

2015 NEA Annual Report



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NUCLEAR ENERGY AGENCY
Organisation for Economic Co-operation and Development

The NEA in Brief – 2015

Governing body:

The Steering Committee for Nuclear Energy

- 31 member countries (25 participating in the Data Bank)
- 57 years of international service
- 7 standing technical committees
- 72 working parties and expert groups
- 21 international joint projects funded by participants
- 3 Secretariat-serviced bodies
- 109 staff (official and voluntary contribution posts, NEA and Data Bank combined)
- € 11 million budget for the NEA in 2015, supplemented by voluntary contributions
- € 3.1 million budget for the Data Bank in 2015, supplemented by voluntary contributions
- 24 publications produced in 2015

The NEA and its mission

The Nuclear Energy Agency (NEA) is a semi-autonomous body within the Organisation for Economic Co-operation and Development (OECD), located in the Paris area in France. The objective of the Agency is to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes.

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Message from the Director-General

The year 2015 continued to be one of significant change, both in relation to the Agency and the global context within which it operates.

As countries around the world plan aggressive nuclear power plant construction programmes, prepare to phase out and decommission plants, or to both build and retire plants simultaneously, issues of economics, waste management, public communication and nuclear safety continue to dominate the global discussion regarding nuclear power. As many countries work to absorb the outcome of the COP21 negotiations at the end of 2015, it is becoming increasingly likely that the future of nuclear power will be determined in great respect by non-traditional suppliers and new entrant countries.

As reflected in this year's *Annual Report*, the NEA completed a significant revision of its management structure, which, it is hoped, will enable it to be more flexible, more efficient and more focused on the issues of greatest concern to its member countries. Our members provided input via the process of developing the new *Strategic Plan of the Nuclear Energy Agency: 2017-2022*, reaffirming their desire to maintain a sharp focus on nuclear safety as our most important mission area, while also reaffirming the vital importance of the NEA as a leading forum for technology co-operation, economic analysis and scientific investigation.

In that respect, the NEA's new role as the institutional home of the International Framework for Nuclear Energy Cooperation (IFNEC) continues the Agency's coverage of complex issues associated with the deployment of new nuclear power plants. The NEA also launched the Nuclear Innovation 2050 initiative in 2015, through which we hope to develop a co-ordinated international agenda for priority nuclear technology research and development on issues ranging from advanced fuel cycles to improved technology and methods for decommissioning retired plants.

The NEA moved its offices in 2015, allowing it to co-locate with OECD elements and, it is anticipated, leading to both near-term and longer-term efficiencies, as well as an improved environment for day-to-day work and for the numerous meetings we host each year. Above and beyond the benefits this move provides for the work of the NEA, even more significant is the greatly enhanced security it provides for our staff and the thousands of delegates from member countries that participate in our activities. Such considerations are, unfortunately, intrinsic aspects of the international environment in today's world.

In all, 2015 was a year of both continued success for the NEA and a year of transition. As old ways of doing business give way to the realities of constrained resources and increasing diversity of views and direction within our member countries, we remain focused on the core activities that make the NEA the premier forum for co-operation among countries with the most developed and experienced nuclear infrastructures.

As always, we bid farewell to many long-serving and highly valued members of the staff and to long-standing delegates to our committees, as many new faces replace them. Their many contributions have benefited all of us and the publics we serve in 31 countries.

William D. Magwood, IV
NEA Director-General

Nuclear Power in 2015

Nuclear energy development

At the end of 2015, there were 442 reactors in operation in 33 countries worldwide, representing over 380 GWe of capacity, with NEA member countries operating 348 of these reactors and 319 GWe, or 84% of the world total. Ten new reactors were connected to the grid in 2015, including Shin-Wolsong 2 in Korea and Beloyarsk 4 in the Russian Federation; construction began on 4 reactors, bringing the total number of reactors under construction to 67. Sendai 1 and 2 became the first two reactors to restart in Japan under the new regulatory regime, with Takahama 3 and 4 expected to return to operations in early 2016 after local government approvals were completed in December 2015.

Significant reactor-related developments in NEA member countries during 2015 are described below.

- The Belgian Federal Agency for Nuclear Control (FANC) approved the restart of Doel 3 and Tihange 2. A new law provides for a lifetime extension of Doel 1 and 2 to 2025.
- In Canada, Bruce Power announced an agreement with the Independent Electricity System Operator to refurbish six of its eight reactors in Ontario, assuming all costs and overruns for guaranteed electricity prices. The agreement and resulting upgrades will allow the plants to operate until the 2060s. Ontario is also planning the refurbishment of four Darlington units, adding 25-30 years to their operational life.
- The Czech Republic announced a national energy policy that favours an ambitious increase in nuclear power from its current 35% to between 45% and 60% by 2040 as a means to reduce carbon emissions and meet European Union (EU) targets.
- In Finland, Fennovoima submitted an application in June 2015 for a licence to construct the Hanhikivi 1 nuclear power plant and updated the application in August to document sufficient Finnish ownership of the project.
- France passed legislation in 2015 for the transition to a low-carbon economy, with a goal of ultimately reducing the percentage of nuclear power to 50% by 2025 through increased deployment of renewable capacity while maintaining the capacity of France's nuclear fleet at its current level. Completion of construction of Flamanville 3 was again delayed by one year until 2018, and the cost estimate was increased to EUR 10.5 billion.
- In Hungary, the EU launched an investigation into the 2014 procurement agreement for Rosatom to supply two new units (approximately 1 200 MWe each) for the Paks nuclear power plant (NPP). The Ukrainian company Turboatom was contracted to upgrade the low- and high-pressure turbines on the four existing Paks units, increasing the plant's power output.
- In Japan, the first two reactors restarted under the new regulatory standards. Currently, a total of 25 reactors have applied for authorisation to restart. The Japanese government announced in 2015 that nuclear energy would ultimately comprise one third of baseload electricity generation and 20-22% of total electricity generation. Imports of fossil fuels for electricity generation to make up for the continued absence of nuclear generating capacity since the accident at the Fukushima Daiichi NPP have resulted in increased greenhouse gas emissions, increased electricity prices and a growing trade deficit.
- In Korea, the government decided to shut down and decommission Kori 1, the first commercial



Aerial view of the Darlington NPP in Clarington, Ontario.



The Kori NPP in Busan, Korea.

2015 nuclear data summary for NEA countries

Country	Operational reactors	Installed capacity (GWe net)	Uranium requirements (tonnes U)	Nuclear share of electricity production (%)
Belgium	7	5.9	870	50.0
Canada	19	13.4	1 850	16.0
Czech Republic	6	3.9	677	33.3
Finland	4	2.8	424	33.9
France	58	63.1	8 000	76.9
Germany	9	12.0	2 000	15.8
Hungary	4	1.9	214	49.0
Japan	48	42.4	367	0.0
Korea	23	20.7	4 200	30.1
Mexico	2	1.3	188	4.4
Netherlands	1	0.5	60	3.5
Russia*	34	25.2	4 400	18.6
Slovak Republic	4	1.8	362	57.9
Slovenia	1	0.7	149	37.4
Spain	7	7.5	1 124	20.4
Sweden	10	9.5	1 433	41.2
Switzerland	5	3.3	250	37.9
United Kingdom	16	9.4	1 514	16.6
United States	99	98.6	17 988	20.2
Total	353	323.9	46 070	19.3

Source: *Nuclear Energy Data 2015* (data as of 1 January 2015).

* NEA estimates. Operational = connected to grid.

NPP to start operation in 1978. Kori 1 will operate until 18 June 2017. Wolsong 1, the first CANDU reactor in Korea, obtained a long-term operation (LTO) grant for ten additional years from its expiration in 2012 to continue operation to 2022. Shin-Wolsong 2 began full power operations in July 2015. The Ministry of Trade, Industry and Energy announced its seventh “Basic Plan for Long-term Electricity Supply and Demand” covering the period until 2029, which calls for an increase of 16 nuclear reactors by 2029, reaching a total of 39 reactors.

- In Poland, Polska Grupa Energetyczna SA (PGE) expressed to the Ministry of Economy its interest in establishing a solution similar to that adopted by the United Kingdom for Hinkley Point C – a contract for difference (CfD) – as a possible support mechanism for the project. Poland plans to implement its nuclear power programme by building two NPPs by 2035.
- In Russia, the BN-800 sodium-cooled reactor at the Beloyarsk NPP was connected to the electric grid in December, and Rostov 3 began commercial operation. Rosatom reached an agreement with Bangladesh to construct the Rooppur NPP with two VVER-1200 reactors, and with Viet Nam for a 1 200 MW AES-2006 design. Additionally, Russia signed agreements with Egypt and Jordan to move towards constructing multiple nuclear power units in these countries. In 2015, Russian NPPs produced a record amount of electricity – 195 TWh, or about 18.6% of the overall power generation. A new fuel fabrication facility at Zheleznogorsk began producing mixed oxide (MOX) fuel pellets

for fast breeder reactors (including the BN-800). Manufacturing of RITM-200 reactors for the nuclear icebreakers Siberia and Ural has started in Podolsk. The Russian regulator, Rostechndzor, granted the final licence allowing construction to start on the sodium-cooled multi-purpose fast neutron research reactor (MBIR) and extended the operating licence of unit 2 (RBMK-1000) at the Smolensk NPP for another ten years.

- In the Slovak Republic, the completion of two additional units at the Mochovce NPP was further delayed, with the first (unit 3) now expected to be in operation in mid-2017 and unit 4 coming online a year later.
- In Spain, the nuclear operator Nuclenor announced that the safety authority had found no safety defects in its inspections of the Santa Maria de Garoña reactor.
- In Turkey, the energy market regulator announced in June that it had granted a pre-licence to Akkuyu Nuclear to complete preparation for its first nuclear power plant. The regulatory authority will consider a final production licence once the preparation process is complete. Construction is expected to begin at the end of 2016. A Japanese-French consortium and a Chinese consortium are also discussing additional reactors.
- In the United States, Entergy announced that it will shut down the Fitzpatrick and Pilgrim plants before the end of their licences. Exelon’s plants in Illinois cleared capacity auctions through 2018, but their continued operation beyond that point remains uncertain. Construction of two AP1000 units each

Shares of uranium resources and production			
Country	Resources (%)*	Production (%)**	Production (tU)**
Australia	28.9	9	5 000
Canada	8.4	16	9 100
China	3.4	3	1 500
Kazakhstan	11.5	40	22 800
Namibia	6.5	6	3 300
Niger	6.9	7	4 000
Russia	8.6	5	3 000
South Africa	5.7	1	500
Ukraine	2.0	2	1 000
United States	3.5	3	1 900
Others	14.6	8	4 200
Total	100.0	100	56 500

Source: *Uranium 2014: Resources, Production and Demand*.
* Identified resources recoverable at less than USD 130/kgU.
** Data as of 1 January 2015 from publically available sources.

at the Vogtle and VC Summer sites continued, with completion now expected in 2019 and 2020. Watts Bar 2 began loading fuel in preparation for startup in early 2016. In September, the US Nuclear Regulatory Commission (NRC) renewed the operating licences of TVA's Sequoyah 1 and 2 units from 2020-2021 to 2040-2041, bringing the 20-year licence extension total to 78, with 16 further units under review. The possibility of additional 20-year extensions, to a total of 80 years, is being discussed.

Uranium production, conversion and enrichment

Global uranium supply declined since 2013 with production having slowed at a number of facilities due to poor market conditions. The most significant of these changes were the cessation of production at Kayelekera in Malawi, at Alta Mesa in the United States and at Honeymoon in Australia. Meanwhile, the Willow Creek and Palangana mines in the United States are facing a situation where no new capital is being invested into developing new wellfields. Other operating projects with significant production cuts include Rössing in Namibia and White Mesa in the United States. However, only one uranium project, the CNNC Azelik mine, was taken offline in 2015. The mine was shuttered in February, mainly due to the uranium price dip and high operating costs. On another note, Cigar Lake's high grade uranium deposit in Canada came into production in 2014 and was declared in commercial operation in May 2015. Cigar Lake mine is performing beyond expectations, with about 3 850 tU mined in the first full year of production – a quantity that is higher than the 2 300-3 000 tU production target set at the start of 2015.

Uranium was produced in eight NEA member countries in 2015, with countries such as Australia, Canada, Russia and the United States accounting for a significant share of the global production (about 35%).

Commercial uranium conversion facilities were in operation in Canada, France, Russia and the United States. Construction of a new conversion plant continued in France at the Comurhex II facility, with development paced to meet market requirements, reaching a total capacity of 15 000 tU.

Two recently built high-efficiency uranium centrifuge enrichment plants (AREVA's Georges Besse II plant in France and the URENCO facility in the United States) continued commercial operations through 2015, with capacity expansions underway or planned at both facilities. In the United States, Global Laser Enrichment announced plans to slow development of its laser enrichment technology owing to poor market conditions. Centrus Energy has received a one-year extension from the United States Department of Energy (DOE) for work related to its American Centrifuge technology, though funding will be cut by 60% and the scope of activities will not include development of its Piketon, Ohio plant.

