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NUCLEAR ENERGY AGENCY
COMMITTEE FOR TECHNICAL AND ECONOMIC STUDIES ON NUCLEAR ENERGY DEVELOPMENT AND FUEL CYCLE

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Final Summary Record of the 4th NI2050 Advisory Panel Meeting

9-10 March 2017
OECD Conference Centre, CC7
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NI2050

4TH Advisory Panel Meeting

OECD Conference Centre, CC7

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SUMMARY RECORD

The well-attended meeting allowed to bring all the Advisory Panel Members on the same page, since not all had been participating on the more restricted meetings of September 2016 and January 2017.

There was agreement to go ahead with the selection of Topical Areas and Topics, using a set of criteria finalised at the meeting. For these topics, templates will be drafted leading to the development of Programmes of Actions, meaning projects and infrastructures, presented with timelines. A few such topics and templates had been prepared in advance of the meeting to allow a fruitful discussion on concrete cases.

As a result of the discussions and as agreed at the meeting, the Secretariat will send the List of Topical Areas and the standard Template to the Members of the Advisory Panel (and possibly other appropriate contacts as useful). Addressees will be asked to provide comments/additions to the List of Topical Areas, and, if so desired, to provide titles for specific Topics for the drafting of a Template. This should be accompanied with the nomination of a lead person to draft the Template.

The resulting consolidated list of topics will be further circulated by the Secretariat to all Members of the Advisory Panel, to give a chance to team up for the drafting of Templates.

Draft Templates need to be provided to the Secretariat for end of August 2017 at the latest, but anticipated interactions will be organised by the Secretariat, in particular to help the lead drafters.

The Secretariat will prepare elements of a NI2050 report for presentation at the next Advisory Panel Meeting on the 25/26 September and for the NDC on the 27/28 September, where the future of NI2050 and the mandate of the Advisory Panel should be discussed.

PREP MEETING WITH CHAIRS (8 March)

Participants: Chairs and Co-Chairs of the NI2050 Adv Panel, Chairs of the NI2050 Expert Groups of March/April 2016, experts who started to draft pilot templates on topical areas selected by the Adv Panel Chairs meeting of January 2017.

The objective was to review the agenda of the 4th Adv Panel meeting and go through the PPTs and subjects to be discussed – so as to build common understanding among the Chairs and involved experts.

During the discussions, a number of remarks were made which may deserve recording:

- Nuclear is at a crossroad, at least in a number of NEA member countries (ia liberalised energy systems). Nuclear R&D budgets have been reduced compared to 40-30 years ago. Nuclear industry of today is still “benefitting” from these past public investments in R&D, but this will

not continue for long. We now need to define what R&D programmes and infrastructures are necessary in the coming decade or two, to make nuclear a potential contributor to the energy mix in 2030-2050 and beyond. The outcome of NI2050 should be tailored to target policy makers.

- NI2050 is much about reducing the "R&D projects risks". Risks are of different nature: safety and waste related risks, public acceptance, increasing complexity of project management (even if, or maybe because, more tools and more knowledge are available), increasing complexity of the regulatory and licensing environment, sometimes dogmatic approach of the independence of the regulator, expected short term returns on investments, tendency of organisations (including R&D) to become more failure adverse,…

- Therefore, NI2050 has to help in de-risking nuclear R&D projects: selecting areas where it is possible to reduce the time to market, proposing the streamlining of the experimental path (testing, validation, qualification, combination of experiments with modelling and simulation), fostering the availability of necessary infrastructures and demonstrators, helping building cooperative approaches, including between R&D/industry/regulators, creating a common knowledge base where possible, leading to accelerated licensing,…

- A strong point was made on the need to identify the necessary R&D infrastructures. A number of facilities are closed down or will soon, and it is vital to define what critical facilities will be necessary for the future. NEA NSC is developing a dedicated activity on this issue, which will be fully linked with NI2050.

ADVISORY PANEL MEETING (9 and 10 March)

1. Participants and Agenda: see the NI2050 website.

2. Opening Message

The NEA DG opened the meeting by clarifying the main objective of NI2050: define what needs to be done in fission R&D to ensure that nuclear energy can be a contributor to the low carbon energy mix in the 2030/2050 timeframes. Because there are many diverse views, the aim is not to get a unique list of priorities agreed by all, but a broad list of significant opportunities for technologies, to allow innovation to take place, accelerating the time to market, involving R&D, industry, regulators. This will take place in an environment which is much more complex than at the early ages of nuclear development, inter alia in terms of the regulatory environment and projects finance structures. The NEA provides the right framework where this can be analysed. The outcomes will be tailored to address the policy makers and the stakeholders, aiming at real implementation of projects through cooperation, as the next step.

3. Status NI2050 Survey

The Secretariat presented the final consolidated picture of the budget data collected via the NI2050 survey launched in September 2015. The Secretariat pursued a further comparison with the data collected by the IEA during their yearly Energy RD&D budgets review – among which nuclear fission is a part. Due to the limited amount of data available for fission on the IEA side, the comparison could only be done for 3 countries: Canada, Japan, USA. Only in the case of the USA are the data more or less comparable for the full period 2010-2014.

The Secretariat indicated that while the survey initially intended to collect data on both the public and private funding of fission R&D, the analysis of the returns clearly shows that the data collected are very largely related to public funding.

Following the discussion, the Chair asked the secretariat to focus the analysis on the general trends in funding over time, for the total figures and for each category.

