

Paper on
The Implementation of the SET Plan Roadmap
“Materials for Low Carbon Technologies”

Recommendations
to the SET Plan Steering Group and
to the European Commission

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EMIRI - Energy Materials Industrial Research Initiative

EERA - European Energy Research Alliance

E-MRS - European Materials Research Society

EMF - European Materials Foundation

EIT/KIC Innoenergy on Sustainable Energy

EUA/EPUE - European University Association

SET Plan Steering Group - Representatives from France, Germany, Austria, Spain, Belgium

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1. Introduction

The Materials Roadmap Enabling Low Carbon Energy Technologies (SEC 2011/1609) published in December 2011 in the context of the Strategic Energy Technology (SET) Plan represents a comprehensive research and innovation agenda in the field of materials and manufacturing for energy applications in the next 10 years, both at the EU and Member States level.

In its conclusions, the Materials Roadmap called upon the identification of implementation mechanisms notably in view of the next Framework Programme for Research and Innovation between 2014-2020, Horizon 2020. To do so, and following a dedicated stakeholders meeting with the SET Plan Steering Group members on 25 April 2012, a Working Group has been established with the objective to investigate and assess various schemes to implement the Materials Roadmap.

This Working Group, set up in June 2012, was chaired by Prof Harald Bolt and was composed of 10 members representing: 4 Member States on behalf of the SET plan Steering Group (France, Germany, Austria, Spain and Belgium), the Energy Materials Industrial Research Initiative (EMIRI), the European Energy Research Alliance (EERA), the European Materials Research Society (E-MRS), the European Materials Foundation (EMF) the EIT KIC on sustainable energy, Innoenergy and the European University Association (EUA/EPUE). The European Commission attended the meetings as observer. It has been operational from June 2012 to April 2013 and met 4 times: on the 9 July, 19 September, 19 November 2012 and 20 February 2013.

This paper presents the findings of the working group. Due to the limited time and resources, this paper should be viewed as an input for further consultation and decisions.

2. Implementation

2.1 *Key elements*

The working Group re-affirms the pertinence of the materials roadmap as the EU research and innovation agenda in the field of materials for energy. Its implementation needs to follow a strategic approach based on:

- A programme logic covering the entire research and innovation chain from (1) Basic research, (2) Advanced Research; (3) Industrial research; (4) Innovation services; (5) European infrastructures network (6) Education and training;
- The mobilisation and integration of national research and innovation capacities at EU level as a pre-requisite for a successful implementation of the materials roadmap. The emergence of EU research and innovation mechanisms such as the European Energy Research Alliance (EERA), the European Energy Materials Industrial Research Initiative (EMIRI), the European University Association, Energy Platform of the European Universities (EUA-EPUE) together with the SET Plan European Industrial Initiatives (EII), the European Institute of Technology Knowledge and Innovation Community (EIT KIC) Innoenergy, the European Strategic Forum on research Infrastructures (ESFRI) are the first steps in this direction; altogether, by grouping industry, research centres and universities, they cover the entire research and innovation spectrum and have already significant activities on which to build for the implementation of each strand of the programmes; the implementation of the roadmap should strengthen such mechanisms and their interfacing.

- The exploitation of synergies by applying a horizontal platform approach. Materials are inherently cross cutting. Building and mutualising cross-cutting materials platforms is a way to leverage research and innovation efforts as shown in figure 1 below. Such platforms would confront the challenges of several application technologies and cover the entire value chain including but not limited to computer aided materials design / modelling, lab based synthesis, scaled up manufacture / fabrication, life cycle assessment, component demonstration / performance validation under real or simulated operating conditions. In addition, in many cases it is not possible to dissociate the functionality from the process and the applied specialised production equipment which are applied into the compound / component manufacturing. So this aspect too will need to be within the scope of the platform. This is especially true for functional layers and composite materials. The individual constituent projects or sub programmes under these platforms should be governed by strict application oriented KPIs linked to the enabling or de-bottlenecking aspect and the valorisation or innovation goal. Due consideration must also be given to the reduction of usage of critical materials, the elimination of hazardous materials during production and in usage and design for recycling.

	PV	Wind	Energy Storage	Fuel Cells	Grids	CCS	Thermal Solar	Ocean Energy	Nuclear
Functional particles / filaments	new functional nanoparticles								
	nano imprinting / nano structuring								
	modelling								
Materials for functional layers / membranes / barriers	coatings and coating techniques								
			novel functional membranes with or without electrocatalysts						
Composite materials	high strength, light weight materials								
		fiber reinforced materials							
High performance materials for extreme application conditions	high temperature, low temperature materials								
		corrosion resistant materials							
Novel chemistry / metallurgy for new materials / systems	valid across the board Ex. Inks, new power electronics, new electrochemistry, new HTS,...								

Figure 1: Example for the relation of horizontal energy materials platforms and energy technologies. Note that not all relevant energies and energy processes and uses are shown.

2.2. Implementation options

Six policy options for the implementation of the Roadmap have been considered by the working group:

- One option would be based on the current framework through collaborative projects, joint actions through a set of ERA-NET or FET schemes and the use of risk finance for industrial activities and of Integrated Research Programmes for advanced research, this option has been defined as "Business as usual".

