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Sustainable Nuclear Energy Technology Platform

EU Multi-annual Financial Framework 2014-2020: Aligning nuclear fission R&D budgets to reach SET-Plan targets

SNETP Position Paper

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Foreword

For sustainable prosperity, an affordable and secure energy supply with minimized environmental impact is a primary need, for Europe and beyond. Currently the major share of energy needs is covered by fossil fuel resources. With a growing world population and energy consumption per capita, fossil resources are becoming scarce, while global ecological impact from greenhouse gas emissions is increasing day by day. Increased geopolitical tensions, negative economic impact due to energy price volatility, and maintained imbalance in world population prosperity can be connected to this. It will be hard to change both the luxury of access to cheap energy, and the convenient way fossil fuels have provided it. The right answer is to replace the large share of energy generation by fossil fuels by a balanced mix of different low-carbon energy sources, whilst reducing energy usage as much as is reasonably achievable. The target to decarbonise Europe's economy by 2050 will lead to a considerable increase in electricity consumption. Therefore looking to massive electricity production by non-emitting sources like nuclear energy is a must.

Nuclear energy has been a reliable energy source for decades, and provides a significant share of current electricity supply (30% in Europe, 16% worldwide). SNETP targets to maintain this share in Europe, as a responsible contribution to the EU's energy mix. This is achieved by ensuring safe and reliable operation of the current nuclear fleet, supported by long term operation, maintenance programmes, and by pursuing the development of new build projects of 3rd generation nuclear plants. Furthermore, significant improvements in terms of resources, efficiency and waste production will be reached with the future deployment of the so-called Generation IV of nuclear systems, which relies on fast neutron technology with a closed fuel cycle.

In addition to its key contribution to the electricity mix, nuclear fission technology can also supply heat, in particular for industrial purposes. In a heat market dominated by fossil fuels, with no alternative from renewables, nuclear cogeneration of heat and power can be a game-changer in reducing the carbon footprint of energy-intensive industries. At low temperature this can come from existing systems, and a new generation is being developed for producing high temperature heat.

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SNETP's 7 key proposals

1. **Secure dedicated EU funding for the SET-Plan**
2. **Align nuclear fission RD&D funding with SET-Plan objectives & vision**
3. **Make available EU grants amounting to 2.75 b€ for the European Sustainable Nuclear Industrial Initiative (ESNII) [25% of total cost]**
4. **Include the Nuclear Cogeneration Industrial Initiative (NC2I) as a SET-Plan EII with available EU grants amounting to 1 b€ [25%]**
5. **Ensure that financial instruments under the MFF are open to nuclear fission research & innovation, in particular:**
   a. Horizon 2020 (Euratom & non-Euratom)
   b. Structural and Cohesion Funds
   c. Relevant EIB instruments including the Risk Sharing Finance Facility (RSFF)
   d. Euratom loans
   e. Other financial tools such as carbon credit instruments (NER type)
6. **Maintain continued support for research in safety and competitiveness of generation II and III plants, radiation protection and waste management – including lessons learned after the Fukushima accident**
7. **Facilitate European consortium building by ensuring that relevant legal structures (ERIC, Euratom JU…) are made available for nuclear prototype or demonstrator consortia**

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About this paper

The **Sustainable Nuclear Energy Technology Platform** (SNETP) gathers **more than 100** European stakeholders involved in the development, deployment and operation of nuclear fission reactors and fuel cycle facilities: industry, research & technology organisations, universities, technical safety organisations, service providers, non-governmental organisations, associations.

Despite industrial competition, SNETP has achieved efficient collaboration and consensus building between its stakeholders. It has developed a common vision on the future contribution of nuclear fission energy in Europe, with the publication of a *Vision Report*, a *Strategic Research Agenda* and a *Deployment Strategy*. Furthermore, SNETP is the umbrella for the preparation of EIIs under the SET-Plan: the **European Sustainable Nuclear Industrial Initiative** (ESNII), launched in November 2010, and the **Nuclear Cogeneration Industrial Initiative** (NC2I), under preparation.

This paper highlights the need for European involvement and significant support in initiatives that contribute significantly to the EU's strategic objectives defined in the SET-Plan, and the orientations given by the *Europe 2020* and *Innovation Union* vision.

In addition to SNETP's own strategic documents, this paper refers to a number of recent publications, including Commission communications or reports issued by advisory bodies, such as the *Centre for European Policy Studies* or the EC's *Advisory Group on Energy*, which back the need for significant EU financial support for nuclear fission R&D.