The number crunching and drawing of graphs are now finalised. Member countries who have not provided their data may still do so in form of graphs similar to the one presented during the meeting. The Secretariat may pursue direct contacts with industry associations (ia EPRI) to try to get some indication of private funding for nuclear fission R&D.

4. Clarifying NI2050 Concepts

The Chair presented a set of slides (see NI2050 website) to review and clarify the NI2050 concept, aim, grand challenges, and technologies domain. This allowed all members of the Advisory Panel, including those who had not participated in the limited meetings of September (2030 and 2050 Working Groups) and January (Chairs meeting), to be informed on the evolution. Indeed while the approach is still in line with the ToRs agreed early 2016, the concept of innovation has been matured. It is now much centred on the accelerated transfer of R&D outcomes towards industrial deployment, in particular for the 2030 perspective. This means that industry and the TSOs/regulators need to be part of the NI2050 process, since licensing is a necessary condition for industrial deployment. For the 2050 perspective, more R&D is necessary, but the industry and regulatory perspectives and involvement should nevertheless be fostered as early as possible in the process, to facilitate the reduction of the time to market at later stages, and so enable the viability of the technology (technical, regulatory, economic aspects).

While NI2050 keeps the ambition to give a broad view of nuclear fission R&D needs for innovation, it would also serve as an incubator for concrete "innovation" programmes (projects and supporting R&D infrastructures), to be then proposed, when mature, for policy makers and stakeholders (Govts, R&D, industry, regulators, financing institutions) to decide on the ad-hoc cooperative implementation mechanisms (ia financial and legal frameworks).

To conclude that part of the presentation, the wording of the "NI2050 Aim" was approved by the Advisory Panel:

NI2050 – Nuclear Innovation 2050 is a broad NEA Initiative:

- aiming at incubating (selecting and developing) large scale R&D and market uptake programmes of actions (projects and infrastructures),

- for proposing them for further implementation by stakeholders (governments, R&D bodies, industry, TSOs and regulators, financing institutions),

- to accelerate the readiness of innovative technologies and help them reach competitive deployment in time to contribute to the sustainability of nuclear energy in the short/medium (2030) to long term (2050).

During the following discussion, a number of remarks were made by participants:

- Beyond safety, waste management should be more visibly added, as joined conditions for future nuclear systems. It should serve as one criteria for the selection of priority topics for NI2050.

- While it is good to have ambition for innovation, realism is necessary when using words like Codes and Norms, Harmonisation, and Acceleration – knowing the constraints of the nuclear

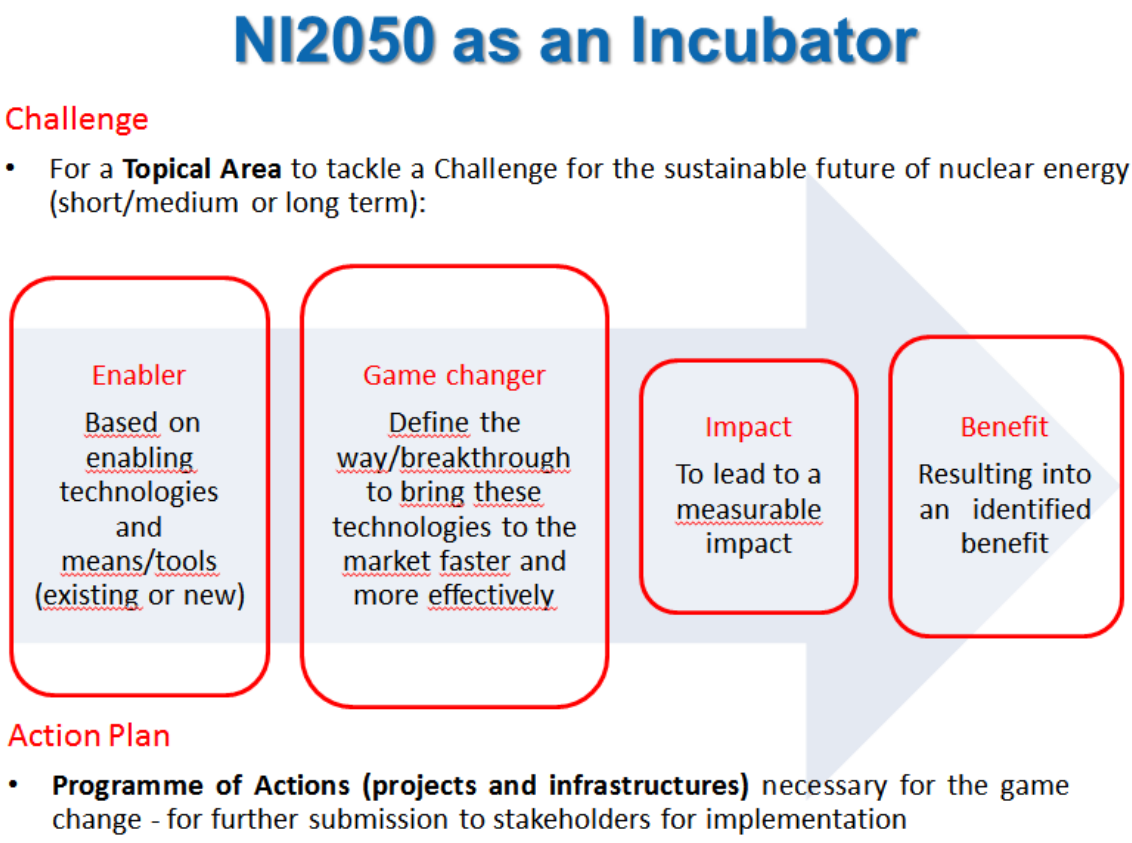
specificities. A lot might be gained in collaborative prenormative and precompetitive approaches and, in particular, sharing of facilities.

