EERA JPNM ANNEX TO THE JOINT INPUT PAPER WITH SNETP
REPLYING TO ISSUES PAPER Nr. 10 – Nuclear Energy
Priorities, gaps and stakeholders
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Vision on nuclear energy

The European nuclear industry can continue to deliver safe low-carbon nuclear energy for the present and the coming centuries, with a commitment towards even higher safety standards and sustainability, by following three overlapping phases:

- Safe extended operation of existing GenII/III nuclear power plants (long-term operation, LTO), including new builds and the construction of GenIV prototypes;
- Subsequent deployment of GenIV fission reactors and systems, guaranteeing more sustainable and safe nuclear energy, through waste minimisation and optimal use of resources, with the potential for nuclear heat generation;
- In the long run, gradual insertion of fusion systems in the energy production market, in cohabitation with fission systems.

In the above context, the priorities and the gaps referred to in this Annex concern mainly **prototype fast reactor systems** (ASTRID, MYRRHA, ALFRED and ALLEGRO), as well as **nuclear cogeneration**. Possible priorities that can be addressed jointly with NUGENIA in a **GenII/III** reactor framework are also mentioned.

Nuclear materials priorities, gaps and stakeholders

GenII/III

Priority 1: Long term operation: **(1)** collect **data** from surveillance and decommissioning corresponding to **EOL fluence**; **(2)** develop **suitable models** rooted in physics in support of improved dose-damage correlations and integrity assessment standards. Action (1) involves necessarily the utilities, involved in NUGENIA. Action (2) may actually be addressed as cross-cutting through GenII/III/IV and even fusion (low temperature radiation embrittlement of steels affects all nuclear systems, including water-cooled DEMO), therefore involving NUGENIA, EERA JPNM and even EUROfusion.

Priority 2: Accident tolerant fuel, i.e. development and qualification of high-temperature resistant materials for cladding for GenII/III reactors. Main issues are **standardization, joining and qualification** in environment. These are transversally of interest also for GenIV systems like GFR and VHTR, thus this are cross-cutting issues to be addressed jointly by NUGENIA and EERA JPNM.

GenIV

Priorities depend on the system:

Sodium fast reactor: the priority is 60 yrs lifetime design. This requires production, collection and assessment of data representative of long-term operation at high temperature and the development of methods/models to extrapolate laboratory data to operational conditions, translating this into design codes. In the long run this effort will be useful also for other GenIV systems (lead, gas, …), given that they all use RCC MRx as design code. It involves EERA JPNM and ESNII, but there may be topics of interest for NUGENIA, too.

Lead fast reactor and systems using heavy liquid metals (Myrrha): the priority is compatibility between steels and the coolant, qualification of materials with respect to corrosion/erosion/dissolution and identification of mitigation strategies (e.g. surface engineering). It involves mainly EERA JPNM in support of ESNII. Similar problems are of **concern also for fusion**, for certain tritium breeding blanket designs, thus EUROfusion could be involved as well.

Gas fast reactor and very high temperature reactor: both systems target **high temperature** and **need refractory materials for which standards and design codes, as well as joining, need to be defined**. These materials and the relevant standardization and codification are of use also for accident-tolerant fuel (see above). Thus on these issues EERA JPNM and NUGENIA have a real opportunity to work jointly. The involvement of materials manufacturers and considerations of market beyond nuclear application is crucial and is being considered by EERA JPNM. For example, refractory materials, ceramic and metallic, are of use for advanced fossil fuel fired plants.

Fuel: the start-up core of all prototypes will be MOX in austenitic cladding, but new geometries, different operating conditions, etc. require efforts for licensing and eventually the need for higher burnup cladding, minor actinide bearing fuel, ceramic pins or plates using U/Pu carbides/nitrides etc. require dedicated research.

Cross-cutting with fusion (TBM in ITER):
Ferritic/martensitic steels are inherently irradiation resistant, are the materials of choice for fusion and will be the materials of future truly GenIV systems, but need to be **improved in terms of high temperature resistance** (creep strength) **and also compatibility with coolants** (surface engineering). Improvements should be achieved also in connection with **low temperature embrittlement** (see GenII/III). The development of steels improved for high temperature and corrosion is mentioned also in the ESTEP (European Steel Technology Platform) SRA for advanced fossil fuel fired plants. Working hands-in-hands with steel producers looking at a wider market than just nuclear is here essential for success.

Irradiation

All nuclear systems, including fusion, need data from neutron irradiation of materials. However neutron irradiation campaigns are expensive and often unaffordable for a single organisation. The number of neutron irradiation facilities is limited and for high neutron dose it becomes almost imperative to consider facilities outside Europe. To make the most rational use possible of available facilities and join forces in terms of bearing costs, **a permanent joint forum involving EERA JPNM and SNETP pillars, and possibly also fusion**, should be created. This forum should **agree upon irradiation needs and design joint campaigns**, making use of available facilities, possibly launching tenders and/or using differences between available reactors to explore specific effects, including, whenever suitable for the purposes, fundamental studies and the use of ion irradiation.

Cooperation issues

The implementation of plans concerning nuclear energy, ranging from GenII/III to GenIV and fusion, imperatively requires **alignment, integration and harmonisation of MS research complemented by EU funding (direct and indirect actions)**. In this respect the role of the platforms (SNETP, its pillars and EERA JPNM, working together) is essential, but requires the **support of MS and the integrating role of the EC**. To this end, **JRC direct actions are of consequence**, especially for the GenIV materials community, in their constructive role in adding to and integrating across MS efforts in the field.
The JRC can play a crucial role also in **connection with GIF** (Generation IV International Forum). The rules of data exchange between GIF and Euratom are currently not sufficiently clear and established to ensure an efficient transfer of information in two directions on equal footing. The role of **JRC serving as facilitator** of exchanges between Euratom and GIF and vice versa is here pivotal.