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I. Rationale of the key proposals

1. Secure dedicated EU funding for the SET-Plan

In November 2007, the European Commission proposed the Strategic Energy Technology Plan (SET-Plan) as the principal EU instrument for the development of low-carbon energy technologies to the year 2050 and beyond. Achieving the goals of the SET-Plan is vital for Europe – first and foremost to combat climate change and ensure security of energy supply; but also to maintain technology leadership and create jobs. Indeed, it is the only means of bringing fully competitive, low-carbon energy technologies to maturity and achieving the EU's 2020 targets, as we move towards the 2050 vision.

The SET-Plan is an ambitious programme designed to accelerate the development and entry of new technologies into the market – including research, technological development, demonstration and early market uptake. According to the European Commission, its success depends on the investment of an additional €50bn by the private and public sectors in the period 2010-2020.

Its adoption by the European Parliament and the Council has therefore raised strong expectations among European industry. The SET-Plan is also aligned with the expectations of European citizens who give priority to affordable and stable prices, sustainable energy sources and security of supply.

European industry has responded swiftly, committing itself to new *European Industrial Initiatives* (EIIs) that bring together *all* energy technology stakeholders – industry, research, Member States and the EU – via joint action plans, with agreed conditions for success. On the side of nuclear fission, the Sustainable Nuclear Energy Technology Platform (SNETP) is the architect of the ESNII – the European Sustainable Nuclear Industrial Initiative – facilitated by the European Commission and launched in November 2010.

Yet more than three years after the official launch of the SET-Plan, it lacks dedicated EU funding. While SNETP fully supports the importance given to the deployment of critical energy infrastructures, we should also like to highlight the key role of low-carbon energy technologies, whose development requires urgent financial support:

- The SET-Plan will bring **substantial benefits** to both the EU's economy *and* its citizens.
- Europe brings **critical mass**: no Member State can single-handedly achieve SET-Plan initiatives; the EU dimension allows the pooling of resources into large-scale demonstration programmes.
- EU public funding **leverages Member State and private funding, and reduces project risks**: in a global competition, public bodies are expected to support pre-commercial R&D and demonstration in order to preserve the interests of European industry.

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- In order to engage successfully in global competition in the field of energy technology, **Europe must act as one**. However, competition does not preclude cooperation and Europe's voice is stronger than that of a single Member State when negotiating with international partners.
- Last, but not least, the European dimension and visibility of the SET-Plan will promote **education and training** initiatives, in sectors where human resources have been identified as a potential bottleneck.

There is therefore **an urgent need for the European Commission to provide visibility for its financial support to the SET-Plan in the coming years**[1] as a lack or insufficiency in EU public funding will make it impossible to realise the implementation plans defined by the EIIs.

Of course the EU is not expected to take the bulk of the financial load, and the use of European public funds for SET-Plan projects will require a sound justification. But it is critical that European Institutions give a concrete signal of commitment: in particular, the ongoing preparatory work on the EU Multiannual Financial Framework (2014-2024) is a unique opportunity to ensure that dedicated financial means and tools are established in order to ensure the effective implementation of the SET-Plan.

2. Align nuclear fission research, development and demonstration funding with SET-Plan objectives & vision

Nuclear energy is one of the SET-Plan's highlighted technologies, with specific goals for 2020 '*to maintain the competitiveness of current reactors (Generation II and III) combined with the implementation of solutions for waste management*' and for 2050 '*to demonstrate the long term sustainability of fission Generation IV technologies*'. The 2020 goal requires efficiency improvements in reactor and fuel performance as well as a better understanding of how to deal with the effects of component ageing; this work is largely financed by nuclear industry with support and leverage coming from the EU Framework Programmes. On the other hand, the 2050 goal will require, in addition to basic research, the deployment of a number of pilot demonstration facilities, for which the commercial risks involved imply a high proportion of public financing.

In November 2010, a first nuclear European Industrial Initiative "ESNII" was launched during the Belgian SET-Plan Conference (see section 3 below).

The scope of funding required is clearly beyond the level of the current Framework Programme. The need for a specific funding mechanism for the SET-Plan, including the nuclear part, is critical. A study made by consultants Deloitte has given insights on the possible mix of financing tools and the legal structures which could be used for the implementation of the different demonstrators under the nuclear initiative. As flagged by the recent report by CEPS (*Centre for European Policy Studies*) on the financing of the SET-Plan, the nuclear part of the SET-Plan has a clear European dimension (unique large and expensive demonstrators at EU level to support the EU global technology leadership). It is nevertheless too far from commercialisation to expect the

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bulk of the financing to come from industry, although the electricity produced in pilot reactors could provide an income stream for reimbursing loans. A substantial contribution to the financing is expected at EU level, over and above what is to be provided by national contributions, in particular from the Member States where the demonstrators are to be built. France and Belgium have already committed respectively 650 and 400 million Euros for the ESNII facilities (ASTRID and MYRRHA) to be built on their territories. In line with the SET plan priorities, it is imperative that the next EU Multiannual Financial Framework 2014-2020 (MFF) incorporates an appropriate budget line for the nuclear technology development.

