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

Summary Record of the 6th NI2050 Advisory Panel Meeting

1 - 2 February 2018

OECD Boulogne Building, Room BB2
46 quai Alphonse le Gallo, Boulogne-Billancourt, 92100, France

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

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SUMMARY RECORD

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92100 Boulogne-Billancourt, Room BB2

Introduction by the Chair (Dr F Rayment) and the Secretariat (M Deffrennes) and discussion:

Objectives of the Meeting

The 6th meeting of the NI2050 Advisory Panel was one of transition. NI2050 was launched in July 2015 by a high level meeting gathering NEA Member Country Representatives and Heads of major Labs and Research Organisations. The Advisory Panel (AP) was established following a recommendation from this high level meeting. Through the AP the purpose of NI2050 was established which is "to accelerate R&D and market deployment of innovative nuclear fission technologies to contribute to a sustainable energy future."

Outcomes of Phase 1 of NI2050, launched in 2015 to collect information on national nuclear R&D activities and budgets through a survey, were presented at the (5th) AP Meeting. Members of the AP (as well as NDC Members) were given a further opportunity to revise their Country Profile. This closes Phase 1 of NI2050.

Phase 2 was initiated in 2016, starting with focussed Expert Meetings aiming at defining priority areas for innovation in nuclear fission. Using the outcomes, the Advisory Panel further elaborated the NI2050 concepts and goals. Using a list of agreed criteria, a more refined list of priority topics was established. This list is not exhaustive and as such NI2050 is an open process for incubation of further topics. 2017 was mainly dedicated to draft the so-called "NI2050 templates (standard format)" for each of these topics. These are "R&D vision documents/roadmaps" on what should be done to accelerate development and market deployment of innovative technologies for the given topics. A number of these "templates" are close to finalisation, and all of them should be finalised for end of May 2018. It is recognised that work will be required when progressing templates with respect to defining the appropriate technology readiness levels (TRLs) and licensing readiness levels (LRLs) that the project will work towards. This will then close Phase 2 of NI2050. The process and results of Phase 1 and 2 will be assembled in a report by the Secretariat around mid-2018 (NDC meeting in October).

The next step ("Phase 3" of NI2050), began in January 2018 and involves engaging a broader range of stakeholders of innovation (e.g. industry and regulators/technical safety organisations (TSOs)). The aim will be, under ad hoc governance structures to be established for each priority topic (for which an "R&D template" is available), to develop a detailed programme of action (projects scope, interactions, timeline, infrastructure needs etc.). Establishing the governance structure and drafting the detailed programme should take less than a year for a given priority topic. Once the programme is developed and agreed

among the willing participants, it would then be proposed to policy makers (Member Countries, investors and industry) to define the ways and means for implementation.

An initial "all stakeholders" meeting took place in January as a combined NSC Workshop on Experimental Needs for Advancements in Nuclear Fuels and Materials, followed by a focussed meeting on the NI2050 templates on Fuels and Materials. The goal was to get first reactions from industry (ia EPRI) and TSOs on these templates and gauge a sense of their willingness to be further involved and their views on how to proceed.

All of the above explains why NI2050, and its Advisory Panel, are at a transition point. The objectives of the 6th meeting were therefore to review and comment on the draft templates to support their finalisation, in order to close Phase 2, and to provide views on the future process of NI2050 – according to the agenda which had been circulated in advance and approved at the beginning of the meeting.

Presentation of the Outcomes of the NSC January Workshop on Experimental Support for Advancements in Fuels and Materials and the NI2050 Meeting with Industry and TSOs (see slides)

The discussion confirmed the importance of having all stakeholders (including waste agencies) involved as early as possible and to ensure a good parallelism between the TRLs and the LRLs – even if the wording may have to be refined to avoid the hard notion of "licensing", which is often connected to specific national practices. There was agreement that pooling regulators with research and industry in an international framework to discuss innovation might be easier at an international level as oppose to at a national level.