- Beyond "technology innovation", it is necessary to innovate also in communication, business models in evolving energy markets, financing mechanisms,… The NEA Secretariat mentioned that there is one project in the DEV Division PoW 2017-2018, dedicated to the analysis of (innovative) financing mechanisms in use or under development for R&D and innovation in the global energy sector – most of these mechanisms being, as of today, not accessible for nuclear projects.

- Noting the actual difficult financing situation of some industry players, either at utility or vendor level, for diverse reasons, it would be important to address the policy makers in governments to realise that public financing will be still necessary and most probably increased compared to the last decades, to foster longer term innovation. Global concerted approaches such as the one developed by the Fusion community should be considered for fission also. NI2050 might help there, once outcomes can be tabled for policy makers.

5. Tools for NI2050 Incubator

To serve the purpose of incubator and help in the drafting of "concrete" innovation programmes (projects and infrastructures) to be proposed for cooperative implementation by stakeholders, a incubation method and a template have been developed by the Secretariat for discussion:



Output of Incub for Topic Areas: Template

- **1. The issue (Challenge/Opportunity) to tackle and objectives to reach**
  Explain what are the problems to be solved and the associated objectives to reach.
- **2. What is done/exist already, who is doing what, what are the means (resources and infrastructures), what are the bottlenecks, why does it not go faster…**
  In most cases, R&D and/or demonstration/validation/qualification programmes and infrastructures already exist and can be briefly described. The reason why more is necessary, identifying in particular difficulties, delays and bottlenecks, justifying the inclusion of the topic in NI2050, should be explained.
- **3. What can be done to improve/accelerate (ia through cooperation)**
  *Explain conceptually how to go beyond what is done under 2, what are the **enabler(s) - game changer(s)** to overcome difficulties, delays, bottlenecks, to improve and accelerate R&D and market deployment (**impact and benefit**).*
- **4. Action plan and necessary means (resources and infrastructures)**
  *Provide an Plan of Actions (scope, sequence and timeline) to implement the concepts described in 3. This should allow the extraction of **concrete large projects, with definition of necessary means and infrastructures for implementation.***

6. Pilot Templates as Examples

At the NI2050 Advisory Panel meeting of January 2017 (see summary record on the NI2050 website), the AP Chairs had approved a first list of topical areas proposed by the Secretariat, for which experts were asked to develop first draft templates to serve as examples, test the process and feed the discussion at the 4th Adv Panel. Presentations were made at the meeting on the work in progress (see the NI2050 website), allowing discussion on the "technical scope", but also on the potential for the process to deliver high quality NI2050 output.

Accident Tolerant Fuels – Kemal Pasamehmetoglu INL (Vice Chair AP, Chair NSC WG on ATF)

This subject is a very good example of the necessary win-win approach to Safety AND Economics. A recent workshop was organised jointly by the NSC and the CSNI on advanced fuels, where utilities insisted on the need to have a real global economic benefit to be convinced to use more expensive ATF in their reactors: either by using some ATF additional safety margins to relax the safety classification of other components, either by inducing costs reduction in refuelling/maintenance. This showed that a global system approach is necessary to judge the innovation opportunity, and targeting all stakeholders: R&D/vendors/utilities/regulators, aiming at reducing the costs and time to market.

Main conclusions of the Advanced Fuels Workshop were as follows:

- A global system approach is necessary with all stakeholders involved,
- The proper combination of Modelling and Simulation AND experimental validation/qualification needs to be further developed and tested,

- Physical transfer of irradiated samples needs to be facilitated for cooperation.

Advanced Fuels – Nathalie Chauvin CEA (Participant in the NI2050 EG 2.2 March 2016)

The proposal, in continuation of the works of the NI2050 Expert Group 2.2 of March 2016 chaired by Mr Mizuno, is to develop one template each for advanced oxide, metal and nitride fuels, and one more template focussing on accelerating deployment by improved qualification process – even if we are here in longer time perspective than for ATF.

The recommendation following the discussion was to concentrate the template on what should be done beyond the activities already engaged, ia in dedicated NEA WGs, to speed up the process of validation/qualification. This should be based on the proper combination of M&S and experiments, and involve industry (vendors and utilities), the regulators at the diverse stages of the development, and not only at the end (eg TRL7) in order to anticipate problems and gain time. To be concrete enough in proposing projects in the template, it might be appropriate to target one type of fuel first, instead of covering all three of them.

Advanced Materials – Lorenzo Malerba SCKCEN (Chair of the EERA JPNM)

EERA JPNM is working on both materials and fuels for advanced systems – up to TRL5. Here the focus is on materials as fuels were covered by the previous presentation. There are two templates proposed: one targeting the availability of 60 years lifetime materials for the Gen IV prototypes – based on known materials in a 2030 timeframe but for which the 60 years lifetime was never proved, and the other for revolutionary materials (F/M steels, hi T composites, coolant compatibility).

The added value under the NI2050 framework would be to broaden the cooperative base, beyond JPNM, to screen the best materials by mechanical and structural characterisation in a larger pool of available data bases and testing facilities, and to foster the modelling and simulation. This might be done in precompetitive mode.