3. Make available EU grants amounting to 2.75 b€ for the European Sustainable Nuclear Industrial Initiative (ESNII) [25% of the total cost]

In line with the SET-Plan objectives, the **European Sustainable Nuclear Industrial Initiative**[1] was launched in November 2010. It targets the demonstration programme which is a key step towards the commercialisation of the technologies, and includes the necessary supporting R&D and facilities.

ESNII has the objective of designing and building over the next 10 years the fast neutron reactor (FNR) prototypes and demonstrators, and associated fuel cycle facilities, necessary to prove the feasibility of sustainable fast reactor operation with a closed fuel cycle and minimum generation of radioactive waste. A detailed 10-year roadmap and an implementation plan for ESNII has been elaborated by SNETP: the **ESNII roadmap** targets to commission by 2020-2025 the prototype and demonstrators needed in order to deploy by 2040 a commercial Generation IV FNR with a closed fuel cycle. The sodium-cooled fast reactor is the reference technology due to the large experience feedback in Europe and worldwide; ESNII also includes an alternative technology development (gas- or lead-cooled fast reactor).

One year after its launch, ESNII is supported by Belgium, the Czech Republic, Finland, France, Hungary, Italy, Lithuania, the Netherlands, Romania, Slovakia, Slovenia, Spain, Sweden and the UK

The overall cost has been evaluated at 11 bn€$_{2009}$ for the ASTRID prototype (sodium), the demonstrators ALFRED (lead) and ALLEGRO (gas), a fast neutron spectrum multipurpose irradiation facility (MYRRHA) and the associated research facilities and programmes. This figure is included in the "*SET-Plan Financing Communication*" adopted by the Commission in 2009 and endorsed by the Council in March 2010.

ESNII financing will be set up in the frame of **Public Private Partnerships** to ensure both early involvement of industry and industry-driven design. The medium to long term commercial horizon (2040) and the ambitious development, with inherent uncertainties, induce project risks that industry cannot take alone. This is the reason for a balanced financing scheme, to be put in

[1] www.esnii.eu

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place via a project-based approach: industry participation, national funding, European funding, EIB and Euratom loans, and tax exemptions.

Industry and some Member States have already committed resources to ESNII, and the Euratom Framework Programme is also contributing in consistency with SNETP's *Strategic Research Agenda*. To maintain momentum, to prepare the construction of the prototype and demonstrators and to take into account the long time-to-market, an average of 25% of EU grants is expected due to the **European dimension of the Initiative and the clear added value of public funding at EU level**.

4. Include the Nuclear Cogeneration Industrial Initiative (NC2I) as an EII under the SET-Plan with available EU grants amounting to 1 b€ [25%]

The cost of the committed CO2 emission reduction will impact the competitiveness of European energy-intensive industry if major efforts are not made to switch to low-carbon energy sources.

Nuclear cogeneration: potential game-changer in reducing industry's carbon footprint

Nuclear energy can contribute massively by supplying not only electricity but also process heat: the combined supply of energy in different forms (electricity, heat, pressure) is generally referred to as 'cogeneration'. **Nuclear cogeneration** will allow the delivery of economic, low-carbon, high-temperature heat to industrial processes; this emerging technology has a considerable potential in **maintaining European industry's competitiveness, while avoiding the 'carbon leakage' effect** of process industries delocalising to less climate-stringent countries.

Since 2009, major industrial companies (such as Solvay, DSM, Air Liquide, ArcelorMittal, Saipem, Technip, Polish chemical companies Pulawy and ZAK) and utilities (E.ON, Fortum…) are expressing interest in the technology, and a programme is being prepared **towards the demonstration of nuclear cogeneration**. Based on current industrial requirements and the foreseen timeframe, the focus is on High Temperature Reactor (HTR) technology, with specific features enabling applications linked to industrial processes. The adoption of other systems for lower temperature applications is also considered, depending on industry support[2].

A prototype is required to demonstrate the technical, economic and licensing feasibility of coupling an HTR to an industrial process. In view of the very large perspectives for this technology, when alternatives to fossil fuels for heat supply to industry are scarce, and of the significant risks in the first steps of implementation, an industrial initiative is being prepared for the SET-Plan framework. This initiative developed under the SNETP umbrella, namely the

[2] Opportunities like using waste heat from existing nuclear power plants, or using moderate temperature heat for seawater desalination or paper production are considered.