N Chauvin made a good summary of the main outcomes/tasks ahead resulting from the NI2050 Meeting of January on Fuels and Materials: all stakeholders to work together:

- to clarify "requirements" (ia safety criteria/requirements);
- to define precisely what needs to be done in terms of technology development to go over the intermediate TRLs (valley of death) – in particular to solve "generic" technology issues;
- to develop a common methodology (process) for qualification – involving TSOs;
- to develop an optimised (realistic) combination of experiments and simulation for validation/qualification. Beyond the availability of experimental facilities, this implies also the need for improved instrumentation of the experiments and data collection/management;
- to use the above to reduce time for the safety demonstration and the licensing.

All of these aspects are to be described in the templates – now ready for entering discussion with industry and regulators.

Template Advanced Structural Materials for Gen IV Systems – L Malerba

The Advanced Structural Materials for Gen IV Systems Template is quasi finalised from a European perspective – EERA JPNM (European Energy Research Alliance – Joint Program on Nuclear Materials) partners have been involved in the drafting. A more in-depth all-encompassing proposal will be created through obtaining further feedback and comments from non-European stakeholders, in particular on relevant projects engaged outside the EU. The proposal has been circulated within the GIF VHTR Materials Group – with few comments received (note: GIF is creating a new cross-cutting Task Force on Materials for the Gen IV Systems – originating from the VHTR Materials Group).

The United Kingdom, Canada and Russia have all indicated their interest.

The template proposes 3 concrete cases to concentrate on – resulting from an analysis of and down selection from classes of materials:

1. Existing austenitic stainless steels: demonstrate capability for 60 years lifetime under Gen IV systems operating conditions (radiation, temperatures, coolant chemistry,…)
2. Develop new high temperature corrosion resistant cladding materials: Ferritic/Martensitic F/M steels and SiC/SiC. This can be connected with some actions under the template on Advanced Fuels.
3. Improving modelling and experimental validation for example for low temperature radiation embrittlement of F/M steels

For each case objectives and a first list of actions have been drafted.

This template constitutes a very good basis to engage in discussion with industry on their visions for priorities and actions. An ad hoc meeting should be organised by the NEA to involve all interested parties and agree on which of the proposed actions are of sufficiently wide interest, so as to develop a more detailed project work plan and relevant management structure.

Template Consolidation of Severe Accident Management in NPPs – D Jacquemain

The template is at an advanced stage of drafting – Section 5 "Plans of Actions and necessary means" still pending. Various people have been involved and extensive interactions have already taken place with NEA WGAMA, ETSON, NRC and CNSC.

Further interactions are planned over the coming months:

- DOE with industry BWR and PWROG and EPRI (note: NEA EPRI MoU);
- CNSC with industry COG;
- Possibly Japan research and industry;
- EU NUGENIA (Forum April 2018);
- WGAMA Bureau in June and Plenary in September 2018;
- ISAM Conference in October 2018.

Five high priority topics have been selected:

- Consolidation of the SA knowledge base;
- Management of degraded fuel (retention and cooling);
- Mitigation of releases and evaluation of source term;
- Improving SA instrumentation;
- Consolidation and harmonisation of tools and methods for validation of SA management measures and consequence analysis.

For this topic it will be important to build on all that has already been done, including at an international level (NEA and IAEA). The main question is, therefore, to clarify what NI2050 can bring. The topic is confirmed as an important one and the work done in drafting the template has value in itself – as already shown by the positive feedback received through comments.

Additional stakeholders, ia industry and dedicated experimental facilities, should be involved in the review and complementarity ensured with what is done elsewhere (IAEA, EC etc.).
Open questions remain with regards to cross-cutting issues: link with Passive Safety template, Gen IV DHRS template etc.

For the moment the template mainly addresses water cooled reactors. Possibility of Gen IV systems?

Template Managing Ageing and LTO – A AlMazouzi

Concepts of asset management of ageing of components, structures and systems can be applied to diverse types of equipment: mechanical, electrical, buildings,… covering metallic pieces, concrete, polymers, cables,… Since there is already a template on metallic materials, the proposal is to focus on concrete.