Nuclear safety and regulation

Most short-term, high-priority nuclear safety issues related to the Fukushima Daiichi accident have already been addressed by NEA member countries. Lessons learnt have led to plant improvements (for example, the improved diversity and robustness of safety functions), enhanced accident management capacities (in relation to instrumentation, guidelines for impaired systems and off-site response capability) and innovative post-accident recovery and clean-up solutions (such as management of contaminated water, recovery strategies and solutions, and regulatory infrastructure enhancements to oversight and guidance). Moreover, NEA member countries have recognised the vital importance of developing and sustaining a strong safety culture in operating organisations and regulatory bodies, together with a clear understanding of the importance of effective crisis communication.

Looking forward, member countries are preparing for opportunities to address safety knowledge gaps through recovery activities and the decommissioning of reactors at the Fukushima Daiichi site. Valuable information can be gained during decommissioning and during subsequent research activities, for example in relation to the performance of safety or safety-support systems beyond their anticipated capabilities, mechanisms for component and system failure, effects of salt water on reactor internals, general behaviour of reactor fuel and of fission products, and the validation of models and computer codes for severe accident consequences. Such information will contribute to the safe and timely completion of decommissioning activities.

Broader safety issues are ensuring continued safety for nuclear power plants around the world, noting the challenges posed by life extensions and end-of-life exercises in the transition to decommissioning. NEA member countries are sharing experiences and best practices on the management of ageing materials and components; improving safety through use of operating experience and through research and analytical tools like probabilistic safety assessments (PSAs); ensuring that changes in plant configuration and operation (e.g. plant refurbishment, plant lay-up, power uprates, use of digital instrumentation and control) do not compromise safety; and improving safety culture and human performance in maintenance, engineering and operation. International collaborative efforts are yielding improvements in regulatory practices, as well as enhanced knowledge and understanding of existing and new technology. NEA member countries have sought to reinforce nuclear safety worldwide by promoting a convergence in safety practices and combining the expertise of regulatory authorities, while improving and expediting the safety review of new designs. Lessons learnt from the Fukushima Daiichi accident will continue to impact the design requirements of new reactors.

Radioactive waste management

In 2015, NEA member countries continued to put in place the necessary infrastructure to ensure the safe management of spent fuel and radioactive waste. With the objective of bringing greater clarity to the debate addressing risks associated with radioactive waste, owners of nuclear waste are increasingly recognising the importance of transparency in relation to information on associated management practices. Following the new European Council Directive 2011/70/Euratom, EU members are also reporting their national waste management programmes to the European Commission. These efforts ultimately improve public confidence, provide a European overview of radioactive waste management and allow for better management strategies to be defined.

The revision and development of legislation in the field of radioactive waste management is an important trend in radioactive waste management developments. New laws, ordinances, national



Kallerna

Pilot cave at final depth, spent nuclear fuel repository site, Olkiluoto, Finland.

radioactive waste management plans and other relevant documents are being developed or updated in NEA countries. In addition, the evolution or updating of funding mechanisms for radioactive waste and spent fuel management is ongoing in some countries. Finland became the first country to begin construction of a permanent repository for high-level radioactive waste, granting a licence to Posiva on 12 November 2015 to construct a final disposal facility for spent nuclear fuel at Olkiluoto.

Other highlights are as follows:

- In Canada, the Nuclear Waste Management Organization (NWMO) is making good progress towards implementing a long-term solution for nuclear fuel waste. The NWMO continues to move forward with its nine-step siting process to find a safe, secure and suitable site in an informed and willing community that would host a deep geological repository (DGR) and centre of expertise for the long-term management of Canada's nuclear fuel waste. As of March 2015, nine communities in Ontario remained involved in the NWMO site selection process (step 3 of a 9-step process). In October, the NWMO released its 2016-2020 Strategic Plan for public review. This plan clearly states that the focus of the next five-year period will be on siting and working with potentially interested communities as they move through the preliminary assessment step in the siting process. Activities will support community learning and engagement, as well as site evaluation.
- In the Czech Republic, the siting process for a spent fuel repository is still being defined, with the implementer, the Radioactive Waste Repository Authority (RAWRA), focusing on dialogue with pre-candidate municipalities. Despite a considerable effort to move forward with the geological survey preparations, no significant progress was achieved.

RAWRA has not received agreement from local municipality representatives to begin geological survey activities at the selected localities.

- In Finland, Posiva applied for a construction licence in 2012 for a final repository, which includes an above-ground encapsulation plant and underground repository for 9 000 tonnes of used fuel from Olkiluoto and Loviisa. The licence for construction was granted in November 2015. Finland is now close to the construction and implementation of a DGR, with construction anticipated to start in late 2016 and an operational disposal facility foreseen in 2023. This first construction licence granted in the world for a spent fuel disposal facility is a significant achievement on a global scale. It is a pioneering step and will provide waste management expertise to other countries developing geological repositories for radioactive waste.
- In France, the process is ongoing for the proposal of a DGR for high-level and long-lived, intermediate-level waste in the Meuse-Haute Marne area (i.e. the Cigéo Project). After a series of reviews of the preliminary design, Cigéo was moving to the basic design phase in 2015. At the same time, studies for amenities are progressing in order to make ready for all the utilities to begin construction of the repository, expected in 2020. As part of the technological programme of the Cigéo project, Andra has developed a scale 1 test bench for evaluating the retrievability of waste packages disposed in underground high-level waste emplacement drifts.
- In Germany, the siting process should restart after a review of the entire process by a federal parliament committee, comprised of waste management experts and members of relevant groups of civil society in accordance with a law that was passed on the strategy and schedule for the siting of a geological repository for high-level waste (HLW).
- In Japan, the work of the geological disposal research programme is ongoing while a policy for HLW management is being debated among several national organisations. In May, the government of Japan issued a basic policy on the final disposal of HLW, a version of the original 2008 policy. This new policy underlines the importance of consensus building between the government and local communities, as well as reversibility and retrievability. In line with the basic policy, the Japanese government has been selecting suitable areas for HLW disposal from a scientific viewpoint.
- In Korea, the Public Engagement Commission on Spent Nuclear Fuel Management (PECOS) that was established to advise the government on long-term management of spent fuel submitted its views on spent fuel management policy to the Ministry of Trade, Industry and Energy (MOTIE). PECOS recommended finding a site for an underground research laboratory (URL) by 2020 in order to undertake *in situ* experiments from 2030, and initiating operation of a DGR from 2051. MOTIE

will establish a basic plan for management of spent fuel mainly based on the recommendations from PECOS.

- In Russia, the design process has begun for the development of a DGR for high-level and long-lived waste in the region of Krasnoyarsk. The first stage of the project consists of building a URL by 2021, with a planned test and demonstration of the disposal of different types of radioactive waste. The final decision on the DGR is expected by 2025.
- In Sweden, the nuclear regulator, the Environmental Court and the municipality of Östhammar are continuing their review of general licence applications for spent fuel disposal. The applications are being reviewed under the Act on Nuclear Activities by the Swedish Radiation Safety Authority and under the Environmental Code by the Environmental Court, in both cases to inform a future decision by the Swedish government.
- In Switzerland, the sectoral planning process for the deep disposal of radioactive waste is currently in phase 2. Areas for potential siting of deep geological waste repositories for either high- or low-level waste have been identified from a technical point of view. In the new phase, logistical and economic aspects will be examined with the relevant communities and cantons in view of reducing the number of identified sites. The National Co-operative for the Disposal of Radioactive Waste (NAGRA) suggested that two areas, Zurich Northeast and Jurassic East, be further investigated as possible sites for a DGR. However, the Swiss Federal Nuclear Safety Inspectorate (ENSI) recently rejected the suggestion of focusing on only two sites.
- In the United States, NRC staff published volumes two and five of its safety evaluation report on the geologic HLW repository proposed at Yucca Mountain in Nevada. Publication of these volumes completed the technical safety review of the Yucca Mountain application by the US Department of Energy (DOE).



US DOE

Yucca Mountain is being considered as a potential site for the first national repository in the US for high-level radioactive waste.

Interim storage

Overall, there has been good progress in both the technical and societal aspects of developing geological repositories, but in many countries, the timing of decision making has made it necessary to consider storage for extended periods, notably in Germany, Japan and the United States. In Spain, a project to implement a centralised interim storage facility for all HLW and spent fuel is on schedule, with construction anticipated to begin in Villar de Cañas in 2018. In the United States, the NRC continues to evaluate technical areas related to extended storage of spent fuel in dry storage systems. The extended storage of spent fuel is being evaluated for safe storage through licence renewals, subsequent renewals and oversight. Licensees must develop ageing management plans that identify potential ageing effects, and that implement surveillance, maintenance and mitigation activities to address these issues during the extended storage period. Meanwhile, the DOE initiated programmes to develop a consent-based approach to siting centralised interim storage facilities.

Low- and intermediate-level waste

Progress has also been made in the area of low-level waste. Highlights are provided below.

- In Belgium, a licence application for a surface disposal facility at Dessel was submitted in 2013, and the procedure leading to the issuance of a “building and operations licence” for the surface disposal of low-level, short-lived waste in Dessel is ongoing.
- In Canada, the Canadian Environmental Assessment Agency was undertaking a public comment period for the last phase of the environmental assessment process in relation to the proposed DGR project for low- and intermediate-level radioactive waste (LILW) in Ontario. An environmental assessment report was submitted by the Joint Review Panel (JRP) to assist the Environment Minister in rendering a decision.
- In Germany, the construction of a DGR for non-heat producing radioactive waste at the former Konrad mine is progressing and operation is expected not later than 2023.

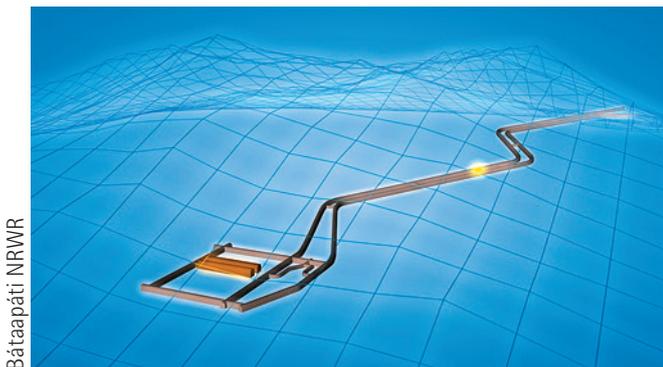


Diagram of the underground storage chambers in the Bataapáti National Radioactive Waste Repository, Hungary.

- On 27 November 2015, the Governor in Council of Hungary extended the time limit by 90 days to 1 March 2016 for the issuance of a decision statement ensuring a thorough environmental assessment. For the LILW repository in Bataapáti, the construction of a special light-structure hall started at the end of 2015, which is designed to protect the work area above outdoor disposal vaults against weather through movable inner containment during waste retrieval.
- In Korea, the LILW repository in Wolsong was licensed in late 2014 and started operation in 2015. The LILW disposal facility at Yangbuk-myeon, Gyeongju city, with a total capacity of 800 000 drums (200-litre size) in an area of 2 100 000 m², started operation in 2015. The first phase of the facility's construction was completed in June 2014 with underground silos having a capacity of 100 000 drums. The construction of the second phase facility is expected to be completed by 2019 with near-surface disposal having a capacity of 125 000 drums.
- In Russia, a concept relating to a regional LILW repository system is in the development stage and the siting process is ongoing at several sites.
- In the United States, the NRC has taken steps to address a lack of commercial disposal availability by supplementing guidance related to extended LLW storage, drafting clarifying guidance related to blending and concentration averaging of waste and re-evaluating the regulatory process by which unique waste streams (such as large quantities of depleted uranium) may be disposed.

Decommissioning

As decommissioning programmes are implemented, the rate of production of very-low-level and low-level waste will generally increase, and waste management organisations will need to accommodate this increased flow through, for example, the extension of existing disposal facilities. Decommissioning plans and decommissioning cost estimation studies continue to be regularly updated in NEA countries. In Germany, a federal parliamentary commission is evaluating the financing of decommissioning and disposal, and whether the provisions made by the nuclear industry are sufficient. In 2015, the Japanese government established the Collaborative Laboratories for Advanced Decommissioning Science (CLADS), under the responsibility of the Ministry of Education, Culture, Sports, Science and Technology (MEXT), to act as a bridge between research and decommissioning sites for the Fukushima Daiichi NPP. Korea is preparing the legislative framework for the decommissioning of the first NPP going into permanent shutdown in 2017. Overall, experience has shown that NEA countries with nuclear power programmes are committed to learning lessons not only about improving safety but also about the decommissioning of plants and the remediation of sites.