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Nuclear Cogeneration Industrial Initiative (NC2I), is driven by the requirements of end-user companies.

The prototype operation is expected to start in the early 2020s, for commercialisation to become effective after 2025. In this timeframe the technology is expected to contribute to energy infrastructure replacement foreseen by industry at their sites in Europe, and to assist new process developments in the chemical, refinery, steel and coal industries for which a low-carbon, economic heat source would be extremely beneficial.

Considering the risks and timeframe, the required investment cannot be borne entirely by industry. A PPP structure is foreseen, in which the public investments are expected in the first phases, where licensing, qualification and testing requirements, require supporting infrastructure and facilities with a significant funding without direct return on investments, in combination with significant research, financial and commercial risks. Once the construction starts, industry's financial involvement will step up. The estimated cost of NC2I is 4 bn€$_{2009}$; contributions with EU grants are expected to reach 25%, in view of **the clear added value to European industry's competitiveness and jobs, while providing game-changing technology to allow industry to massively reduce its carbon footprint**.

Europe's partners are also investing significant effort in this field. In the US, big players such as Dow Chemical, Chevron, ConocoPhillips, Eastman, PotashCorp and Entergy, along with nuclear developers, have created a joint corporation dedicated to prepare the HTR-based NGNP project. In China, construction of a 2-unit HTR demonstrator has started. Developments are also ongoing in South Korea and Japan. Considering the global nature of process industry, combining efforts internationally would alleviate the financial burden and contribute to the establishment of a generic, globally accepted licensing approach. International collaboration is therefore an integral part of the initiative.

5. **Ensure that financial instruments under the MFF are open to nuclear fission research & innovation, in particular:**

a. Horizon 2020 (Euratom & TEU)

The SET-Plan has defined an ambitious roadmap which deserves an increased EU contribution in the next MFF up to 2020. In the area of nuclear fission research, it was anticipated that it could come from an increase of the Euratom FP budget above business-as-usual figures and also from the possibility of financing under a dedicated SET-Plan Budget line nuclear research infrastructures and demonstrators, even under the TEU/TFEU legal base. In fact, the European Commission proposal for HORIZON 2020 doesn't include such provisions and could therefore not be considered, in the present state of play, as supportive of all low-carbon energy industrial initiatives of the SET-Plan on equal footing. SNETP wishes that the ongoing discussion in the Council and European Parliament will be able to offer some progress, including towards the financing of nuclear research infrastructures needed for the timely implementation of the European Sustainable Nuclear Industrial Initiative of the SET-Plan.

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b. Structural and Cohesion Funds

Structural and Cohesion Funds have been used in the past for financing a nuclear research facility. In the next MFF, the use of these funds should be more aligned with the priorities of the Europe 2020 Strategy. "Climate/Energy" and "Research/Innovation" are clear priorities: the SET-Plan being at the intersection of both, strong support from the Structural and Cohesion funds should consequently be made available. This would apply specifically to nuclear fission research infrastructures and demonstrators when they fit with Cohesion policy goals.

c. Relevant EIB instruments, including the Risk Sharing Finance Facility (RSFF)

RSFF has been recognised as a very effective tool for boosting innovation in areas where the financial risk does not allow access to standard investment schemes. The RSFF, financed by FP7 and the European Investment Bank (EIB), has not been open to nuclear innovation projects because of legal base issues. This should be reviewed for the next MFF and the corresponding tool designed so as not to exclude a priori one technology out of the low-carbon portfolio. The EIB has declared it is open to the financing of nuclear research and innovation infrastructures and demonstrators when a revenue stream is expected: this is the case both for ESNII and NC2I.

d. Euratom loans

Euratom loans have been used in the past for demonstration plants and safety upgrades. The increase of the Euratom Loan ceiling has to be renegotiated in the near future in order to maintain the availability of this facility. At the same time, the scope should be revisited to include the financing of those nuclear research infrastructures and demonstrators with planned revenue streams.

e. Other future financial tools such as carbon credit instruments (NER type)

NER300 has reserved the value of 300 million tons CO2 for the financing of the development of low-carbon energy technologies, focusing on RES and CCS, with the notable exclusion of nuclear technologies. This exclusion should be avoided in the future when carbon credits are used to support sustainable low-carbon energy research and innovation projects.

6. Maintain continued support for research in safety and competitiveness of generation II and III plants, radiation protection and waste management – including lessons learned after the Fukushima accident

SNETP was launched in order to develop technologies that fit with the 2020 and 2050 EU objectives in the energy domain. Considering the next 2 or 3 decades, it appears that there is a continuous effort from European nuclear stakeholders towards a continuous improvement of the safety and competitiveness of existing or newly built NPPs. Indeed, the European operators, the designers and the technical safety organizations are very keen to keep good records in terms of safety and production performance.