The template could focus on understanding the ageing phenomenon of concrete affecting critical NPP infrastructures, their monitoring using appropriate instrumentation, the modelisation (requiring experimental phases with proper instrumentation to collect data for the models development and validation), for better anticipation and remedial actions. New technologies for concrete structures, already developed in civil engineering, could also be investigated to evaluate their potential use in the nuclear sector.

It is necessary to involve EPRI and the industry producing smart concrete structures in the drafting of the template.

NEA WIAGE will hold a meeting on concrete in April 2018 – where the draft template can be presented and discussed.

Template Passive Safety Systems – JM Evrard

NEA WGAMA recently initiated a 2,5 year activity to produce a status report on Thermal Hydraulics Passive Systems Design and Safety Assessment. The IAEA also has extensive activity in this field. This should not be repeated but, from there, focus could be given to selecting a few representative cases in order to move towards an experimental programme to close open issues: assessing the physical phenomena underneath the passive systems, and get clarity on performances, uncertainties and reliability (ia for PRAs) for such systems. This would also include the modelisation and the validation of models through experimental programmes in facilities to be identified.

The outcome of the previous activities might lead to establishing an internationally-shared approach for safety demonstration (methodology, data validation, reliability).

The role of NI2050 here has to be clarified: what should be done to accelerate the recourse to passive systems whilst increasing safety and reducing costs.

There is a link with the template on (Passive) Decay Heat Removal System for Gen IV Systems.

Template Advanced Fuels – K Pasamehmetoglu and N Chauvin

The two templates on ATF and Advanced Fuels have been regrouped into one as the process for qualification might look much similar, with the combination of predictive codes and associated experimental tests (including irradiations) devoted to code validation. The ultimate objective would be to reduce the qualification of fuels from 25 years to 10 years by better involvement of all actors at the appropriate time and a more streamlined (working in parallel) sequence of actions. Very much at the core is the optimised combination of experiments and modelling with, central to this, the need for adequate coupling of required data and instrumentation.

This template has served as the pilot for the first meeting with industry (ia EPRI) and TSOs (ia IRSN). Once the template is finalised, a further more detailed meeting needs to be organised by the NEA to expand the template into a detailed programme of action (sequence of projects, timelines, interfaces, infrastructures, cases of work) and to set up a project type management structure with participants coming from R&D organisations, TSOs and industry. In order to proceed a project structure is recommended whereby interested stakeholders come together as a project team with a defined scope. The project should make best use of existing projects and build on the data from these.

Template Fuel Cycle Chemistry and P&T – P Baeten

There has been no progress over recent months on the template. Activities to be reactivated to provide a consolidated template along 4 axes described in a previous meeting. CEA, SCKCEN, JRC ITU, Japan and Russia to contribute.

Template Gen IV Components – DHRS – H Kamide

The template was already well developed at the previous meeting. One main question is the potential (or not) to progress on generic issues: is it possible noting the variety of coolants and specific geometries proposed under the Gen IV Systems? Is it possible to focus on generic aspects of validation of models, data collection and uncertainties – starting with one type of coolant?

The list of facilities mentioned in the template would need to be broadened – a number of existing facilities are missing (ia Cheops, Plinius II,…).

Under CSNI, WGAMA worked for passive safety for LWRs. A proposal has been made to create a new group for Gen IV Systems – with a first meeting between June and end of 2018: would be necessary to have the template reviewed and commented by this new group. Circulating the draft within GIF and consolidating with the GIF TF Infrastructures and the RSWG would also help better define the goals and scope that need to be achieved under NI2050 – what more can be done under NI2050.

Template HTR and Co/Heat Generation – D Hittner

D Hittner started by reporting on the state of play of the decision making in Poland on HTRs: a report has been submitted to the Minister of Energy by a Committee for Analysis and Preparation of Conditions for Deployment of HTRs, chaired by G Wrochna (Member of the NI2050 Advisory Panel). The following schedule was recommended for a 165MWth HTGR:

- 2018: preconceptual study;
- 2019-2023: design;
- 2023-2026: preparation for construction of the first HTGR;
- 2016-2031: construction and commissioning.