The discussion focused on the potential for acceleration and cost reduction, ia by using ion beams instead of neutron irradiation. This may have implication in terms limitations of the modelling and simulation.

A request was also made to integrate the decommissioning waste management/recycling issues from the early stages of material selection.

Finally, NI2050 seems also to be the opportunity to engage earlier and more effectively the industry and the regulators in the development and qualification of advanced materials and fuels.

Modelling and Simulation (in support to Fuels and Materials) – Tim Valentine ORNL (and al.)

M&S is to be seen as an enabler in support of innovation in Fuels, Materials, Reactor Design (Neutronics, T&H), etc… M&S is to be coupled with experiments from a double perspective: experimental validation of codes, and, after appropriate evaluation of the domain of validity of the codes, subsequent substitution of experiments by M&S for the qualification of fuels, materials, reactor designs. Experiments (and the associated measuring instrumentation) need to be tailored to the needs for development and validation of M&S, then modelling may be used to interpret results of qualification experiments…

The NEA NSC is the place where the mixing of the two communities can take place. NI2050 can serve as a boost for some concrete initial project.

There will be no template for M&S per se, since it is an enabler. M&S aspects should be embedded in templates where M&S is contributing to innovation.

Cogeneration and Heat Supply – Dominique Hittner HTR Consultant (Participant in the NI2050 EG 4.0 March 2016), and Kazuhiko Kunitomi JAEA (HTTR)

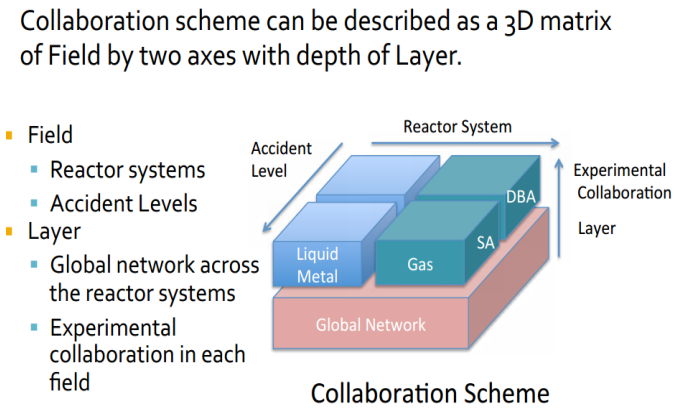
The focus is on high/very high temperature heat generation for cogeneration or industrial processes, as a possible important contributor to decarbonisation. A group of organisations/countries is already gathering in the "PRIME" project and can serve as the nest for cooperation. The template might be divided into two time frame: the first targeting a 550°C HTR demo for 2030, the second focussing on much higher temperatures for 2050. One major piece into the timeline might be the demonstration of the coupling between the existing HTTR and H2 facility at JAEA. Designing, building, licensing, testing this coupling seems a necessary milestone to attract the interest of user industry for nuclear generated high temperature heat. HTTR is presently shutdown and the restart is dependent on the relicensing according to new stringent (seismic) post-Fukushima regulation.

During the discussion, comments were provided on the need not to duplicate what is done elsewhere (GIF, GESAR). The IAEA has also HTR safety related activities, but not on the issue of coupling with an industrial process.

One may note that the demonstration of the coupling per se has value not only for HTGR/VHTR, but for all other reactors which may deliver heat above 500°C (FNRs, MSRs). It might therefore be a central element of the template – once the potential for restarting HTTR is confirmed.

Safety and Economics of Gen IV: DHRS – Hideki Kamide JAEA (Vice Chair AP, Co Chair NI2050 EG 1.2 March 2016, Vice Chair GIF PG)

The challenge for this template was to find the way to address cross-cutting issues for Gen IV systems. Removal of the Decay Heat using passive safety systems in case of Station Blackout might be a good case, illustrated by the following picture:



A number of experimental facilities are existing for some GEN IV systems and may be pooled through cooperation to progress faster in testing, simulating, validating and verifying, and licensing DHRS for Gen IV systems.

Again in this case, modelling and simulation comes back, but with a focus on TH for advanced reactor systems.

IAEA mentioned their free access Data Base on LMFR experimental facilities and infrastructures.

Advanced Manufacturing and Construction – NEA Secretariat Daniel Iracane (CNO)

The possible scope for a template on this topical area may focus on the use of existing new concrete structures in the nuclear sector. Such methods are already used in civil works and, if imported for nuclear construction, may lead to construction time and cost reductions (civil works is 1/3 of the cost of a new NPP). Informal contacts have been taken by the secretariat with industry, and may result in the development of a template. In such a case the aspects of licensing and the relations with the regulators will be key, ia in terms of the qualification not only of the "concrete per se", but of the "system as a whole" (ia interfaces between the modular manufactory built pieces).

This might be a good example of import of new technologies into the nuclear sector, with the necessary condition to have the regulatory approach adapted. Therefore the involvement of regulators in this project will be necessary.

During the discussion, the possibility to embed sensors into the concrete to follow the ageing in-situ was flagged as an additional domain for innovation – linked with an enabler on measuring and monitoring devices.

Beyond concrete structures and civil works, advanced manufacturing and assembling of mechanical equipment (with embedded sensors), ia 3D printing, might also be a good subject for a template.

7. Discussion on Criteria for Topic Selection, Template Format, List of Topical Areas/Topics, Tasking and Schedule

7.1 Criteria for the Selection of Topics

The topics discussed in the section above were selected just to serve as pilot models to test the draft template proposed by the Secretariat and help the Advisory Panel discuss the NI2050 process of using the templates to develop concrete programmes of actions for innovation.