- A second option builds on the "business as usual" scheme with the inclusion of EMIRI supported by other empowered actors as part of the European Industrial Initiatives of the SET Plan. This option, once formalised, would use the existing framework of the SET Plan.
- A third option consists of setting up some form of Public Private Partnership under Horizon 2020 via a contractual agreement between the parties and without the use of a dedicated Community body. This option should target comprehensive topical approach, integration of committed partners efforts and managing agility.
- A fourth option would be the creation of an institutional Public-Private Partnership or Joint Technology Initiative under Article 187 of the TFEU.
- A fifth option would be the creation of a partnership based on Article 185.
- A sixth option would be the use of public procurement; this option could be coupled with any of the previous options described above.

3. Key findings

3.1 Key finding related to the implementation options

The implementation options have been assessed against three criteria, namely, leadership, implementation and resources. In order to provide an analysis that considers the views of the different stakeholders represented in the working group, the analysis has been split per groups of stakeholders, namely, Industry represented by the EMIRI, Member States represented by France, Germany, Austria and Spain and Research Community represented by EERA, EIT (KIC Innoenergy), EPUE and the materials society. It is understood that the results of the analysis do not mirror the full view of the stakeholder class as the generic names would imply, but this simplification enables a better reading. The complete analysis of Industry and Member States inputs is provided in Annex 1. The preferred options per stakeholder grouping is summarised as follows:

3.1.1 Industry

Industry aims at having Option 3 (contractual PPP) as the best solution that would provide thrust towards innovation. However it is ready to support Option 2 (Bau with EMIRI supported by other relevant and empowered bodies as part of the EIIs) as a kick start option for bridging to a contractual PPP during a start-up phase.

3.1.2 Member States

Member States expressed their preference for Option 2 (Bau with a grouping around EMIRI as part of the EIIs) as a first step while investigate possibility of co-fund mechanisms to possible reach in the long term Option 5 (Public Public Partnership). Member states indicates their interest to engage in ERA-NET activities in order to harmonize the strategies and approaches among member states and the EU.

3.1.3 Research Community

European Energy Research Alliance (EERA)

Coordination along the innovation chain requires close co-operation of research organisations, industry, Member States, and the European Commission. This could be achieved by granting EERA an effective role for instance in the EII's. Alternatively new forums or actions need to be created that effectively address the research coordination and definition of research agenda.

European University Association (EUA/EPUE)

EUA-EPUE supports Option 1 and an enhanced Option 2 that would include mechanisms and tools to support and improve the link between research, education and innovation, with the particular involvement of universities, which would benefit the outcomes and impact of materials research in Europe.

KIC Innoenergy

KIC Innoenergy supports option 3 (a contractual PPP) as the best way to give the right impetus to the Materials Roadmap. This option presents the advantage of integrating R&D efforts at pan-European level with a global market view.

European Materials Research Society (E-MRS) and the European Materials Foundation (EMF)

E-MRS and EMF support option 3 as the most suitable way to address the needs of the materials community in the long term.

3.2 Further elements and aspects essential for successful implementation

3.2.1 Role of education and training

Education of students in the field of energy materials is of major importance to establish a long-lasting leadership of the European energy materials industry. This requires the commitment of universities to integrate the energy materials subject in their curricula. In addition the universities, many of them are engaged in the EUA-EPUE, should be continuously enabled to participate in European R&D activities in the energy field. This requires transparent and simple rules for universities to join European R&D consortia in this field. Universities and especially the KIC could also assume a significant role in training activities to familiarize professionals with developments in the field of industrial materials innovation and their relevance to market conditions for developing entrepreneurship.

3.2.2 Enhancing the integration of stakeholders along the RD&I value chain

Important European stakeholders in the energy materials field are EMIRI, EERA and KIC Innoenergy. They fulfil complementary roles with regard to the process from energy materials science to successful industrial innovation.

A process should be initiated by which these stakeholders integrate themselves towards a research and innovation partnership. Within this partnership the three actors could assume and sharpen their roles with regard to the entire knowledge and innovation chain.

Guidance on the industrial needs in the field and support to the implementation of collaborative R&D activities in industry would be a main role of EMIRI. Integration of related R&D activities in research organisations would be supported by EERA and the relevant EERA

integrated programme members. Training towards the implementation of industrial innovation and support to emerging industrial start-ups could be provided by KIC.

This integration could take place in a gradual process which would allow the definition of the roles of the actors, harmonization of the approach towards EU, EIT and member states. As a first step a MoU would demonstrate the willingness of EMIRI, EERA and KIC to engage in this process.

3.2.3 Enhancing the European R&D infrastructure base and its accessibility

European Strategic Forum on Research Infrastructures (ESFRI)

ESFRI is a forum of the European member states with support by the European Commission. In this forum processes take place that lead to the identification of research infrastructures which are needed within Europe. On this basis, ESFRI issues calls for proposals for new research infrastructures to which institutions/consortia with explicit support by their member states can respond. For positively evaluated proposals some cofunding can be provided by the Commission to support the planning and implementation of the infrastructure.

In the field of energy RDI, the respective strategic working group of ESFRI will be preparing an analysis of the needs for research infrastructures in 2013. This will take place in consultation with the stakeholders in European energy RDI like EERA, EUA-EUPE, technology platforms and industrial technology initiatives, especially those proposed by EIIs.

This analysis will form the basis for a call for proposals for research infrastructures to be issued by ESFRI towards the end of 2015 (according to present planning).

Research infrastructures that aim to support R&D on energy materials can play a significant role in this ESFRI process. Thus stakeholders are invited to contribute to the gap analysis and subsequently to submit proposals for research infrastructures.