This first reactor would serve as Demo/FOAK for a fleet of such reactors to replace (plug-in) gas fired steam production installations in chemical complexes.

A company is in the process of being established, including Polish and foreign partners, to drive the project.

The template should be built so as to offer a necessary “international framework” in support to this project – for which the basis exists in PRIME. Focus should be put on what can be done internationally:

- Safety and licensing framework, ia for the coupling between the reactor and the heat user process;
- Network of test facilities for R&D and qualification;
- Knowledge management, etc.

It is important for this specific case to engage and involve the user industry in the process, from now on, to progress from the template to the programme of action to be agreed with industry and regulators.
Such a broad project might well constitute a good shell for a link with NEST.

In addition, as mentioned by the WNA representative, this project being connected with the issue of the global necessary flexibility of nuclear to integrate in the wider energy context with more RES, this might be linked with the CAN/US/JP Initiative in the Clean Energy Ministerial.

Presentation on Innovation in the UK – R Whittleston

An interesting presentation was given providing an even wider perspective of innovation and where it can bring real value to the nuclear industry. Innovation is broader than just R&D and to ensure it is fully implemented it needs involvement from a broad range of stakeholders that are leading developments at all stages of the TRL and LRL phases. Engagement with industry early on in the project lifecycle is key. Innovation can touch the nuclear industry across a number of areas including but not limited to:

- Enabling innovative technologies to enter the nuclear field from other industries;
- Driving innovation in regulation through early engagement with innovators;
- Creating new approaches to programmes and risk management;
- Creating new and enhanced commercial models and financing approaches for nuclear to be cost effective;
- Enabling N^{th} of a kind and learning to drive economies of scale;
- Driving collaboration and partnership approaches when engaging with the supply chain;
- Providing the right culture and leadership to drive innovation.

Overall state of play and perspectives on the templates

In all cases, valuable work has been done by the drafters. Once finalised, the templates will be incorporated into a report to illustrate the main results of NI2050 until now. The templates are public documents which may be used in any other frameworks (ia the NEA Committees and Working Groups), in particular by their authors as they see fit.

The Fuels Template is the most advanced and in order to ensure progression it is suggested that a project team is implemented to fully define the scope to progress. Other templates that are in the advanced stages are Materials and HTR Co/Heat generation.

Some other templates are well developed but it remains to be seen what can be done in the NI2050 framework specifically (beyond pursuing on-going activities already engaged in the NEA framework and which may just have to be boosted): Severe Accidents (WGAMA), Passive Safety (WGAMA)/Gen IV DHRS(GIF).

Other templates need to be further developed: LTO/Concrete, Fuel Cycle Chemistry and P&T.
It might be of interest, once the templates are finalised to integrate them more specifically in one or two NEA Committee(s) (and associated Working Groups/Parties) for creating an "ownership" beyond the NI2050 Advisory Panel.

NSC: would overarch Fuels and Materials, Fuel Chemistry and P&T; CSNI: Severe Accidents, Passive Safety, and LTO; NDC: HTR/Cogen and Fuel Cycle and P&T. This being said, CSNI/CNRA need to be involved in all of the templates as it is the best way to engage regulators and their TSOs.

Links with GIF should also be reinforced, in particular with the recently launched GIF cross-cutting activities on Materials, and TF on Research Infrastructures. The GIF Symposium in October 2018 in Paris may be an opportunity to initiate such links.

As repeated many times, the templates selected until now were all considered by the Advisory Panel as a priority (based on criteria discussed by the AP), but it is not an exhaustive list. NI2050 is an open process where additional topics may be proposed and further templates developed. Going back to the NI2050 Expert Meetings of March/April 2016, Decommissioning and Waste Management were also areas of interest. The Chair of the RMWC (JP Minon) and the Chair of the Expert Meeting on Decommissioning propose to add one template on the topic. This was supported by the Advisory Panel. The proposal will be discussed by the RWMC Bureau in March 2018.