To justify the selection of topics, the ones above, but also additional ones (up to ten at least to have a good representative first outcome of NI2050 as an incubator), the Advisory Panel discussed and agreed a set of "selection criteria":

Criteria for Selection (of Priorities): « Action in the proposed Topical Area… »

- **Matches a Top Level Goal:**
  - adds value for a positive impact on Safety and Waste, Sustainability, Public Acceptance AND Economics
  - accelerates the readiness for market deployment
  - has the potential to attract investment
  - helps sustainability of infrastructures, know-how, skills and competences needed for realising nuclear projects

- **Serves an Enabling Goal:**
  - reduces the risks of the innovation process by solving challenges through pre-competitive international cooperation

- **Increases Effectiveness**
  - is a breakthrough
  - fills a gap or is necessary element in a chain
  - is cross-cutting
  - enables parternships among the technical, regulatory and financing communities

- **Is a necessary Tool**
  - is a necessary R&D infrastructure (hardware and/or software)

7.2 Template format

It was agreed that the template will be modified to include a first section asking to justify the selection of the topic by using the set of criteria above. Topics do not need to fulfil all the criteria but at least some of them. The modified template can be found in annex.

On the content of the templates, the Chair insisted that all of them, in the section Plan of Actions, include a clear sequential timeline of the actions (projects). To illustrate this on a generic basis, a model was found in the presentation on ATF, and another in the presentation on Cogeneration:

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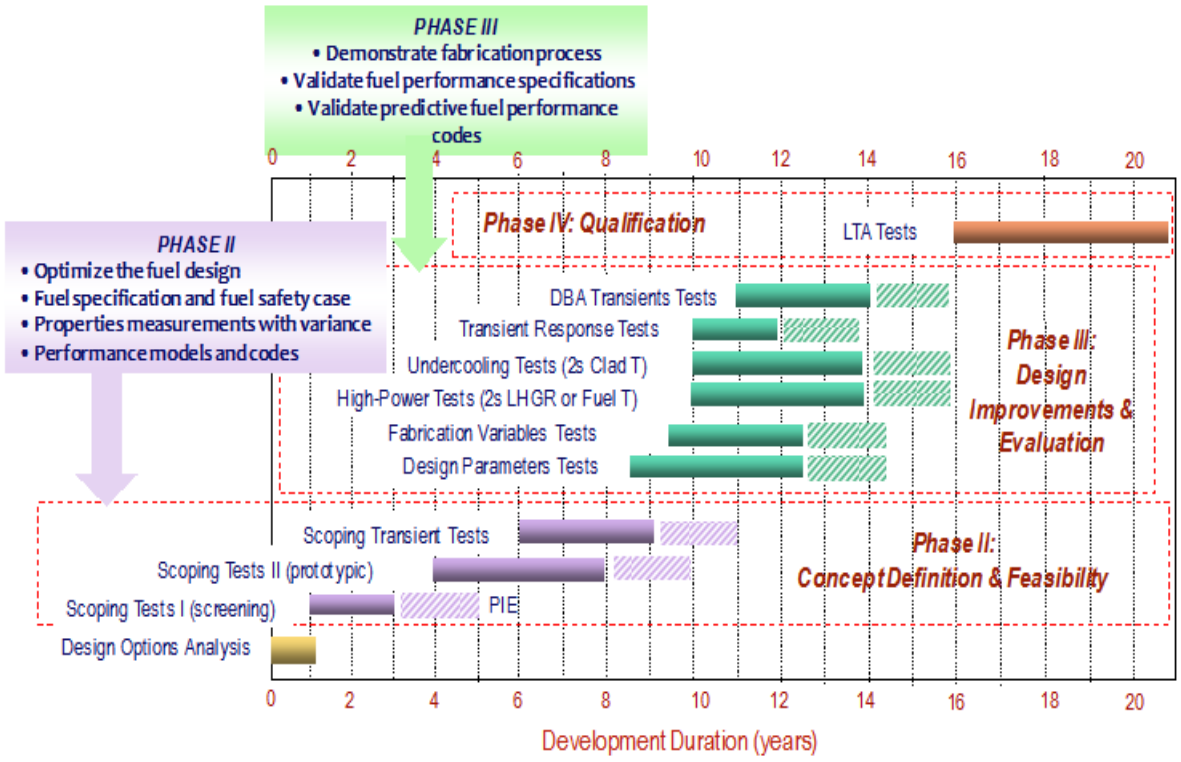
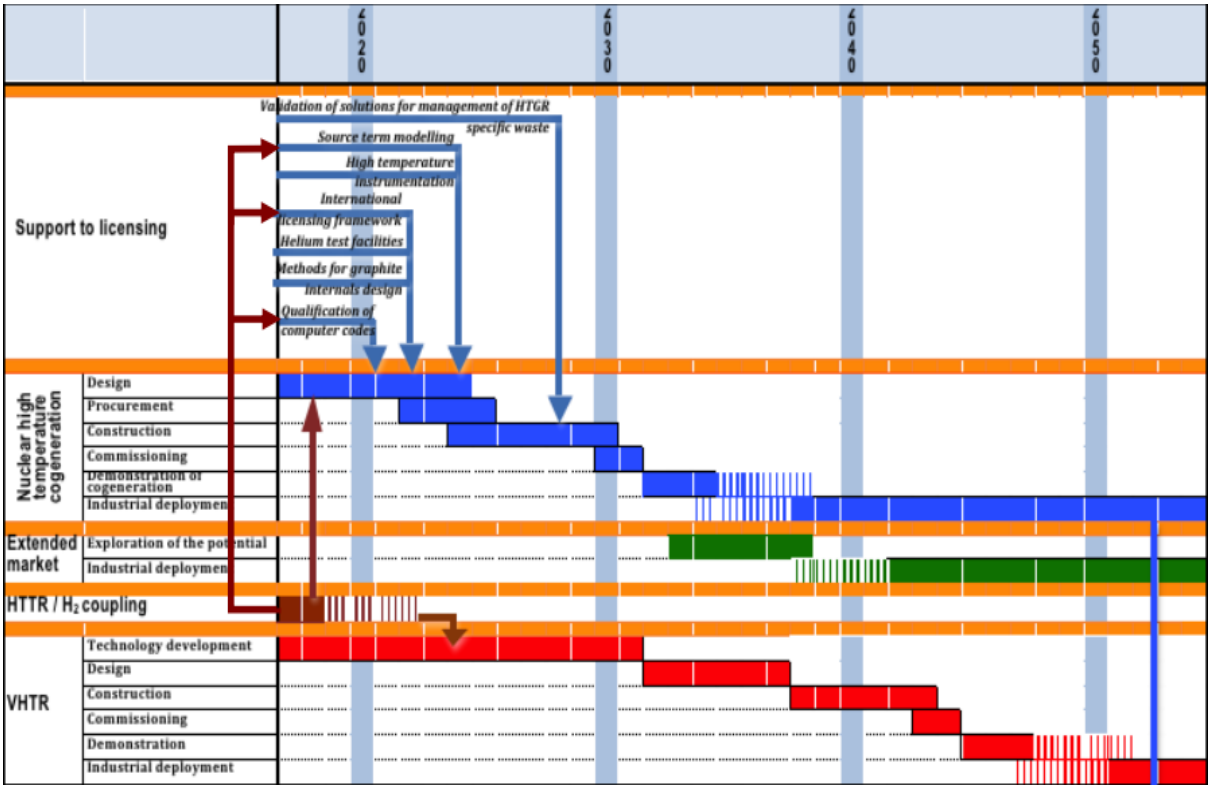