Radiological protection

The end of 2015 marks almost five years since the Fukushima Daiichi accident. The 20-km zone around the accident site and extended evacuation zones are being actively decontaminated, with management and implementation being carried out by the central Japanese government. Residents are now allowed to return to certain decontaminated areas. Decontamination of affected areas beyond the evacuation zones has also continued under the direction and implementation of municipal governments. Individual exposures are decreasing, with the average values for individual annual doses in many places at around 1 mSv/a or less. In spite of this progress, the level of social disruption caused by the earthquake, tsunami and nuclear accident remains very high. Approximately 100 000 people are still not able to return to their homes, or have chosen not to return. Agricultural production has broadly declined, and often continues to fall under the stigma of emanating from Fukushima.

Broad lessons that are applicable beyond Japan continue to emerge from the experience. In terms of government lessons, with time, responsibility for protective actions will shift away from the central government, with the latter continuing to support protective actions. However, while modelling using large-area characterisation data is useful for support prioritisation and resource allocation, there is no “average person” or “average concern”. As such, concerns will need to be addressed on an individual basis, when possible. The resources needed for such efforts will be extensive and should be pre-planned. For this, a multi-risk, integrated national approach would be effective. Experts should be trained in public interactions to facilitate effective, non-confrontational exchanges, because of the difficulties involved in building trust. Building or maintaining trust is a long-term process which can be facilitated by experts who are, and remain, locally connected. For stakeholders to have trust in government, the government must trust stakeholders.

In terms of lessons for affected populations, experience has shown that they are capable of learning practical radiological protection principles and making good choices to protect themselves and their families. The necessary knowledge to understand doses and risks comes from trusted experts. For example, measurements are easy to achieve, but scientific input is necessary to understand these measurements. It takes time to develop radiological context and judgement, particularly if the appropriate support is not provided. Generally, annual exposure measurements have shown that real exposures can be substantially below modelled exposure estimates based on ambient dose rate measurements and behaviour assumptions. Recovery is “achieved” when the “new normal” becomes “normal”. The radiological protection focus for stakeholder involvement in recovery should be on long-term technical support, which can be very resource intensive. Trust is again a necessary and central component of successful stakeholder involvement.

Further advances in radiological protection science were achieved in 2015. New epidemiology, more specifically the million-man study of a large, relatively well-documented cohort of workers exposed in the United States, is underway and has substantial statistical power. It is hoped that this study will bring further understanding of low-dose rate radiation effects. Studies in the southern Urals cohorts also continue. This project includes exposed workers from the Mayak production facility, as well as exposed members of the public along the Techa River. As with any epidemiological study, accurate dose assessment can be difficult, but the results suggest that chronic exposures carry a similar risk to that of acute exposures. Studies also continue to suggest that statistically significant risks (e.g. cancer incidence and cancer-caused death) may be associated with exposures in the 50 to 100 mSv range, and that a linear, non-threshold model of the dose/risk relationship remains among the possible options to describe existing data.

European radiological protection science and application studies of low-dose effects appear to be the most advanced, and approaches through broad, international co-ordination of studies are being pursued.

Nuclear science

Over the past decade, the dwindling availability of nuclear research facilities has led to gaps in experimental capabilities, a worldwide trend noted by many NEA member countries. As a result, the use of such facilities has come under increased scrutiny. While, historically, these facilities have had a multifaceted mandate to perform fundamental research, support the commercial applications of nuclear technology and train highly qualified personnel, a clear shift towards the latter is emerging in order to address shortages in the expertise needed to improve current nuclear technologies and develop novel systems. These shortages are expected to become more acute with time, owing to the demographics of nuclear professionals. Various countermeasures have been taken with a recent revival of critical facilities in the United States, and a refurbishing of BFS facilities in Russia and pursuit of MBIR developments to replace the BOR-60, representing an upgrade of capabilities for fast reactor research. Investments in the modernisation of the Advanced Test Reactor (United States), the Transient Reactor Test Facility (United States) and the Cabri Research Programme (France) are also enhancing experimental capabilities, while construction continues on the Jules Horowitz Reactor (France), which will augment the availability of high-flux capacity in Europe. New and existing infrastructure are increasingly being used for domestic training, and at the same time, are becoming increasingly accessible as “user facilities” where parties, including universities, can submit proposals to perform experiments at the facility. What this means for science is an increased capability to perform experimentally driven research, facilitating more robust validation of recently



The Jules Horowitz Reactor in Cadarache, France.

developed high-performance computer codes that leverage advances in computer power made over the past decade.

Advances in computer technology have facilitated the development of multi-physics and multi-scale coupled methodologies, and is requiring new validation approaches to confirm the credibility of these simulations. Moving from validation of decoupled phenomena to coupled phenomena is challenging the nuclear community to develop novel approaches, including new measurement techniques for integral experiments to provide data on the required scales and resolution. The movement towards the application of best estimate plus uncertainty (BEPU) methods for accident analysis and extrapolation beyond the horizon of available experiments for fuel cycle, minor actinide and radioactive waste management has also been generating new validation needs. Overall, the objective is to provide rigorously derived uncertainty estimates that help maximise performance while maintaining appropriate safety margins.

Nuclear law

Notwithstanding best efforts to ensure high levels of nuclear safety, the possibility remains that accidents may occur within a nuclear installation (i.e. not only nuclear power plants but also any installation in which there are nuclear fuel, nuclear substances, radioactive products or waste) or during the transport of nuclear substances to and from a nuclear installation. As experience shows from the accidents that occurred at Three Mile Island (1979), Chernobyl (1986) and Fukushima Daiichi (2011), severe accidents can have varying and potentially far-reaching consequences affecting both people and property.

There is wide consensus on the importance of providing nuclear liability regimes that address the concerns of all countries that might be affected by a nuclear accident with a view to providing appropriate compensation for nuclear damage. To

date, 24 out of the 31 NEA member countries have adhered to one or other of the international nuclear liability conventions. The trend since the Fukushima Daiichi accident has been for countries, especially newcomer or potential newcomer countries (such as Jordan, Kazakhstan and Saudi Arabia) to adhere to the enhanced Vienna Convention regime, i.e. the Protocol to amend the Vienna Convention. However, the main highlight of 2015 was the entry into force of the Convention on Supplementary Compensation for Nuclear Damage (CSC) on 15 April 2015, 18 years after its adoption. The CSC counts seven contracting parties as of December 2015.

NEA member countries that signed the 2004 Protocols to amend the Paris Convention and the Brussels Convention Supplementary to the Paris Convention ("Brussels Supplementary Convention") continue to work towards implementing the provisions of those protocols into their national legislation, to significantly increase the amount of compensation to be made available, broaden the scope of damage for which compensation may be granted and ensure that more victims will be entitled to compensation. Almost all signatories to both protocols are now ready to deposit their instruments of ratification of these protocols. However, the decision of the European Council (2004/294/EC) of 8 March 2004 requires that the eleven contracting parties to the Paris Convention which are also EU member states take the necessary steps to deposit simultaneously their instruments of ratification, or accession to the 2004 Protocol to amend the Paris Convention. It is expected that Italy and the United Kingdom will adopt ratification and implementation legislation, which should allow the 2004 Protocols to enter into force by 2017. Belgium, Finland, France, the Netherlands and Spain have already adopted transitory legislation which transposes into national legislation the compensation levels provided in the 2004 Protocols pending their entry into force. More information on the Paris Convention is available at www.oecd-nea.org/law/paris-convention.html.

The Fukushima Daiichi Accident and NEA Follow-up

Nuclear regulation

Since the Fukushima Daiichi nuclear power plant accident in March 2011, the NEA has provided direct assistance to the Japanese authorities to help in the development and implementation of national safety reviews and stress tests, to define the main elements in achieving effective regulatory reform, and to encourage best practices in the remediation of land contaminated with radioactive materials, as well as the planning and effective management of decontamination and decommissioning activities.

Numerous international activities have been organised, including joint research projects and meetings among nuclear regulators, nuclear safety experts, public health specialists and civil society stakeholders. Following the 2013 publication of a summary report of key NEA actions and member country responses to the Fukushima Daiichi accident, entitled *The Fukushima Daiichi Nuclear Power Plant Accident: OECD/NEA Nuclear Safety Response and Lessons Learnt*, a five-year milestone report has been prepared for release in 2016.

The milestone report provides a high-level summary of the outcomes of activities initiated by the NEA to address safety issues arising from lessons learnt since the accident. The objective is to demonstrate what has been done by the NEA and its member countries to continue with improvements to safety since 2011. While the NEA Committee on Nuclear Regulatory Activities (CNRA) has led the production of the report, input was also provided by the NEA Committee on the Safety of Nuclear Installations (CSNI), the NEA Committee on Radiation Protection and Public Health (CRPPH) and the NEA Nuclear Law Committee (NLC).

NEA committees have completed short-term, high-priority activities to address issues arising from the accident, including filtered containment venting, hydrogen management and related computer codes, and probabilistic safety assessments (PSAs) of natural external hazards such as earthquakes. Reports were produced on these subjects as well as on spent fuel pools under loss-of-cooling and loss-of-coolant accidents (LOCAs), metallic component margins under high seismic loads and on the robustness of NPP electrical systems in light of the Fukushima Daiichi accident.

The NEA continued to progress on other important initiatives. For example, a Working Group on External Events (WGEV) was formed in 2015 to improve the understanding and treatment of external hazards, and thereby support the continued safety

performance of nuclear installations and help improve the effectiveness of regulatory practices in NEA member countries. A Senior Expert Group on Safety Research Opportunities Post-Fukushima (SAREF) has also been reviewing possible areas for international collaboration, and is making good progress in determining potential safety research that would address safety knowledge gaps and support the safe and timely decommissioning of the Fukushima Daiichi reactors. The Benchmark Study of the Accident at the Fukushima Daiichi Nuclear Power Plant (BSAF) – initiated in 2012 to improve severe accident (SA) codes, to analyse accident progression and examine the current core status – continues to support remediation and decommissioning activities. In 2015, a report was issued for phase 1 of the project, covering the first six days of the accident. A second phase, covering a longer time frame and including 11 NEA member countries, has started and is analysing fission product behaviour.

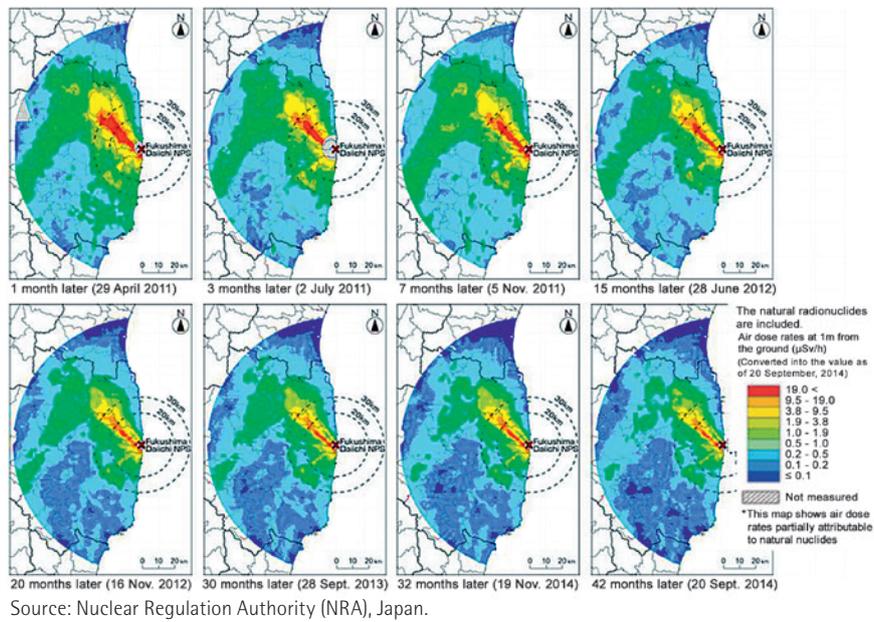
Nuclear safety defence in depth

The NEA Senior-level Task Group on Defence in Depth (STG-DiD) completed its regulatory guidance report, which provides advice in the area of DiD implementation. A key observation is that the use of the DiD concept remains valid after the Fukushima Daiichi accident. Indeed, lessons learnt from the accident and its impact on the use of DiD has reinforced its fundamental importance in ensuring adequate safety. The report also makes recommendations to enhance the implementation and use of defence in depth, while taking into account the lessons learnt from the Fukushima Daiichi accident.

Radiological protection

By the end of 2015, nearly five years after the accident, significant decontamination and infrastructure work had been accomplished, both in the evacuated areas managed by the central Japanese government and beyond the evacuated areas, which are managed by municipal governments. Many people have stayed in the Fukushima Prefecture, working mostly with local experts to try to understand the radiological nature of their situation and to adjust their lives to their new reality. Yet contamination and structural issues remain to be resolved, and many of those who evacuated have not returned, in particular young people and families with young children. Some of the evacuated areas have now been decontaminated and radiologically characterised such that evacuees have been permitted to return and live in these areas if they so choose.

