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

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Summary Record of the 5th NI2050 Advisory Panel Meeting

25-26 September 2017

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NI2050

5th Advisory Panel Meeting

OECD Boulogne Building, BB3

25-26 September 2017

SUMMARY RECORD

1. Main Objective of the Meeting and Agenda

The main goal was to review the state of play of eight templates (Programmes of Actions – sequence of projects and necessary infrastructures) under preparation – following the decisions taken at the previous Advisory Panel meeting in March 2017 and the Advisory Panel Chairs Meeting in June 2017.

- Consolidation of Severe Accident Management – D Jacquemain
- Qualification of Passive Safety Systems – JM Evrard
- Managing Ageing and Long Term Operation – A Al Mazouzi
- High Temperature Heat Production and Cogeneration – D Hittner
- Innovative Fuel Qualification (ATF & Advanced Fuels) – K Pasamehmetoglu & N Chauvin
- Advanced Structural Materials for GENIV Systems – L Malerba
- Safety and Economics of Gen IV Components – Qualification of DHRS – H Kamide
- Advanced Fuel Cycle and P&T – H Ait Abderrahim

The meeting was also used to present the final outcomes of the NI2050 Survey, launched in September 2015 via a questionnaire sent to the NDC: (i) the final consolidated graphs based on the collected budget figures (and additional trend curves based on IEA data as requested by the Advisory Panel in March), and (ii) draft Country Profiles (for 10 countries for which enough technical information had been provided via the questionnaire).

The agenda can be found on the NI2050 website: <https://www.oecd-nea.org/ndd/groups/ni2050ap.html>.

2. Opening remarks

Dr Kemal Pasamehmetoglu, acting Chair in absence of Dr Fiona Rayment, recalled the importance of the meeting to progress towards concrete outcomes for NI2050.

NEA DDG/CNO Daniel Iracane viewed the NI2050 as a framework of opportunity to reactivate the necessary proactive interaction between the stakeholders (science/labs, industry, regulators, policy makers) to foster nuclear innovation. Within the NEA, divisions, committees and expert groups, parties can be pulled together to support the dynamics of cooperation – with each stakeholder acting within their mandate demonstrating a proactive approach to search for efficiency and efficacy.

In particular he mentioned:

- An upcoming NSD Workshop in Paris on Experimental Needs and Infrastructures for fuel and material development in January 2018 (that has direct links with the NI2050 templates on Fuel and Materials).
- A high level meeting with EPRI in November in Washington, to develop some specific objectives for the signed NEA-EPRI MoU – where innovation and interaction between stakeholders will be one topic for discussion.
- The upcoming joint Bureau meeting of CSNI and CNRA will take place in December in Paris and will provide an opportunity to address the regulators with the question of technology evolution and innovation and inform about NI2050. This may be followed by a meeting on “Regulators and Innovation” in June 2018.
- A message delivered recently by the NEA DG (at IAEA GC and for the Ministerial Conference in Abu Dhabi) for policy makers that innovation is occurring in some parts of the world, and those who do not keep pace will fall behind and risk dependence on others’ nuclear technologies.

In order to establish a common framework for each participant, NEA Secretariat Marc Deffrennes delivered a presentation to recall the main vision, objectives, concepts, steps/timelines and tools developed for NI2050 which were agreed upon by the Advisory Panel at previous meetings.

The broad nature of the NI2050 Initiative at a global NEA level was recalled by showing the number of NEA Committees and Working Groups where activities connected to the templates under development are already on-going. NI2050 is therefore also an opportunity to streamline NEA Committees and WGs activities when connected with innovation (from R&D to deployment, and with safety embedded). It will be necessary to properly engage these diverse Committees and WGs in NI2050 and in the review of the templates – a way to build a large consensus of stakeholders on the Programmes of Actions - before starting to talk on the practical implementation (questions to solve, infrastructures, risk management, financing and legal aspects).