7.3 Establishing a List of Topical Areas/Topics

The Secretariat proposed the following first list of topical areas for the development of templates:

Safety

- Accident Tolerant Fuels
- Severe Accident Knowledge and Management
- Passive Safety Systems
- …

Rx Design/Construction/Operation + Fuel Cycle

- LTO Gen II 80 Years: Ageing Mechanisms and Monitoring
- Fuel Economics and Maintenance/Outage/Overhaul Optimisation
- Design/Manufacturing/Construction of SSC (Civil Works, Mech, I&C,…)
- Advanced Fuels and Materials (vs Coolant)
- Advanced Systems and Components (vs Coolant)
- Fuel Cycle Chemistry/Recycling
- …

Decommissioning and Waste

- Decommissioning
- Waste Management and Geological Disposal
- …

Integration in the Energy System

- Heat Production and Cogeneration 550 deg C
- Heat Production and Cogeneration 1000 deg C
- Hybrid Systems
- …

There was a discussion on the need to have "safety" mentioned as a specific category, since safety is an intrinsic element of any project/programme related to nuclear energy. The Secretariat indicated that it was introduced as a result of a request from the meeting of the Chairs of all NEA Committees.

It is evident that the topical areas as proposed in the list above are too broad for a single template. Therefore more precise topics should be selected underneath as subjects/titles for the templates and for the development of concrete Plan of Actions for innovation in these specific fields.

A preliminary list of enablers was also discussed:

- Modelling and Simulation (ia in support of ATF, Fuels and Materials, Rx Design,…)
- Big Data Collection and Management - PLM (ia for Maintenance/Outage Optimisation)
- I&C; Measurement Techniques (ia in support of R&D Programmes – testing, validation)
- Robotics (ia for Maintenance, Waste, Decomm,…)
- Power Conversion Systems
- Main R&D Infrastructures and Demonstrators – existing and new (list to be established)

(ia research reactors, fuel cycle and PIE facilities, loops and test benches for materials and SSCs,…)

It was decided that there will be no templates for the enablers but that their need and/or use will be embedded in the templates for topics. The typical example, coming out of the pilot cases, is Modelling and Simulation as an enabler for innovation in fuels, materials and systems design. NSC is the body where the optimisation of the interaction between advanced simulation and experimental activities has to be furthered to accelerate timelines and reduce costs.

7.4 Tasking and Schedule for Templates production

Members of the Advisory Panel will be asked to provide their comments/additions on the list of topical areas and enablers, noting that the objective is not to have a consensual exhaustive list of priorities, but a list of important topics with high innovation and cooperation potential. They will also be asked to propose more precise topics/titles for templates – noting that a proposal should be associated with the nomination of a volunteer for leading the drafting. The topical areas/topics already used as pilots are supposed to be kept and further developed.

Dr Kamide confirmed the title for the more precise topic under the topical area "Advanced Systems and Components" (Safety and Economics of Gen IV): Decay Heat Removal System with passive safety feature (for advanced nuclear systems).