Figure 1: Progression of radiation levels in affected areas



Decontamination

Contamination levels in the Fukushima Prefecture have steadily decreased, mostly through natural radiological decay. Figure 1 shows the progressive status of the contamination footprint resulting from the accident. The affected areas in the Prefecture remain divided into two sections: those to be decontaminated and managed by Japan’s central government (broadly within the 20-km zone and the evacuation zone to the northwest of the installation), and those to be decontaminated and managed through the Prefecture of affected municipalities. This delineation was made based on modelled annual doses that are either above or below 20 mSv/y.

The designation was enacted by law with the passage of the August 2011 Act on special measures concerning the handling of radioactive pollution. According to this act, which came into force in January 2012, the government and municipalities are required to develop decontamination implementation plans and to implement decontamination projects (collection, transfer, temporary storage and final disposal). The areas designated by the act are the special decontamination areas and the intensive contamination survey areas (see Figure 2).

It is in the special decontamination areas – the 11 municipalities in the formerly restricted zone or planned evacuation zone (< 20 km from the NPP, in

Figure 2: Status of the evacuation areas

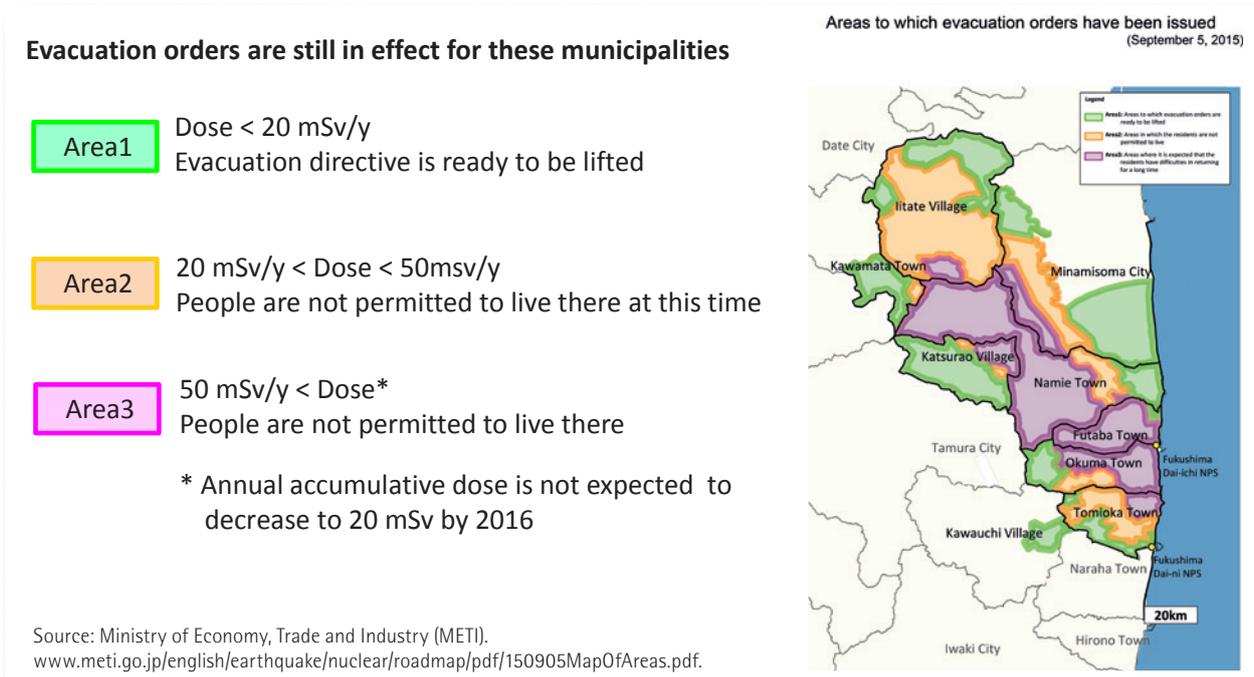


Table 1: Status of decontamination activities managed by the central government

Prefecture	Population in decontamination target area (approx. no. of people)	Decontamination target area (ha, approx.)	Progress of the decontamination work (as of the end of October 2015)				Schedule	
			Decontamination plan	Temporary storage site	Consent of land-owners, etc.	Decontamination activities	Residential areas completed	Remaining areas completed
Tamura	400	500	April 2012	secured	completed	completed in June 2013	completed in FY 2013*	
Naraha	7 700	2 100	April 2012	secured	completed	completed in March 2014	completed in FY2013*	
Kawauchi	400	500	April 2012	secured	completed	completed in March 2014	completed in FY2013*	
Okuma	400	400	Dec. 2012	secured	completed	completed in March 2014	completed in FY2013*	
Iitate	6 000	5 600	May 2012	Secured	Almost completed	in progress	completed in FY2015*	2016
Minamisoma	13 300	6 100	April 2012	~ 90% secured	~ 90%	in progress	FY2015*	FY2016*
Kawamata	1 200	1 600	August 2012	secured	almost completed	in progress	completed in FY2014*	2015
Katsurao	1 400	1 700	Sept. 2012	secured	almost completed	in progress	completed in FY2014*	2015
Namie	18 800	3 300	Nov. 2012	~ 70% secured	~90%	in progress	FY2015*	FY2016*
Tomioka	11 300	2 800	June 2013	secured	almost completed	in progress	FY2015*	FY2016*
Futaba	300	200	July 2014	secured	~80%	in progress	FY2015*	

*FY = Fiscal year. In Japan, the fiscal year runs from 1 April to 31 March.

which the annual cumulative dose is > 20 mSv) – where decontamination is to be implemented by the national government. These municipalities include the entire areas of Naraha, Tomioka, Okuma, Futaba, Namie, Katsurao and Iitate, and some areas of Tamura, Minamisoma, Kawamata and Kawauchi.

As of the end of 2015, decontamination of Tamura, Kawauchi and Naraha has been completed to the point that the Japanese central government authorised people to return permanently to their homes. Few so far have elected to return. Decontamination in Katsurao, Kawamata and Minamisoma has progressed well and preparations for allowing people to return are beginning. See Table 1 for the status of decontamination activities in the different municipalities.

Management of contaminated food

A key concern since the accident has been the management of food from affected areas. The current contamination limits for food are based on conservative assumptions that 50% of consumption is contaminated at the limit value, and that this should result in less than 1 mSv/y for those most at risk. Using these assumptions, the limit values have been fixed as follows: general food (100 Bq/kg), milk (50 Bq/kg), infant food (50 Bq/kg) and drinking water (10 Bq/kg).

Through significant efforts to reduce uptake by plants, focusing on caesium-137 and using approaches such as potassium fertiliser or removal of contaminated bark from fruit trees, the number of samples of various foods exceeding the limit has been significantly reduced from 2011 to 2014 (see Table 2). Real food contamination was rare, particularly of food that was in the trade channels. Extensive measurements of rice from the region demonstrated low contamination on the one hand and an excellent measurement network for agricultural products on the other hand. Although working somewhat independently, the central Japanese government – alongside private farmers and food distribution organisations – continues to measure food from affected areas before it is sold.

Continuing efforts

Although much has been accomplished, a significant amount of physical and social work remains to be undertaken in the Fukushima Prefecture. The Japanese government is continuing its activities in areas such as environmental monitoring, decontamination, distribution of safe food, health surveillance of residents, health surveillance of NPP workers, assistance to residents who decide to return home, reconstruction work, compensation of residents and the decommissioning of the Fukushima Daiichi nuclear power plant.

Table 2: Food sampling results

Category	No. of samples FY2014*	Sample > limit			
		FY2014 (no.)	FY2014 (%)	FY2013* (%)	FY2011* (%)
Rice	10 990 000	0	0.0003	0.0003	2.2
Beans	2 586	2	0.1	0.4	2.3
Vegetables	16 712	0	0	0	3.0
Fruits	3 302	0	0	0	7.7
Tea	206	0	0	0	8.6
Milk	1 846	0	0	0	0.4

*FY = Fiscal year. In Japan, the fiscal year runs from 1 April to 31 March.

Remaining challenges

Much progress has also been made in terms of clean-up activities in the various affected areas, but again more remains to be accomplished, in particular with regard to individuals' concerns. Social reconstruction is the primary aspect, which includes providing evacuees with information and advice to help them decide whether or not to return, and providing those who stayed with information and advice to help them decide whether to leave. Concerns go well beyond radiological aspects, and relate more specifically to ensuring a sufficient number of schools, hospitals, stores, infrastructure and employment. Along with concerns about risks to children, these factors appear to be the most important for citizens in the Fukushima Prefecture. It is essential for affected individuals to be appropriately informed and supported in making decisions about where and how to continue their lives.

One of the more sizeable challenges that has arisen during work in the region thus far is that of enhancing trust in the Japanese government, a trust that was seriously eroded by the accident. The NEA has provided substantial support to the work of the International Commission on Radiological Protection (ICRP) with stakeholders in the Fukushima Prefecture. These efforts have indicated that the central government's decontamination initiatives are having little influence on stakeholders' actions because government work and measurements are often distrusted. The re-establishment of trust in the central government would therefore be an important step in improving the efficiency of extensive government efforts being undertaken to address the consequences of the accident.

One remaining challenge is the absolute magnitude of the issue, and the need for experts to address concerns on an individual level, or at least at the level of small groups. Experts should keep in mind that there are no "average" concerns and that for trust to be re-established, advice will have to adequately address individual concerns.

Radioactive waste management

Since the Fukushima Daiichi accident, approximately 1 million m³ of all forms of radioactive waste have been stored at the Fukushima Daiichi site. This volume of waste is expected to increase once full-fledged work on decommissioning and dismantling of the reactors and buildings begins.

The NEA Expert Group on Fukushima Waste Management and Decommissioning R&D (EGFWMD) aims to offer advice on the management of large quantities of Fukushima Daiichi on-site waste with complex properties and to share experiences with the international community. The EGFWMD is composed of international experts with experience in past nuclear accidents, as well as Japanese experts and waste management specialists from the NEA. These experts have extensive experience in waste management during radiological contamination or in decommissioning and waste management R&D, for example, after the Three Mile Island or Chernobyl accidents. They are expected to provide technical opinions and advice on waste management and R&D at the Fukushima Daiichi site.

Since the establishment of the group in 2014, the EGFWMD has held four meetings with two site visits, the first to the Fukushima Daiichi site and the second to the Chernobyl NPP site in Ukraine. The EGFWMD will release an advisory report in 2016 with the results of its research on waste management at the Fukushima site. The gaps between past experiences with nuclear accidents or contamination situations and current activities at the site will be identified in different technical areas such as radiological characterisation, waste classification and the strategy for final waste destination. Human aspects, such as stakeholder engagement with the regulatory authority and implementer interactions, will also be addressed.

NEA Activities by Sector

Nuclear Development

The goal of the NEA in this sector is to provide governments and other relevant stakeholders with authoritative, reliable information on the current performance and future viability of nuclear power generation – including economic and resource analyses, public opinion and perceptions, advances in nuclear technology and the nuclear fuel cycle, electricity production data and nuclear knowledge management – as well as to provide forecasts on the future role of nuclear energy in a sustainable development perspective and within the context of national and international energy policies. The staff works closely with the Committee for Technical and Economic Studies on Nuclear Energy Development and the Fuel Cycle (NDC) and its expert groups in this area. The nature of this area is such that some efforts are necessarily cross-cutting, and as such, the staff ensures co-ordination with other NEA sectors, committees and working parties as needed.

Highlights

- The NEA published the *Projected Costs of Generating Electricity – 2015 Edition*, analysing the levelised cost of electricity across all main electricity generating technologies.
- The 2015 update of the *Technology Roadmap: Nuclear Energy* was published in January in co-operation with the International Energy Agency (IEA).
- Together with the International Atomic Energy Agency (IAEA), the NEA participated in COP21 in Paris, with side events highlighting the potential of nuclear energy to help combat global climate change.
- The NEA launched the Nuclear Innovation 2050 initiative to evaluate current nuclear energy research and development plans, to help set R&D priorities and to foster their implementation through co-operation.
- A report on *Nuclear New Build: Insights into Financing and Project Management* was released in July.
- *Nuclear Energy Data 2015* (the “Brown Book”) was published with official information on member countries’ nuclear energy developments, projections of total electrical and nuclear generating capacities along with fuel cycle requirements to 2035.
- A fourth mandate for the High-level Group on the Security of Supply of Medical Radioisotopes was approved for the period 2015-2017.