Support to the access and use of existing European infrastructures

Existing European Research Infrastructures or those that are under implementation can play a significant role in advancing R&D on energy materials. Examples are photon facilities and neutron facilities for use in energy materials and components characterization or European supercomputing capacities for modelling and simulation.

Implementation Instruments to support the access and use of such facilities on a European basis should be made available to the energy materials research community. This could be done by coordination and support activities that might become part of the implementation options described in Annex I.

4. Recommendations

Considering the views of the different stakeholder groupings, the working group recommends to:

- Kick-start the implementation of the roadmap based on Option 2, with the following elements:
 1. The materials roadmap should be an integral part of the SET Plan Agenda both at EII and EERA level;

2. A grouping of relevant R&I key actors around EMIRI should be a member of the EII teams;
 3. A set of programme co-funded actions could be launched as a way to pool EU and MSs resources. Industry and the Research Community should be closely associated in the definition of the priorities.
 4. Access and use of research facilities and benchmarking platforms should be available to the energy materials RDI community at EU level. To this end, a link should be made with the ESFRI roadmap process.
 5. Basic research should be fully addressed in the implementation of the roadmap, in close coordination between EERA and the EPUE.
 6. Education and training supporting the Materials roadmap implementation should be further organised and structured at EU level in close coordination with the EPUE and KIC Innoenergy as regards markets and entrepreneurship insight.
- Establish a coordination mechanism on materials research and innovation within the SET Plan. This task could be taken up by the current working group. As part of its mandate such coordination group will report annually to the Steering Group. Based on the experiences and results of the implementation of Option 2, it will also investigate the possibility for a public-public-private partnership (Options 3 and/or Option 5) for the implementation of the materials roadmap in the long run.

ANNEX 1 - Analysis of the Implementation Options

1. Implementation options

The Working Group considered for its analysis on the implementation of the roadmap the following dimensions:

- **Governance:** Which type of governance for the research and innovation system to enable the engagement and the commitment of all stakeholders in a coherent programme that addresses materials and manufacturing priorities for energy applications on the short, medium and longer terms?
- **Implementation:** How to establish a more effective implementation, execution and management of all activities across the whole innovation process including an active and dynamic monitoring of the activities?
- **Resources:** How to ensure a cost-effective and results-oriented allocation and increase of means (private and the public investment), that facilitates and streamlines resources allocation from multiple origins at the service of a coherent pan-European endeavour?

The combination of different options for the above three dimensions would in theory lead to many different options. To make the analysis feasible and meaningful a simplified approach has been followed, resulting in the analysis of six options:

Option 1: Business as usual

Option 1 is to continue with the current framework, where the research and innovation Agenda of the Materials Roadmap would be implemented through individual research programmes at different levels: EU, national, regional, corporate, etc. with their own priority setting mechanisms, governance and funding. The roadmap would be implemented mainly through collaborative projects, joint actions through the ERA-NET schemes, research infrastructure projects, use of risk finance for industrial demonstration activities and of Integrated Research Programmes for advanced research. Industry and the research community would have an advisory role in the priority setting following the processes of each individual research programmes and the SET Plan Governance. Research Infrastructure projects would be dealt within the European Strategy Forum on Research Infrastructures (ESFRI).

Option 2: Business as usual with a strengthening of the materials dimension in the SET Plan EIIs

Option 2 is similar to option 1 with the difference of the strengthening of the industrial dimension of materials and associated manufacturing research in the Agenda of European Industrial Initiatives (EIIs) of the SET Plan by including EMIRI as a member of the EIIs Team.

Option 3: A contractual Public Private Partnership (PPP)

Option 3 consists of a contractual agreement between public and private actors to implement specific fields of Horizon 2020, the exact terms of such an agreement will depend on the outcome of the discussions on Horizon 2020 that are currently taking place among the Commission, the Parliament and the Council. The contractual agreement between the partners will specify the objectives of the partnership, respective commitments of the partners,

management process including priority setting mechanisms, key performance indicators, and outputs to be delivered including the identification of research and innovation activities that require support from Horizon. The European Strategy Forum on Research Infrastructures (ESFRI) would continue to be involved for research infrastructure projects.

Option 4: A dedicated Article 187 TFEU

Option 4 proposes to implement the Materials roadmap through the establishment of a Joint Technology Initiative (JTI) using Article 187 of the TFEU. JTIs are public-private partnership in key areas where research and technological development could contribute to Europe's wider competitiveness goals and where the traditional instruments of the Framework Programme (such as collaborative research) are not sufficient. This implies a dedicated structure which results in an independent legal entity, under the form of a Joint Undertaking, managing projects in an integrated way with industry joining forces with other stakeholders. The European Strategy Forum on Research Infrastructures (ESFRI) would continue to be involved for research infrastructure projects.

Option 5: A dedicated Article 185 TFEU

Option 5 envisages the implementation of the Materials roadmap through the establishment of a Public-Public Partnership based on Article 185 of the Treaty TFEU. Under this arrangement, the EU provides financial support to the joint implementation of the (parts of the) national research programmes involved, based on a joint programme and the setting-up of a dedicated implementation structure. This type of partnership implies a strong participation and engagement of Member States which commit in integrating their research efforts in joint research programmes in which the EU promotes the voluntary integration of scientific, managerial and financial aspects. This would result in a wider pool of resources to carry out large scale research and innovation programmes leveraging industrial investments. The European Strategy Forum on Research Infrastructures (ESFRI) would continue to be involved for research infrastructure projects.

