency and renewable energy technologies. The EU could encourage Member States to similarly reinforce National Innovation programmes, without changing their current implementation modalities.

- Allocating further resources to venture capital projects in the field of low carbon technology, mainly through the "eco-innovation" budget under the CIP mandate to the EIF. These resources would be particularly desirable with regards to supporting small firms adapting and transferring new, previously demonstrated (but not widely available) technologies to the market.

- A significant increase in the RSFF budget may be thought wise so as to enable the requisite leveraging of significant amounts of financing towards the realisation of riskier projects, in particular large scale demonstration projects. These projects, which also require a significant cooperation are, at present, the only ones in which their size and complexity might prevent a meaningful RSFF contribution. (for example in the case of CCS the large scale demonstration programme may require the roll out of up to 12 large scale demonstration plants at a cost of EUR 7-12 bn[30]).

- In the case of infrastructure funds, the Commission could take a participation in Marguerite (fund created by the EIB to support the financing sustainable energy infrastructures) in order to spur the financing of low carbon technologies; moreover a strengthening of the currently existing instruments could take the form of increased EIB participation in infrastructural funds in the energy sector, and particularly those focussed on mitigating the effects of climate change. The aim would be to increase funds capacity to bring products to market, and particularly to leverage participation in SET plan technologies so as to better enable the construction of large demonstration projects. One aspect of this is simply scale, EIB investments in private infrastructure funds are relatively small at present, this is something that could be significantly expanded in financial terms and then aimed at both large scale demonstration and market replication.

- Further resources could be deployed under the various technical assistance programmes of the EIB Group (e.g., JASPERS). These would help to facilitate market take up and enhance the benefits gained from the EIB Group's programmes.

- Cohesion Funds – planned allocations directly supporting energy efficiency, renewables, clean urban transport investments account for approximately €15.2bn or 4.4% of total Cohesion Policy funds for the period 2007-2013; these funds can play an important role supporting market replication and technology dissemination. In the context of the European Economic Recovery Plan, Cohesion Policy has taken a number of steps allowing Member States to increase support for low carbon technologies.[31] For example, the proposed amendment of the ERDF regulation, allows Member States to dedicate up to 4% of their total ERDF allocation to energy efficiency and renewables investments in housing. This, should offer new possibilities for demand-side measures, and might therefore also provide some incentive for enhanced supply in the field of renewables and energy efficiency. Member States are encouraged to ensure that investments in low carbon technologies under Cohesion Policy support the priorities of the SET-Plan.

4.3. A strengthening of the investment vehicles within modified institutional arrangements (option 2)

This policy option considers supplementing, where appropriate, the measures to strengthen the instruments described in Option 1, with an institutional restructuring aiming to increase the co-ordination and overall effectiveness with which those instruments are implemented.

- For an accelerated development of technologies the implementation of the SET-Plan offers new opportunities for modified institutional arrangements mainly in the context of the European Industrial Initiatives (EIIs) and the European Energy Research Alliance. These could take a number of forms, including formalised Joint Programming (between MSs and the EC) of research to achieve critical mass in given sectors, on the basis of Art 168 or 169 of the Treaty, and the setting up of Public-Private Partnerships (PPP) through legislative proposals, such as Joint Technology Initiatives or Joint Undertakings on the basis Article

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30 McKinsey

31 COM(2008) 876/3 Commission Communication "Cohesion Policy: Investing in the real economy"

171 EC. Such options amount to changes from the business as usual option, even if they have already been applied in other sectors.

- On the innovation side, examples of possible measures could be the creation of new institutional arrangements to greatly expand the market replication activities of the CIP or new partnerships/structures to change the current paradigm of investment in energy efficiency activities which are by their very nature highly dispersed and fragmented, due to the multiple market actors and customers. The changing nature of the energy services industry, encouraging energy savings rather than simply supplying energy may need to be supported by innovative new instruments and approaches that are not currently envisaged in the CIP or other policies.

- With regards to venture capital, the idea of refocusing the Capacity Building Scheme (CBS) under CIP towards low carbon technologies could be explored. This would come under the scope of the CIP decision, and would focus above all on providing grants so as to improve financial institutions capacity to assess the commercial viability of projects with a significant eco-innovation component.

- In the case of Debt Financing the possibility of establishing a far stronger link between the SET-Plan Steering Committee and the EIB could be explored. Under this scenario, the Steering Committee might be able to mobilise increased joint (Community, Industry and Member State) financing and better coordinate efforts in support of low carbon technologies on a more frequent and more effective basis than is currently the case.

- When discussing infrastructural funds it might be possible to envisage a specific mandate for the EIB to invest in infrastructural funds focussed on low carbon technologies. The establishment of such a mandate would allow for increased support, and increased emphasis being placed on these funds by the EIB. It would also permit an increased development of expertise regarding infrastructural funds within the EIB, meanwhile the new mandate would gain a degree of leverage through being associated with the high repute of the EIB.

4.4. A set of new investment vehicles taking specific institutional arrangements (option 3)

In many cases the problems concerning the coordination of the current instruments are severe, and it might be considered that the additional coherence brought by SET-Plan Steering Committees and new institutional arrangements might be insufficient. In addition, there are some areas where the existing instruments, even if strengthened could be viewed as not containing the necessary ingredients for the needed promotion of low carbon technologies. In these cases it might be thought necessary to combine an increased level of investment with new and more efficient vehicles. In respect of the previous policy options, this can be considered as the 'radical change' option.

- One possibility is to set up new centralised structures for energy research and innovation with the remit of devising and implementing a strategy on energy innovation at the EU level in line with the EU policy objectives. Such structures could follow an Intergovernmental approach (c.f. the European Space Agency), new Community bodies or public-private bodies. They would be autonomous bodies with their own Governance structures and would set, endorse and review a multi-annual strategy and detailed work plan managed and monitored by its own management structure. Objective evaluation of such a structure could be met via different formats and advice to it could be provided through the SET-Plan governance. Funding would be increased above the current level and provided by the Member States, the European Commission and the industry either on a case by case basis or through fixed grants, and would be allocated by the Governing Board through its work plan. As an illustrative example, as proposed by the America COMPETES Act, the US is setting up a new Advanced Research Projects Agency for Energy (ARPA-E), within DoE to change the current paradigm of basic research funding in the US. The new body will focus on transformational and innovative high-risk/high pay-off energy research and is devised specifically to alleviate many of the shortcomings, including bureaucracy, poor coordination and lack of innovation within the DoE's current approach to energy RDD. Another possibility would be a move to EU procurement-based RDD, such as long been practised at national level in the defence sector, which would require new institutional arrangements. Such a scheme is currently in operation within the European Defence Agency.

- With specific regards to the EIB Group activities (including Venture Capital, Infrastructural Funds, and Debt Financing), new investment vehicles and altered institutional arrangements would appear to be unnecessary except in the case of large scale demonstration projects; as co-ordination is not a problem except in these cases which of necessity involve a large number of actors and significant amounts of funding. Here it might be thought worthwhile to consider an EIB structured action in support of large demonstration projects across various technologies. One could envision providing support to a number of organisations by combining a variety of financing mechanisms, including channelling grants from RDD and innovation programmes, ETS allowances, infrastructural funds and debt based financing. The increased funding would be provided to the action by the Member States, the European Commission, the EIB and the industry on a case by case basis. The actions to be funded would be selected through calls for proposals, open to all stakeholders.

5. ANALYSIS OF IMPACTS

5.1. Main assumptions

This analysis focuses on the impact of the policy options described in the previous Chapter on the successful development of low carbon energy technologies and their timely availability for market take-up. In other words, this analysis aims at identifying the right policy measures that can best trigger the development of low carbon technologies, leverage the required additional investment in research spending, and address the different market failures, as explained in Chapter 2.

Building on the commonalities of technologies with regards to innovation needs that led to the forming of technology groups in Chapter 2.2, this assessment focuses on the identification of the best policy option per group of technologies, rather than on a technology-by-technology basis.

5.2. Economic and social impacts

The EU energy and climate change policy comes at an overall cost to the economy. In particular, the impact assessment of the energy and climate package[32] indicates that the cost efficient reference scenario with a 20% reduction of the GHG emission by 2020, combined with a renewable energy share of 20%, results in a loss of GDP of around 0.35%. This impact would be restricted to a loss of 0.21%, however, by a redistribution of the national targets in the Non-ETS sectors and by allowing for emission reductions outside the EU through the use of the Clean Development Mechanism of the Kyoto Protocol. These calculations are based on the technological development expected under a "business as usual" approach, which includes the continuation of existing technology development trends and implementation of the already agreed decided policies (including the ETS as of 2005).

Market-based instruments such as the ETS or carbon taxation can orient the technology base of the energy system towards low carbon technologies that are commercialised and/or at the verge of large scale deployment by influencing their cost competitiveness. Whether deployment will be motivated by the ETS alone to meet the required pace and scale to address climate change is doubtful. The fact that energy efficiency measures, which would themselves pay-off in the long term, are not adopted is an argument that the ETS alone is not likely to be sufficient. Likewise the significant taxes on transport fuels have in the past been helpful in fostering the market penetration of biofuels in so far as the latter have enjoyed exemptions from these taxes; on the other hand, the tax system alone might be insufficient to prompt the necessary R&D investment in those alternative fuels which remain far from marketability. Therefore, it is self-evident that transformational, high-risk technologies and technologies that are not nearly marketable will not be directly influenced by the EU's ETS in the short term.

Recent research indicates that an active policy to stimulate technology development in parallel to an emission trading system could be more cost efficient in achieving the set abatement target than relying solely on the emission trading system. This policy could address

32 SEC(2008)85, Impact assessment: Package of Implementation measures for the EU's objectives on climate change and renewable energy for 2020.

the positive spillovers effects of research through both general RDD subsidies and through more targeted subsidies for the adoption of the new technologies, (Otto and Reilly (2008)[33] demonstrate this with respect to the introduction of the CCS technology with a CGE model for the Netherlands;[34]).

To the extent that this policy reduces the costs to achieve the emission reductions targets, the negative impact on employment can also be assumed to be mitigated. The IA of the climate and energy package estimated a small negative impact on employment in the cost efficient reference case (-0.04%[35]), which actually turned positive in the case with redistribution of the Non-ETS targets and the use of the Clean Development Mechanism (+0.05%). The policy analysed here can be assumed to mitigate and possibly amplify this effect, as the costs of the emission reduction policy is reduced. However, the impact can be expected to be small as the original impact of the target is limited.