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The process of improvement goes on for some decades already and it induces a large confidence in plants which have a well-understood behaviour in all operating situations, so that any change in the behaviour of the NPP is very rapidly detected. It induces also a regular effort in R&D, a part of which is still devoted to better understanding and operating Gen II reactors, as well as anticipating their ageing features. Research is also performed for the new builds and for the improved Gen III reactors in the fields of safety and technological innovations.

Since the beginning of 2010, SNETP clearly identified the R&D needs of Gen II/III reactors. A first prioritisation was proposed in September 2010 and since the beginning of 2011, a large effort is devoted to organising future projects along a limited number of technical lines facilitating the management of projects and priorities. In the spring of 2011, a specialised working group was created to investigate the Fukushima Daichi NPP accident; the present status splits the research needs according to the following domains, including the first lessons learned from the Fukushima Daichi NPP accident:

1. Fuel, waste management and dismantling
2. Integrity assessment and ageing of Structures-Systems-Components
3. Plant safety and risk assessment
4. Severe accidents
5. Core and Reactor performance
6. Innovative Gen III design
7. Harmonization

The process for building the research programmes was proposed, and a dedicated institute (called NUGENIA) has been established in November 2011 by industry, research and safety organisations for defining a roadmap and coordinating projects devoted to the SNETP Gen II/III research needs. The majority of these projects are funded by industry, but some aspects require coordinated actions, with some financial support by the EU.

7. Facilitate European consortium building by ensuring that relevant legal structures (ERIC, Euratom JU…) are made available for nuclear prototype or demonstrator consortia

To attract public funding - whether from Member States, associated states or third countries - or private funding, a robust and efficient legal framework, fit for the purpose of the individual projects, must equally be established.

Europe already offers tools such as the Joint-Undertaking (under EURATOM treaty) or ERIC (under European treaty) as legal frameworks for establishing European consortia. Both these structures incorporate tax exemption clauses that are a significant contribution in the funding of a project.

However, although the creation of a JU can be decided with a qualified majority in Council, tax exemption will require unanimity as well as direct European Commission funding, and possible long negotiations may delay the process of creation of a European consortium.

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In comparison, the ERIC[3] framework, tailored for European research infrastructure consortia, offers a greater level of flexibility for its establishment and participation from third countries. Additionally, it gives access to supplemental, adequately-oriented financing tools from the EIB (RSFF loan type).

Therefore, it would be beneficial to ensure the possibility of optimal choice and facilitate the use of the ERIC framework when the project involves a high level of innovative development and/or for projects that are also taken up in the ESFRI[4] roadmap high priority list.

[3] European Research Infrastructure Consortium, a legal framework proposed by the EU for large research infrastructures.
[4] European Strategic Forum for Research Infrastructures

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II. Benefits of nuclear fission to the EU

Nuclear energy fulfils the established objectives of EU energy policy – sustainability, energy security and competitiveness. Nuclear power plants contribute around 30% of electricity generation in the EU and account for 2/3 of low-carbon electricity generation.

During operation, nuclear power plants are essentially carbon emission-free, and through their lifecycle only small quantities of greenhouse gas emissions are released. This gives nuclear energy a significant competitive advantage in a carbon constrained economy.

Sources of uranium to make the fuel for nuclear plants are, for the majority, located in politically stable countries. The fuel volume requirements of a nuclear power plant are relatively small and fuel stocks, enough for several years' operation, can be easily stored, contributing to the security of supply. Nuclear is virtually free from supply interruption problems and therefore offers additional guarantees on the availability of nuclear power plants, typically above 90%. In addition, 3rd and future 4th generation technologies permit a more efficient use of these resources.

Europe's indigenous nuclear energy industries are global leaders in nuclear fuel fabrication, enrichment, reprocessing and recycling activities, which support security of supply.

Nuclear fission…

- *Is a massive low-carbon energy source*
- *Ensures security of energy supply for Europe*
- *Has an excellent safety record in Europe*
- *Minimizes its waste with the new generations of nuclear plants*
- *Benefits from distributed and geopolitically stable uranium supply*
- *Offers operational availability above 90 %*
- *Provides economic energy for a competitive European industry and affordable electricity for consumers, independently from fossil fuel price volatility*
- *Is a sector where Europe has industrial leadership which needs to be maintained*

Nuclear power generation is significantly less sensitive to fuel price increase than fossil fuels. The OECD IEA World Energy Outlook 2006 found that a 50% increase in the cost of uranium, coal or gas prices would make nuclear generating costs rise by only 3%, while coal generating costs would rise by 20% and CCGT generating costs by 38%. The cost of uranium has a limited impact on the electricity price and compared to gas and coal fired technologies, nuclear generation shows greatest resilience to upside fuel price risks.