General Discussion

Feedback and Lessons Learned from NI2050

- Mr Carré proposed a positive way to present the progress allowing for the diversity of topics and approaches – while all have their value:
  - Acceleration of technology development: Fuel and Materials
  - Acceleration of demonstration: HTR and Cogen
  - Methods and data to build common vision and ways to assess: Severe Accidents, Passive Safety, Ageing LTO, Fuel Cycle
- This was supported by Mr Ogata. He indicated that views on priorities may vary depending on the stakeholder. Industry is certainly most interested in solving open issues for Gen II and III reactors: LTO, Severe Accidents and Passive Safety Systems.
- Mr Jacquemain also supported this positive view, confirming that NI2050 can play a role in helping to gather and share methods and data for Severe Accidents Analysis and Management, involving all necessary stakeholders and parties. It already helped build the template: common identification of issues on the longer term. It should now help for the implementation.
- Mrs Strati raised the issue of the "measurement of success" of NI2050. The real success will be visible when a template becomes a programme of action "agreed" by interested stakeholders, is discussed with policy makers and when ways and means for implementation are defined.

Enablers and Cross-Cutting Issues: Modelling and Infrastructures

- Modelling and Simulation exists everywhere. But it is probably better to handle it as an enabler in the different templates (Fuels and Materials, Severe Accidents and Passive Safety). But what is more cross cutting and linked:
  - the research infrastructures necessary as the experimental basis for the validation of the models
- There is no real interest within NI2050 to build a global database of infrastructures – such databases (some partial) already exist: NEA, IAEA, EC, GIF Task Force etc. But what could be helpful is to develop a focussed "database" for each template developed under NI2050. This was started by the Expert Group on Advanced Reactors (March 2016 – Chaired by P Baeten and H

Kamide) and for the template on Gen IV DHRS (H Kamide), but needs to be more exhaustive. It should also be done for the other templates, on an ad hoc basis.

- Beyond the infrastructures per se, what needs to be incorporated is the concept of optimisation of the coupling between experiments and modelling: what data is necessary for the modelling, what experiment is needed to gather such data, which instrumentation is needed, being realistic in timelines and budgets, using and sharing to the best extent existing facilities and data.

Additional Targets/Topics for NI2050

- Mr Pieraccini proposed an additional topic in Decommissioning/Waste Management on the handling of graphite reactors legacy (FR, UK, ES, RF, JP?). A template will be developed rapidly and discussed with RWMC (Chair JP Minon supports the proposal). It will be centred around the creation of a centre of excellence with experimental facilities for the development/validation/qualification of techniques, tools and personnel for the handling of the graphite legacy.
  WNA supports the proposal.
- Mr Carré proposed some further ideas for reflection:
  - Geological disposal: the site specificities (nature of the underground) may render a "common approach" difficult, but what is common is the necessary dialogue between the stakeholders in such a project
  - HTTR H2 production: may be embedded in the HTR Cogen template if indeed the restart of HTTR is possible
  - Convergence of safety authorities approaches for accidents analysis: very much a topic for CNRA/CSNI. But the principle of better convergence between regulatory approaches might be (carefully) embedded into templates – for discussion with and among regulatory authorities when involved in the broadening of the stakeholder base.

Revisiting the NI2050 Website

The main page of the website is outdated and will be reviewed by the Secretariat.
The Secretariat propose to also "open" the restricted part of the website (where all presentations and reports are assembled) as a free access website. As of today the access is for NDC Members, Advisory Panel Members, and all Experts of the March/April 2016 Meetings.
The principle was agreed, with the exception of the data collected during the survey (which are not on the website anyway, except some general curves and diagrams produced by the Secretariat), and the presentations/documents of the Expert Meetings of March/April 2016.

Conclusions: Way Forward, Next Steps, NI2050 Report

- NI2050 is in a transition period. On one hand it is necessary to bring a close to the "Project of the NDC PoW 2015-2016 on Nuclear R&D and Innovation" – which served as the host of what became NI2050 - by producing a report for publication at the end of the year (NDC meeting in October) summarising the outcomes. On the other hand the concept of transition fits well with the end of NI2050 "survey (mainly as result of year 2016)" and "template (mainly as result of year 2017)" phases, and the start of the next phase.
- This sets the timeline for the finalisation of the templates to be part of the report: end of May 2018.