Hence, even if it can be assumed that the overall impact of a doubling of the financial support to the development of low carbon technologies can reduce the overall costs to the economy of achieving the carbon emission reduction target, there is no reason to assume that any policy option considered in this Impact Assessment will produce purely economic or social benefits of a significantly greater magnitude than another (excluding 'business as usual'). All the policy options assume a doubling of the financial resources, and mainly differ thereby in the pace, timing and manner in which the various technologies are deployed. Although the chosen policy option will influence the environmental and societal characteristics of the energy system, in view of its impact on the availability and cost competitiveness of new technologies, there is no direct unambiguous relationship between RDD activities on energy technologies and their consequent market deployment. This has been demonstrated by the results of a recently finalised FP6 project funded by DG RTD (SRS NET AND EEE[36]). Market roll-out is a result of the combined effects of technology development, and market incentives and regulation, such as the EU's emission trading system (ETS).

5.3. Environmental impacts

The overall environmental impact will accumulate over time as the technologies are deployed. Again the difference between the options will mainly affect both the timing and the nature of the closing financial and industrial deals, and thereby accelerate progress along the technology roadmaps towards the environmental goals set. An illustration of the

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33 Otto, V.M. and Reilly, J. (2008), Directed technical change and the adoption of CO2 abatement technology: The case of CO2 capture and storage, Energy Economics, 30, p. 2879-2898. See also Fischer (Fisher, C. (2008), Emission pricing, spillovers, and public investment in environmentally friendly technologies, Energy Economics, 30, 487 - 502)[33] which similarly finds R&D policy to be a complement to an emission reduction policy, in particular in cases where the carbon externality is not fully internalised

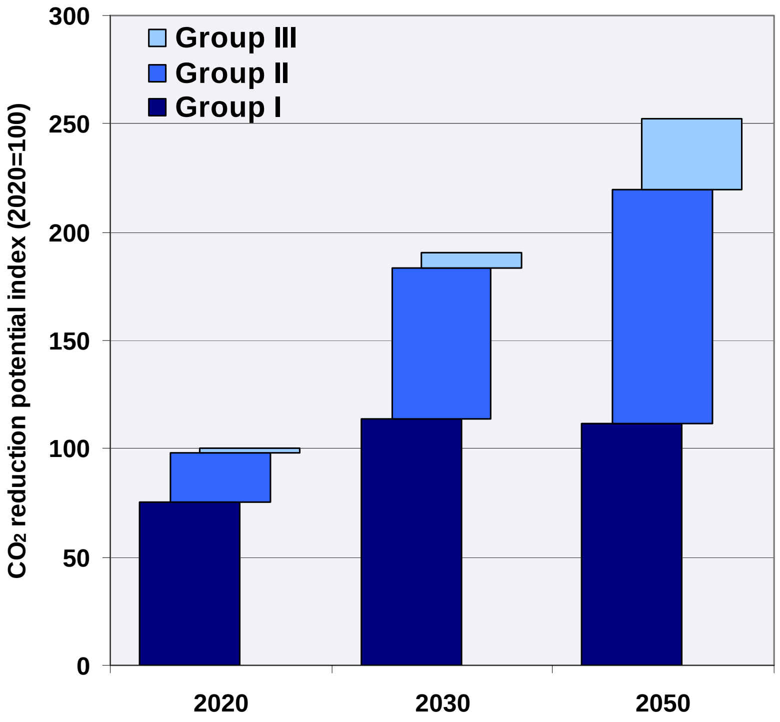
34 It is shown that an optimal set of differentiated RDD subsidies across industrial sectors in combination with an emission trading system (differentiating between CO2-intensive and non-CO2-intensive industries) both leads to a faster adoption of the CCS technology and is the most cost effective policy choice. However, it is also demonstrated that a directed RDD subsidy to CCS with an emission trading system would be more cost effective than the emission trading system alone, and lead to a somewhat faster take-up of the technology. The result is similar for an adoption subsidy, which would induce a much faster take-up of the technology, while still being more cost-effective than a situation with an emission trading system alone.

35 Assumes full auctioning with in ETS and recycling through transfers to households.

36 Scientific Reference System on new energy technologies, energy end-use efficiency and energy RTD

environmental benefits arising from the deployment of the different technology groups with respect to CO2 emissions are shown in the Chart 2 below.

Chart 2. Additional CO2 Reduction Potential Compared to the Baseline[37]



This graph reveals that each group of technologies will deliver its potential at different times due to their status of maturity. The achievement of the long term goals of the European energy policy requires a portfolio of technologies from all technology groups. Beyond 2030, the technologies in Group II have a potential for CO2 reduction equivalent to that of the technologies in Group I. Group III constitutes a necessary long term investment to fulfil the imperative of a sustainable energy system beyond 2040.

5.4. Assessment criteria

The revitalisation of the financing environment of RDD for the development of low carbon energy technologies will have a direct impact on:

- Competitiveness, investment flows and business operations:

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[37] This Figure shows the additional CO2 reduction potential to the baseline[37] (see EU energy and transport trends 2007, BAU scenario) that can be achieved at different time scales by each Technology Group, normalised to the 2020 potential. More specifically, an optimistic scenario for the deployment of each group of technologies until 2050 has been developed, based on the 2007 Technology Map – SEC(2007)1510- and recent inputs from stakeholders in the context of the preparation of the EIIs. The analysis was based on scenarios that have been developed for each technology individually and did not consider systemic effects. Therefore, it shows the theoretical maximum potential that can be achieved at a given time horizon. Part of it will be realised as the energy infrastructure evolves and system effects will enter into play. The CO2 emission reduction achieved by this scenario compared to the baseline was normalised by the CO2 emission reduction achieved in 2020.

– through the proposed revitalisation of RDD investment in the energy sector,

– the foreseen reallocation of investment to low carbon energy technologies

– the strengthening and possible modification of existing instruments and institutional arrangements, and

– the enhancement of the current investment cycle.

- Innovation and research in the energy sector:

  – through the promotion of a new innovation model in Europe capitalising on public-private risk sharing partnerships,

  – the strengthening of cooperation and joint funding structures between academic and industrial research,

  – the restructuring of technology and the research base of the energy system through the development and deployment of low carbon energy technologies.

For the purpose of this assessment, these impacts have been clustered into four main indicators (described in the table below), namely:

- mobilisation of financial resources, which reflects the ability of the policy option to increase RDD funding, both private and public
- suitability of financial instruments, which analyses how the instruments envisaged in a policy option match with the specific technology needs
- flexibility of implementation, which addresses the capacity of the policy option to adjust quickly to evolving trends
- effectiveness of financial instruments, which refers to the impact of the implementation of the policy option at system level

Our assessment of the various policy options with respect to each of these indicators will guide our determination of the most suitable option.

Mobilisation of financial resources	**Suitability of financial instruments**	**Flexibility of implementation**	**Effectiveness of financial instruments**
• Adequacy for financing technology needs • Financial flows to match infrastructure development needs • Stimulation of private investment	• Tailored to the type of innovation activities required for each technology. • Appropriate to the given innovation risk • Proportional to the level of actions and needs • Ability to engage all necessary actors	• Degree to which the institutional arrangements under the policy option are able to respond quickly and effectively to an altered environment.	• Stimulates the improvement and restructuring of the European innovation base • Increase of competitiveness of the European industry

5.5. Policy Option 0: BAU

5.5.1. Mobilisation of resources

Main Strengths

- The increase in investment levels will be left to the private sector, which would avoid cherry picking and would maximise competition between technology options.

Main Weaknesses

- Table 2 (section 2.4) highlighted a number of areas in which further financing is either necessary or desirable, but would not be provided under this option:
  - Further resources are required for all RDD and Innovation programmes.
  - Further resources are also necessary for all investment vehicles concerned with the financing of large scale demonstration projects.
  - Further resources are also necessary to aid the market replication of low carbon technologies, particularly through the innovation programmes, and venture capital and infrastructural funds.

5.5.2. Suitability of financial instruments

Main Strengths

- Diverse and well-established portfolio of instruments already in place that cover different aspects and types of innovation and scales of implementation (although these instruments differ in terms of the scope and scale of allocated resources for the same technology). A degree of instrument strengthening is proceeding in a number of Member States e.g., creation of a French Research demonstrator Fund to finance early stage of development of new energy technologies (€ 400 million).
- As shown in table 2 (section 2.4) the current level of co-ordination with regards to EIB Group instruments is both appropriate and adequate, (with the notable exception of large scale demonstration projects), thus helping to address the uncertainty and risk associated with long term investments.
- For technologies with a high degree of maturity and close to cost competitiveness (e.g. energy efficiency, on-shore wind, PV, etc), the instruments in place are effective, (albeit underfunded) with respect to the specific technology needs as indicated by their growing, but still insufficient, market shares.
- Diversity of programs capitalising on regional strengths and resources, hence tailored to the industrial preference and the increased regional character of the majority of low carbon technologies, e.g. energy efficiency, renewables, etc.

Main weaknesses

- Insufficient to mobilise and coordinate the necessary actors for large scale projects on technology and infrastructure that spans across countries or is used by several technologies, e.g. off-shore, CCS, H2 & FC.

- Limited consideration of dissemination of information across the EU, with concomitant effects on technology roll-out and hence partial exploitation of the benefits offered by the European internal market.

- Limited co-ordination of innovation and RTD programmes. In particular current transnational cooperation concentrates on a small number of MS with the highest spending.

- Diverse and uncoordinated administrative procedures; which fragment the market and add to the cost of high risk, capital/research intensive or information sharing programmes (a good example being the non harmonised IPR issues).

- Not having rigid partnerships allows the system to remain technology neutral while making temporal efforts where they have the greatest potential

5.5.3. Flexibility of implementation

Main Strengths

- The large numbers of relatively uncoordinated, independent instruments have demonstrated flexibility in response to a changing situation. Both the level of energy spending, and the framework in which it is conducted have changed significantly over the past few years,

- The EIB Group with its 50% increase in Energy lending as a response to the financial crisis showed its ability to adapt its implementation to the requirements of a given environment. In particular, the EIB Group has an established record of creating new instruments, when appropriate, in order to fulfil its objectives (e.g. RSFF).

Main Weaknesses

- Although the individual instruments can react relatively quickly and effectively to changing environments, they are incapable of doing so in a coordinated fashion.

5.5.4. Effectiveness of financial instruments

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.

- A significant (albeit insufficient) recent increase in the amount of resources and priority designated to energy related research. To the extent that the various EIB instruments are used, a significant higher leverage of the provided financial resources can be achieved as compared to only relying on RTD and innovation programmes.

Main weaknesses

- Duplication of efforts and sub-optimal use of research capital due to the absence of an integrated European innovation system 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.