At the meeting, Dr H Ait Abderrahim proposed a topic under the topical area "Fuel Cycle Chemistry/Recycling": Industrialisation of P&T (preliminary title). Dr A Khaperskaya volunteered to join for the drafting.

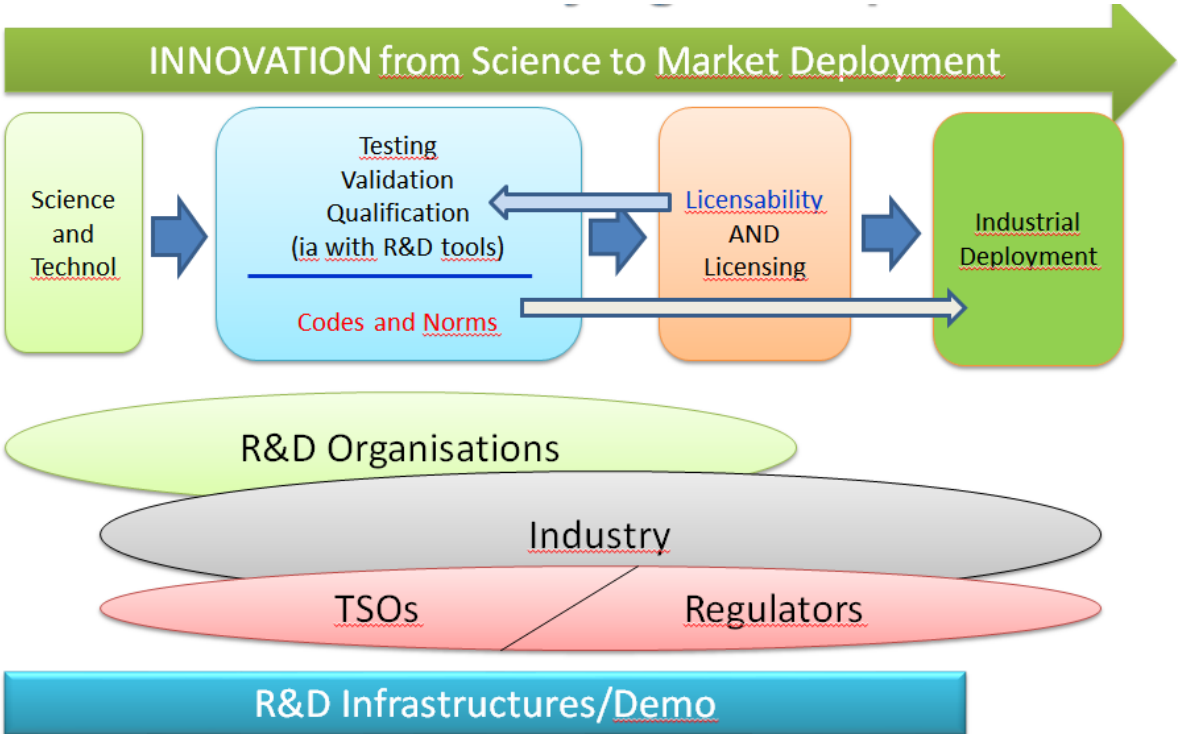
The Secretariat (members of the Divisions of Safety, Waste, Science, Development, as appropriate) will support the lead drafters, helping in ensuring consistency among the templates, and, as necessary, organise a supporting network of experts/reviewers.

The objective is to have a number of draft templates before end of August – in time for their presentation at the next Advisory Panel meeting scheduled for the 25/26 September and the NDC on the 27/28. From there, templates will continue to be further improved, targeting end of 2017 for the delivery of final versions after review by the Advisory Panel.

8. Involvement of Industry and Regulators – a necessary enabler for innovation

As it can be seen from the clarification of the NI2050 concept in section 3 above, and illustrated by the picture below, innovation, fostering the transfer of R&D outcomes towards market deployment, can only happen if, next to R&D actors, industry and regulators are fully part of the process. This transfer, mainly in the form of testing, validation and qualification of technologies for market deployment, and the upfront R&D, needs to be designed taking early consideration of the licensing requirements, to ensure that what is "qualified" is licensable.

Up to now WNA has been participating in the NI2050 Advisory Panel, as well as ETSON (European Technical Safety Organisations), and some experts from industry have participated to some NI2050 Experts Meetings in March/April 2016. But, there is a clear need to largely expand the interaction with industry and TSOs/Regulators since they are at the center of innovation for the short/medium term perspective (deployment before 2030) and need to help focus R&D for the longer term perspective (deployment before 2050 and beyond).



In order to start the discussion on this issue, the Secretariat had invited two presentations (posted on the NI2050 website):

Luc Chanial, NEA Deputy Head of Division of the Safety Division presented the activities under the CNRA (Committee of Nuclear Regulatory Activities), in particular regarding the Working Group on Regulation of New Reactors (WGRNR) and the Ad-hoc Group on the Safety of Advanced Reactors (GSAR).

The WGRNR focuses on Gen III and III+ reactors. Contacts with industry and research are seldom.

The Ad-hoc Group on the Safety of Advanced Reactors is a more open forum, connected with GIF (there is a Vice Chair of GIF in charge of Regulatory Issues who is the contact person for GSAR), where safety design principles and criteria, and safety research of advanced reactors are addressed (for the moment SFR is used as pilot to identify additional research needs coming from the regulatory perspective).

NEA is also serving as the Technical Secretariat for the MDEP – Multilateral Design Evaluation Programme, where regulators of various countries work together to assess the safety aspects of Gen III industrial designs, with the objective to facilitate the further licensing in the countries where these designs might be built.