Nuclear energy is a stable, sustainable and affordable baseload low-carbon resource and an energy source capable of ensuring the competitiveness of European industries. It is generally agreed that nuclear energy represents the most economic option for base-load power production, as stated in the ENEF Competitiveness SWOT Report Part-1: *"In a wide range of*

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scenarios, nuclear energy is currently recognised as the least cost option for base-load centralised generation, even in low CO2 price scenarios".

For European industry (in particular energy-intensive industries) and residential consumers, stable, predictable and affordable energy prices are of paramount importance to boost economic growth and create jobs in the EU. Additionally, nuclear power plants are able to cogenerate power and heat for large scale industrial processes, such as oil refineries, chemical plants, steelmaking plants and hydrogen or oxygen producers.

Finally, nuclear energy also supports technological and scientific development in the EU and has led to many spin-offs and applications with major social benefits, like nuclear medicine.

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III. Added value of public funding at European level

There is a need for public support for technological developments which are costly and not without research, financial and commercial risks -- but which will eventually contribute greatly to Europe's objectives in terms of climate change, energy security, and competitiveness. SNETP, and the nuclear EIIs, are a Europe-wide initiative, which needs to be partially, but significantly, supported by EU public funding. Indeed, the added value for Europe to provide financial support to nuclear fission R&D is justified by the technology's benefits to European citizens and industries, as detailed above. Additionally, the nuclear programmes themselves have a European dimension that requires involvement at continental scale, in complement to developments carried out by individual Member States and industries.

a. SNETP addresses the pan-European challenge of shifting to low-carbon energy

SNETP fully supports the SET-Plan objectives for the development of low-carbon technologies for energy supply.

As stated above, nuclear fission is the largest low-carbon energy source in Europe. R&D activities on the 2nd and 3rd generation of nuclear reactors address technology challenges in the next ten years to meet the 2020 target expressed in the SET-Plan: *"maintain the competitiveness in fission technology, together with long term waste management solutions"*. R&D in this area, focussing in particular on lifetime management and plant optimisation, is in large majority funded by the private sector.

The European Sustainable Nuclear Industrial Initiative (ESNII) addresses technology challenges in the next ten years to meet the 2050 vision: *"complete the preparations for the demonstration of a new generation (Gen-IV) of fission reactors for increased sustainability"*. The 'ESNII Task Force' of SNETP coordinates European efforts in the domain of fast neutron systems with the vision of a closed fuel cycle for fully sustainable nuclear energy, thus multiplying by a factor of up to 100 the energy potential of uranium reserves.

In an intermediate timeframe, the Nuclear Cogeneration Industrial Initiative (NC2I), under preparation, addresses the opportunity for energy-intensive industrial sectors to benefit from nuclear energy, not only for electricity, but also for process heat, thereby cutting CO_2 emissions in a large area of energy consumption supplied today almost exclusively by fossil fuels. This will in turn allow industry in Europe to maintain or increase its competitiveness, and, in the context of stringent climate policies in Europe, avoid both the 'carbon leakage' effect and job migration from the continent.

b. Europe brings the critical mass required to achieve the ambitious goals of SNETP

No single Member State can provide the necessary resources (financial, manpower or infrastructures) for the achievement of the SNETP initiatives, which hence need to be carried out at an EU level, in order to pool resources into large-scale demonstration programmes.

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The initiatives launched under ESNII are already planning a European dimension to their respective consortium.

- ASTRID is the prototype for the reference technology of sodium fast reactor (SFR): decisions on construction of the prototype in France are expected by 2012-2014, with discussions underway for the creation of a European investors/users consortium.
- MYRRHA[5] is a multipurpose fast neutron spectrum irradiation facility that is proposed to be operated as a pan-European large research infrastructure under ERIC. The construction of MYRRHA is expected to start in Belgium in 2016. It shall serve:
  - as experimental pilot plant for the lead technology and therefore in full support of ALFRED
  - as technological system for waste transmutation and its economic viability
  - as a flexible irradiation facility for material and fuel development in support of the prototypes and demonstrators of Gen IV.
- ALFRED is a demonstration programme targeting the construction of a lead fast reactor (LFR) demonstrator in Central / Eastern Europe (Romania has proposed to host)
- ALLEGRO is a demonstration programme jointly managed by several Member States (CZ, HU, SK, with PL possibly joining) targeting the construction of a gas fast reactor (GFR) demonstrator in Central / Eastern Europe

The NC2I initiative, although less advanced in its preparation, has already raised the interest of several Member States such as Poland or the Netherlands.

c. EU scale financial support allows sharing the risk and leveraging investments

The development of breakthrough technology always comes with a risk. This is true for the development of the next generation of nuclear fission systems. Initiatives at European level allow sharing this risk.