- Continuous reliance on an innovation system for the energy sector that was not developed for a liberalised energy market.

5.6. Policy Option 1 (PO1):

5.6.1. Mobilisation of resources

Main Strengths

- The strengthening of the existing investment vehicles that brings about the doubling of annual RDD investments can bridge the financial gap for the development of low carbon technologies identified in Section 2.

- Sufficient pull of public resources to strengthen the incremental innovation needs of technologies through market replication, as well as to fund demonstration projects of technologies that are on the verge of commercialisation and hence are attractive for private investment.

- The increased public funding will stimulate private investment through soft partnerships to at least the same level, or higher for EIB Group activities, hence helping to generate the necessary critical mass for key projects.

- The increase in funding will improve technical assistance that will stimulate market take-up and generate further resources for EIB activities.

Main Weaknesses

- It seems unlikely that the existing instruments or soft partnerships can secure and focus their financial resources to the degree necessary to support very large scale RDD programmes over long time period.

5.6.2. Suitability of financial instruments

The strengths and weaknesses of this Policy Option in terms of coordination and implementation are the same as of the BAU Policy Option since no changes are foreseen in the instruments and arrangements used to finance projects.

That being said, the strengthening of the existing instruments by increasing budget and possibly enhancing cooperation through soft partnerships will reduce to a degree some of the weaknesses of the BAU policy option. In particular, the increased public funding combined with the development and sharing of common strategic research agendas and implementation programmes will stimulate and guide the mobilisation of industrial actors on large projects (e.g large demonstration projects for emerging and new technologies); and the increased resources ought to help both grant and financial instruments in compensating for the particular market failures towards which they are targeted.

Notice should be taken, however, of the fact that this policy option cannot guarantee the necessary coordination of European efforts and the implementation of common agendas over long time periods. On the other hand, not having rigid partnerships allows the system to remain technology neutral while making temporal efforts where they have the greatest potential, hence it provides a logic for shifting resources between technologies and over time according to the latest developments.

5.6.3. Flexibility of implementation

Main Strengths

Since no changes are foreseen in the institutional arrangements used to finance projects, the flexibility under BAU is maintained. However the possibilities to frame RDD activities with soft partnerships that do not require legislative proposals allow for a quick and flexible implementation of the strategic agendas of EIIs and joint RDD programming activities and any reallocation of efforts based on the achieved progress.

Main Weaknesses

Due to the soft nature of partnership envisaged, it is likely that implementation will occur at the project level hence not guaranteeing the coherence of the European efforts and the implementation of all necessary activities envisaged in the sector's work programme.

5.6.4. Effectiveness of financial instruments

The strengths and weaknesses of this Policy Option are the same as in the BAU Policy Option. The possibility of soft partnerships combined with the increase in funding delivered may stimulate the innovation chains of the identified key technologies and kick-start the reinforcement of the European innovation base. However, the extent that can be achieved by such soft measures may not be sufficient and comprehensive enough to bring about the necessary restructuring of the European innovation system to meet its long term challenges. As in all cases with increased public funding, there is a risk of "crowding out" or a situation in which public funding substitutes for rather than being additional to private funding.

5.7. Policy Option 2 (PO2):

5.7.1. Mobilisation of resources

Main Strengths

- In general the strengths of this Policy option are similar to PO1. In this case however due to the combination of having strong public and private partnerships and increased public funding resulting from the strengthening and modification of the institutional arrangements, the risk aspect for large scale technology and infrastructure development projects for new and emerging technologies is better addressed and hence such projects become even more attractive to private investment. A recent example is the FC & H2 JTI.

- The establishment of a specific mandate for the EIB to invest in infrastructural funds might result in an increased degree of security and increased investments over that which would be the case under PO1.

- The re-establishment of the Capacity Building Scheme (in particular Partnership Action) will increase the capacity of venture capital funds to deal with eco-innovation projects and should thereby increase the amount of funding generated for these projects.

Main Weaknesses

- It is expected that there will be possible investment crowding effect for technologies with an industrial chain ready to absorb the increased investment (such as CCS, wind or solar) at the detriment of others with a more emerging supply chain (e.g. ocean and geothermal). In addition, in view of the difficulty to establish and dismantle institutional arrangements, it will take time to reallocate financial resources due to the shifting of priorities, as may be deemed necessary on the basis of the monitoring framework.

5.7.2. Suitability of financial instruments

Main Strengths

- The modified institutional arrangements allow for strengthening the coherence and the leverage of market replication type of activities in confronting the uncertainty and risk associated with new technologies (although acting at the European level may not be the optimal implementation mechanism to account for regional specificities). In particular, stronger links between the EIB and the SET Plan Steering Committee could allow for increased mutual contributions from both European and National institutions, who through focussing their resources on specific objectives could thereby increase their combined leverage.

- Technology-focused partnerships formed under a coherent implementation framework and legal base help to ensure that the innovation requirements of those emerging and new technologies are met, even when environmental externalities and other market failures lead to a need for significant cross-sector and international support.

- The proposed instruments and arrangements respond to the needs of funds with shortage of experience and risk analysis capability in the specific sector of low carbon technology SMEs. They should help to increase funds capability to reach those SMEs, and thereby increase the effectiveness of public interventions in the venture capital sector.

Main weaknesses

- Compromises may have to be made for the agreement of investment between technologies.

- The formation of industrial partnerships in PPPs may be inhibited due to competitive issues and pervasive know-how monopolies, hence hindering economies of scale and leverage effects.

- The creation of further levels of organisation will absorb a degree of time and energy while being founded; and could possibly add further complexity and rigidity to the overall institutional structure.

- The modification of institutional arrangements linked to a regulation will take time delaying the innovation process.

5.7.3. Flexibility of implementation

Main Strengths

- Due to the strong nature of partnership envisaged, implementation will occur at the programme level hence ensuring the coherence of the European efforts and the implementation of all necessary activities envisaged in the sector's work programme over the necessary timeframe. This policy option has some flexibility within each technology programme with respect to the allocation of resources to activities to better match the evolving maturity level.

Main Weaknesses

- Having legal based partnerships focusing on single technologies will create rigidity for shifting resources and priorities as could be necessary, based on the progress of technology development.

5.7.4. Effectiveness

Main Strengths

- The combination of increased resources, strengthened coordination and strategic steering can accelerate the delivery of technologies, hence ensuring the competitiveness of the European industry on a global scale.

Main weaknesses

- It is possible that centralisation and increased co-ordination at a European level could lead to the stifling of regional and local creativity and innovation.
- The need for consultation liaison and agreement, with decision making authority being spread over a large number of bodies may lead to initially slow and cumbersome responses to crises or opportunity.
- The funding which can be distributed under the Capacity Building Scheme is limited by competition law, and will, therefore, be restricted to a relatively limited impact.

5.8. Policy option 3 (PO3):

It should be noted that this option proposes both new institutions (with respect to energy research and innovation) and a new EIB Group structured action channelling funding from a variety of sources to support large scale demonstration projects. This option, therefore, contains two different but complementary proposals and for that reason the analysis has been split; although it should be noted that many of the points are relevant to both sets of instruments.

5.8.1. Mobilisation of resources

Main Strengths

Innovation and energy research:

- Same as in PO2, however a reinforced public (Community, intergovernmental, EIB, etc) institutional base at European level addressing technologies and infrastructure can facilitate the provision of very large amounts of investment when required, such as for CCS, nuclear fission-Generation IV and off-shore grid.

- The setup of Community bodies will ensure strong financial commitment to technology priorities for which the EU added-value is maximised.

- Intergovernmental bodies may be the most suitable vehicle to attract financial resources from public and private national bodies from Member States interested and committed in the development of a specific portfolio of technologies.

EIB Group financing:

- A specific and dedicated EIB structured action may be the most appropriate vehicle to attract large amounts of financing from its partner organisations alongside EIB resources.

Main Weaknesses

- It may be difficult to rise the necessary funding for the proposed structure(s) to execute their mission due to competition for resources with the existing national and European programmes and organisations. In particular, Member States may be less willing to delegate financial resources to an external organisation (or action), than they would be to a partnership within which they played a significant role.

5.8.2. Suitability of financial instruments

Main Strengths

Innovation and energy research

- Large scale technology and infrastructure demonstration programmes are best implemented through the centralised structure(s) due to the provision of enhanced level of steering, critical mass of actors, and economies of scale for implementation.

- Centralised structures with a broad technology portfolio can facilitate the necessary coherence and balance of RDD activities and provide the necessary support to accompany the shift of the European industry towards new and emerging technologies with an inherent element of risk.

- Direct transposition of policy objectives into a visible strategy and action plan through a dedicated European structure for RDD and innovation ensures coherence between policy objectives, technology development and funding.

- The increased level of coordination of grants and loans within a clear policy framework may well ensure improved targeting of resources so as to address the most severe market failures, above all helping to address the high costs associated with basic research, and the helping to mitigate for the impact of environmental externalities.

EIB Group

- EIB leadership and organisation of the structured action will ensure a large degree of coherence between the activities of the various actors, and EU policy objectives.

- The participation and close coordination of EIB and partner capital should ensure the necessary level of coordination on large scale projects, and the ability to alter priorities as appropriate.

Main weaknesses

Innovation and energy research

- A centralised structure for RDD and innovation which supports mainly large demonstration and infrastructure projects is not necessarily suitable to meet the innovation needs of all low carbon technologies.

- 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 RDD and innovation organisation to adjust its priorities as required, could cause market distortions, and may lead to restrictions on the activities of smaller more innovative institutions.

- Unless the interfacing and integration with existing programmes is established via the statute of the newly formed organisation for RDD and innovation, there is a risk of the latter becoming an additional organisational layer with no clear positive impact on the optimisation of the current innovation process.

- Subsidiarity concerns may limit the scope of action of the centralised structure(s), as research and innovation is a shared competency between the Member States and the European Union.

- Community bodies that address a limited number of technologies may lead to favouritism over long times due to their institutional character.

- The setup of new centralised structures may require significant amount of time since it will be subject to subsidiarity issues and will require long periods for negotiations, decisions and implementation, hence delaying the innovation process.

EIB Group

- The continued need for partnership with other actors in the case of the EIB structured action might lead to a relatively slow and complex decision making process.

5.8.3. Flexibility of implementation

Main Strengths

Innovation and energy research

- New Community bodies that consider a set of technologies can allow shifting of priorities according to the latest technology and policy developments.

- The Intergovernmental approach is flexible as it is tailored to the willingness and commitment of partners with common interests to advance specific technology developments with respect to their energy mix.

