Nuclear Innovation 2050

A broad NEA Initiative to accelerate nuclear fission R&D through cooperation

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EU SET PLAN CONFERENCE
BRATISLAVA 2016
A source of expertise: The NEA's committees bring together top governmental officials and technical specialists from NEA member countries and strategic partners to solve difficult problems, establish best practices and to promote international collaboration.
**Major NEA Cooperative Funded Activities**

**Secretariat-Serviced Organisations**

- **Generation IV International Forum** — with the goal to improve sustainability (including effective fuel utilisation and minimisation of waste), economics, safety and reliability, proliferation resistance and physical protection.

- **Multinational Design Evaluation Programme** — initiative by national safety authorities to leverage their resources and knowledge for new reactor design reviews.

- **International Framework for Nuclear Energy Cooperation** — forum for international discussion on wide array of nuclear topics involving both developed and emerging economies.

**20+ Major Joint Projects**

(Invoking countries from within and beyond NEA membership)

- **Nuclear safety research** and experimental data (thermal-hydraulics, fuel behaviour, severe accidents).
- **Nuclear safety databases** (fire, common-cause failures).
- **Nuclear science** (thermodynamics of advanced fuels).
- **Radioactive waste management** (thermochemical database).
- **Radiological protection** (occupational exposure).
2°C requires a drop in the carbon intensity of primary energy

...which has been stable on a global level over the last 50 years.

Source: Energy Technology Perspectives, 2016
Global progress in clean energy needs to accelerate

Technology Status today against 2DS targets

<table>
<thead>
<tr>
<th>Technology</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric vehicles</td>
<td>On track</td>
</tr>
<tr>
<td>Solar PV and onshore wind</td>
<td>On track</td>
</tr>
<tr>
<td>Other renewable power</td>
<td>Not on track</td>
</tr>
<tr>
<td>Nuclear</td>
<td>Accelerated improvement needed</td>
</tr>
<tr>
<td>More efficient coal-fired power</td>
<td>Not on track</td>
</tr>
<tr>
<td>Carbon capture and storage</td>
<td>Not on track</td>
</tr>
<tr>
<td>Biofuels</td>
<td>Not on track</td>
</tr>
<tr>
<td>Transport</td>
<td>Not on track</td>
</tr>
<tr>
<td>Industry</td>
<td>Not on track</td>
</tr>
<tr>
<td>Buildings</td>
<td>Not on track</td>
</tr>
<tr>
<td>Appliances and lighting</td>
<td>Not on track</td>
</tr>
<tr>
<td>Energy storage</td>
<td>Not on track</td>
</tr>
</tbody>
</table>

- ● Not on track
- ○ Accelerated improvement needed
- ○ On track

Global clean energy deployment is still overall behind what is required to meet the 2°C goal, but recent progress on electric vehicles, solar PV and wind is promising

Source: Tracking Clean Energy Progress, 2016
Power sector almost completely decarbonised in the 2DS

Generation today:
- Fossil fuels: 68%
- Renewables: 22%
- Nuclear: 11%

Generation 2050:
- Fossil fuels: 17%
- Renewables: 67%
- Nuclear: 16%

Source: Energy Technology Perspectives, 2016
- 910 GW by 2050 and 16% share in the electricity mix
- But still a formidable challenge (multiply current capacity by 2.3 in 35 years)
- Annual investments in nuclear plants have to increase from USD 21 billion in 2015 to USD 110 billion on average over the period 2016-50
Nuclear investment requirements in 2DS, 2012-2050
Next 20 years critical for further reductions in cumulative emissions beyond 2°C

- By 2025, already 50% of the cumulative emissions of the power sector over the period 2015-2050 have been emitted.
- By 2035, the amount increases to 80% and to 90% by 2040.
Industry and transport accounted for 45% of direct CO2 emissions in 2013, but they are responsible for 75% of the remaining emissions in the 2DS in 2050.

Source: Energy Technology Perspectives, 2016
... Climate change... Air pollution... Increasing population worldwide... Increasing the level of welfare and access to energy...