3. NI2050 Survey

Danielle Zayani (NEA Secretariat) presented the graphs compiling the nuclear R&D budget figures (2010-2015 – public financing) collected via the NI2050 survey questionnaire sent to the NDC representatives in September 2015. A comparison has also been developed with the budget figures collected by the IEA through their annual energy R&D financing survey. This comparison was only possible for three countries and the consistency of the data was fairly acceptable for two of them. The Advisory Panel of March 2017 asked the Secretariat to look at trends in the data. Therefore, an additional effort was made to compile the IEA budget figures, for nuclear and other sources, for the period 2000-2015 (in fact 2014). A brief analysis of these trends was presented.

Byungho Jung (NEA Secretariat - Korean Intern for three months at NEA) briefly presented the work he did in drafting Countries Nuclear R&D Profiles, based on the technical data collected through the NI2050

Survey and additional open source information. This work was conducted for ten countries for which enough data had been provided through the questionnaire.

The NEA Secretariat concluded by indicating that the analysis phase had been completed. The Country Profiles will be sent in electronic form to the AP Members and the NDC Representatives – giving them a chance to either review/update/improve (for the ten countries for which the Secretariat drafted a Country Profile), or draft (for the others) their Country Profile. Ultimate Deadline is 30 November 2017.

The Secretariat will draft a summary report on the Survey, for final discussion at the next Advisory Panel and NDC early 2018, and decision on publication.

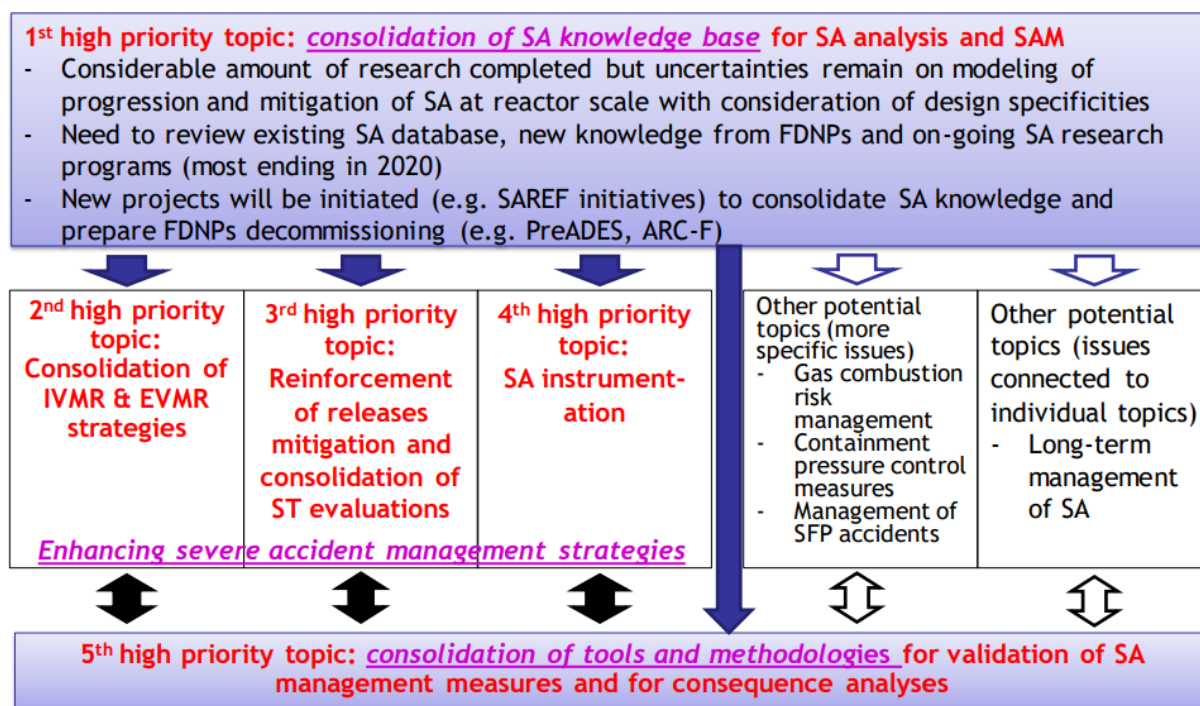
4. Review of Draft Templates

4.1 Consolidation Severe Accidents Management – D Jacquemain

Sections 1 (justification of selection), 2 (challenges and opportunities) and 4 (how to improve) of the template had been drafted and were presented at the meeting. Sections 3 (what exist) and 5 (Programme of Actions) were to be further developed.