EIB Group

- The EIB structured action is a flexible vehicle that is able to respond rapidly to meet the needs of a wide variety of different technologies

Main Weaknesses

- Having strong institutional bodies focusing on single technologies will create rigidity holding back the necessary reallocation of resources and priorities in response to technological and market developments.

5.8.4. Effectiveness

Main Strengths

Innovation and energy research

- Intergovernmental structures spearhead the innovation change based on the willingness of a few Member States hence meeting short term targets (industrial competitiveness, EU goals) while they can expand to allow more Member States to join hence propagating this new impetus for innovation.

- A common monitoring mechanism embedded in the centralised structure and 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 RDD, demonstration and business support, and, (iii) promotes synergies between technology options.

- EIB Group

- The continued provision of funding for the EIB structured action through competitive calls for proposals will help secure the most competitive and effective means to achieve European policy goals.

- The EIB structured action can best combine the skills and expertise of the EIB with those of its partner organisation towards this achievement. It would also be flexible in creating new mechanisms to address the rapidly changing environment for the financing of low carbon technologies.

Main weaknesses

- As explained above, such an institutional arrangement can best support only a limited number of technologies and industries, those requiring large up-front investment and the coordination of a large number of actors.

6. COMPARING THE OPTIONS

The strengths and weaknesses of each indicator for every policy option 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.

6.1. Methodology

The evaluation of policy options is performed for each Technology Group as defined in Chapter 2. This evaluation relies on a qualitative grading of each indicator, on a scale from (-) to (++), based on a comparison to a BAU, which by definition is set to (0). More specifically: The **BAU** refers to the process of financing low carbon technologies as it stands today. This entails:

– *Mobilisation of financial resources:* There is funding available, however not sufficient to bridge the gap required to make all low carbon technologies well performing and cost-competitive. Although private investment is increasing, the coverage of risk associated with most of these technologies is insufficient and deters the required boost of private investment.

– *Suitability of financial instruments*: Although there is currently a portfolio of financial instruments and institutional arrangements that address different innovation schemes and market failures, they neither cover the needs of all technologies in terms of scope, coherence and magnitude, nor address the market failures driving the financial gap. A particular problem is mitigating for the significant risks faced by new and emerging technologies which in many cases require large investment and the mobilisation of a significant number of actors.

– *Flexibility of implementation*: There is some flexibility to adjust financial flows to evolving technology needs however, there are limitations to shifting priorities and building critical mass at the scale required to advance the low carbon energy technology portfolio.

– *Effectiveness of financial instruments*: The current financial support to low carbon technologies is fragmented and hence is not able to deliver technologies at the right pace, with detrimental effects to European industrial competitiveness.

- A (++) grade is granted when the indicator for a given policy option provides a significant improvement to the financing environment.

- A (+) grade is granted when the indicator for a given policy option provides satisfactory improvement compared to the BAU.

- A (0) grade is also granted when no decisive impact is made.

- A (-) grade indicates a possible deterioration compared to BAU

Grading

6.1.1. Technology Group I: Technologies close to market competitiveness

It is remembered that this group of technologies requires mostly market replication measures with supporting RDD to lift the last bottlenecks to competitiveness and spear the development of improved generations, accompanied by the adaptation and reinforcement of the existing infrastructure. Furthermore, a critical factor is the need to tailor innovation measures to market conditions. The industrial fabric is heterogeneous, ranging from large corporations to SMEs, with a rather well-established supply chain.

Mobilisation of financial resources

The BAU Policy Option is granted (0) by definition.

The increase in financial resources proposed in **Policy Option 1** meets the requirements of the technologies of Group I. Furthermore, funding for the adaptation of the infrastructure is adequate, and the proposed increase of public funding should trigger further private investment. Some problems may occur due to the currently limited co-ordination of innovation instruments. As a consequence a grade of (+) is granted.

Since **Policy Option 2** has broadly similar characteristics to PO1 with regards to the mobilisation of financing. The refocusing of the Capacity Building Scheme, the new innovation instruments and approaches under CIP, and the establishment of a specific mandate for infrastructural funds under the EIB Group might be expected to mobilise further funding for market replication activities, however. Hence, this Policy Option is granted (++).

Policy option 3 has the same attributes with respect to funding. Centralised structures might better secure better necessary funding, however, the associated centralised administrative character of this Policy Option may deter or delay private investment for the technologies in Group I. On the other hand, the centralised authority of PO3 may be more efficient than the distributed authority of PO2, since, sometimes a rigid hierarchical structure can be more effective and fast moving than a committee. Hence, a grade of (+) is given.

Suitability of financial instruments

Policy Option BAU is granted (0) by definition.

The existing instruments**,** envisaged in **Policy Option 1**, match to a certain extent the innovation requirements of these technologies. Their industrial base is already developed and mostly requires further and targeted financial assistance in mitigating the risks and uncertainties associated with new technology. This Policy Option is granted (+).

The strength of **Policy Option 2** lies on the provision of a stronger coordination and the extension of the remits and eligibility of the existing instruments, which match quite well with the needs of the industrial fabric of this Technology Group. In particular, a stronger coordination and the concentration of innovation resources can have a positive impact on infrastructure development; whilst stronger linkages between the EIB Group and the SET Plan steering committee could result in more appropriately targeted funding, and aid in demonstrating the bankability of these technologies. This Policy Option is granted (++).

Policy Option 3 does not bring any clear added-value for this Group of technologies due to the strong regional character of some technologies and the need for considering different scale of projects and market status of actors, except possibly for the adaptation and reinforcement of infrastructure. Hence, it is granted (0).

Flexibility of implementation

Policy Option BAU is granted (0) by definition.

The possibility to setup soft partnerships in **Policy Option 1** that do not require legislative proposals maintains the flexibility of BAU. Furthermore, it allows for a flexible and quick implementation of sector strategic agendas and the reallocation of efforts based on progress monitoring. This Policy Option is granted (++).

Policy Option 2 will create rigidity for this Group of technologies, for which activities need to respond quickly to evolving market trends. This Policy Option is granted (-).

Policy Option 3 brings additional inflexibility due to its strong centralised character, hence does not offer an added-value for this Group of technologies. Hence, it is granted (-).

Effectiveness of financial instruments

Policy Option BAU is granted (0) by definition.

Policy Option 1 makes the most of the existing innovation system hence is already operational. In view of the needs of the technologies in this Group with regards to overcoming the initial barriers to market deployment, the increase in financial resources complemented by the possibility to develop soft partnerships should be sufficient to significantly mitigate for technological and regulatory risk, accelerate and deliver cost competitive technologies. This Policy Option is likely to boost the competitiveness of the industries around these technologies. This Policy Option is granted (++).

The advantage of **Policy Option 2** lies in its ability to strengthen the industrial supply chain by aligning the available resources with strategic planning through strong partnerships. A concern could be the comprehensiveness and the complexity of the envisaged arrangements with respect to a diversified industrial fabric, spanning from large utilities to SMEs. It is uncertain whether this option will bring significant improvement in terms of speeding up the roll-out of technologies to the market. This Policy Option is granted (+).

The institutional centralisation of innovation activities in **Policy Option 3** may cause some delays in the delivery of cost-competitiveness due to the time required to create new institutional arrangements. It brings the restructuring of the European innovation system, however it is questionable how necessary this is for this group of technologies. Nonetheless, there may be some added value regarding infrastructure issues. This Policy Option is granted (0).

The scores for Technology Group I are summarised in the Table below.

	Mobilisation	**Suitability**	**Flexibility**	**Effectiveness**
BAU	**0**	**0**	**0**	**0**
PO1	+	+	++	++
PO2	++	++	**-**	+
PO3	+	+	**-**	**0**

6.1.2. Technology Group II: Technologies close to market competitiveness

It is reminded that this group of technologies requires large scale demonstration programmes to prove their commercial viability, along with RDD support to pursue their development. The industrial fabric comprises mainly large corporations with further consolidation expected.

Mobilisation of financial resources

The BAU Policy Option is granted (0) by definition.

The increase in resources proposed in **Policy Option 1** meets the financial requirements of large scale projects as needed by the technologies of Group II. Furthermore, the funding for the development of new infrastructure is adequate; however, problems may arise due to lack of guarantee for the sustainability of funding and of strong coordination which is needed for this type of technologies. Finally, the proposed increase of public funding will reduce the risk perception for private investment. As a consequence a grade of (++) is granted.

Policy Option 2 has similar characteristics with Policy Option 1 with regards to the mobilisation of financing. Funding for large technology and infrastructure demonstration projects, so as to overcome the large uncertainties surrounding these technologies, will be easier due to an increased coordination at a European level. Hence, this Policy Option is granted (++).

Policy option 3 has the same attributes with respect to funding with PO2. Centralised structures can secure the necessary funding and match the scale of actors and projects involved. Hence, a grade of (++) is given.

Suitability of financial instruments

Policy Option BAU is granted (0) by definition.

The existing instruments and the possibility for soft partnerships**,** envisaged in **Policy Option** 1 can meet part of the requirements for this group of technologies. Nevertheless, the technological risk involved and the magnitude of investments necessitate a more sustained and coordinated approach, involving different instruments and greater public participation than is the case for technology group 1. This Policy Option is granted (+).

Policy Option 2 brings both stronger coordination and the development of a coherent and all-inclusive framework better able to mobilise the requisite financing and absorb the risks integral to the research and demonstration work. The strong public-private collaborative character of this Policy option, from joint programming for research to coalitions for demonstration projects, echoes the driver for the development of these technologies, which is currently more policy than market driven. Technology risk is reduced due to the involvement of a critical mass and the stronger engagement of the public sector. The need for economies of scale for the development of these technologies, is fulfilled. It is however noted that strong partnerships may require time for their setup, delaying the innovation process. This Policy Option is granted (++).

Implementing **Policy Option 3** is not necessarily proportional to the needs of all technologies in Group II. It is best suited to technologies that require very large scale technology and infrastructure demonstration projects. For these technologies, this framework of implementation can stimulate the formation of partnerships, and it is uncertain whether further coordination would bring significant improvement. In addition, this policy option may require significant amount of time to be setup since it will be subject to subsidiarity issues and will require long periods for negotiations, decisions and implementation. Hence, it is granted (+).

<u>Flexibility of implementation</u>

Policy Option BAU is granted (0) by definition.

The possibility to setup soft partnerships in **Policy Option 1** allows for a flexible and quick implementation of sector strategic agendas and the reallocation of efforts based on progress monitoring. However at the detriment of the required stability and sustained RDD commitment which are essential for these technologies. This Policy Option is granted (+).