Projected Costs of Generating Electricity

The eighth edition of *Projected Costs of Generating Electricity* was published in August, analysing the levelised costs of electricity (LCOE) generation for all the main electricity generating technologies and revealing a number of interesting findings that have implications for policymakers. Drawing on a database that includes a greater variety of technologies and a larger number of countries than previous editions, the report demonstrates that the cost drivers of different generating technologies remain both market- and technology-specific. Low-carbon technologies remain highly capital-intensive, and their overall cost depends significantly on the cost of capital. The relative cost of coal and natural gas-fired generation is shown to be heavily contingent on fuel costs and the price of CO₂ emissions, should such policies be fully implemented. One key trend that emerges is a decline in recent years in the cost of renewable generation as a result of the use of improved technologies and continued governmental support. The report also reveals that nuclear energy costs remain in line with the cost of other baseload technologies, despite persistent reports to the contrary. Market structure,

the policy environment and resource endowments all play a strong role in determining the final levelised cost of any investment.

IEA/NEA Technology Roadmap: Nuclear Energy – 2015 Edition

According to the two-degree scenario (2DS) described in this new roadmap, nuclear energy will play a major role in decarbonising the world’s power sector with, as noted above, a projected installed capacity of over 930 GW (gross) in 2050 compared to just under 400 GW today, and a global share of 17% electricity generation up from 11%. Nuclear energy would therefore be the largest source of electricity among all generating technologies in 2050, as well as the technology that would allow the most CO₂ savings cumulatively over the next decades. The roadmap describes the technological evolutions that could support such growth, including progress in long-term operation of power plants, improved safety and competitiveness of generation III designs and more innovative developments such as small modular reactors or generation IV reactors. It also identifies a number of challenges and recommends actions

that governments, industry, research or financial institutions could take to allow nuclear energy to further develop. A Chinese translation of the roadmap was published in November.

Nuclear Energy at COP21

Two side events were held jointly by the NEA and the IAEA on “Why the Climate Needs Nuclear Energy” at the 21st Conference of the Parties (COP21) on 10-11 December 2015. The purpose of these side events was to highlight the role of nuclear power in helping to limit the rise in global mean temperatures to less than 2°C above pre-industrial levels. To avoid exceeding this critical threshold, the global electricity sector, which currently emits 40% of global carbon emissions, will essentially need to be decarbonised by 2050. According to projections, the share of nuclear energy in global electricity production would need to rise from 11% in 2014 to 17% in 2050 in order to achieve this goal, with installed capacity rising from 396 GW to 930 GW. As the only low-carbon source of dispatchable and scalable power, nuclear energy would remain the biggest contributor to low-carbon energy after hydropower.

In addition to the role of nuclear power in reducing greenhouse gas emissions, presenters at COP21 highlighted other contributions of nuclear power, for example to economic development more generally and to the security of energy supply.

Nuclear Innovation 2050 (NI2050) initiative

The NI2050 initiative is designed to answer the question of whether current R&D plans and resources, including planned demonstrations, will be sufficient to foster the required innovation in nuclear fission technologies to ensure that nuclear fission can fulfil its role in a low-carbon future. It seeks to do so by evaluating current plans, helping to set nuclear fission R&D priorities and fostering their implementation through co-operation. At the NI2050 July 2015 workshop in Paris, representatives from NEA member countries and heads of research organisations agreed to organise future work into three phases: i) to collect information on existing nuclear fission R&D programmes and infrastructures; ii) to define priority areas and topics where R&D is necessary; and iii) to determine potential co-operation frameworks to more effectively address needs and gaps identified in phases 1 and 2.

A questionnaire on existing nuclear fission R&D programmes and infrastructures was sent out to NEA member country representatives at the end of September 2015. The first meeting of the advisory panel that guides and oversees the work of experts took place in early October 2015. Phases 1 and 2 are to be completed by the end of 2016, with a final workshop scheduled at the end of phase 2 to review the outcomes and discuss possible future steps.

Nuclear new build

Under the oversight of the NEA Working Party of Nuclear Energy Economics (WPNE), a report on *Nuclear New Build: Insights into Financing and Project Management* was published in July. Drawing on a combination of conceptual analysis, expert opinion and seven in-depth case studies, the study provides an overview of the principal challenges facing nuclear new build and proposes possible ways of addressing them. Due to the high capital-intensity of nuclear power, which is comparable to that of other low-carbon generation technologies, investors in nuclear power must commit a large proportion of total lifetime costs before commissioning. Given this high share of fixed costs, nuclear power is vulnerable to declines in electricity prices and is thus more exposed to electricity market risk than other dispatchable technologies such as gas or coal. The study concludes that providing revenue stability is a key factor to enable investment in nuclear projects. Tariffs, power purchase agreements with guaranteed prices, long-term contracts and contracts for difference are some examples of mechanisms that are available today. In the management of the construction process and the supply chain, the global convergence of nuclear engineering codes and quality standards remains a key step to promoting both competition and public confidence. Design completion before the start of construction, early supply chain planning and “soft issues” such as leadership, team building and trust have also emerged as key factors in the new build construction process.

Data and resources

Nuclear Energy Data 2015 (the “Brown Book”) was published in October. It contains official information provided by member countries on nuclear energy developments, including projections of total electrical and nuclear generating capacities along with fuel cycle requirements to 2035. Total electricity generation in OECD countries declined slightly from 2013 to 2014 (0.3%). However, electricity generation from nuclear power plants increased by 1.4%.

Security of supply of medical radioisotopes

In 2015, the NEA High-level Group on the Security of Supply of Medical Radioisotopes (HLG-MR) continued its efforts to help ensure the global security of supply of molybdenum-99 (⁹⁹Mo) and its decay product, technetium-99m (^{99m}Tc), the most widely used medical radioisotope. The NEA issued the “2015 Medical Isotope Supply Review: ⁹⁹Mo/^{99m}Tc Market Demand and Production Capacity Projection 2015-2020”, underlining that market demand is around 10% lower than had been previously estimated and that the recent demand level is relatively flat. The overall conclusion was that supply capacity should be sufficient in 2016 to manage adverse events. If planned additional capacity is successfully introduced in 2017, then the supply until 2020 should also be secure.

The NEA reviewed the status of the global $^{99}\text{Mo}/^{99\text{m}}\text{Tc}$ market, drawing attention to a continued decline in market value at the generator step of the supply chain (> 10% value decrease in the year 2013). The NEA expressed concern that a market that was contracting in value at the end-user level seemed at odds with the need to accept increased costs throughout the supply chain, a necessary step in the move towards achieving full cost recovery pricing and paid outage reserve capacity. Pressure continued on health care budgets and only limited progress has been made in reviewing or adjusting reimbursement

rates, which is hampering change. A fourth mandate of the HLG-MR was approved for the period 2015-2017.



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Secretariat-serviced bodies

Generation IV International Forum (GIF)

Established in 2001, the Generation IV International Forum (GIF) brings together 12 countries – among which Canada, China, France, Japan, Korea, Russia, South Africa, Switzerland and the United States are the most active – as well as Euratom, to co-ordinate R&D into advanced nuclear energy systems. The Framework Agreement that formally organises the work of the GIF was extended for another ten years on 26 February 2015, in a ceremony hosted by the OECD Secretary-General, Depositary of the Framework Agreement, with the signatures of France, Japan, Korea and the United States. Signing ceremonies for Russia, Switzerland and South Africa took place in June, August and September 2015 respectively. Canada, China and Euratom are expected to sign in the first half of 2016. Moreover, GIF is actively reviewing an application from Australia to join the Forum to support its interest in several of the advanced technologies under consideration.

Six conceptual nuclear energy systems were selected in 2002 for collaborative R&D: the sodium-cooled fast reactor (SFR), the very-high-temperature reactor (VHTR), the supercritical water-cooled reactor (SCWR), the gas-cooled fast reactor (GFR), the lead-cooled fast reactor (LFR) and the molten salt reactor (MSR). The *Technology Roadmap for Generation IV Nuclear Energy Systems* (2002) described how the development of these systems was envisaged a decade ago. In January 2014, GIF released a ten-year update entitled *Technology Roadmap Update for Generation IV Nuclear Energy Systems*. The 2014 update provides a clear outline of how GIF members will focus their R&D efforts in the coming decade, with several systems having already entered (VHTR, SFR and LFR) or entering (SCWR) their so-called “performance phase” (testing of processes and materials at engineering scale under prototypic conditions) in the period to 2023.

During 2015, GIF continued to work on the goals of achieving the highest levels of safety for generation IV

systems, with the development of safety design criteria and safety design guidelines that incorporate lessons learnt from the Fukushima Daiichi accident. It also continued in its efforts to engage with regulators in discussions on reactor safety criteria and safety objectives, whether at the national or the international levels, and particularly through the NEA Committee on Nuclear Regulatory Activities (CNRA) and the NEA Committee on the Safety of Nuclear Installations (CSNI). An Ad hoc Group on the Safety of Advanced Reactors (GSAR) was set up by these two committees, with a work plan focusing on safety research needs for SFRs and regulatory requirements. GIF representatives have been invited as observers to the meetings of the GSAR to update regulators and technical support organisations on progress in the design of SFRs and the safety design criteria, as well as on guidelines developed by GIF.

In terms of formal agreements to organise R&D efforts, Seoul National University (Korea) signed the Memorandum of Understanding (MoU) overseeing the collaborative efforts on the LFR in November, joining Euratom, Japan and Russia. In the same month, the Paul Scherrer Institute (Switzerland) signed the MoU on the MSR, joining Euratom, France and Russia. The amendment to the Project Arrangement on Advanced Fuel for the SFR system, allowing China and Russia to join Euratom, France, Japan, Korea and the United States, became effective in October 2015. The System Steering Committee for the GFR met in October 2015, resuming its activity with a stronger involvement of European partners.

The NEA has continued to provide support to the technical bodies in charge of the development of the six systems and the three methodology working groups, and at the request of the Policy Group, to the Senior Industrial Advisory Panel. The NEA is fully compensated for its support to GIF through voluntary, financial and in-kind contributions made by individual GIF members.

International Framework for Nuclear Energy Cooperation (IFNEC)

The International Framework for Nuclear Energy Cooperation provides a forum for collaboration among participating countries to explore mutually beneficial approaches to ensure that the use of nuclear energy for peaceful purposes proceeds in a manner that is efficient and meets the highest standards of safety, security and non-proliferation. Participating countries do not give up any rights and voluntarily engage to share the effort and gain the benefits of economical, peaceful nuclear energy. At the end of 2015, IFNEC membership included 34 participating countries (including 14 NEA member countries), 4 international observer organisations (Euratom, GIF, the IAEA and the NEA) and 31 observer countries (including 10 NEA member countries).

On 17 October 2014, the IFNEC Executive Committee (EC) invited the NEA to serve as IFNEC Technical Secretariat, with funding exclusively provided through voluntary contributions from IFNEC members. The NEA Steering Committee agreed to this role at its meeting on 23 April 2015. The transition of the IFNEC Technical Secretariat to the NEA was agreed by the IFNEC Steering Group (SG) at its meeting on 16 June 2015 in Paris, with several IFNEC members pledging voluntary contributions. Following receipt of the latter, the NEA began its work supporting IFNEC activities. A first report from the NEA was given at the IFNEC SG and EC meetings hosted by Romania in Sinaia, 22-23 October 2015, at

which the NEA outlined how it would support the organisation of these meetings and those of the two working groups (WGs) dedicated to infrastructure development and to reliable nuclear fuel services. This will effectively start in May 2016 when the NEA hosts the SG and WG meetings, as well as a joint IFNEC/NEA conference on financing for nuclear projects. The topic has been the subject of much attention in recent years, with IFNEC organising a series of workshops gathering world-class experts, and the NEA having recently completed a study on nuclear new build (see [oe.cd/13p](#)). Financing is one of the key issues for the development of nuclear energy programmes. In his keynote address during the IFNEC EC in Sinaia, Romania, the NEA Director-General underlined the importance of financing, as well as other challenges and opportunities facing nuclear energy. The meeting was also an opportunity for IFNEC members and observers to share experiences and lessons learnt in relation to work carried out by the Agency on topics such as safety culture and regulation, technology development and innovation.

In order to better support IFNEC, the Technical Secretariat has been tasked by the Executive Committee to draft an annual work plan (starting in 2016), which details the different activities that IFNEC is undertaking. Finally, the NEA has initiated the process of migrating the IFNEC website to its own servers so as to manage the site directly.



The 2015 IFNEC Executive Committee meeting held in Sinaia, Romania.

Nuclear Safety and Regulation

The goal of the NEA in this sector is to assist member countries in their efforts to ensure high standards of safety in the use of nuclear energy, by supporting the development of effective and efficient regulation and oversight of nuclear installations and activities, and by helping to maintain and advance the associated scientific and technological knowledge base. The staff works closely with the Committee on the Safety of Nuclear Installations (CSNI), the Committee on Nuclear Regulatory Activities (CNRA) and their expert groups in this area.