The template is organised around five selected priorities (which are then further analysed and developed in the five sections of the template):

- Consolidation of the Severe Accidents knowledge base.
- Consolidation of In Vessel and Ex Vessel Mitigation Strategies.
- Improving release mitigation and consolidation of the source term evaluation.
- Improving Severe Accidents Instrumentation.
- Collaboration on methods and tools for Severe Accident consequence analysis and management.



The draft template was already shared by the author with some other selected experts in the field (CSNI WGAMA Bureau and ETSON).

An updated draft version of the template, taking all comments (also the ones of the AP meeting of September) into account, and including section 3, was issued early October and will be shared with the WGAMA for further comments.

What then remains to be drafted is section 5: the Programme of Actions for each of the five priorities, which will deserve discussion with all stakeholders, including industry and regulators to reach broad agreement. The Programme of Actions will be drafted for three timelines: starting in 2020 (time for which a number of collaborative projects are already on-going), up to 2025, 2030 and 2040.

A general comment from the discussions at the meeting: the template as of now is still very “science based”. It will be important to streamline the Programme of Actions (including with industry and regulators) to define and focus on the real game changer, fostering broad harmonisation and convergence, to tackle severe accident issues once and for all.

4.2 Qualification of Passive Safety Systems – JM Evrard

The objective followed is not to consider the development or the validation of specific passive safety system designs, but to develop commonly-recognized methodologies and produce necessary data to assess the performance and the reliability of such systems and consider suitable safety demonstrations, which is a key step in their generalized use in nuclear power plants.

Actions are proposed along three themes:

1. Thermal-hydraulic performance of passive safety systems
 - A first action is initiated in the framework of the CSNI/WGAMA which aims at producing a “status report on thermal-hydraulics passive systems design and safety assessment”. The proposal has been discussed at the WGAMA meeting in September 2017 and will be submitted at the CSNI meeting in December 2017. The completion of the action is planned within 2.5 years.
 - A second action, based on the conclusions and recommendations from the previous one, should be to undertake an experimental project in order to get suitable experimental data to support an in-depth understanding of thermal-hydraulic phenomena involved in most commonly considered passive system designs. Potential appropriate experimental facilities have to be identified in a first stage. Then a joint research project should be initiated with various research organizations, industry and TSOs.
2. Reliability assessment of passive safety systems
 - In conjunction with the action engaged by WGAMA, WGRISK should review and discuss methodologies suitable to perform probabilistic safety assessment of passive systems, in order to agree on an internationally-shared methodology.
3. Safety demonstration for designs including passive safety systems
 - Based on the results and conclusions from previous actions, NEA should establish a collaborative action with IAEA in order to establish an internationally-shared approach for the safety demonstration of nuclear designs including passive safety systems.

S Monti recommended looking at IAEA activities in this field to ensure complementarities, in particular on what is happening on SMRs. G Bruna recommended to start with defining requirements for passive safety systems. This could be discussed within NEA frameworks (under CSNI/CNRA). A potential risk of some duplication was identified between this template and the one on Gen IV DHRS – also relying on passive phenomena.

4.3 On Line Monitoring for Lifetime Management – A Al-Mazouzi

Three challenges have been identified:

Challenge 1: develop multi-scale and multi-physics methodologies that take simultaneously into account the load history experienced by any and each critical component during its previous service lifetime and all known and properly assessed ageing induced degradation mechanisms to predict the reliability limits of any components under flexible operating conditions.

Challenge 2: detecting and characterizing small local changes from among natural variability in a nominally homogeneous material using a modest number of sensors to interrogate critical regions (what, how, where and how many measurements?).

Challenge 3: Implementation of rigorous performance demonstration programs and development of new codes and regulatory guidelines before this technology can be widely implemented by the nuclear power industry.

During the discussion a recommendation was made to rapidly enlarge the pool of stakeholders to involve in this template to more industrial actors (EPRI) and regulators – to evaluate the real potential (appetite) for collaboration on methodologies and knowledge sharing.