- Since its launch in July 2015, NI2050 has been mainly gathering the R&D community. This was reflected in the membership of the Advisory Panel and the experts involved, in particular the drafters of the templates. It is now necessary to broaden the stakeholder community by involving industry (interalia using the NEA-EPRI MoU as a framework) and the regulators (to be done with care – the international framework under CSNI/CNRA whilst respecting the necessary national independence). This involvement will be done on concrete cases on an ad hoc basis: case-by-case: using the templates as starting points.
- This will constitute the next phase of NI2050 – leading, case-by-case tailored programmes of action (10 year detailed programmes, with sequence of projects, timelines, interfaces, infrastructures, focussing on the generic aspects of technology development and on the process of qualification). In parallel, a project type ad hoc management structure will also be proposed for the implementation of the ad hoc programmes of action.
- Once such programmes and management structures are developed, the NEA will help present them to policy makers (Member Country authorities, industry, investors, financing institutions), offering an opportunity to discuss the ways and means for implementation.
- The Fuels and Materials Templates are ready to engage the broader stakeholder community and may serve as pilots (which does not exclude other cases in parallel).
- One issue is to raise the visibility of NI2050 now that first outcomes (templates) are becoming available and the transition towards implementation has to be launched.
  - The NEA Steering Committee should take the overall ownership (over and above the NEA Committees NDC, NSC, CSNI/CNRA). A proposal should be developed to take this forward.
  - Industry has been involved in the Advisory Panel through WNA and a MoU NEA-EPRI is a framework for further industry engagement. This might be further complemented by other mechanisms for interaction with industry.
  - Regulators can ideally be involved via the NEA CNRA/CSNI.
- The Advisory Panel will have one more meeting around end September/early October to develop the draft NI2050 report (Phases 1 and 2 as described above) and discuss the progress of the first cases of bringing a template to a broader stakeholder community (industry and regulators). From there on, the membership and operation of the NI2050 Advisory Panel may have to be revisited to reflect this broadening of the stakeholder community. This "new" Advisory Panel should work at high level: including Chairs of NEA Committees (NSC, CNRA-CSNI, NDC, RWMC), CNO EPRI, DG WNA and meet once a year to discuss progress and provide orientations.
- It would be useful to organise a high level event towards the end of 2018/early 2019, maybe embedded or back to back with one or a few major nuclear conference(s), to inform/advertise NI2050 (the concepts, achievements and perspectives). In the second half of 2018, one can already foresee the GIF 2018 Symposium (which takes place every 3 years) in Paris, the HTR 2018 Conference in Warsaw and even the Clean Energy Ministerial at a certain stage.

ACTION PLAN

- Template drafters to finalise their templates at the latest for end May 2018. This should include the review/comments by a wider community – as appropriate.
- Mr Pieraccini to propose additional template on Decommissioning/Waste if possible for the same deadline.

- Secretariat to start the drafting of the NI2050 report
- Secretariat with Chair and template drafters to initiate the interaction with industry and regulators on most advanced templates (starting with Fuels and Materials, possibly HTR/Cogen,…)
- A project team to be established from interested stakeholders to fully define (including cost estimate) how to implement the fuel programme.
- Final Meeting of Advisory Panel in current form– end of September/early October 2018.
- Secretariat and Chair to reflect on the increased visibility of NI2050: NEA Committees, high level participation of all stakeholders in "next" Advisory Panel, nuclear conference,…
- A new approach to be developed by NEA Secretariat and Chair for the governance of NI2050 beyond September (through NEA Steering committee)

Annex: Draft Content of the NI2050 REPORT

1. The concept of Innovation, Why NI2050, Aims of NI2050
2. Organisation of NI2050: Phases and Governance.
3. Survey Outcomes: General Trends and Country Profiles (available on a specifically dedicated website)
4. Selecting NI2050 areas and topics of priority
5. NI2050 Templates for selected priority topics
6. Main Outcomes, Recommendations and Next Steps.

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