Option 6: Public procurement

Option 6 consists of an implementation of the materials roadmap through pre-commercial procurement or procurement of innovative solutions carried out by the Commission or the relevant funding body on its own behalf or jointly with contracting authorities from Member States and associated countries. Pre-commercial procurement is a form of procurements of research and development services involving risk-benefit sharing under market conditions, and competitive development in phases, where there is a separation of the research and development phase from the deployment of commercial volumes of end-products, while public procurement of innovative solutions is a form of procurement where contracting authorities act as a launch customer for innovative goods or services which are not yet available on a large-scale commercial basis, and may include conformance testing. The European Strategy Forum on Research Infrastructures (ESFRI) would continue to be involved for research infrastructure projects.

2. Analysis of the implementation options

2.1 Assessment Criteria

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

Leadership	Implementation	Resources
<ul style="list-style-type: none"> • Ability to engage all necessary actors; • Capacity to stimulate the improvement and restructuring of the European innovation base • Capacity to mobilise and commit resources from multiple origins at the service of a coherent pan-European endeavour 	<ul style="list-style-type: none"> • Delivery effectiveness • Administrative leanness • Flexibility to new priorities 	<ul style="list-style-type: none"> • Leveraging effect of private investments • Optimisation of public resources

In order to provide an analysis that consider the views of the different stakeholders represented in the working group, the analysis has been split per groups of stakeholders, namely, Industry represented by the EMIRI, Member States represented by France, Germany, Austria and Spain on behalf of the SET plan Steering Group and Research Community represented by the Energy Materials Industrial Research Initiative (EMIRI), the European Energy Research Alliance (EERA), the European Materials Research Society (E-MRS), the European Materials Foundation (EMF) and the European University Association (EUA/EPUE). It is understood that the results of the analysis do not represent a comprehensive view of the stakeholder class as the generic names would imply, but this simplification enables a better reading. EUA-EPUE broadly agrees with the general points under the “Researchers community” headings in Options 1 and 2 but wants to abstain from judgements in the same headings in Options 3 to 6 at this stage of the assessment exercise.

2.2 Option 1 (Business as usual)

2.2.1 Leadership (option 1)

Main strengths

Industry

- These are proven model that are familiar to all actors and so are inside their comfort zone. They can mobilise and obtain the commitment of stakeholders into results-oriented projects.

Member States

- Capitalisation on national strengths via a diversity of programs with different scales of implementation.

Main weaknesses

Industry

- The different scheme to date are not well coordinated at a European level with the inherent risk of having a fragmented project-based approach to materials research rather than a programmatic one;
- BAU implies complex and costly process for projects application, which discourages player to participate;
- Limited involvement of industry in the decision-making level for the implementation of the roadmap;
- Projects prioritization is made without industry's commitment;
- The SET Plan materials roadmap would remain an ad-hoc initiative with limited ownership.

Member States

- Low ability to accelerate industrial exploitation and to strengthen the research base due to an implementation based on individual programmes both at EU and MS level without joint actions.

2.2.2 Implementation (option 1)

Main strengths

Industry

- The roadmap can be implemented immediately as there is no need to establish a new legal framework and new structures;
- The way the current framework works, with the use of competitive calls, encourages excellence.

Member States

- There is a decision making structure already in place;
- There is no need to establish new instruments;
- The role of the Commission, Member States, Industry and Research Community is clear;
- There are clear and transparent rules of procedure.
- Capacity of combining several tools (Eranet, IRP etc.)

Main weaknesses

Industry

- There is a typically long lead time between the initial project call definition and the start of a project. Added to the time it takes to actually complete the project work means it is very challenging to ensure the market relevance of a project without having a flexible approach along the way;
- Lack of coordination to ensure a coherent implementation of the Roadmap especially at a European level.

Member States

- Low management and delivery effectiveness which can lead to fragmentation;

- Limitations for the establishment of optimal critical mass, the launch of capital- and research-intensive programmes and the exchange of information, due to diverse administrative rules and procedures.

2.2.3 Resources (option 1)

Main strengths

Industry

- Funding is potentially available, although Europe is under-spending on energy materials research compared to its main competitors.

Member States

- Capitalisation on national and EU resources via a diversity of programs with different scales of implementation.

Main weaknesses

Industry

- Difficulty in raising funds for new very large projects, as funding programmes have limited amounts of additional resources and usually apply instruments that are not attractive to business.
- Resources (intellectual, physical and financial) are not sufficiently structured at a European level meaning that some aspects are most likely underfunded and others over funded with the risk of unnecessary duplication.

Member States

- Restricted capacity to commit resources between public (EU/MS) and private stakeholders as no dedicated frame for the implementation of the roadmap;
- Risk of dilution of leverage effect.

2.3 Option 2 (Business as usual with EMIRI part of the EIIs)

2.3.1 Leadership (option 2)

Main strengths

Industry

- As for Option 1
- Industry's participation as advisor may help to better align projects and their objectives in line with industry's priority to innovation.

Member States

- There is a clear involvement of EU materials industry in the priority setting of the SET Plan EIIs.

Main weaknesses

Industry

- As for Option 1;
- The role of industry is limited to an advisory one without effective decision making powers;
- Projects are prioritised without industry's commitment;
- The SET Plan materials roadmap would remain an ad-hoc initiative with limited ownership.

Member States

- Low ability to accelerate industrial exploitation and to strengthen the research base due to an implementation based on individual programmes both at EU and MS level without joint actions.