4.4 High Temperature Nuclear Heat – D Hittner

G Wrochna informed the Advisory Panel of the on-going process in Poland to make a decision on the potential for HTRs to replace fossil fuel boilers for chemical plants (plug-in market). If this goes ahead, it might provide a real opportunity for an industrial demonstrator of coupling a nuclear reactor with a heat user process. This would require a large collaborative framework, assembling a number of interested stakeholders and parties, and may well become a model where the NEA NI2050 could come in support. Therefore, while not being strictly tight to this potential large demo project, the template should define a programme of action which comes in support.

The template (Programme of Action) will need to define the main areas of future work on the side of the reactor, but also on the coupling (which should be the centre piece of the demo):

- Fuel qualification (a large programme is on-going in the US financed by DOE).
- Materials and Components (HXs).
- Coupling (potential to use HTTR as a pre-small scale-demo if can be restarted).
- Qualification and Licensing, i.e. reactor and coupling.

International groups of interested stakeholders already exist and are at work: PRIME, NC2I, NGNP, JAEA and KAERI. Some have been involved in reviewing the template. This process needs to be pursued and broadened to other stakeholders such as regulators.

Depending on the evolution of the file in Poland, this topic might become a major case for NI2050, since build around a real industrial demonstration plant.

4.5 Qualification of ATF and Advanced Fuels – K Pasamehmetoglu and N Chauvin

It was decided to assemble all fuel issues into one template, with a double timeline; short/medium term ATF for LWRs and medium/longer advanced fuels, since the approach is the same: established a “common” methodology for qualification of fuels – which might then be used by industry to get their products licensed and to the market.

If indeed this qualification methodology can be developed, demonstrated and agreed in a multinational context (with involvement of all interested parties – science, industry and regulators), in a kind of de facto bottom up harmonization, it would ease and enlarge the access for fuel products to a broader market base. Ultimately the aim is to accelerate the licensing process with a different approach which goal is to be safer (covers more situations) and wider (based on material characteristics instead of fabrication processes). Indeed this licensing approach will be based on: calculations with predictive codes with higher reliability and improved dedicated tests (separated effects, steady state, safety tests).

The Programme of Action is based on four steps:

- TRL/LRL (licensing readiness level): establish detailed criteria and metrics for each level.
- Development of codes: more predictive (models, material parameters...), extension of its validation domain.
- Design of experiments in connection with the models (separate/coupled effects; multiphysics and multi-scale approach steady-state/transient).
- Inpile testing/instrumentation/PIE.

The programme should be developed for all types of fuels (at least solid ones).

The NSD Workshop planned for January 8-10 on Fuels and Materials is a good opportunity to engage the wider industry and regulator communities. See below.

4.6 Advanced Structural Materials for Gen IV Systems– L Malerba

The NEA could act as a facilitator for the creation of committees and signature of agreements whereby the following is pursued:

- Harmonisation of test and characterisation methodologies and procedures; best practices for microstructural characterization technique application and data analysis.
- Establishment of unified international databases of reference and rules concerning protection and disclosure of data collected in databases.

- Overview the use of major research facilities worldwide (mainly materials test reactors, but also for exposure of materials to HT & coolants); optimisation of complementary use of these facilities; design of large joint experimental programmes of (possibly) cross-cutting interest.
- Harmonization in the development of computer simulation materials models for better mutual complementarity and compatibility.
- Setting up funded schemes for mobility of researchers in the framework of the four missions above, while harmonising rules for access of scientists to facilities.

Three case studies were proposed:

- 60 year design lifetime: high temperature properties, compatibility with coolants, irradiation (on existing materials).
- Development of high temperature resistant cladding materials: creep resistant F/M steels and SiCf/SiC (mainly).
- Low temperature embrittlement of F/M steels.

Item 2 might be covered by the template on Advanced Fuels – but this still needs to be further decided (issue for the next meeting of the Advisory Panel). Items 1 and 3 are focussed on concrete materials (down selection done) – for which some research is on-going (Euratom programmes).