Highlights

- The Senior-level Task Group on Defence in Depth and the Senior-level Task Group on the Safety Culture of the Regulatory Body completed their mandates, and their respective reports are to be published in early 2016.
- A new working group on the safety of electrical power systems was created and will collaborate on enhancing the robustness of electrical systems, improving the analysis of electrical system performance and addressing safety challenges associated with electrical systems.
- Several international workshops, including on operational and regulatory aspects of criticality safety in fuel cycle facilities, were held enabling experts from member countries to share their experiences on safety analysis and research activities, as well as to establish best practices.
- The last two of a series of eight short-term, high-priority issues that were identified for follow-up after the Fukushima Daiichi nuclear power plant accident were completed.

Nuclear regulation

Regulatory impacts of the Fukushima Daiichi accident

The NEA report, *Five Years after the Fukushima Daiichi Nuclear Accident: Nuclear Safety Improvements and Lessons Learnt* was finalised and approved for publication in 2016. The primary objective of the report is to share with regulatory bodies and other interested stakeholders what has been done by the NEA and its member countries to improve nuclear safety since the 2011 accident. This milestone report received input from the CNRA, the CSNI, the NEA Committee on Radiation Protection and Public Health (CRPPH) and the NEA Nuclear Law Committee (NLC).

Operating experience

The NEA Working Group on Operating Experience (WGOE) focuses on follow-up actions related to national trends and lessons learnt from national events submitted to the joint IAEA/NEA International Incident Reporting System (IRS). The IRS is the only international system that provides regulators with information about lessons learnt from safety-significant events at NPPs. The *Nuclear Power Plant Operating Experience from the IAEA/NEA Incident Reporting System 2012-2014* (Blue Book) was approved for publication in 2015 and is expected to be released in early 2016. In 2015, the group completed its evaluation/trend analysis of containment integrity events

and concrete anchor bolt issues. Two reports were issued in 2015: “Update on the Use of International Operating Experience Feedback for Improving Nuclear Safety” and “Operating Experience Programme Effectiveness Measures: Workshop Proceedings”, and a task proposal was developed on tools for safety bodies to identify and share information on non-conforming, fraudulent and suspect items (NCFSI). The group has completed the output for phase 1 of the task, which included the development of NCFSI reporting criteria, a process map and supporting guidance, and it was requested to pilot the process through phase 2 with past NCFSI examples.

Regulation of new reactors

The NEA Working Group on the Regulation of New Reactors (WGRNR) is reviewing regulatory activities in relation to the siting, licensing and oversight of new commercial NPPs. In 2015, the group issued a second synthesis report to summarise the lessons learnt from 63 events reported to the WGRNR Construction Experience Database by NEA member countries between 2011 and 2014. In parallel to this effort, the WGRNR completed a study on recent regulatory activities in member countries in relation to the licensing, resources and skills needed to perform design reviews and assessments of construction oversight, as well as the training needed to support these activities. Volume 2 of the “Report on the Survey

of the Design Review of New Reactor Applications: Civil Engineering Works and Structures” was also issued in 2015, and the WGRNR issued a subsequent report on construction oversight meant to facilitate sharing of information related to the on-site oversight of new reactor construction.

In 2015, the group launched a new task on the regulatory practice to assess passive safety systems used in new NPP designs, as well as a task on regulatory oversight of new licensee organisational capabilities. The WGRNR has been organising a joint workshop with MDEP on “Regulatory Oversight of the Commissioning Phase for New Reactors” that will be held in March 2016 in Korea.

Regulatory inspection practices

The NEA Working Group on Inspection Practices (WGIP) completed its report on “The Role of the Inspector during an Emergency: Addendum to the Inspection of Emergency Arrangements”. The group co-ordinated two NPP benchmarking inspection observations in 2015. The first inspection observation was hosted by Canada at the Darlington NPP in Clarington on 27 April to 1 May 2015 with participants from Finland, France and Korea. The second inspection observation was hosted by France at the Bugey NPP on 7-11 September 2015 with participants from Canada, Poland and the United States. By participating in and observing planning, performance and inspection enforcement actions, member countries assist in overall improvements to inspection techniques.

Preparations continued in 2015 for the 13th International Workshop on Nuclear Regulatory Inspection Activities, which is to be hosted by the

Belgian Federal Agency for Nuclear Control (FANC) and the FANC subsidiary Bel V in Bruges, Belgium on 17-21 April 2016. Topics will include inspection activities during the transition from an operating reactor to a defueled status with a commitment to permanently cease power operations, inspection of modifications and the inspector’s role in the enforcement process.

Senior-level Task Group on Defence in Depth (STG-DiD)

The CNRA approved the regulatory guidance booklet from the senior-level task group examining the *Implementation of Defence in Depth at Nuclear Power Plants: Lessons Learnt from the Fukushima Daiichi Accident* at its December 2015 meeting, with publication scheduled for early 2016. A key observation in the booklet is that the use of the DiD concept remains valid after the Fukushima Daiichi accident, and that lessons learnt from the accident and its impact on the use of DiD has reinforced its fundamental importance in ensuring adequate safety.

Ad hoc Group on the Safety of Advanced Reactors

The Ad hoc Group on the Safety of Advanced Reactors (GSAR) was established in 2014 to provide regulatory perspectives on a selected, advanced design, including identification of required safety research. In December 2015, the GSAR decided as its first task to focus on regulatory perspectives on safety aspects related to sodium fast reactors.

Nuclear safety

Analysis and management of accidents

The NEA Working Group on Analysis and Management of Accidents (WGAMA) has continued to focus on the in-vessel behaviour of degraded cores, the thermal-hydraulics of the reactor coolant system, containment behaviour and protection, computational fluid dynamics (CFD) and fission product release and transport. The WGAMA initiated four activities related to Fukushima issues in 2012, two of which published reports in 2014: “Status Reports on Filtered Containment Venting” and “Status Reports on Hydrogen Management and Related Computer Codes”. The third, a joint WGAMA-Working Group on Fuel Safety (WGFS) activity, completed in early 2015 a “Status Report on Spent Fuel Pools under Loss-of-Cooling and Loss-of-Coolant Accident Conditions”. The final activity, a joint WGAMA-Working Party on Nuclear Emergency Matters (WPNEM), approved its report in December 2015 to be issued in early 2016 on “Benchmarking of Fast-Running Software Tools Used to Model Releases during Nuclear Accidents”.

Three CFD-related reports were approved in December on the latest benchmark investigating a containment issue (erosion of a stratified layer by a buoyant jet), on the proceedings of a biennial WGAMA workshop held in 2014 and on a review of uncertainty methodologies. The proceedings of a workshop that was held in Marseille, France on iodine chemistry, jointly organised by the NEA and NUGENIA in March, were also approved. Finally, the activity on quantification of the uncertainty of physical models in system thermal-hydraulic codes completed its report for release in 2016. Five new activities were approved by the CSNI for launch in 2016.

Ageing and structural integrity of reactor components

The NEA Working Group on Integrity and Ageing of Components and Structures (WGIAGE) focuses on the integrity, ageing and seismic behaviour of metal components and concrete structures. In 2015,

proceedings were issued for a workshop on the use of Bayesian statistical techniques for seismic hazard assessment, providing methodologies and recommendations for assessing the robustness of concrete structures in nuclear facilities. The results of the workshop led to two new activities on the comparison of probabilistic seismic hazard analysis (PSHA) results in areas with different levels of seismic activity, and on assessments of structural robustness against on-site observations. The activity on the assessment of structures subjected to concrete pathologies (ASCET) started its second phase with benchmark simulations of concrete pathologies and resulting concrete swelling, and a report on the results of the questionnaire on long-term operation of commercial nuclear power plants was issued. The responses of 13 countries identified several technical areas for which multiple partner countries expressed interest in additional common research projects.

Risk assessment

The main mission of the NEA Working Group on Risk Assessment (WGRISK) is to advance the understanding and use of probabilistic safety assessment (PSA) as a tool to support nuclear safety decision making in member countries. A report was issued in 2015 on a joint task with the NEA Working Group on Human and Organisational Factors (WGHO) concerning the establishment of appropriate attributes for current human reliability analysis techniques in nuclear risk assessments, providing guidance in the selection of techniques that would include human reliability in PSAs.

The report of the NEA Workshop on Fire Probabilistic Risk Assessment was completed in June, concluding that fire PRA has achieved a reasonable level of maturity and that there seems to be a common understanding of its weaknesses at the international level.

Three new tasks were launched in 2015, resulting in: i) a report on the status of site-level PSA developments, which will establish how PSA is being used for sites with more than one nuclear reactor; ii) a report on current practices in the use of level 3 PSA to assess off-site radiological consequences; and iii) an update on the use and development of PSA in member and non-member countries, which was previously assessed in 2010.

Fuel safety

The NEA Working Group on Fuel Safety (WGFS) focused its work on four activities in 2015. The first two concerned fuel behaviour during a loss-of-coolant accident (LOCA) and a benchmark for reactivity-initiated accidents (RIAs). The RIA benchmark constitutes phase 2 of the project and is following up on improvements identified during an earlier activity in 2013. The report on the first part of this activity, a comparison of RIA analyses, was finalised in December, with uncertainty and sensitivity analyses continuing. The remaining two activities concern the development of workshops, in particular on pellet-clad interaction.

A report on the joint WGFS-WGAMA activity on the behaviour of spent fuel pools under loss-of-cooling and loss-of-coolant accident conditions was issued in 2015. As a follow-up, a new joint WGFS-WGAMA activity will be undertaken on phenomena identification and a ranking table prepared for spent fuel pool accidents.

Fuel cycle safety

The NEA Working Group on Fuel Cycle Safety (WGFC) brings together regulatory and industry specialists to address a broad range of interests, including safety assessments, nuclear criticality safety, PSAs, safety management, decommissioning, site remediation and fire protection.

The working group follows and periodically reviews the joint NEA/IAEA Fuel Incident Notification and Analysis System (FINAS), which is the only international system providing regulators and government bodies with information about lessons learnt from safety-significant events at fuel cycle facilities.

Proceedings were finalised in 2015 for the workshop on operational and regulatory aspects of criticality safety in fuel cycle facilities. The report considers how to determine the appropriate balance in the use of deterministic and risk-informed approaches in safety assessments of fuel cycle facilities, as well as in applying DiD and double contingency principles in design.

External events

The Working Group on External Events (WGEV) works to improve the understanding and treatment of external hazards to support the continued safety performance of nuclear installations and improve the effectiveness of regulatory practices. The initial focus of this group has been on severe weather events with high winds and flooding, and a workshop on severe weather and storm surge is planned for February 2016. Two new activities have also been initiated to identify best practices and knowledge gaps in the use of science-based approaches for characterising external hazards, and to identify key issues with deterministic and probabilistic approaches associated with risks assessment of riverine floods.

Robustness of electrical systems

One of the outcomes from the NEA Task Group on Robustness of Electrical Systems of NPPs in Light of the Fukushima Daiichi Accident (ROBELSYS) was a recommendation to establish a more permanent international group that deals with safety issues of NPP electrical systems. In 2015, the ROBELSYS task group met and developed a proposed mandate and work scope for such a working group, which was approved by the CSNI in December. As such, the Working Group on Electrical Power Systems (WGELEC) has been established and will conduct its first meeting in March 2016.

Post-Fukushima safety research opportunities

The Senior Expert Group on Safety Research Opportunities Post-Fukushima (SAREF) is identifying opportunities to address safety research gaps and advance safety knowledge related to the Fukushima Daiichi accident, which in turn supports safe and prompt decommissioning in Japan. The group is identifying research options that use existing information from the Fukushima Daiichi site or information that will be obtained during decommissioning. Recommendations will also be made for short-term activities (two to three years) that

can be undertaken in preparation for more complex undertakings, such as sampling damaged reactor core components over the long term.



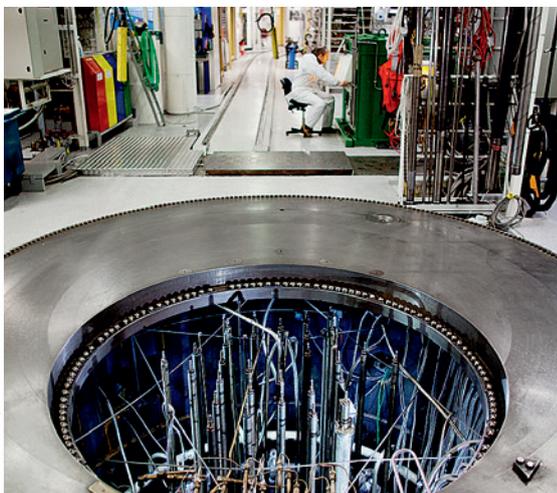
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Joint Projects

Nuclear safety research

The Halden Reactor Project

The Halden Reactor Project, operated by the Norwegian Institute for Energy Technology (IFE), was established in 1958 and is the largest NEA project. It brings together an important international technical network in the areas of nuclear fuel reliability, integrity of reactor internals, plant control/monitoring and human factors. The programme is primarily based on experiments, product prototype developments and analyses carried out at the Halden establishment in Norway. It is supported by approximately 130 organisations in 19 countries. The project benefits from a stable and experienced organisation and a technical infrastructure that has undergone substantial developments over the years. Its objectives have been continuously adapted to users' needs.