BAU – Business As Usual – is NOT an option...
Need a new model... « Atom for Change »... « Nuclear AAA »...

Need to transform the way nuclear reactors are designed, regulated, built, operated, decommissioned...
... to be competitive, flexible, deployable, sustainable...

Competitive: with other energy sources, for diverse energy uses, in a energy system perspective, and consideration of the long term

Flexible: for integration of nuclear into the wider energy mix, ensuring complementarity and multiusage – electricity and beyond

Deployable: in large scales and diverse regions to have an impact, with consideration of security issues

Sustainable: meaning environmentally friendly, with levels of safety and ways to manage high level waste which are acceptable at large by the energy consumers, and making best use of resources

... these are the Challenges...
... how to tackle them...

Some keywords as drivers/areas for innovation...
The combination of them can provide answers to the challenges...

improved materials
improved fuels
modularity
advanced manufacturing and factory building
phased and timely licensing
improved monitoring and reduced maintenance
closed fuel cycle
cogeneration
hybrid systems
harmonisation
...
NI 2050 GENERAL OBJECTIVE – as per agreed ToRs

The general objective of the NI2050 is to identify R&D strategies and associated priorities to achieve commercial readiness of innovative sustainable nuclear fission technologies in a fast and cost effective manner

... through cooperation
Background
2015 NEA/IEA Nuclear Technology Roadmap

Contents and Approaches

- Provides an overview of nuclear energy today, and identifies regions growth profiles
- Identifies key technological milestones and innovations that can support significant growth in nuclear energy
- Identifies potential barriers to expanded nuclear development
- Provides recommendations to policy-makers (govt, industry, R&D, finance) on how to reach milestones & address barriers
### Example High Level Recommendations: Reactor Technology

<table>
<thead>
<tr>
<th>This Roadmap recommends the following actions:</th>
<th>Proposed timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governments to recognise the value of long-term operation to maintain low-carbon generation capacity and security of energy supply, provided safety requirements are met. Clearer policies are needed to encourage operators to invest in both long-term operation and new build so as to replace retiring units.</td>
<td>2015-30</td>
</tr>
<tr>
<td>R&amp;D in ageing of systems and materials is needed to support safe, long-term operation of existing nuclear power plants (NPPs) for 60 years operation or more.</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Vendors to optimise Gen III designs to improve constructability and reduce costs. The learning rate from new build construction needs to be accelerated by rapidly integrating lessons learnt from FOAK projects (design optimisation, project management, supply chain, interactions with regulators) to ensure that NOAK plants are built on time and to budget.</td>
<td>Ongoing</td>
</tr>
<tr>
<td>To open up the market for small modular reactors (SMRs), governments and industry should work together to accelerate the development of SMR prototypes and the launch of construction projects (about 5 projects per design) needed to demonstrate the benefits of modular design and factory assembly.</td>
<td>2015-25</td>
</tr>
<tr>
<td>Governments to recognise the long-term benefits of developing Generation IV (Gen IV) systems in terms of resource utilisation and waste management, and support R&amp;D and development of at least one or two Fast Breeder Reactor Gen IV prototypes.</td>
<td>2015-30</td>
</tr>
<tr>
<td>Public-private partnerships need to be put in place between governments and industry in order to develop demonstration projects for nuclear cogeneration in the area of desalination or hydrogen production.</td>
<td>2015-30</td>
</tr>
<tr>
<td>Incorporate feed-back from operation of Gen IV prototypes to develop FOAK Gen IV commercial plants.</td>
<td>2030-40</td>
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</tbody>
</table>
And now... post COP21...
Implementing 2015 NEA/IEA Technology Roadmap

Roadmap Recommendations

- Governmental Recognition of value of low-carbon capacity
- R&D to support long-term operation
- Optimise constructability of Gen III designs
- Accelerate development of SMRs
- Support development of 1 or 2 Gen IV FBRs
- Demonstrate nuclear desalination or hydrogen production
- Incorporate feed-back from Gen IV prototypes into FOAK Gen IV commercial plants
- Invest in environmentally sustainable use of uranium
- Ensure long-term storage and disposal policies and sites are in place
- ...