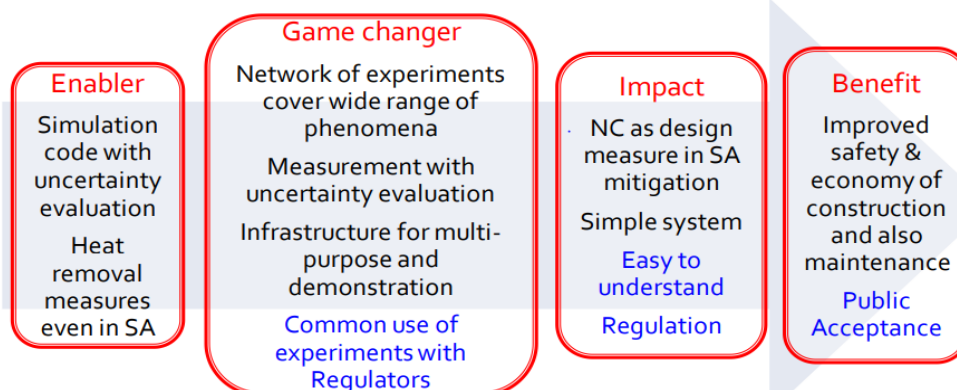
Expected benefits of international cooperation: Optimized/harmonized use of infrastructures; harmonization of procedures and methodologies; data collection and sharing; synergy on modelling. EERA JPNM is involved in the review of the template. Other communities need to be further involved, including industry and regulators.

A synergy has been identified with the starting cross cutting activity on Materials in GIF – centred on high temperature materials (VHTR SSC). Formal contacts have been taken, the draft template has been presented at the corresponding PMB, and this community will soon receive the template for further revision.

4.7 Safety and Economics of GENIV Systems and Components – DHRS – H Kamide

Challenge

- Experimental network for code V&V on wide spectrum of required phenomena
- Uncertainty evaluation of code and experimental data
- Adequate decay heat removal measures for DBE and Severe Accident



Actions:

- Development of simulation methods with uncertainty evaluation where local and complex phenomena interact system behaviour via flow and temperature distributions along multiple flow paths of NC.
- Wide range of validation experiments with uncertainty evaluations of measurements, e.g., large test facilities with high similarity.
- Effective and robust DHR measures by Natural Circulation for Post Accident Heat Removal.
- To share experimental programme and data with researchers and the regulation side.
- Need an optimised network of experimental facilities
- To contribute a wide range of phenomena to be understood for variety of DHR systems, geometry, and conditions.
- To overcome the difficulty of wide spectrum of phenomena and common idea of uncertainty treatment.
- Common understanding of phenomena between developers and regulators

This template is giving preliminary lists of infrastructures – to be further developed:

Infrastructure

- Existing: ▪ NSTF RV wall cooling by natural draft (Air) ▪ STELLA-1 Sodium components, e.g., IHX, Air cooler, Pump (Sodium) ▪ PLANDTL-2 Core thermal hydraulics with DRACS and NC (Sodium) ▪ PHEASANT DHR of damaged core and core catcher (Water)...
- Planning: ▪ STELLA-2 DHRS of natural circulation and ex-vessel cooling (Sodium) ▪ AtheNa-RV/DHRS Integrated thermal hydraulics test with various DHRSs (Sodium)...