IFE, Norway

View of the Halden reactor hall.

Work in the fuel area has included continued testing of high burn-up fuel under loss-of-coolant accident (LOCA) conditions. These are the only LOCA tests that are currently being performed in-pile worldwide and they complement the work done at laboratory scale in other institutions, notably in Japan and the United States.

Long-term irradiations have been carried out with advanced and standard nuclear fuel at high initial rating conditions. Corrosion and creep behaviour of various alloys have been studied. The experimental programme on the effect of water chemistry variants on fuel and reactor internals materials continued. Tests to investigate the cracking behaviour of reactor internals materials in boiling and pressurised water reactors also continued, with the aim of characterising the effect of water chemistry and material ageing. The project also contributed to international generation IV research in the areas of instrument development and material testing.

The programme on human factors has focused on experiments in the Halden man-machine laboratory, related data analyses, new control station designs, evaluations of human-system interfaces, process and instrumentation optimisation, and digital instrumentation and control (I&C). This involves the use of the Halden Virtual Reality Centre among others. Progress has been made in the area of human reliability assessment (HRA), which aims to provide data suitable for probabilistic safety assessments and to improve the validity of HRA methods.

The results of the programme were reported at two meetings, the 103rd Halden Management Board (MB) in June 2015 and the 153rd Halden Programme Group in November 2015. The United Arab Emirates became a member of the Halden Reactor Project in 2014. The Norwegian Radiation Protection Authority recommended approval of a renewed licence for the Halden boiling water reactor (HBWR) to continue operating, and the final approval of the renewed

licence for a period of six years was given by the King of Norway in December 2014. The NEA is involved in advising the operating agent and the Management Board on further restructuring and harmonising the recent Halden Agreement (2015-2017) with the standard NEA model.

The ATLAS Project

The Advanced Thermal-hydraulic Test Loop for Accident Simulation (ATLAS) Project is a thermal-hydraulic integral effect test facility for advanced LWRs located in Korea. It was commissioned in 2006 and has been carrying out beyond-design-basis accident (BDBA) tests since 2012.

Following the Fukushima accident, the ATLAS Project was proposed by KAERI to study design and BDBAs in the ATLAS facility. The ATLAS Project investigates safety issues such as:

- prolonged station blackout (SBO), including asymmetric, secondary active or passive cooling;
- small-break loss-of-coolant accidents (SBLOCAs) during SBO, including reactor coolant pump (RCP) seal failure and steam generator tube rupture (SGTR);
- total loss of feedwater (LOFW), including anticipated transient without scram (ATWS) and additional multiple failures;
- medium-break loss-of-coolant accidents (MBLOCAs), including risk-informed break size definitions;
- open tests to address scaling issues by performing counterpart tests to previous integral effects tests (IETs).

The project's mandate runs from April 2014 to March 2017. It has 15 members (including non-NEA members such as China, India and the United Arab Emirates) and 22 signatories, following the inclusion of two new partners from existing member countries. The experimental programme is being delivered successfully and to schedule – five successful tests were performed from the eight test programmes.



KAERI, Korea

View of the ATLAS experimental loop.

The outcome of the benchmark test selected in 2014 and related analyses will be discussed at a joint benchmark workshop with the PKL-3 Project to be held in Pisa in April 2016, where a further counterpart test will be considered by the ATLAS Project to reproduce a PKL-3 test. Partners continue to carry out significant analytical work alongside the experimental tests, a key to demonstrating the practical application of test data that is being collected and analysed.

The BIP

The Behaviour of Iodine Project (BIP), hosted by Atomic Energy of Canada Limited (AECL) and supported by 13 member countries, started in September 2007. Phase 1 was completed in March 2011.

A three-year follow-up project, BIP-2, started in April 2011 and has attempted to answer some of the outstanding questions raised during BIP-1. Although progress was made towards determining the rate of iodine adsorption on paint under various conditions, the mechanism of the phenomenon is not known in detail. Similarly, while good progress was achieved in quantifying the rates of formation for methyl iodide from irradiated paint, the mechanism is not yet understood. The specific technical objectives for BIP-2 were:

- to obtain a more detailed and mechanistic understanding of iodine adsorption and desorption on containment surfaces by means of new experiments with well-characterised containment paint constituents and novel instrumentation (spectroscopic methods);
- to obtain a more detailed and mechanistic understanding of organic iodide formation by means of new experiments with well-characterised containment paint and paint constituents and novel instrumentation;
- to develop a common understanding of how to extrapolate with confidence from small-scale studies to reactor-scale conditions.

The BIP-2 experimental phase was completed in 2014. The final report was issued in 2015 and presents details on the following general results:

- the graduation of the degree of iodine adsorption from the solution and gas phases onto a variety of polymers, zinc primers and calcium silicate insulation, and the effects of Cl_2 and NO_2 in the gas phase;
- how well or poorly organic iodides formed on polymers and paints with and without irradiation;
- how well advanced techniques detected iodine and could examine surfaces.

Project participants have identified further aspects that require investigation and clarification, which were discussed during 2015 with the objective of establishing a third BIP phase. The BIP-3 Agreement (2016-2018) was issued for signature at the end of 2015.

The BSAF

The Benchmark Study of the Accident at the Fukushima Daiichi Nuclear Power Station (BSAF) was established among eight NEA member countries in

2012. The BSAF is intended to improve severe accident (SA) codes, and to analyse accident progression and current core status in detail for preparation of fuel debris removal as a part of the R&D projects for the mid- to long-term response for decommissioning Fukushima Daiichi units 1 to 4.

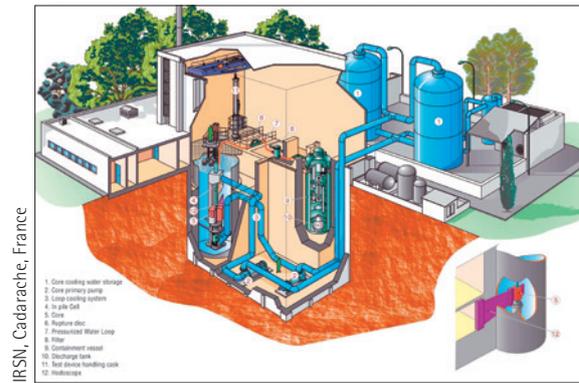
The project is hosted by Japan and brings together international experts to advance the understanding of the phenomena of severe accident behaviour specific to the Fukushima Daiichi nuclear power plant accident while also improving the methods and codes for modelling such behaviour. A phased approach is applied in the NEA benchmark exercise. The range of analysis for the first phase, which was completed in 2015, was a full-scope analysis of Fukushima Daiichi units 1 to 3 using currently available SA integral codes, using a time span for analysis of accident events of about six days from the occurrence of the earthquake, and analysing in full a number of key phenomena such as initial transient, core heat-up, core melt, release of fission products (FPs) from fuel, core status including debris behaviour, and molten debris-coolant interaction.

In 2015, BSAF phase 2 began with membership expanded to 11 NEA member countries. The scope of analysis for phase 2 is approximately the first three weeks following the accident, and it includes fission product behaviour in the reactor buildings, as well as on the Fukushima site, and releases into the environment beyond the site. Meetings were held in June and December 2015 to plan the activities for phase 2 and to exchange information on the latest findings from the damaged Fukushima reactors.

The CIP

The Cabri International Project (CIP), which began in 2000, is investigating the ability of high burn-up pressurised water reactor (PWR) fuel to withstand the sharp power peaks that can occur in power reactors due to postulated rapid reactivity insertions in the core, or reactivity-initiated accidents (RIAs). The project participants, from 12 member countries, intend to determine the limits for fuel failure and the potential consequences of possible ejection of fuel into the coolant environment. Different cladding materials and fuel types are being studied. The experimental work is being carried out by the Institut de Radioprotection et de Sûreté Nucléaire (IRSN) in Cadarache, France, where the Cabri reactor is located. Programme execution can, however, involve laboratories in participating organisations, for instance, in relation to fuel fabrication and characterisation and instrumentation.

Project execution involves substantial facility modifications and upgrades as well as design, construction and safety authorisation of a new pressurised-water-filled experimental loop. Twelve experiments will be completed with fuel retrieved from power reactors and refabricated into rodlets. Two tests using the initial sodium-filled loop were carried out with high burn-up fuel clad with zirconium-niobium material. Fuel that had been in service in Spanish and French reactors, with ZIRLO



Cabri reactor with water loop scheme.

and M5 cladding respectively and with burn-up in excess of 70 MWd/kg, was subjected to a ~100 cal/g energy injection during the transients. No fuel failure was registered.

The Cabri tests are complemented by additional RIA tests performed in Japan. These tests, which constitute the in-kind contribution from the Japan Atomic Energy Agency (JAEA) for its participation in the project, are being carried out in both cold and hot coolant conditions, and using both BWR and PWR fuel.

In 2015, commissioning of the experimental facility was completed following the loading of new fuel in 2014. The French regulator authorised operation of the refurbished reactor in October 2015 and the first criticalities of the core were produced on 20 October. In 2015, qualification of the experimental equipment was completed, in particular the imagery and spectroscopy measurement station, as well as the hodoscope. A number of rodlets are now manufactured and ready for the first experiments in the new water-filled loop. The need for project extension beyond March 2015 has been pursued with all partners and an agreement was reached in principle for a three-year extension to March 2018. At the Cabri Technical Advisory Group (TAG) meeting in October 2015, participants discussed the test matrix and made a number of decisions related to the types of fuel for the tests. The next meeting of the TAG is scheduled for September 2016. The Project Steering Committee met in December 2015 and was given a conducted tour of the refurbished Cabri facility.

The HEAF Project

Massive electrical discharges, referred to as high energy arcing faults, have occurred in nuclear power plant switching components throughout the world. These incidents have been increasing as a result of ageing infrastructures and increasing energy demands. The High Energy Arcing Fault Events (HEAF) Project was initiated in 2012 to perform experiments to obtain scientific fire data on HEAF phenomena through carefully designed experiments.

The HEAF Project was planned as a three-year programme to be conducted by the United States Nuclear Regulation Commission (NRC) at a facility in the United States. The project's aim is to conduct

experiments in order to explore the basic configurations, failure modes and effects of HEAF events. The equipment to be tested and considered primarily consists of switchgears and bussing components. Since the switchgears and other equipment necessary for testing is very expensive, the programme relies on signatories' in-kind contributions.

The project has two objectives:

- to draft an international, peer-reviewed guidance document (in the NRC NUREG series) that can be readily used to assist the regulators of participating countries;
- to draft a joint nuclear safety project report covering all testing and data captured.

A significant amount of full-size equipment has been tested. The initial testing took place in June 2014 in the presence of project members, followed by three further campaigns in November 2014, March 2015 and October 2015. No further tests are currently planned. Data, including high-speed high-definition video, has been captured by the NRC team and will be shared among participants in February 2016. Partners will carry out an analysis of the data and should then be able to contribute to the final report, which is planned for June 2016, and will necessitate an extension of the project end date to December 2016.

The HYMERES Project

The Hydrogen Mitigation Experiments for Reactor Safety (HYMERES) Project was initiated in 2013 with the objective of improving understanding of the hydrogen risk phenomenology in containment and of enhancing the modelling of hydrogen behaviour in support of safety assessments that will be performed on current and new nuclear power plants. The HYMERES Project is specifically aimed at topics of high safety relevance



Paul Scherrer Institute, Switzerland

The PANDA reactor pressure vessel.

for both existing and future nuclear power plants. It explores measured parameters, configurations and scales, and thus enhances the value of the data in terms of code improvements.

The unique and complementary features of the PANDA facility in Switzerland and the MISTRA facility in France, with their difference in size and configuration and their comprehensive instrumentation in terms of both spatial and temporal resolution, allows for high-quality experimental data. This data can be used to improve the modelling capabilities of CFD and advanced lumped parameter (LP) computer codes designed to predict post-accident, thermal-hydraulic conditions in containments, and thus enhance confidence in their use in plant analyses. Operating agents may also consider new experiments in response to specific participant requests during the project.

Testing is on schedule at the PANDA and MISTRA facilities. The programme review group and management board each held a meeting in 2015 in conjunction with HYMERES analytical workshops in Switzerland.