2.3.2 Implementation (option 2)

Main strengths

Industry

- There is no need to establish a new legal framework and new structures;
- The way the current framework works, with the use of competitive calls, encourages excellence.

Member States

- There is no need to establish a new legal framework and new structures;
- High management and delivery effectiveness which results in avoiding the risk of fragmentation and duplication and in adding value to the EIIs implementation plans;
- Rules and procedures are clear and transparent;
- Capacity of combining several tools (Eranet, IRP etc.).

Main weaknesses

Industry

- There is no obligation for industry to give any commitment;
- The vertical technology-oriented implementation of the roadmap would make it more difficult to promote synergies between material classes and research actions across technologies.

Member States

- There is a long lead times from initial project call definition to the start and finish of the project which makes projects losing relevance;
- There is the need to further integrate the Materials Roadmap in the EIIs implementation plans (this work should be done by EMIRI and the respective EIIs), hence this can create some delays in the implementation (*comments: this latter point refer to the inertia issue*).

2.3.3 Resources (option 2)

Main strengths

Industry

- Funding is already available, although Europe is under-spending on energy materials research compared to its main competitors.

Member States

- Ability to promote the pooling of public and private resources for materials research using the SET Plan EIIs mechanism. Allows a supply chain perspective for implementation from materials to technology first-a-of-kind commercial demonstration projects, hence enhancing the effectiveness of public investments.

Main weaknesses

Industry

- Difficulty in raising funds for new very large projects, as funding programmes have limited amounts of additional resources;
- Resources (intellectual, physical and financial) are not sufficiently structured at a European level meaning that some aspects are most likely underfunded and others over funded with the risk of unnecessary duplication.

Member States

- Restricted capacity to commit resources between public (EU/MS) and private stakeholders as there is no dedicated frame for the implementation of the roadmap;
- Risk of dilution of leverage effect.

2.4 Option 3 (A contractual PPP)

2.4.1 Leadership (option 3)

Main strengths

Industry

- Industry is an equal partner in the decision making;
- The priority setting should involve all stakeholders equally EC, MS and Industry with support from the research community;
- Industry is highly motivated and committed to drive projects through to full valorisation;
- It presents a cross cutting approach and synergies in materials research to optimise resources usage and maximise the return on investment.

Member States

- There is a clear commitment from EC and Industry.

Main weaknesses

Industry: none

Member States

- It does not bring new added value compared to existing instruments;
- Little involvement of MS that prevents reaching a critical mass of resources.

2.4.2 Implementation (option 3)

Main strengths

Industry

- Robust governance system will ensure transparent priority setting and implementation always with a view to innovation;
- The option implies a cross cutting approach and synergies in materials research; It allows for a management at programme level;
- There is the possibility of streamlining procedures in order to save costs and shorten the lead times making the whole process more relevant to industry;
- It will provide a cross cutting technological capability for the different SET Plan EIIs and is conceptually fully in line with the Advanced Materials KET;
- There is no need to establish a new legal framework because this scheme would be run as a contract under Horizon 2020.

Member States

- There are several success stories and lessons learned from running PPPs;
- This scheme would be managed by the EC;

Main weaknesses

Industry

- The scope and modalities of PPPs under Horizon 2020 are not yet known publicly which is causing confusion and squandering of efforts;
- Care will be required to avoid unnecessary duplication of governance with SET Plan EIIs and a complex decision making process.

Member States

- The PPP scheme risks to be in competition with the current structures (i.e. EIIs);
- Compared to Option 2, there is a lower management and delivery effectiveness with a risk of fragmentation and duplication of structures;
- Lack of information about using of funds
- In some cases, PPP have received the whole budget dedicated to a field, so that no other action could be undertaken in the current framework (call for proposals, Eranet). This could lead in particular to a lack of support to basic research.

2.4.3 Resources (option 3)

Main strengths

Industry

- Allows implementing the roadmap at programme level, hence ensuring high leverage of private investment along the entire value chain.;
- Since EU, MS and Industry are all involved in priority setting and governance, the funding resources and infrastructures will be more in line and tuned with the needs or economic value creation.

Member States

- This scheme would run open and competitive calls.

Main weaknesses

Industry

- Member States need to be involved and equally committed otherwise it limits the capacity to reach a critical mass for the implementation of the roadmap.

Member States

- Industrial commitment is not guaranteed up-front, hence can limit the leverage effect.
- Risk of dilution of industrial investments since the EII structure will be kept in parallel on the same technology fields;
- The absence of Member States limits the capacity to reach a critical mass for implementation of the roadmap
- A low industrial participation would make difficult to reach the 50/50 leverage commitment of PPPs;
- The fixed allocation of the budget would burden interactions with the EIIs;
- Financial commitment of industrial actors is not clear (clearer in the Article 187).

2.5 Option 4 (A dedicated Article 187)

2.5.1 Leadership (option 4)

Main strengths

Industry

- There is a direct and transparent legal frame between public and private stakeholders;
- Industry is highly motivated and committed to drive projects through the full valorisation;
- It will encourage industry's involvement and support basic research;
- The engagement and commitment of all stakeholders is embedded into the governing board of the organisation, which accelerates the decision making process. This is especially important for undertaking large scale actions at the European level.
- It will provide a cross cutting key enabling technology capability for the various SET Plan EIIs.

Member States

- There is a clear commitment from the Commission and Industry on a project basis.

Main weaknesses

Industry

- If Member States are not part of the JTI this will limit the capacity to reach a critical mass for the implementation of the roadmap.