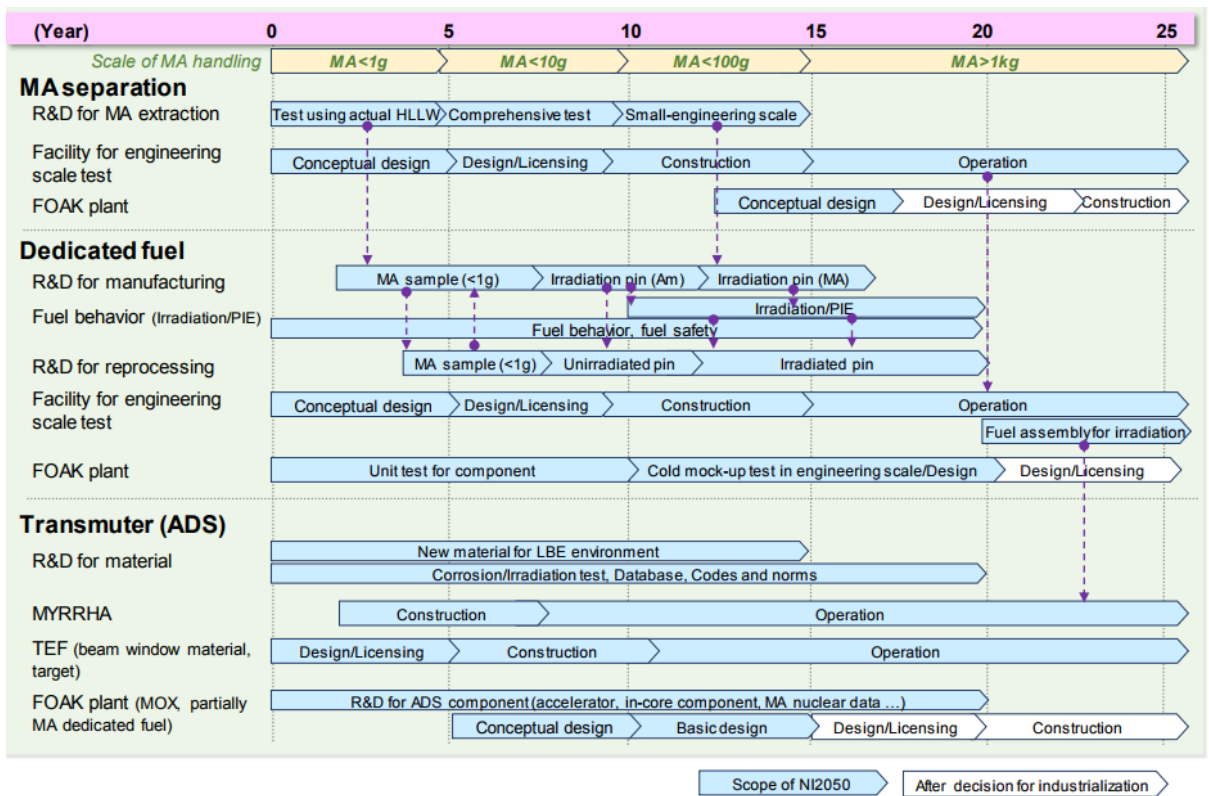
Interaction between this template and the one on Passive Systems Safety needs to be clarified.

4.8 Advanced Fuel Cycles - H Ait Abderrahim

The Programme of Actions is under development based on long standing collaborative schemes (EU), along four main axes:

- Minor Actinide (MA) separation
- MA bearing fuel fabrication
- MA transmutation
- MA fuel reprocessing

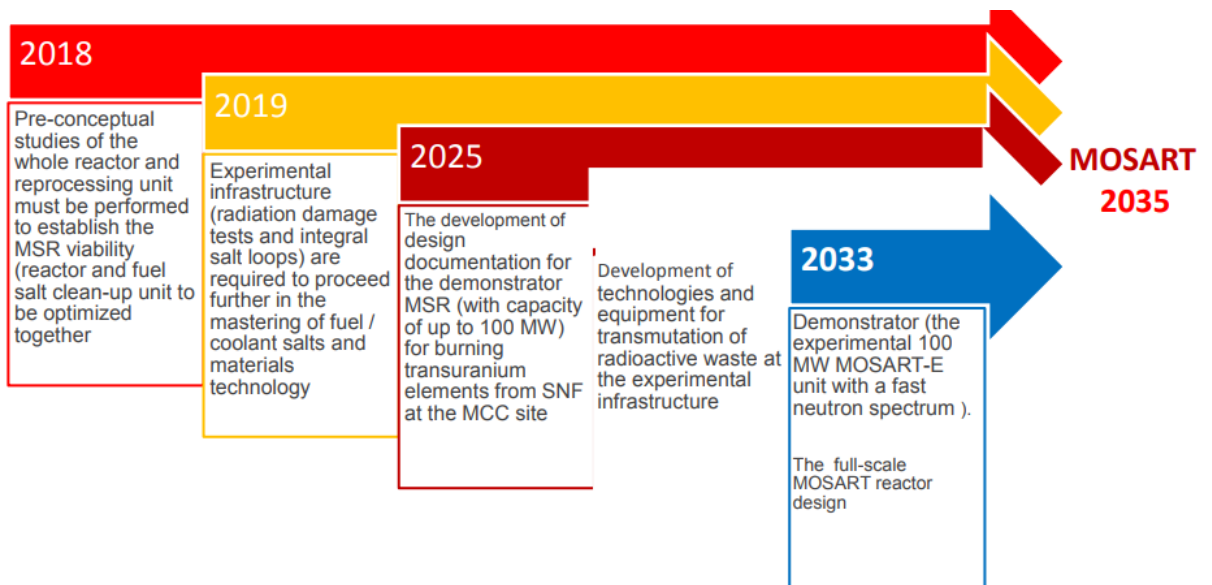
Time lines associated with “quantities of MA” are as follows:



Work in progress towards a full version of the template for the end of 2017, aiming to include:

- The facilities that are needed to allow the economical assessment of the technology as presently too large uncertainties are still present in various components
- The potential of the numerical simulation and modelling in reducing these uncertainties and alleviating heavy technical investment

A Kaperskaya gave a short presentation on the Rosatom plan to build a MSR transmutation demonstrator MOSART – MOlten SAlt Reactor for Transmutation:



General discussion/lessons on templates:

One participant rightly summarized the 3 central targets of NI2050 as follows:

1. Agree on common methodologies and practices to design, test/validate, and qualify innovative technologies
2. Interact with and involve regulators (early) on technology evolution.
3. Define and share the necessary infrastructures.

All templates have progressed and for some, a wider review process has been already engaged with individual experts or existing groups. It is the freedom/responsibility of each drafter to engage the review process. NEA Secretariat stands ready to help interacting with NEA Working Groups/Parties as appropriate – see list below:

Target Area/TOPIIC	Leaders	Groups Engaged
Accident Tolerant Fuels	K. Pasamehmetoglu, INL	NSC (EGATFL), CSNI (WGFS)
Severe Accident Knowledge and Management	G. Bruna/D Jacquemain, IRSN	CSNI (SAREF, WGAMA) ETSON, NUGENIA
Passive Safety Systems	G. Bruna/JM Evrard, IRSN	CSNI (WGAMA) ETSON
LTO Gen II 80 Years: Ageing Management	A. Al Mazouzi, EDF	CSNI (WIAGE) NUGENIA
Advanced Fuels and Materials (Gen IV)	N. Chauvin (Fuels), CEA L. Malerba (Materials), SCKCEN	NSC (WPFC, WPMM), EERA JPNM, GIF
Advanced Components (Gen IV)	H. Kamide, JAEA	GIF, CSNI/CNRA (GSAR/WGRNR)
Fuel Cycle Chemistry/Recycling (P&T)	H. Ait Abderrahim, SCKCEN	NSC (WPFC), CSNI (WGFCS)
Heat Production and Cogeneration	D. Hittner, NC2I	PRIME/GEMINI (NC2I, NGNP, JAEA, KAERI)
Modelling and Simulation	T. Valentine, ORNL	NSC (WPMM, EGMPEBV)
Measures and Instrumentation	G. Bignan, CEA	ANIMMA, NSC Wkshp
Infrastructures and Demos	All	NSC, CSNI (ia TAREF), DB (RTFDB)

More work is still necessary on defining more precisely what can/should be done to improve and accelerate innovation (item 4 of template) and on developing concrete Action Programmes (item 5 of template) with timeline (10 years +) and to couple them with infrastructures (existing or to be built).

The target is to have a revised (final) draft version of the templates for end 2017 – to be discussed at the next Advisory Panel – to decide which ones will be ready to go ahead for facing interface with industry and regulators for implementation.

5. Link with activities under NSC/NSD (Nuclear Science Committee and Division)

NEA Head of Division Tatiana Ivanova informed the Advisory Panel about the Workshop NSD is organising from 8 to 10 January in Paris: Enhancing Experimental Support for Deployment of new Fuels and Materials.

The main ultimate goal is to reduce the time required to deploy innovative fuels (and materials) in commercial reactors.