Policy Option 2 may cause some rigidity with regards to shifting resources between technologies as may be necessary. However, this Policy Option will allow flexibility of activities within a coherent and stable strategic framework of implementation, which is essential for this group of technologies. This Policy Option is granted (++).

The new centralised structures in **Policy Option 3** m may create rigidity for shifting resources and priorities as could be necessary, based on the progress of technology development. However, a centralised structure that addresses a portfolio of technologies will be able to accelerate technology development by allowing the shift in priorities according to the latest technology and policy developments. Hence, it is granted (+).

Effectiveness of financial instruments

Policy Option BAU is granted (0) by definition.

Policy Option 1, through increased financing, technical assistance and coordination resulting from soft partnerships, will bring improvements in accelerating technology development, yet it is questionable if this Policy Option will be able to address all technology challenges which require sustained effort over long periods of time along with a clear strategy at a programme level. This Policy Option is granted (+).

Policy Option 2 brings about the necessary restructuring of the innovation system through a degree of coordination to accelerate the development of the concerned technologies and mitigate for the market failures which would otherwise result in sub-optimal research expenditure. It is clear that, although some delays can be expected for the modification and setup of institutional arrangements, this option through the EIB link with the SET Plan Steering committee, and the improved co-ordination of research and innovation instruments, unlocks a major weakness of the current system. This Policy Option is granted (++).

Policy Option 3 is best suited for very large scale technology and infrastructure projects, having a strong positive impact on the industrial fabric of these technologies. However, since a centralised organisation risks stifling creativity and increasing organisational complexity, it is not necessarily beneficial for all technologies within this group. As a result, this Policy Option is granted (+).

The scores for Technology Group II are summarised in the Table below.

	Mobilisation	**Suitability**	**Flexibility**	**Effectiveness**
BAU	**0**	**0**	**0**	**0**
PO1	++	+	+	+
PO2	++	++	++	++
PO3	++	+	+	+

6.1.3. Technology Group III: New Technologies

These technologies require strong RDD and pilot/demonstration activities to be tested under market conditions and to prepare the ground for large scale roll-out. These technologies in most cases are developed by innovative SMEs, under contracts by large industrial players and public research centres.

<u>Mobilisation of financial resources</u>

The BAU Policy Option is granted (0) by definition.

The increase in financial resources proposed in **Policy Option 1** meets the requirements of the technologies of Group III. Considering that this policy option does not foresee JTIs, with the exception of hydrogen and fuel cells that has already been formed, the main issue is to commit and sustain financing for all these technologies with broadly consented multi-annual strategies. This is critical in view of the fact that these technologies have a long term prospect and carry significant technological, market and financial risks. As a consequence a grade of (+) is granted.

The increased financial resources envisaged in **Policy Option 2** meet the requirements of these technologies. Furthermore, the coupling of increased funding with the enhanced coordination under which, multi annual strategies can be consented and pursued makes this Policy Option suitable for triggering public and private investments. Hence, this Policy Option is granted (++).

Policy option 3 has the same attributes with the above option with respect to funding. The centralised institutional approach can secure the necessary funding over the long term period required for the development of these technologies. Hence, a grade of (++) is given.

Suitability of financial instruments

Policy Option BAU is granted (0) by definition.

The existing instruments**,** envisaged in **Policy Option 1**, are in many cases, insufficient for technologies in Group III. These technologies carry significant risks, due to the combined effects of large requirements for RDD and early demonstration, and an emerging industry. Although EIB Group debt financing might be capable of financing such risks, it is uncertain that any other instrument would be able to guarantee the required programme level approach for a sustained period of time. As a result this Policy Option is granted (0).

The strength of **Policy Option 2** lies on the provision of legally bound joint RDD programming, the support to innovative SMEs and funds for prototype and infrastructure demonstration which matches the needs of these technologies. This option allows for a strong public intervention in the development of technologies, which reduce the innovation risk linked to their long term market prospective. The European dimension embedded in this policy option is proportional to their future market perspectives. Finally this policy option establishes a pan-European framework to engage all relevant actors. This policy option is granted (++).

Policy Option 3 combines the positive elements of PO2 with a more focused and secure framework for investment in innovation, needed for the development of this type of technologies. The danger, as associated with every large bureaucratic organisation is of locked in policies, operational complexity, and frameworks which stifle rather than abet innovation. Hence, this policy option is granted (++).

Flexibility of implementation

Policy Option BAU is granted (0) by definition.

The possibility for soft partnerships in **Policy Option 1** does not improve significantly the environment for the development of technologies compared to BAU. It contains some flexibility of implementation of sector strategic agendas and the reallocation of efforts based on progress monitoring, however due to the upstream nature of these technologies more stable frameworks are needed. This Policy Option is granted (0).

Policy Option 2 will create the necessary stable framework to build up an industry, perform the necessary RDD activities and avoid shifting resources to other technologies with shorter pay-back time in times of resource constraints. This Policy Option is granted (++).

Policy Option 3 brings the necessary stability due to its strong centralised character, hence does offer an important added-value for this Group of technologies, however it may prove too rigid when there is a future need to adjust radically priorities and resources. Hence, it is granted (+).

Effectiveness of financial instruments

Policy Option BAU is granted (0) by definition.

Policy Option 1 as explained above, although it increases the financing, does not contribute to the acceleration of delivery of the technologies in Group I. This Policy Option is granted (0).

The strength of **Policy Option 2** is the provision of a broad portfolio of instruments, available in a flexible manner that is essential during the building phase of an emerging industry. The proposed scheme can bring about the necessary changes to the innovation system, allowing for the development of these technologies. Although some delays can be expected for the modification and setup of institutional arrangements, these may have a limited impact in view of the time scale for technology development. This Policy Option is granted (++).

Policy Option 3 is suitable only for technologies with a very intensive RDD programme. In this case, the required preparation time of these RDD programmes allow for the setup of new institutional arrangements. This option having enhanced decision making mechanisms can have a strong influence on the restructuring of the European innovation system regarding long term technologies, hence positioning the European industry in the market of new technologies. This Policy Option is granted (+).

The scores for Technology Group III are summarised in the Table below.

	Mobilisation	**Suitability**	**Flexibility**	**Effectiveness**
BAU	**0**	**0**	**0**	**0**
PO1	+	**0**	**0**	**0**
PO2	++	++	++	++
PO3	++	++	+	+

6.2. Summary of the comparison

The comparison of the policy options brings out the following key aspects:

- Policy Option 2 emerges as a universal option that could be suitable for all three technology groups;
- Policy Option 1 (or parts thereof) could be suitable for Group 1 technologies (close to market competitiveness);
- Policy Option 3 (or parts thereof) could be suitable for Group 3 technologies (new technologies).

This assumes an equal weighting given to all the assessment criteria. It furthermore does not include the possibility of adopting hybrid structures integrating proposals contained under different policy options. It is clear, however that, in reality, some criteria may turn out to be more important than others (particularly where the element of time is crucial and taking political factors in consideration), and that hybrid options may be considered where appropriate.

6.3. Recommendation

The first recommendation emerging from the assessment is that achieving the objectives of this policy requires significantly increased resources. A provisional estimation of the resources necessary to effectively implement this policy, maintaining the desired broad and neutral technology portfolio, reveals the need to double the current level of investment.

But, this should be combined with new approaches to implementation. Although it would be possible to recommend solely PO2, it remains the case that different technologies are in different stages of development and face different financing challenges intrinsic to the nature of the technology, the sector structure and the market conditions. The multidimensional nature of this policy leads us to recommend a combination of the assessed policy options.

At the present time it is absolutely crucial to realise the short term potential of technologies within Group 1 (close to market) notably energy efficiency. For a number of these technologies it might be appropriate to implement PO2. In particular, establishing new institutional arrangements to greatly expand the market replication activities of the CIP or new partnerships/structures to change the current paradigm of investment in e.g. energy efficiency activities which are by their very nature highly dispersed and fragmented, due to the multiple market actors and customers.

For other technologies in Group 1 and in Group 2 (emerging technologies), and given the urgency to act quickly, there is a strong argument for a hybrid policy option, combining PO1 and PO2. An immediate start with PO1 is therefore recommended, with a subsequent migration towards PO2 and/or PO3 were the changes put into place not to deliver the necessary acceleration of technology development or if the involved actors were to develop a particular interest in stronger and more stable partnerships. The degree of migration may of course vary depending on the technology and investment vehicles concerned.

With regards to Group 3 (new) technologies, it should be noted that some already benefit from the sort of dedicated institutional arrangements proposed under PO2 (the joint undertaking established under EURATOM for the implementation of ITER and the Joint Technology Initiative for Fuel Cells and Hydrogen). The development of Generation IV nuclear fission reactors could also benefit from PO3.

The European Commission is already working jointly with industry, the research community and Member States to establish European Industrial Initiatives and the European Energy Research Alliance (new institutional arrangements). Similarly the EIB Group, in concert with the Commission, has and will continue to explore the possibilities offered by new and innovative instruments. In order to effectively implement these varied actions, however, the mobilisation of additional resources will be essential.

7. MONITORING AND EVALUATION

The proposal for financing low carbon technologies contains provisions for the periodic evaluation of its activities. The purpose is to ensure that the necessary financial resources are mobilized and are most efficiently used for the development of low carbon technologies and the improvement of their cost competitiveness and marketability. To this end, and in view of the fact that flexibility of implementation is a key element for the timely deployment of low carbon energy technologies, financing activities and its results should be monitored on a continuous basis, with independence and objectivity.

The proposed financing effort will benefit from the SET-Plan monitoring and evaluation information system (SETIS), which has recently been established. SETIS is operated by the EU's Joint Research Centre (JRC), which secures its independence and objectivity. In particular, the monitoring of financial research investment in low carbon energy technologies will be done continuously and reported periodically in the Capacities Map published by SETIS. Similarly, the impact of research financing on technology development and deployment will be closely monitored by SETIS on a continuous basis, and its analysis will be published bi-annually in the Technology Map. In addition, technology developments performed under the SET-Plan umbrella, through the European Industrial Initiatives or other programmes in the context of the European Energy Research Alliance will be reviewed periodically by SETIS based on Key Performance Indicators (KPIs) that address both the technology and the sector. These KPIs will be devised jointly by SETIS and stakeholders as part of the process for the conception and definition of corresponding SET-Plan activities. Typically, KPIs will address costs and performances of technologies.