- **Reduction of research risk**

Working in European consortia helps to lower the risks, thus enabling research to take place and enhancing the participation of the private sector.

The harmonisation of methodologies at EU level (reliability assessment of innovative systems, probabilistic methodologies for safety assessment, etc.) is a clear example of the added value of working at European scale. As another example, European research synergies on the ageing of second generation reactors enable key in-depth understanding, thus easing the licensing processes for plant lifetime extension.

As European initiatives, ESNII and NC2I allow the coordination of national policies in the areas of fast neutron reactors and nuclear cogeneration, of common interest for a number of Member

[5] MYRRHA has been taken up in the ESFRI roadmap 2010 high priority list of energy projects as a large research infrastructure for Europe.

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States. This avoids overlapping and fragmentation of R&D efforts, thus targeting public investments more efficiently.

For the fast neutron reactor technologies, various countries in Europe (BE, IT, SE, ES, DE, RO, NL, CZ …) are allocating funding to design and research activities:

- Sodium fast neutron reactor (SFR) technology: FR, IT, DE, SE, NL, CZ, UK
- Lead fast neutron reactor (LFR) technology: BE, IT, SE, ES, DE, RO, NL, CZ
- Gas fast neutron reactor (GFR) technology: CZ, SK, HU, FR, NL, PL, UK

As regards the high temperature reactor (HTR) technology, a number of Member States also have R&D programmes: NL, CZ, UK…. In addition, this builds on the past experience of 2 Member States (DE, UK) which had HTR programmes in the 60s to 80s. Finally, Europe also benefits from experience with low-temperature cogeneration, for district heating for instance (CZ, FI, CH…).

- **Reduction of financial risk**

New and investment-intensive technologies need be demonstrated in order to minimise financial risk for future investors; this is key to opening the market potential. The expected benefits for Europe (society and economy) fully justify the need for significant public support in the demonstration phase.

Commitment by stakeholders in European public-private partnerships to engage in costly demonstration programmes enables reduction of the financial risk, as compared to national programmes. EU public funding will allow the leveraging of private and public investment: with EU financial schemes, private companies and public bodies can collaborate at a scale usually not possible at national level.

Furthermore, EU funding under the SET-Plan is expected to exercise a “catalytic” effect on national funding for ESNII and NC2I. As regards external investors, the EU decision to fund a project also stands as a quality criterion.

- **Reduction of commercial risk**

Working at EU level helps ensure that the developed technological solutions are applicable across Europe (and beyond), enables the development of harmonised European norms, and offers the potential for exploitation in a market of 450 million people.

For instance, one of the key actions initiated under ESNII is the definition of harmonised European codes and standards.

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d. SNETP promotes the interests of European industry in a worldwide competition

The international context for the nuclear industry today is an increase in global competition, with 'traditional' nuclear developers from Europe, the US and Japan now competing with developing programmes mostly from Russia and Asia (China, India, South Korea). This is true for current (Gen III) technologies but also for the next step -- Gen IV.

Europe's leadership in the nuclear industry needs to be maintained. In addition to obvious benefits in terms of economy and jobs within the sector, the need to keep a competitive domestic capacity is crucial in the light of Europe's future energy needs.

ESNII is led by European industry (utilities, nuclear vendors and engineering firms, along with research & technology organisations), and provides a unique opportunity for this industry to preserve its leadership in the future nuclear landscape.

NC2I not only associates nuclear developers and power companies, but also involves conventional process industries which see in nuclear fission a potential for a massive economic and low-carbon heat source.

e. A European position is stronger when discussing with international partners

International cooperation is commonly seen as a way to leverage the developments made in Europe:

- It gives access to the international trends in technology development and is a benchmark to assess the excellence of European R&D.

- It is the best way to build an internationally recognised consensus on safety requirements and solutions both for existing and future generations of reactors. In this respect, Europe has a major role to play when considering the interests of its nuclear industry.

- It is an opportunity to share the costs of the main R&D or testing facilities and to share the costs of technology demonstrators or pre-industrial reactor prototypes.

- It is an opportunity to maintain European technological leadership.

For the development of the fourth generation of nuclear fission, international dialogue is already structured in the *Generation IV International Forum* (GIF[6]) established by a number of countries involved in Gen IV research (US, EU, China, Japan, South Korea, Russia, South Africa, France, Switzerland, Argentina, Brazil, Canada). This forum opens a formalised dialogue to avoid gaps or duplication in research. The EU is represented in GIF by the Joint Research Centre as implementing agent.