Member States

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

2.5.2 Implementation (option 4)

Main strengths

Industry

- The organisation develops its own operational procedures, hence offering a common framework for implementation and re-alignment of the actions.
- The organisation of research activities is simplified;
- There is no need for a new legal framework;
- There is a cross-cutting approach and synergies in materials research.

Member States

- The implementation of priorities across Europe is secured by the allocation of budget to the organisation over a certain period, both for operational purposes and for funding of the individual actions.

Main weaknesses

Industry

- The JTI has a high level of bureaucracy and presents a long lead time to set-up its structure (The current experience from the JTI on Fuel Cell and Hydrogen has proved to be complex due to the need to abide by community regulations and procedures);
- The option implies the establishment of an additional structure that carries additional administrative costs (mainly facilities and staff).

Member States

- This option presents some problems already showed by the current JTIs, such as slow start-up times, implementation problems, low ability to manage the allocated budget, low flexibility;
- Unless the interfacing and integration with existing programmes is established via the statute of the newly formed organisation, there is a risk of the latter becoming an additional organisational layer with no clear impact on the optimisation of the current innovation process;
- This scheme requires a new structure which would be in competition with the current EIIs;
- Lack of information about using of funds;
- In some cases, PPP have received the whole budget dedicated to a field, so that no other action could be undertaken in the current framework (call for proposals, Eranet). This could lead in particular to a lack of support to basic research;
- Compared to Option 2, there is a lower management and delivery effectiveness, since no open and competitive calls can be ensured, as well as the risk of fragmentation and duplication of structures with the EIIs and EMIRI;
- It does not present any added value compared to the current SET-Plan.

2.5.3 Resources (option 4)

Main strengths

Industry

- The scheme allows strategic long term planning and funding commitment;
- It gives a greater chance of valorising returns on investments in research, development and innovation;
- The financial resources required for large scale projects may be easier to raise with a dedicated central organisation.

Member States

- There is the possibility of having a cash contribution from Industry.

Main weaknesses

Industry

- The extra overhead costs can reduce the effectiveness and eat into available research budgets.

Member States

- It presents low leverage effect due to the lack of industrial partners and dilution of industrial commitment because industry would be also part of the EIIs;
- The JTI has restricted capacity to commit resources from both Commission and Member States side;
- The fixed JTI budget allocation would burden the interactions with the EIIs;
- It does not have the ability of leverage additional investments.

2.6 Option 5 (A dedicated Article 185)

2.6.1 Leadership (option 5)

Main strengths

Industry

- Engagement and commitment of EC and MS in a single framework.

Member States

- There is a clear commitment from the Commission, Member States and Industry;
- Powerful instrument to coordinate Member States programmes on a precise area with European added value.

Main weaknesses

Industry

- Due to the strong influence of Member States and Commission, Industry has a little role in the decision making process;
- There is no guarantee that priorities are set according to the market reality and to industrial priorities;
- There is no clear commitment from the Industry to exploit research results;
- Low chance of valorisation.

Member States

- It does not present any European added value compared to the current SET-Plan.

2.6.2 Implementation (option 5)

Main strengths

Industry

- This scheme presents a lighter administration structure than a Community body and it is relatively easy to implement.

Member States

- There are success stories and lessons learned from running Article 185.

Main weaknesses

Industry

- The non-involvement of industry in the decision-making might results in a mismatch between priorities and market needs;

Member States

- There is a need for a new structure in competition with the current structures, such as the EIIs which already include materials in their implementation plans;
- It presents a lower management and delivery effectiveness than Option 2;
- This scheme would substitute and duplicate existing structures;
- Article 185 shows low ability to accelerate industrial exploitation.

2.6.3 Resources (option 5)

Main strengths

Industry

- There would in principle be a better coordination of a large pool of resources at an European level that could be used to leverage industry's resources.

Member States

- Clear visibility on resources provided by Member States and Commission;
- Avoidance of duplication of efforts as resources are consolidated in one framework.

Main weaknesses

Industry

- There is no guarantee that public resources can leverage private resources if the programme objectives are not fully aligned with industry's requirements for innovation;
- The added-value for this option relies on the capacity to pool large resources, hence reducing its effectiveness if some MSs are reluctant to contribute.

Member States

- There is a limited capacity for Member States to commit resources thus an Article 185 would not help more in leveraging resources than Option 2.

2.7 Option 6 (Public procurement)

2.7.1 Leadership (option 6)

Main strengths

Industry

- Driven by customer needs, this approach ensures the rapid engagement and the commitment of stakeholders;
- Market-driven procurement conveys and ensures realistic, results-oriented, cost-effective short term priorities.

Member States

- There is clear commitment from the Commission and Member States;
- It implies actions close to the market;
- It implies high scale impact on industrial competitiveness and sustainable growth.

Main weaknesses

Industry

- It does not contribute directly to industry's objectives;
- The priority set is not clear;
- Procurement is an implementing tool that does not provide a partnership and management frame for the implementation of the entire roadmap.

Member States

- It does not foster collaboration between public and private research;
- It is likely that the procurement will not be dedicated to materials as such but to contract for a whole energy system.

2.7.2 Implementation (option 6)

Main strengths

Industry

- Support through public procurement can be a very interesting tool to develop a next product offering/market through a public "lead customer";
- Direct efforts to concrete and well defined short-term and market oriented actions;
- Public procurement requires little administrative effort;
- This option can be bolted on independently to any of the other options;
- Effective instrument for large scale action.