The continuous monitoring of financing and technology development activities, performed by SETIS will enable the evaluation of the measures proposed in this Communication and the identification of corrective measures if needed. It will ensure the pursuit of a portfolio approach with a set of technologies at various stages of technological development, in view of reaching our energy policy goals and strongly linked with innovation policies. It does not create new layers of bureaucracy; it will instead create greater communication, transparency and coherence to approaches and decisions to support technologies and their differing stages of innovation. In addition, it will provide the Community with unbiased information to allow strengthening efforts in the most promising areas while avoiding 'lock-ins', satisfying the required neutrality in supporting the development of low carbon technologies to achieve the policy objectives.

ANNEXES

ANNEX I: The SET-Plan Technology Challenges

The SET-Plan identified a series of key challenges that need to be addressed in the next 10 years, not only to meet the 2020 targets, but also to ensure that the EU is on track to address the 2050 ambition of reducing green house gas emissions by 60-80%.

Achieving the 2020 targets

Key EU technology challenges for the next 10 years to meet the 2020 targets:

– Make second generation biofuels competitive alternatives to fossil fuels, while respecting the sustainability of their production;

– Enable commercial use of technologies for CO2 capture, transport and storage through demonstration at industrial scale, including whole system efficiency and advanced research;

– Double the power generation capacity of the largest wind turbines, with off-shore wind as the lead application;

– Demonstrate commercial readiness of large-scale Photovoltaic (PV) and Concentrated Solar Power;

– Enable a single, smart European electricity grid able to accommodate the massive integration of renewable and decentralised energy sources;

– Bring to mass market more efficient energy conversion and end-use devices and systems, in buildings, transport and industry, such as poly-generation and fuel cells;

– Maintain competitiveness in fission technologies, together with long-term waste management solutions;

Achieving the 2050 vision

Key EU technology challenges for the next 10 years to meet the 2050 vision:

– Bring the next generation of renewable energy technologies to market competitiveness;

– Achieve a breakthrough in the cost-efficiency of energy storage technologies;

– Develop the technologies and create the conditions to enable industry to commercialise hydrogen fuel cell vehicles;

– Complete the preparations for the demonstration of a new generation (Gen-IV) of fission reactors for increased sustainability;

– Complete the construction of the ITER fusion facility and ensure early industry participation in the preparation of demonstration actions;

- Elaborate alternative visions and transition strategies towards the development of the Trans-European energy networks and other systems necessary to support the low carbon economy of the future;
- Achieve breakthroughs in enabling research for energy efficiency: e.g. materials, nano-science, information and communication technologies, bio-science and computation.

ANNEX II: Potential of low carbon energy technologies

The graph in Section 2.2 is a mapping of the potential of low-carbon energy technologies over the next fifty years. It attempts to answer three inter-related key questions:

- When a set of technologies could be considered as "established" to become a "relevant" option for the energy sector?
- How challenging is the development and deployment of the technologies?
- What is the relative potential of the technologies?

It is based on the findings of the Technology Map[38], but also includes recent inputs from stakeholders in the context of the preparation of the EIIs and the potentials of energy efficiency measures in end-use sectors as described in the Energy Efficiency Action Plan.

For each technology, the maximum potential, on a final energy basis, is indicated by the size of the corresponding circle. The colour shading differentiates between the maximum potential expected to be exploited in the business-as-usual (BAU) scenario[39] (light coloured part of the circle) and the remaining potential that could be exploited provided that sufficient RDD support is given. The level of exploitation of the additional potential of each technology, as well as its timing, could be assumed as the SET Plan leverage effect. An exception to this presentation format is energy efficiency (in transport, buildings and industry). In this case, the size of the circle represents only the savings potential, which is additional to the baseline[40], calculated based on the potential identified in the Energy Efficiency Action Plan[41]. The relative position of each technology on the **Time Horizon axis** indicates the approximate time period when a specific technology or set of technologies are expected to become a tangible option for the energy sector. The **Challenge for Implementation** axis indicates in relative terms how demanding the development and deployment of a given technology is with respect to other technologies within the same time period.

It is noted that for graphical purposes, the energy potential, indicated by the size of the circles, is shown in a static way and does not evolve over time. In reality the exploitation of the potential is dynamic and can not be captured "over night". A conical shape would have been more appropriate, but more difficult to graphically represent in a 2D space. Therefore, the exploitation of the potential of each technology over time is embedded also in the deployment "waves". For instance, wind technologies, considering their current market penetration and growth rates can be assumed as a nearly established technology stream, therefore belonging to short-to-medium timeframe. However, its maximum potential, including off-shore technologies, will not be captured before the medium term horizon. Consequently, wind technologies belong graphically to the first technology wave, with its maximum potential being shown at that time horizon. However, as indicated by the waves and its relative position on the y-axis, wind potential will not be exploited completely within this time frame and requires further efforts and development. The same rational could be use to explain the

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38 SEC(2007)1510

39 Derived from the EU Energy and Transport Trends 2007, "Business as usual scenario"

40 This is done for presentation reasons, since the total energy savings due to energy efficiency (BAU and additional) are larger than the energy potential of other technologies, hence the corresponding circle would mask the potential of other technologies presented in this graph.

41 COM(2006)545.

relative position of current nuclear fission technologies and generation IV nuclear reactors that have different time horizons.

ANNEX III: Criteria for the grouping of low carbon technologies in this Impact Assessment

Each low carbon technology faces its own technology challenges, which requires specific research and innovation efforts. The Technology Map[42] of the SET-Plan describes all those in detail. However, there are commonalities between technologies. In the context of this Impact Assessment, these technologies have been grouped into three families based on their common positioning in the innovation cycle and their requirements for advancement through the innovation chain. These groups constitute a qualified simplification enabling analysis of the policy options, yet without jeopardising the quality of the assessment. This characterisation of technologies is based in best available information, however it should be noted that technological breakthroughs or strong regulatory measures could significantly change the suggested grouping.

It is accepted that technologies within the same group may require different types of funding. However, it is thought that further specification of appropriate funding for each individual technology within a group would be undesirable as it would introduce unnecessary inflexibility into the operations of the SET-Plan and make the analysis overcomplicated. The toolbox approach allows each technology within a group to select the source which is most appropriate to it from within a range of available sources. Different technologies will require different funding, but this is best dealt with at this stage by implementing monitoring through the SET-Plan information system and retaining a sufficient degree of flexibility within the system to respond to changing circumstances. For this reason the flexibility of the instruments used was one of the criterion used in the analysis.

These technology groups were formed by applying the following criteria and are described below.

A. Technological maturity, reflected on the timing of mass market deployment

(1) Short to Medium (2010, 2020+)

(2) Medium to Long (2020 to 2035)

(3) Long term (> 2035)

B. Technological innovation needs

(1) Market replication/early commercialisation

(2) Large scale demonstration, coupled with RDD to remove competitiveness bottlenecks

(3) RDD programmes to mature the technology and large scale pilot/demonstration

C. Implementation in the existing energy infrastructure

(1) compatible with the current energy infrastructure

(2) adaptation/reinforcement of the energy infrastructure needed

42 SEC(2007)1510

(3) development of new infrastructures and/or new industry required

ANNEX IV: The SET-Plan at work

The implementation of the SET-Plan begun officially in June 2008 with the launch of the Steering Group. The SET-Plan proposes new institutional arrangements to render the European research and innovation system more efficient. Within the framework of these arrangements, industry, the research community, the Commission and Member States are working together to define their common objectives and activities, as well as to assess the financing needs.

The European Industrial Initiatives are ambitious industry-led programmes established as public-private partnerships which aim to change the prevailing philosophy and strengthen industrial energy research and innovation in a cost-effective way. They will focus, rationalise and when needed increase the efforts of industry, the financial sector, the Community and the Member States to collectively achieve concrete technological objectives.

Initially six sectors for EIIs are: CCS, wind, solar, bioenergy, the electricity grid and nuclear fission; all of which have corresponding European Technology Platforms containing industry specific visions and strategies. Discussions have been initiated across all sectors (mainly through the corresponding Technology Platforms) seeking to establish an effective implementation of those strategies through the EIIs.

The Commission is working with research centres to establish the European Energy Research Alliance (EERA). The mission of the EERA is to strengthen, expand and optimise EU energy research capabilities though the sharing of world-class national facilities in Europe and the joint realisation of pan-EU programmes. The first step is the amalgamation of existing research resources into joint activities, thereby building experience and trust through a learning-by-doing approach. Once the structures and capacities are in place the Alliance will become a powerful force in the energy research landscape and will be capable of delivering the knowledge and technologies needed; for this, it will require increased funding.

ANNEX V: Financing instruments

This section will aim to expand on section 2.5, outlining the investment vehicles available; before going into some detail on the drivers of each of these investment vehicles in the context of the technology groups[43] to which they are relevant.

Overview of the existing investment vehicles and applicability to the technology groups.

Investment vehicles	Group 1: Technologies close to market competitiveness	Group 2 : Emerging technologies on the verge of mass market penetration	Group 3: New technologies
RTD programmes (EU/ MSs)		Applicable, but further resources and coordination required.	Applicable, but further resources and coordination required.
Innovation programmes (EU/ MSs)	Applicable, but further resources and coordination required.	Applicable, but further resources and coordination required.	
Debt Based financing (EIB / national) incl. RSFF	Applicable.	Applicable, but further resources [and coordination] required.	Applicable (for pilot and demonstration projects), but further resources required.
Venture capital funds (private / public-private)	Applicable, but further resources desirable.	Limited applicability, further resources desirable.	
Infrastructure funds (EIB / national)	Applicable, but further resources required.	Applicable, but further resources and coordination desirable.	
Market-based instruments	Applicable.	Limited Applicability	

In this context, it is important to note that although the EIB Group instruments[44] are cost effective (they only loan on market rates and recover what they loan), add to rather than distort the market, and can leverage significant private sector support[45]. On the other hand, however, because they only ever operate on market terms, no EIB Group instrument can fully compensate for spill-over effects or environmental externalities; and no EIB instrument can function independent of a sufficiently secure revenue stream, hence the importance of market based instruments such as the ETS or taxes which put a price to carbon.

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43 Technology group 1; Close to market competitiveness: Group 2; emerging technologies on the verge of mass market penetration: Group 3; new technologies. See section 2.2 and annex III for further details.

44 Debt, Venture Capital or Equity. All are supported by JASPERS (Joint Assistance to Support Projects in European Regions), is a joint initiative of the European Commission and EIB and ERBD which provides assistance for the preparation of major infrastructure projects financed under Cohesion Policy. The environment, including energy efficiency and renewable energy, as well as clean urban and public transport are key areas for JASPERS support.

45 up to 6 times for venture capital

RDD Programmes–.