To do so, the Workshop aims at strengthening connections and promoting communication between TSOs/regulators, licensees, experimental facilities, and ensuring that best practices in experimental support are followed when deploying innovative fuels (and materials).

Some scientific issues to be addressed:

- Design of ‘smart’ experiments
- Advanced methods for interpretation and extrapolation of experimental measurements
- Advanced instrumentation
- Coupling of state-of-the-art modelling and simulation with experimental capabilities...

The Workshop will be organised in five sessions: industrial perspectives, TSOs and regulatory perspectives, science, infrastructures, conclusions.

This Workshop is fully consistent with the objectives of NI2050 to boost innovation by accelerating development, testing/validation (combining experiments and simulation/modelisation), qualification of advanced fuels and materials, for which two templates are under preparation (K Pasamehmetoglu/N Chauvin and L Malerba).

Therefore the authors of the templates will be invited to attend the Workshop. The Adv Panel Chair (Dr Fiona Rayment who also will attend the Workshop) will draw conclusions at the end of the Workshop on how to proceed further towards concrete implementation of the NI2050 templates, i.e. on Fuels and Materials.

On the following day, 11 January, the NEA Secretariat plans to organise a half day follow-up meeting, specifically focussing on discussing further, in a smaller group with some industry and TSOs representatives, the practical next steps for the implementation of NI2050 ATF template.

For information, NSD plans to also organise the last meeting of the EGATFL (Expert Group on ATFs) – chaired by K Pasamehmetoglu - on the 11pm/12am January.

6. Link with activities under RTFDB (Database Division)

<http://www.oecd-nea.org/rtfdb/index.html>

NEA Secretariat Elena Poplavskaia (Data Bank) gave a presentation of the actual status of the RTFDB Research and Test Facilities Data Base.

It is a tool resulting from a report of 2009 under NSD on Research and Test Facilities required for Nuclear Science and Technology. In the recent months interns have worked on trying to update the RTFDB, including by adding new information. But the tool has been developed on an «ad-hoc basis», is not optimised and could hardly be improved as such.

The idea is therefore to start the design of a new database. Diverse groups, including NI2050 Advisory Panel are invited to contribute to this process, meaning: be informed, provide feedback and inputs as appropriate.

As a first step, the “R&D infrastructures” related information, collected via the NI2050 Survey, can be extracted and provided to the RTFDB.

In the coming months, information on existing and necessary infrastructures will also be extracted from the Programmes of Actions (templates) produced in NI2050, and can be fed into RTFDB. RTFDB might also help the template drafters when establishing their lists of infrastructures and needs. For the longer term, NI2050 should help in the design of the new RTFDB.

Stefano Monti (IAEA) referred to their existing Database on Research Reactors. R Garbil (European Commission) highlighted their consolidated inputs on Infrastructures resulting from the Euratom Research Programme and the European Nuclear Technology Platforms.

7. Conclusions/Actions

- NEA Secretariat to circulate draft Summary Record to participants for their comments: end of October.
- NEA Secretariat to send to NI2050 AP and NDC Members their draft/model Country Profile (based on the technical inputs received from the Survey). Deadline for returns 30 November 2017.
- Drafters of Templates to send their revised (as far as possible) final drafts to the NEA Secretariat before 15 December 2017.
- 8 to 10 January 2018: NSD Workshop on Experimental Support for Fuels and Materials Innovation. Invited: F Rayment, K Pasamehmetoglu/N Chauvin, L Malerba. F Rayment asked to draw the conclusions within a NI2050 perspective.
- 11 January 2018 am: dedicated NI2050 meeting with industry and TSOs representatives on practical way and steps forward on Fuels and Materials.
- Planned dates for next Advisory Panel Meeting: **1 and 2 February 2018 at NEA Boulogne** (Note: NDC is on 14 and 15 February 2018).

Some topics on the Agenda:

- Discussion of the final drafts of the Templates.
- Return of experience/lessons learned from the January Workshop and NI2050 session with industry and regulators/TSOs.
- Reflection on NI2050 added value versus number of other « initiatives » (US GAIN, CAN and UK SMRs, GIF R&D Outlook 2018+10, GIF cross-cutting on materials (based VHTR).
- Next steps.

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