[6] http://www.gen-4.org/

f. R&D infrastructures are shared across Europe

Initiatives at EU scale allow the sharing of research and test infrastructures, by opening access to European research teams.

For instance, ESNII launched an exercise of mapping and gap analysis of research infrastructures at EU scale. Under the so-called 'ADRIANA' project, the necessary investments for R&D and test facilities to support the development and the construction of the ESNII programme have been identified in June 2011. There will be consequent opportunities to refurbish or build new facilities throughout Europe.

g. SNETP enhances researchers' education, training and mobility

SNETP considers the question of human resources as critical for the future of nuclear energy in Europe. A dedicated SNETP working group was set up to address education, training and knowledge management ("ETKM"). The European Nuclear Education Network (ENEN), grouping more than 40 higher education institutes from all over Europe, is also an active member of SNETP.

Large European initiatives create momentum and attract young Europeans into the nuclear field (researchers, engineers, technicians), at a time when the need for qualified staff is increasing. They will also enhance researchers' mobility by opening opportunities and breaking down barriers.

Some of the ESNII facilities (e.g. MYRRHA) are conceived as research infrastructures and are therefore partially operated as open user facilities. The criterion of research excellence will apply and research project selection shall be made through an independent programme access committee (PAC). It is therefore providing equal opportunity to European researchers.

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IV. Appendix: nuclear fission R&D funding in Europe today

(sources: SNETP Deployment Strategy, ESNII Implementation Plan, EURATOM Work Programmes, ESNII Team report)

Funding of R&D for the fleet under operation (Gen II) or construction (Gen III)

According to the IEA R&D statistics and to the EC report "*R&D investment in the priority technologies of the European Strategic Energy Technology Plan*", R&D investments in EU27 in nuclear technology amounted to EUR_{2009} 400 million per year and are equally financed by the private and the public sector; more than 95% of R&D investments in Gen II and III come from private companies and national R&D programmes.

In the period 2010-2020, the total R&D investments for Gen II / III are estimated to be 5 bn $€_{2009}$. The coordination made possible by SNETP allows reducing this budget to 4 bn $€_{2009}$. The share expected to be conducted as collaborative R&D under SNETP is expected to be 1.5 bn $€_{2009}$, funded 2/3 by industry and 1/3 by national or EU public sources.

Funding of R&D and demonstration for the next generation (Gen IV)

Over the 2010-2020 period, European funding needs for the RD&D effort of the ESNII initiative are estimated at 11 bn $€_{2009}$, and for the NC2I initiative, at 4 bn $€_{2009}$. These figures could be significantly reduced in case of international partnerships. The expected share of the cost is estimated at 80% from the public sector (national and EU) and 20% from industry. For ESNII projects, 650 M€ were committed by France, and 400 M€ by Belgium. For the period 2010-2012, the ESNII budget is 690 M€ (as stated in the ESNII Implementation Plan).

Funding of nuclear fission R&D by European Framework Programmes

The Euratom FP7 typically provides fission R&D funding of 50 M€ per year, including research on radiation protection, medical use of nuclear, geological disposal, nuclear safety, and advanced systems. The share dedicated to activities in the scope of SNETP (safety and systems) is usually around 15 to 20 M€. In contrast, the Euratom FP7 annual budget for fusion is usually around 400 to 500 M€.

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Quotes

- *"The European Commission should lead in areas with important cross-border or scale effects, notably (smart) grids, CCS and nuclear"* (CEPS Centre for European Policy Studies, May 2011)

- *"Substantial public money contribution, both at national and European level, is expected under the SET-Plan for Gen IV development, in addition to investment by the industry. This EU public financing instrument for ESNII needs to be integrated in the ongoing work on the European Multiannual Financial Framework 2014-2020"* (European Nuclear Energy Forum, WG Opportunities / sWG Financing, 2011)

- *"Nuclear energy has a significant role to play in realisation of the objectives set out in the SET-Plan, i.e. reduced carbon emissions, increased security of supply, decreased dependence on delivery of energy sources from unstable world regions, and increased industrial competitiveness"* (EC Advisory Group on Energy, June 2011)

- *"Electricity generated by nuclear power plants does not cause end-of-pipe GHG emissions. A high share of nuclear electricity generation in total electricity generation contributes to reduced GHG emissions reductions"* (European Environment Agency, October 2011)

- *"A special Low Nuclear Case examines what would happen if the anticipated contribution of nuclear to future energy supply were to be halved. (…) Such a slowdown would increase import bills, heighten energy security concerns and make it harder and more expensive to combat climate change"* (International Energy Agency, November 2011)

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