- **Characteristics:** Public RDD programmes usually aim to enhance the transformation of the research results into commercially valuable innovations through support for research projects that can bring high societal benefits. Both Member States and the European Union have dedicated research budgets. On the European level, energy research is supported under the Seventh Framework Programme (FP7, 2007-2013). FP7 funding in the form of grants is normally allocated through the publication of "calls for proposals", and usually requires a trans-national partnership structure. Through funding for projects aiming at a longer-term paradigm shift in the way Europe generates and consumes energy, FP7 funding directly contributes to providing the knowledge base needed to support EU climate and energy policy. In addition, the Cohesion Policy support to regional innovation and RTD. Cohesion policy aims to support the harmonious and sustainable development of the EU and in this regard, it supports regional investments in research, technological development and innovation. Therefore, in order to assist regions lagging behind in these areas, Cohesion Policy has allocated € 86 B for innovation between 2007 and 2013; this includes € 50 B for RDD and innovation. A part of these allocations can be dedicated to the energy sector according to the operational programmes of the assisted regions. In addition, Cohesion allocations are supported by National co-financing helping leverage considerable private investment.
- **Drivers- Group II:** The funding source and driver of RDD programmes is the public sector, whether that be the Member States or the Community. The political priorities, capabilities and co-ordination of the public bodies are, therefore, key in determining the amount and effectiveness of the RDD funding available. The co-ordination and motivation of the political actors is particularly important for group 2, as many of the large demonstration plants in question (particularly CCS) require large, up-front investments which require significant political and economic capital.
- **Drivers- Group III:** As for Group II, RDD funding is driven by the political will, priorities, and capacities of the Member States and the Community; the key difference being that Group III is even further from the market and even more dependent upon RDD funding. An important limiting factor for this group is the availability of research expertise and infrastructure; as without a sufficient pipeline of high quality research projects even a significant public support will make little short term difference.

Innovation programmes –

- **Characteristics:** These aim to encourage the competitiveness of European enterprises, often through leveraging EU support for small and medium-sized enterprises (SMEs). Such programmes support innovation activities (including eco-innovation), provide better access to finance and deliver business support services in the regions. Many of the EU innovation programmes come within the framework of the Competitiveness and Innovation Framework Programme (CIP). Through grants to business and public actors all over Europe and beyond, the CIP Programme co-finances pilot and market replication projects and fosters best-practice exchange and networking. To this end, grants are determined on the basis of calls for proposals and evaluation procedures, which are highly competitive. In order to complement national programmes, activities funded from CIP must have a "European added value".
- **Drivers- Group I:** a key driver is public policy in respect of the political choices made regarding the national energy mix. Innovation programmes are more likely to support those technologies that can contribute to national priorities, such as expanding wind power generation or solar power because of resource availability. At EU level, with no preferred

energy mix, the main driver is to foster the emergence of a broad portfolio of technologies that can become widely applicable.

- **Drivers- Group II:** as for Group I, but with a greater emphasis on bringing forward new generations of technologies that bring additional benefits to those already on the market.

Debt based financing including the RSFF –

- Characteristics: These can take the form of loans from the EIB or other financial institutions in a variety of forms. Although flexible, most debt based finance is used to fund infrastructural projects regardless of the developmental stage of the technology concerned. Within this category, the RSFF is particularly useful in funding riskier projects, whereas EIB Global Loans and the SME guarantee facility under the CIP can be used to help support SMEs seeking to market new technology. EIB debt instruments are particularly useful with regards to assuming or mitigating the uncertainty associated with large scale long term energy projects.

- **Drivers- Group I:** All EIB loans are essentially driven by the provision of a sufficiently sure revenue stream (including from the ETS and renewable energy support schemes); which for group I technologies amounts to any additional revenue from the use of this particular technology on the markets. Limiting factors here are the availability of co-financiers, the ease of access to collateral and liquidity, the availability of viable bankable projects (with guarantors if necessary), and the overall economic situation.
- **Drivers- Group II:** As for Group I technologies, the driver here is the provision of a sufficiently sure revenue stream. Group II technologies, however, are generally riskier investments than Group I due to their lower technological maturity, and higher time horizon before return on investment. As a result some of the loans might need to be against future revenues from grants; and in many cases might need guarantees (from the state, a corporate or a financial institution) or risk sharing devices in order to become viable. The provision of guarantees, the availability of bankable projects, the willingness of the public sector to share risks, the overall economic situation, the ease with which the EIB (and other IFIs) can access funding, and the availability of co-financiers are all key for this group.
- **Drivers- Group III:** Here it is unlikely that it will be possible to lend against future market revenues to the high risk, long time to market, and inherently speculative nature of many of the investments. The key drivers will be the availability of viable projects backed by sufficiently secure revenue streams in the form of grants or other public sector support, alongside the ease with which the EIB can access funding.

Venture Capital Funds -

- **Characteristics**: this takes the form of equity investments in newly created and innovative firms; and through it public investment can typically leverage significant private sector contributions. It is most efficient at supporting a portfolio of relatively small firms and projects, mitigating against the uncertainties related to new technologies, leveraging significant private sector participation, adapting relatively late stage technologies to market needs and broadening their take-up by the market. In particular, a number of successful solar and wind power investments have been financed by the EIF through intermediary funds; notably under the mandates conferred on it by the EIB and the Community (above all the GIF and the Eco-Innovation facility under the CIP). Similarly, venture capital supporting energy investments can be provided through the Cohesion policy initiatives JEREMIE (Joint European Resources for Micro to medium Enterprises) and JESSICA (Joint European Support for Sustainable Investment in City Areas) initiatives led by the Commission together with the European Investment Bank Group (EIB).

- **Drivers- Group I:** The main driver of Venture Capital is the possibility of gaining revenues and making a profit on the investment; something which is strongly linked to the overall economic circumstances, the market framework (including any incentives towards green technologies, particularly the ETS), and the availability of Venture Capital expertise in the still underdeveloped European Market.
- **Drivers- Group II:** Venture Capital is of only very limited use to group II technologies; but again the possibility of future profits, and the availability of the requisite venture capital expertise is key.

Infrastructure Funds -

- **Characteristics:** this takes the form of equity investments in infrastructure projects, including Public Private Partnerships (PPPs). Such investments can support large scale, relatively late stage, demonstration projects as well as bundles of smaller projects. Notable in this field is "Marguerite", the 2020 fund for Energy, Climate Change and Infrastructure currently under development by the EIB and other institutional investors. As in the case of the debt instruments, infrastructural funds are particularly competent at contributing to the large sums of capital which may be required, mitigating for long term uncertainties and leveraging significant private sector participation.
- **Drivers- Group I:** As for the all other market instruments the provisions of a sufficiently secure revenue stream in the form of bankable projects (supported by e.g. ETS); alongside the availability of liquidity and sufficient expertise in Infrastructural Funds are key.
- **Drivers- Group II:** Infrastructural funds tend to have longer maturities than most other types of funds, which means they can be more relevant to Group II technologies. Nevertheless, however, the projects must be bankable with a more or less secure revenue stream, and in some cases might need to be backed up by a state guarantee.

Market Based Instruments -

- **Characteristics:** these instruments are particularly useful to support technologies in the market deployment stage, i.e. when the aim is to create economies of scale and reduce costs. The EU Emissions Trading Scheme is one general instrument which creates incentives to invest in low carbon technologies as do taxes which put a price on carbon. Examples of more targeted instruments include feed-in tariffs and certificate systems for renewable electricity**.**
- **Drivers- Group I:** These instruments, through increasing the price of carbon increase the incentives for investment in low-carbon technologies. As, outlined above, this is absolutely key both for the spread and market adaptation of these low-carbon technologies. This is also important because without a revenue stream no EIB Group support (or other financial support independent of the state) can be provided.
- **Drivers Group II:** as for group I, market based instruments can also have a facilitating role for increasing the attractiveness of emerging technologies, although in these cases additional and more direct ways of supporting R&D investment will in any case be needed in parallel.

ANNEX VI: Policy co-ordination failures and drivers

Introduction

Currently, the EU 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.

In particular, and as described in the Impact Assessments of the climate and energy package[46] and the Joint Programming Communication[47], pan-European cooperation in low carbon energy technologies is hampered by diverse organisational structures and support schemes in energy R&D and the lack of a strategic approach to technology development

The following analysis of spending under FP6 clearly demonstrates the lack of transnational cooperation.

Joint Programmes and Cooperation- ERA-NETS

NETWATCH data show that transnational **R&D co-operation in low carbon energy R&D has been rather limited until now**.

Under **FP6 energy R&D represents 7% of the whole ERA-NET activity**, or **5 ERA-NETS in 5 different low carbon energy areas**.[48] Unsurprisingly, those countries accounting for the majority of European low-carbon R&D expenditure are also the most active in ERA-NET. So far 22 countries have been involved (albeit with widely varying degrees of participation): 19 EU Member States and 3 associated countries, Norway being very active with 3 participations.

The fields covered by the FP6 ERA-NETS are Photovoltaic solar energy (PV-ERA-NET), innovative energy technologies (INNER), Hydrogen and fuel cells technology (HY-CO), clean energy fossil technologies (FENCO-ERA) and bio-energy (BIOENERGY). Most of the calls had a clear experimental character and were used by the ERA-NETS to develop and test possible strategies of future cooperation.

Eleven joint calls have been launched by these five ERA-NETS between 2006 and 2008, with it taking an average of two years from the start of the ERA-NETS to the first call (this seems to be a standard in all ERA-NETS, not only energy). Future transnational co-operation initiatives will therefore have to take into account a certain delay in the launch of first calls. All calls were funded through a virtual pot mode, enabling countries and regions to apply existing national procedures and to pay for their own participants, without trans-national flows of national funding.

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46 http://ec.europa.eu/energy/renewables/doc/sec_2008_85-2_ia_annex.pdf

47 http://register.consilium.europa.eu/pdf/en/08/st11/st11935-ad01.en08.pdf

48 Those EU countries originating 98% of the aggregated public national (nuclear and non-nuclear) low-carbon R&D budgets are on average also the ones being most active in ERA-NETS, Germany and The Netherlands being the only ones participating in all 5 co-operations, and also co-ordinating all ERA-NETS in energy. Sweden, Denmark, Austria, Spain, France and United Kingdom participate in 4 of them. Italy is underrepresented with participation in only 1 ERA-NET. The new Member States on average participate in only in 1 ERA-NET in this field, Poland leading with 2 participations and 1 observer role.