Member States

- There are success stories and lessons learned from public procurement under FP7 (i.e. ICT and security), the CIP and the actions taken forward by DG Enterprise (Lead Market Initiatives);
- There is no need for new structures and instruments;
- It has a high delivery effectiveness;
- It has the ability to accelerate industrial exploitation;
- Some flexibility for new priority on the condition that it is defined in the clauses of the procurement on a case by case basis.

Main weaknesses

Industry

- Public procurement agencies in Member States should be encouraged to keep an EU wide perspective;
- Risk of lack of flexibility to new priorities once the procurement is launched unless clearly specified in the contract, but can only be to a limited extent.

Member States

- There is the risk of low management effectiveness;
- Low ability to strengthen the research base;
- It raises some questions :
 - do the concerned public authorities always have the expertise to evaluate the procurement?
 - Potential conflicts of interest in case of government owned company in the field of energy.

2.7.3 Resources (option 6)

Main strengths

Industry

- It would provide a useful funding launch path for initial commercialisation of new technologies.

Member States

- It leverages additional investments in comparison to the current situation;
- Public procurement has a European added value because it complements investments through the SET Plan;
- Incentive funding for industrial actors.

Main weaknesses

Industry

- Implementing the entire roadmap through procurements is unlikely due to the variety of actions (from long term research to market-oriented actions) needed and resources required.

Member States

- Strong competition for procurement resources between different policies and sectors of activities; in particular in time of fiscal consolidation.

3. Comparing the options

3.1 Methodology

The evaluation of each implementation option rely on a qualitative grading on a scale from (-) to (+++), based on a comparison to the Business As Usual (BAU) option which by definition is set to 0. The BAU refers to the process of financing materials research as it stands today.

The three main assessment criteria of each option are:

- *Leadership*: ability of mobilising actors, engaging them and stimulating the European innovation base;
 - *Implementation*: flexibility of implementation, ability to adjust financial and administrative resources to the new schemes, flexibility to set priorities and delivery effectiveness;
 - *Resources*: the ability of leveraging resources and private investments as well as the optimisation of public resources.
- (a) A (++++) grade is granted when the indicator for a given implementation option provides a significant improvement.
 - (b) A (++) grade is granted when the indicator for a given implementation option provides a satisfactory improvement.
 - (c) A (+) grade is granted when the indicator for a given option provides some improvement compared to the BAU.
 - (d) A (0) grade is granted when no decisive impact is made.
 - (e) A (-) grade indicates a possible deterioration compared to BAU.

3.2 Grading

3.2.1 Industry

Leadership

Option 1 is granted (0) by definition, being the baseline. The level of leadership achieved by Option 2 does not change significantly compared to Option 1, although the role of the European materials industry would be strengthened in the work of the SET Plan EIIs. Nonetheless, projects are prioritised without industry's commitment; the grade is (0). Option 3 places industry as an equal partner, in the prioritisation decision making and willing to commit if the priorities are in line with its needs therefore the grade for leadership increases to (+++). An even stronger involvement comes in Option 4 where there is a clear and direct involvement of industry in the governance. Option 4 is also graded (+++). In Option 5, the level of involvement of industry in the governance raises some concerns as to how the priority setting would be comprehensive enough to respond to the market reality and in fact would be any different from Option 1, therefore a grade of (0) is granted. Option 6 is considered more as an instrument than an implementation frame. Therefore it is considered that the situation would not change compared to the baseline, hence the grade is (0).

Implementation:

Implementation in Option 1 is graded (0) by definition. Option 2 relies on the flexibility and administrative leanness of the SET Plan EIIs, hence this Option provides a slight improvement compared to Option 1, hence it is granted a grade (+). Option 3 is graded (++++) since it would provide a focused single frame for implementation for the materials roadmap, implying procedures streamlining and a cross cutting approach. The risk of having duplication of governance with SET Plan EIIs and unnecessary overhead costs along with a complex decision making system can be avoided if the process is correctly designed. Option 4 is graded (-) because although art. 187 is a known instrument, it looks from an industrial perspective too bureaucratic and complex to bring advantages in terms of implementation. Option 5 is seen

relatively advantageous from the point of view of implementation because it would pool resources from both EC and MSs into one single frame, which would allow carrying out bigger actions, without duplication of administrative procedures. Nonetheless to be effective, close involvement of industry and the research community is required for the priority setting, therefore the grade is (+). Option 6 requires a strong coordination of national public procurement agencies to be activated for the EU procurement. In addition, procurement is quite well fitted for industrial demonstrations which cover only one part of the roadmap action lines; therefore Option 6 is graded (-).

Resources:

The level of resources in both Option 1 and 2 does not change from the industry's perspective therefore both options are graded (0). Option 3, on the other hand, reinforces an alignment between EC, MS and Industry funding, therefore the grade is (++). Option 4 brings also advantages from the resources perspective, however it presents extra overhead costs which can undermine the advantages, hence the grade is (0). Option 5 brings resources from both Member States and EC, allowing industry to carry out larger actions. Hence, the grade is (++). Option 6 in terms of resources represents a good opportunity for extra funding, although only for a certain part of the roadmap, hence a grade of (+) is given.