NOW: foster implementation... NI2050...
NI2050 Objective

As defined by the Advisory Panel and endorsed by NDC in January 2016:

The general objective of the NI2050 is to identify R&D strategies and associated priorities to achieve commercial readiness of innovative sustainable nuclear fission technologies in a fast and cost effective manner ... through cooperation

... after one year « down the road »:

- it is not a full exhaustive roadmap (already exists)
- it is a collective approach
- identifying and tackling together major challenges for nuclear energy
- by proposing concrete cooperative R&D projects (= outcome of NI2050 in 2017)
- for interested stakeholders to implement jointly (= next phase beyond 2017)
NI2050 Process/Timeline


*Questionnaire sent out by DEV to NDC in September 2015 – most MCs replied but diverse levels of quality*

*Number crunching ongoing (dec 2016), further analysis (june 2017)*
2. Top Down Setting of Fission R&D priorities for the future – in line with the objective of NI2050

- Starting from high level Challenges defined by the Advisory Panel,
- Using more detailed inputs collected during Experts Meetings,

Extract a set of concrete large R&D (or Demonstration) projects – programme and/or infrastructures – which are recognised as of high priority for nuclear energy’s role in the future, and for which cooperation would foster the faster and more effective implementation.

Some projects may already « exist » - NI2050 is then an « enabler ».

This set of projects, together with the survey, will constitute the outcome of NI2050 in 2017 (September).

From there, but beyond this phase of NI2050:

3. Engage stakeholders to discuss the legal and financial mechanisms for the effective implementation of the selected projects
From Adv Panel Subgroups Meetings Sept 2016: NI 2050 Key Challenges/Opportunities

- Economics and Competitiveness of Nuclear
- Integration of Nuclear in the Energy Mix - Flexibility
- Better use of Resources (Uranium)
- Innovative Materials, Fuels, Coolants
- Innovative Licensing
- Availability of Competence
- Public Acceptance (Safety and Waste Management)
- Public Awareness in the global energy perspective
- Decommissioning (Economics and Public Acceptance)

... building collective view on real priorities... helping going away for national/individual interests... leading to consensus on possible large projects (programmes and/or infrastructures) for cooperation...
### Timeline:
Timeline is for technology readiness (for commercial deployment)
From there: some preliminary possible areas for cooperation

- **Safety = No release off site:** Severe Acc prevent/remediation (expand Nugenia and NEA JP); ATF (expand NEA activities)
- **Waste Mgmt:** extended SNF storage + GD International R&D Center (expand IGDTP on real case)
- **Decommissioning:** International R&D Center on real case
- **Fukushima R&D Center for Sev Accident/Corium Mgmt, Decomm of damaged plant** (expand NEA JP)
- **Future Reactors and Fuels:** GIF phases towards Demonstration – ?see SSCs
- **Closed Fuel Cycles:** Partitioning and Transmutation (prepare the Demonstration phase for partitioning and transmutation of MAs)
- **Flexibility in Elec and non Elec uses:** Hybrid systems, SMRs and cogeneration demonstration (HTR?)
- **Crosscuttings:** Adv Materials/Fuels and manufacturing and NDT (harmonisation, C&S); Modelling and Simulation + Validation; I&C/IT and big data; Power Conversion Systems; Robotics, ...
- **Sharing/Pooling Infrastructures for irradiation/PIE,T&H loops,**
- **E&T, competence and skills:** NEST dimension of NI2050
...
In Conclusion

NI2050 – Nuclear Innovation 2050 - is a broad NEA Initiative aiming at selecting priority large scale R&D (and Demonstration) projects (programmes and infrastructures) for cooperative implementation by stakeholders (governments, R&D organisations, industry, financing institutions) to accelerate the readiness of innovative nuclear fission technologies and help them going over the “valley of death” and reach commercial deployment in time to contribute to long term sustainability challenges

...