The budget committed by these five ERA-NETS to the eleven joint calls has been € 23,3 Million (2.3% of the aggregate low-carbon energy R&D budgets of the MS. Clearly, **given the low spending, and widely varying degree of participation, there remains a high potential for transnational co-operation in this field.**

Regulatory fragmentation

Adding to the fragmentation, non-aligned research strategies and subcritical capacities; the variety of national regulations and technical specifications (as described in the climate and energy package impact assessment) fragment the market and inhibit industry investments in high- risk technologies.

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 necessary incentives to generate the necessary breakthrough new technologies and market innovation. By way of contrast, global competitors invest in a more coherent research and innovation system; and they have larger domestic markets, allowing them to make use of greater efficiency savings and economies of scale.

In this case fragmentation is a key problem that requires action. The message from the stakeholder consultation is clear. The inability to harness the potential of the internal market to overcome the intrinsic barriers to the innovation of energy technologies constitutes a severe lost opportunity.

Drivers of the lack of coordination

While EU policies are addressing the problems stemming from a lack of coordination through e.g. the EU Research Framework Programmes, within which a large part of the non-nuclear energy R&D support is dedicated towards low-carbon technologies.

Much of the fragmentation and incoherence results from a lack of strategy in streamlining public funding and financing instruments with the set EU policy goals. In particular

- Most funding and financing instruments were designed before 2007, when the EU policy goals were set.
- There is currently no funding mechanism tailored to the investment needs of the low-carbon energy technologies sector.
- Both the EU and the Member States appropriate money for individual projects which may bear little or no relation to each other.
- There is uncertainty as to the extent existing instruments that are not geared to achieve EU climate and energy policy targets can deliver the scale and type of funding required.

The picture is similar on the financing front.

In this case, although the EC and the EIB Group manage a set of financial sources and instruments dedicated to low-carbon energy technologies.; and which allow contributions and interventions in the form of grants, loans and loan guarantees, equity, technical assistance, interest rate subsidies, etc. It remains the case that the EU lacks a strategy in using public spending to boost investment in low-carbon technologies since most of these instruments appropriate money for individual projects which may bear little or no relation to each other.

Given their number, complementarities and potential overlap, these instruments could be put to better use through stronger coordination and dissemination efforts and in some cases by better focussing, in particular by using the full potential for leveraging private investment from Cohesion Policy funds and Competitiveness and Innovation programmes. In this context, there are certainly other sources and instruments of important funding either from financial institutions (EBRD, WB) or national support programmes which, among other things, can bring synergies to EU funding.

Data on international co-operation in low carbon energy R&D are very limited but show high importance of energy R&D co-operation with Brazil, Russia and India.

SET-Plan structures

The SET-Plan hopes to correct this and make the most out of the synergistic effects of Joint Programming. Specifically, a SET-Plan Steering Group will progressively become the main structure for strategic coordination of energy research priorities at EU level; it is expected that the situation will improve.

The implementation of the SET-Plan priorities will happen in the context of the European Industrial Initiatives (EIIs) and the European Energy Research Alliance (EERA) on the basis of agreed Key Performance Indicators (KPIs). The EIIs currently discuss what could be joints objectives and activities at EU level, whilst the EERA is in the process of identifying areas for Joint Programming at EU level. The 'construction' of these coordination structures is currently is in the set-up phase, and therefore, their exact impact on coordination at EU level cannot yet be analysed.

ANNEX VII: Justification for EU action with regards each individual technology group

This table by giving further specific details on the targets, needs, drivers of financing and scope for public action with regards to each of the specific technology groups; aims to further detail the justification for EU level action in the context of each. It does not in itself constitute a justification; but sums up the information given with regards to the financing gap and co-ordination failures.

Group	**Group I**	**Group II**	**Group III**
Targets	• Widespread adoption by the market, including winning public acceptance in the short term.	• Market adoption in the medium term. • Greater understand of practical needs in the short term.	• Long term adoption by market. • In the Short term to gain a greater understanding of potential.
Needs	• Immediate financing and adoption for public use.	• Large demonstration projects. • Adoption of infrastructure. • Further research.	• Intensive research.
Drivers	• These are close to the market; and should be driven by the market and market based instruments (particularly ETS).	• The market potential of these projects is unproven. They represent risky project and will need public support. • Demonstration projects, even if unprofitable, will produce some revenue and market drivers, could, therefore become involved.	• Solely public support. These technologies are generally too unproven, too risky, and too far from the market to be attractive to private finance.
Scope for public sector action	• Overcoming the market failures identified in section 2.4; risk aversion and other market failures specific to energy. • Working towards	• Providing and co-ordinating funding for large scale demonstration and infrastructural changes. • Overcoming the co-ordination and regulatory failures	• Ensure the existence of a well-resourced, vibrant research community. • Distributing grants and resources' strategically targeted to the SET-Plan technologies.

	public knowledge and acceptance of the new technologies.	identified in the capacities map. • Researching and aiding the development of the SET-Plan technologies.	
Scope for EU action	• Co-ordinating and funding cross-border actions aimed at addressing market failures. • Ensuring the transfer of expertise and good practise across borders.	• Driving and co-ordinating the implementation of very large demonstration projects. • Working towards consistent EU wide regulations and specifications.	• Facilitating EU wide synergies through the unification of standards, and EU wide programmes. • Promoting EU policies and focussing research activities in priority areas.

ANNEX VIII: Overview of recent initiatives in the context of the financial crisis

The recognition of the need to reinforce financing of technology development in the energy sector is already producing positive results. The EU has put in place an enabling framework which establishes clear market conditions and contributes to lower financial risks. New measures have been agreed and others enhanced to reverse the downward trend in energy research investment seen since the 1980s. The EU is currently demonstrating it is maintaining its commitment to shift to a low carbon economy despite the dire financial context. The EERP provides the right balance to combine an immediate stimulus with the long-term perspective needed to meet the challenges of a world economy geared towards low-carbon and innovative activities.

The overall policy framework

The EU is piecing together a far-reaching jigsaw of policies and measures: binding targets for 2020 to reduce greenhouse gas emissions by 20% and ensure 20% of renewable energy sources in the EU energy mix; a plan to reduce EU global primary energy use by 20% by 2020; carbon pricing through the Emissions Trading Scheme and energy taxation; a competitive Internal Energy Market; an international energy policy.

A comprehensive set of measures on energy efficiency is being put in place to tap into the enormous potential for energy savings in every sector of our economy. Building codes, appliance standards, lead market policies, public procurement and so on are all directed towards giving the right price and policy signals to turn the undoubted technology potential into profitable business opportunities.

EU research policy is directed towards achieving a new vision of a European Research Area, in which all actors fully benefit from the “Fifth Freedom” across the ERA: free circulation of researchers, knowledge and technology. The ERA aims to provide attractive conditions and effective and efficient governance for doing research and investing in R&D intensive sectors in Europe.

The European Economic Recovery Plan (EERP)

The EERP has prioritised action to raise skills, to boost investment in research, to promote the conditions for innovation, to renew existing energy infrastructure, including through increased use of public private partnerships, to upgrade energy efficiency and to increase renewable energy.

The EERP will provide an additional 3.5b€ to improve gas and electricity interconnections, stimulate the development of offshore wind energy and kick-start the demonstration of carbon capture and storage technologies. In addition, three new Public Private Partnerships in the fields of 'green cars', 'energy efficiency buildings' and 'manufacturing', with a combined budget of 7b€, will contribute to reducing greenhouse gas emissions in key sectors of the economy.

The EU is now entering a new phase of implementation of its Recovery Plan, with a need for effective co-ordination of the measures being taken to ensure that they work to best effect on the real economy.

National Recovery Programmes

Most Member States have drawn up national recovery plans in response to the EERP and their implementation is now under way. These National measures will also play a role in stimulating investment in clean technologies.

Examples of measures adopted include: tax breaks on more environmentally-friendly cars (AT, DE, FR, LU, IT, NL, PT, SK, ES, UK, RO); R&D programmes for green cars (FR, DE, UK); investment in energy-saving materials and green technologies (AT, HU, LU, SI, EE, IE, ES, FR, DE, IT); and, increased R&D for the development of green and sustainable technologies (DE, ES, FR, SE, UK).

The EU Emissions Trading Scheme

Aside from the incentive effect of the ETS itself for innovation, the revised ETS Directive *[ref]* sets aside up to 300 million allowances (with a possible monetary value in the range of 6-9b€) from the New Entrants Reserve to be made available for the funding of large-scale demonstration projects for innovative carbon capture and storage technologies and renewable energy sources in the period between 2013 and 2015. Also at the European Council of 12 December 2008, Member States declared their willingness to use at least half of their ETS auctioning revenues for the period between 2013 and 2020 (possibly in the region of 50-70b€) in support of actions to reduce greenhouse gas emissions, mitigate and adapt to climate change, including research and development.

Increasing investments in energy R&D

By 2013, the annual budget for energy research in the Seventh EU Research Framework Programme will be double that at the start. Investment in energy technology research has also ticked upwards in several Member States after two decades of stagnation at a low level. In 2007, total EU public investment in energy technologies reached 2.38b€, but this is still a long way off the 5.24b€ invested in 1985 and only starts to address the accumulated under-investment in energy research capacities and infrastructures *[ref IPTS paper]*.

In the framework of the European Economic Recovery Action Plan, the EIB has increased its lending target in the energy field to €9.5bn in 2009 and €10.25bn in 2010. In addition to which the EIF has increased its support to eco-innovation under the new CIP mandate. Further measures include the Risk Sharing Finance Facility, jointly developed by the EC and EIB and which is expected to create a total financing capacity from the EIB of up to €10bn, of which a significant percentage of which will be taken up by energy technology projects.

The Third Internal Energy Market package *[not yet approved]* includes the provision: "*In fixing or approving the tariffs, the regulatory authorities shall ensure that network operators are granted adequate incentive, over both the short and long term, to increase efficiencies,* *foster market integration and support the related research activities*". This should stimulate much-needed research into energy networks.

Re-orientating the implementation of these increased funds towards SET-Plan priorities will provide a substantial boost to the development of technologies with the greatest EU added value.

International developments

Globally, the total new investment in clean energy increased from $33 billion to $148 billion between 2004 and 2008, two-thirds of this outside the EU. In the US, the Stimulus Package adopted in February 2009 includes $2.5 billion for energy efficiency and renewable energy research, $6 billion for new loan guarantees for low carbon electricity, $11 billion to modernise the electricity grid.

Even if the current economic situation has dampened the trends, the underlying dynamics should quickly reassert themselves. These prospects forecast growing global market opportunities in low-carbon technologies. The EU has every interest in maintaining its strong and competitive knowledge base in this domain.