There was also a mention of the NEA Joint Projects in Nuclear Safety, overarched by the CSNI (Committee of the Safety of Nuclear Installations) – already presented to the Advisory Panel at their meeting in June 2016.

Markus Birkhoffer and Lou Martinez Sancho, presented the AREVA innovation activities "Nuclear 2.0". The central aim, similar to NI2050, is to foster the role of nuclear energy in the future, while reducing duration and costs, with safety "embedded" in design and not added-on, and ensuring the integration in an energy market with RES. Three scenarios 2030 are serving as background. One of them - Nuclear 2.0 - needs to be intrinsically safe, minimize waste, be affordable and flexible. Areas such as digitalisation, new materials, advanced core and fuels, advanced manufacturing, transversal issues were mentioned – and are much in line with topical areas proposed for NI2050. Some subjects coming from Industry 4.0 – ia 3D virtual reality, big data, modelling and simulation, systems engineering and PLM, collaborative work and knowledge management – also fit well with NI2050 enablers.

Out of nearly 50 advanced reactor designs at diverse level of development, AREVA has down selected 3, in the range of 300-700 MW, to complement their existing portfolio of large reactors: a medium modular LWR, a SC-HTGR, a MSR. At the same time targeting the non-electric market is also on the agenda for large decarbonisation.

As an outcome of the follow-up discussion, one might introduce the idea of a necessary Institutional/Organisational Enabler: the need to interact effectively and in time with the regulators in the process of innovation. Regulatory frameworks need to become more dynamic and responsive to the triggers from research, in particular when there is an increasing industry driven interest for picking the outcomes of research for further market deployment. Regulators need to get involved at early stages of the innovation process (low TRLs) and not only at late stage.

The independence of regulators is a sensitive issue. Working at international level, such as in the NEA framework, might ease the interactions.

John Herczeg, chair of the NSC, recommended NEA to engage more in communication on what is feasible, beyond "silicon valley type" announcement – having high media coverage – but sometimes underestimating development challenges ahead.

As an overall conclusion, one might list the following industry/regulators related crosscutting and global issues as enablers for innovation:

- "innovative licensing": expand innovation to regulation with the support of international structures (ia NEA Committees), moving from initial technical involvement (TSOs) towards regulation, leading to a more easy access to markets at the end;

- "Knowledge and tools sharing": build-up and share a common background of knowledge and tools, across research labs, industry, TSOs and regulators. Pool research infrastructures and competences through international mechanisms meeting shared priorities;

- "Industrial cooperation": foster collaborative work by industry as it happens in other non-nuclear sectors (ia car industry), which necessarily leads to address proprietary issues and the definition of the domain for joined precompetitive activities;

- "Innovative financing": foster macro-economic analysis by the nuclear industry (increased financing of research leading to increased benefits at the end of the value chain), as it happens in other non-nuclear sectors, fostering Public-Private Partnerships.

The Secretariat will have to further develop the ways and means to interact with industry and regulators, in line with the mandates and operation of the NEA.

9. R&D Infrastructures

Tatiana Ivanova, Acting Head of the Nuclear Science Division, informed on the intention to launch a new activity on establishing a register of experimental needs and related R&D Infrastructures. The decision is expected in June 2017 by the NSC. NI2050 is expected to introduce "experimental needs and R&D infrastructures" into the register, but also, the other way around, the incubator should use the register once in operation. NI2050 will also help interface with industry and regulators.

Anzhelika Khaperskaya gave a presentation on the MBIR facility under construction at RIAR in Dimitrovrad-Russia, as a unique multipurpose fast neutron research facility available for international research.

Both presentations can be found on the NI2050 website.

10. Conclusions, Next Steps and Actions List

There was general agreement that the meeting had been useful to clarify the process of NI2050 and put it on track to reach concrete outcomes toward the end of the year.

The Secretariat will prepare elements of a NI2050 report for presentation at the next Advisory Panel Meeting on the 25/26 September and for the NDC on the 27/28 September, where the future of NI2050 and the mandate of the Advisory Panel should be discussed.

As a main element of this report, templates on a selected set of topics will provide first concrete outcomes of NI2050, serving as an incubator for innovation in nuclear fission. These templates, when reviewed by the Advisory Panel and at the right level of quality and maturity, should then be used to address the stakeholders, in particular policy makers in national governments, industry and regulatory authorities, on the importance to support the implementation (cooperation, financial and legal frameworks). As it was said by Vice-Chair Kemal Pasamehmetoglu, at the end of the meeting: Templates are kind of "Advertisement" papers to attract: 1. Groups of interested dedicated people to develop a project in cooperation, 2. Investors to finance it. It is not a full roadmapping for research, but a set of valuable proposals for innovation.

For this to happen, the Secretariat, together with this Summary Record, will send the List of Topical Areas and the Template to the Members of the Advisory Panel (and possibly other appropriate contacts as useful). Addressees will be asked to provide comments/additions to the List of Topical Areas, and, if so

desired, to provide titles for Topics for the drafting of a Template. This should be accompanied with the nomination of a lead person to draft the Template.

The resulting consolidated list of topics will further be circulated by the Secretariat to all Members of the Advisory Panel, to give a chance to team up for the drafting of Templates.

Draft Templates need to be provided to the Secretariat for end of August 2017 at the latest, but anticipated interactions will be organised by the Secretariat, in particular to help the lead drafters.

MD 24 March 2017.