3.2.2 Member States

Leadership

Option 1 is graded (0) by definition, being the baseline. The level of leadership achieved by Option 2 is (+) because it implies stronger involvement of the EU materials industry in the work of the EIIs. Option 3 in terms of leadership increases the commitment to industry and the Commission, however the advantages are partly jeopardised by the little involvement of Member States and by the low ability to accelerate competitiveness, hence a grade (+) is given. Option 4 brings a clear commitment from industry and the Commission, but presents little involvement of Member States, therefore this option is graded (0). Option 5 implies a clear commitment from all actors, in particular this option give the opportunity to coordinate national programmes on specific areas. On the other hand it is not fully clear if Option 5 can bring a new added value compared to the one of the SET Plan, therefore a grade (+) is given. Option 6, despite guaranteeing a clear commitment from both the Commission and Member States, and bringing high scale impact on industrial competitiveness, does not foster the collaboration between public and private research and it does not imply a dedicated action on materials. Therefore the grade is (0).

Implementation

Option (1) is granted (+) because it benefits from the existing structure with clear rules of procedures and a clear role of all actors, however it presents a low management and delivery effectiveness. Option 2 relies on the benefits of Option 1 which are well-established structure, transparent rules, clear role of each stakeholder and a good capacity of combining different tools, while providing a stronger supply chain perspective which is key for industrial competitiveness. Nonetheless, the need to further integrate the materials roadmap into the EIIs implementation plans might cause certain inertia of the EIIs current structure. This option is then graded (++). Option 3 can count on the success stories of the current PPPs and on the fact that it is managed by the Commission, this gives confidence to Member States. On the other side Option 3 could create a potential competition with the EIIs, and would have the limit of an assigned budget for a specific field without improving the management and delivery

effectiveness that Option 2 could have. Therefore the grade is (0). Option 4 does not present any advantage and it shows some important weaknesses, such as the problems already experienced with the current JTIs, the too bureaucratic structure required which does not guarantee a higher management and delivery effectiveness than Option 2, moreover it does not create an added value compared to the SET Plan framework. Hence Option 4 is graded (-). Option 5 is graded (-) as this Option despite pooling resources from both EC and MSs into one single frame, which would allow to carry out bigger actions, without duplication of administrative procedures, implies a new structure that risks being in competition with the existing EIIs producing a duplication of existing structures. Option 6 presents several advantages such as flexibility and good experience from the public procurement under FP7, however it does not guarantee high management effectiveness, and can create a conflict of interest while posing the problem of the level of expertise of national public authorities dealing with public procurement. Hence the grade is (+).

Resources:

Option 1 is graded (0) by definition. Option 2 reinforces the involvement of the European materials industry into the SET plan framework, hence additional industrial leverage. It is graded (+). Option 3 implies open and competitive calls, but on the negative side it has a low leverage effect as will relies mostly on EC funding from the public side. In addition, it may produce a dilution of industrial commitment because the EIIs will be maintained; it will have also to deal with a limited fixed budget granted by Horizon 2020 which would also risk burdening the interaction with the EIIs and it does not present a clear financial commitment. Therefore the grade is (+). Option 4 gives the possibility of having cash contribution from industry, however, building on past experiences, this option has a restricted capacity to commit resources from Member States, and a low ability of leverage additional investments, hence the grade is (+). Option 5 gives a clear vision on resources provided by Member States and the Commission although it requires strong willingness from Member States to commit resources jointly, therefore the grade is (+). Option 6 represents an additional instrument to leverage funding, if there is a well-designed pre-commercial procurement option 6 will have a leverage effect from industry. Option 6 is graded (+).

3.3 Summary

A summary of the analysis is shown in Table 1 below.

Option:	01	02	03	04	05	06
INDUSTRY						
Leadership	0	0	+++	+++	0	0
Implementation	0	+	+++	-	+	-
Resources	0	0	++	0	+	+
Total score	0	1	8	2	2	1
MEMBER STATES						
Leadership	0	+	+	0	+	0
Implementation	+	++	0	-	-	+
Resources	0	+	+	+	+	+
Total score	1	4	2	0	1	2

From the industry perspective, the preferred option is Option 3 (a contractual PPP) as the best solution that would provide thrust towards innovation. However it is ready to support Option 2 (BaU with EMIRI part of the EIIs) as a kick start option for bridging to a contractual PPP during a start-up phase.

From Member States the preferred option is Option 2 (BaU with EMIRI part of the EIIs) as a first step while investigate possibility of co-fund mechanisms to possible reach in the long term Option 3 (PPP) and/or Option 5 (Public Public Partnership).

It should be noticed that Option 6 has been recognised by all stakeholders group, more as a separate instrument to be coupled with any implementation options, rather than an implementing framework.

From the Research Community side (Universities), EUA-EPUE recognises the complexities associated with the implementation of the Materials Roadmap and values the performed by the Working Group to plan implementation processes and instruments that would result in good coordination of European efforts in materials research and innovation. EUA-EPUE agrees that it is essential to combine effective governance with appropriate progress monitoring and with the mobilisation of private and public resources at national and European level.

In particular, EUA-EPUE supports Option 1 as one of the implementation options that has to be retained in the development of the Materials Roadmap. EUA-EPUE abstained from grading the other five implementation options at this stage as it considers that a more in-depth assessment is necessary which should include additional elements, such as:

- to link the analysis of the implementation options to the thematic priorities to propose instruments which are appropriate to different technology development status, while retaining some core elements of open competition to attract the best research teams and be supported by transparent selection processes and exhibit a clear European added value.
- to incorporate an estimation of the necessary effort (e.g. political support, infrastructure, funding) for those options requiring additional commitment from MS.

- . to consider the need for several implementation options for each thematic priority according to their merits, seeking the right balance in achieving continuity and change from FP7 to Horizon 2020 instruments.