The LOFC Project

Following a recommendation of the CSNI Task Group on Advanced Reactor Experimental Facilities (TAREF) for gas-cooled reactor safety studies, the Loss of Forced Cooling (LOFC) Project started in April 2011 with seven countries participating. The LOFC experiments study the effects of the reduction of reactor cavity cooling system (RCCS) performance and are highly relevant for safety assessments of advanced reactors such as the high-temperature reactor. The experiments are to be run by JAEA in its high-temperature engineering test reactor (HTTR) in Oarai, Japan, but the project remains on hold with reactor restart now estimated for October 2016.

The objectives of the project are to conduct integrated large-scale tests of LOFC in the HTTR reactor, to examine high-temperature gas-cooled reactor (HTGR) safety characteristics in support of regulatory activities, and to provide data useful for code validation and improvement of simulation accuracy. The objectives of the experimental programme are to provide experimental data to:

- clarify the anticipated transient without scram (ATWS) in case of LOFC with occurrence of reactor re-criticality;
- validate the most important safety aspects regarding reactor kinetics, core physics and thermal-hydraulics;
- verify the capabilities of the codes regarding the simulation of phenomena coupled between reactor core physics and thermal-hydraulics.

No meetings were held in 2015 but the operating agent, JAEA, produced progress reports in July and December. The latter confirmed that there were ongoing interactions with the regulator to move the reactor facility towards restart and presented a justification to the management board for a further project extension to March 2019. No meetings will take place until a restart is confirmed.



AREVA, France

Top view of the PKL facility in Erlangen.

The PKL Project

The PKL-2 Project, which ran from July 2007 to December 2011, consisted of eight experiments carried out in the Primärkreislauf (PKL) thermal-hydraulic facility, which is operated by Areva NP in Erlangen, Germany, together with side experiments conducted in the PMK facility in Budapest, Hungary and in the ROCOM facility in Rosendorf, Germany. The experiments investigated safety issues relevant to current PWRs as well as to new PWR design concepts, and focused on complex heat transfer mechanisms in the steam generators and boron precipitation processes under postulated accident situations.

The follow-up project, PKL-3, began in April 2012. PKL-3 tests investigated safety issues relevant to current PWR plants as well as to new PWR design concepts by means of transient tests under postulated accident scenarios and systematic parameter studies on thermal-hydraulic phenomena. They also addressed current safety issues related to beyond-design-basis accident transients with significant core heat-up, for example station blackout (SBO) scenarios or LOCAs in connection with failure of safety systems. Events in cold shutdown (i.e. failure of the residual heat removal system [RHRS]) was also covered.

Two meetings were held in 2015, and the final tests were completed in November. A counterpart test was performed to compare with a test conducted in the ROSA facility in Japan.

With all tests completed, the operating agent, Areva, is progressing on the results analysis and production of the final report, which is targeted for completion in July 2016. The project participants and the operating agent have completed discussions on a follow-on project, based on known gaps in knowledge, which will start in mid-2016. There will be a benchmark workshop with two PKL-3 benchmark outcomes in collaboration with the ATLAS Project benchmark activity in Pisa, Italy on 13-16 April 2016.

The PRISME Project

Fire is a significant contributor to overall core damage frequency for both new and old plant designs. Some of the technical studies related to fire probabilistic safety analysis that remain open are: the propagation of heat and smoke through a horizontal opening between two

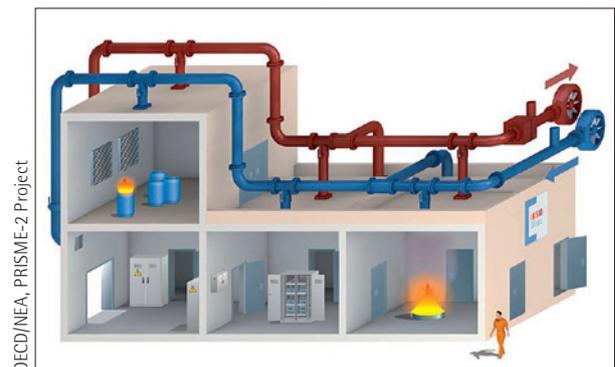
superposed compartments; fire spreading on real fire sources such as cable trays and electrical cabinets; and fire extinction studies of the performance of various fire extinction systems.

Phase 2 of the Fire Propagation in Elementary, Multi-room Scenarios (PRISME-2) Project (from the French *Propagation d'un incendie pour des scénarios multi-locaux élémentaires*) is a follow-on project from the PRISME project that ran from 2006 to 2011. The PRISME-2 Project began in July 2011 and will run until June 2016. It currently has nine participating countries. The project's objective is to answer questions concerning smoke and heat propagation inside a plant by means of experiments tailored for code validation purposes mainly within the IRSN DIVA facility at Cadarache. In particular, the project aims to provide answers regarding the failure time for equipment situated in nearby rooms and the effect of conditions such as room-to-room communication and the configuration of the ventilation network. The results obtained for the experimentally studied scenarios will be used as a basis for qualifying fire codes (either simplified zone model codes or computational fluid dynamics codes). After qualification, these codes could be applied when simulating other fire propagation scenarios in various room configurations with a good degree of confidence.

The main experimental programme is made up of four large-scale test campaigns (20 tests) in the DIVA facility, in addition to other support tests. The first vertical smoke propagation (VSP) testing is complete, and the cable fire spreading (CFS) testing is nearing completion. The specifications for the fire extinguishing system (FES) test have been completed and work has begun on defining the open fire tests. A slight delay has occurred due to the IRSN request to carry out important glove box fire tests.

In 2015, the PRISME-2 management board and programme review group held meetings in May and November. Experimental work has been completed, and discussions on phase 3 took place at the November meeting where follow-on topics were identified from both the PRISME and PRISME-2 project phases. Phase 3 will start in January 2017 for a period of five years.

The application report for the project, detailing practical applications of the results, is scheduled to be issued in June 2016 and the final report will be completed in December 2016.



OECD/NEA, PRISME-2 Project

The IRSN DIVA facility for fire propagation studies.

The SCIP Project

The Studsvik Cladding Integrity Project (SCIP) started in July 2004 and completed its first five-year mandate in 2009, when several power ramps and a hot cell programme addressing the various failure mechanisms were executed. SCIP-2 began in July 2009 with the participation of 13 countries (2 more than in the first phase). The main objective of SCIP-2 was to generate the high-quality experimental data needed for improving the understanding of dominant failure mechanisms for water reactor fuels and to devise means for reducing fuel failures. In addition to reviewing existing Studsvik ramp data, the project studied the following fuel failure mechanisms:

- pellet-clad mechanical interaction (PCMI), the mechanical driving force for pellet-clad interaction (PCI) and hydrogen-induced failures;
- PCI, notably when cladding fails due to stress corrosion cracking;
- hydrogen-induced failures, in particular as regards zirconium alloys.

The SCIP-2 project completed its mandate in 2014, and a final project report was produced for members, as well as a summary report for wider distribution.

The process to formalise the SCIP-3 project began in July 2014, with the agreement signature process closing in 2015. China is considering joining SCIP-3 in 2016. Three meetings of SCIP-3 steering bodies (the programme review group and management board) were held in 2015. The SCIP-3 project, which runs from July 2014 until June 2019, will:

- determine parameters affecting fuel fragmentation and dispersal in LOCAs;
- analyse consequences of off-normal peak cladding temperatures and transients for handling and storage of fuel rods;
- study the impact of power ramp rates on PCI failure risk;
- support model development and verification.

The SFP

The Sandia Fuel Project (SFP), supported by 13 member countries, began in 2009. The objective of the project was to perform a highly detailed thermal-hydraulic characterisation of full-length, commercial fuel assembly mock-ups to provide data for the direct validation of severe accident codes. Code predictions based on previous results indicate that fuel assemblies can ignite and radially propagate in a complete loss-of-coolant accident. Hence, there is a need for qualified data obtained under representative fuel configurations. The experiments focused on thermal-hydraulic and ignition phenomena in PWR 17x17 assemblies and supplemented earlier results obtained for BWR assemblies. Code validations based on both the PWR and BWR experimental results considerably enhance the code applicability to other fuel assembly designs and configurations.

The project was conducted in two phases. Phase 1 was performed in 2011 and focused on axial heating and burn propagation. Phase 2, performed in 2012,

addressed radial heating and burn propagation and included effects of fuel rod ballooning. A final phase 2 report, along with a final DVD, was issued to project members in 2015. The CSNI agreed at its December 2015 meeting to consider using two NRC NUREG reports on the outcomes of the project (to be published in 2016) as the final SFP Project reports.

The STEM Project

The Source Term Evaluation and Mitigation (STEM) Project was initiated in 2011 to improve the general evaluation of the fission product source term for reactor accidents. The STEM Project is a four-year programme supported by seven countries and conducted at the IRSN facilities in Cadarache, France. It addresses three main issues:

- Radioactive iodine release in the mid- and long term: to complement previous programmes, experiments have been proposed to study the stability of aerosol particles under radiation and the long-term gas/deposits equilibrium in a containment.
- Interactions between iodine and paints: no experiments are planned at this stage, but a literature survey specifically focused on the effect of paint ageing will be carried out. The survey is likely to lead to the definition of experiments in a possible follow-up project.
- Ruthenium chemistry: to complement previous programmes, experiments have been proposed to study ruthenium transport in pipes.

The first series of experiments (iodine behaviour under radiation) were dedicated to the analysis of radiation effects and were therefore realised in benches built on the Experimental Programme of Iodine Chemistry under Radiation (EPICUR) facility. The second series of experiments (ruthenium transport) in the START facility aimed to analyse the chemistry of ruthenium in pipes including the reactor coolant system, and in filters. They were performed in dedicated benches allowing the injection of different chemical compounds followed by their transport through high-temperature gradient tubes up to aerosol filters and bubblers for gas-trapping.

The final meeting of the STEM steering bodies took place in June 2015. Detailed reports were drafted for each of the test series. The STEM project was completed in 2015, but further work has been identified to form the basis for a further phase (STEM-2) starting in 2016.

The THAI Project

Phase 2 of the Thermal-hydraulics, Hydrogen, Aerosols and Iodine (THAI) Project started in 2011. The new experiments are being conducted in the THAI facility operated by Becker Technologies GmbH in Germany.

The objective of THAI-2 is to address specific water-cooled reactor aerosol and iodine issues, and hydrogen mitigation under accidental conditions. The project is exploring open questions concerning: i) the release of gaseous iodine from a flashing jet and iodine deposition on aerosol particles; and

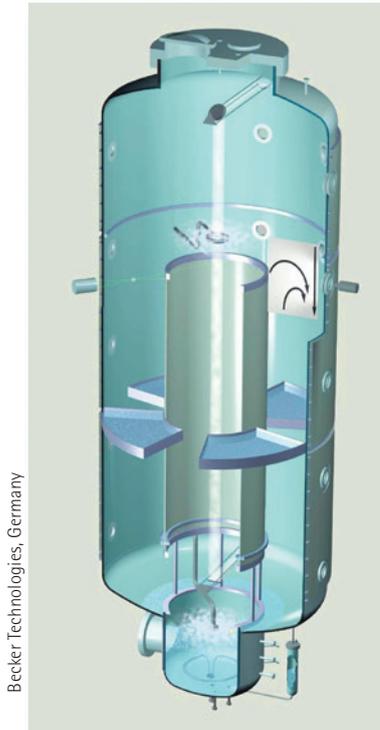


Diagram of the THAI containment vessel.

ii) hydrogen combustion during spray operation and passive autocatalytic recombiner (PAR) operation in case of extremely low oxygen content. Understanding the respective processes is essential for evaluating the challenges posed by the amount of airborne radioactivity during accidents with core damage (iodine and aerosols) and containment integrity (hydrogen).

The overall test matrix of experiments was modified and agreed in 2012 in view of new priorities arising from the Fukushima accident. Testing was completed in 2014, and the final report and open summary report were delivered in May and December 2015. The proceedings of the Post Project Open Seminar in Frankfurt (18-19 November 2014) on the application of the THAI and THAI-2 data to real reactor problems have also been issued to THAI participants, and a DVD will be provided at the close of phase 2.

The agreement for phase 3, to be conducted over three and a half years, was issued for signature to 12 NEA member countries, plus China and India. The initial meeting will take place in February 2016, with this phase covering four topics:

- PAR performance under counter-current flow conditions;
- hydrogen combustion and flame propagation in two-compartment systems;
- fission product re-entrainment from water pools at elevated temperatures;
- resuspension of fission product deposits upon impact of a high-energetic event (for example hydrogen deflagration).

The CADAK Project

The Cable Ageing Data and Knowledge (CADAK) Project started in 2011 as a follow-up to the cable ageing part of the Stress Corrosion Cracking and Cable Ageing Project (SCAP). The CADAK Project focuses on the relevance of cable ageing for plant ageing assessments and implications for nuclear safety. The main objective of the CADAK Project is to establish the technical basis for assessing the qualified life of electrical cables in light of the uncertainties identified following the initial (early) qualification testing and for estimating the remaining qualified lifetime of cables used in nuclear power plants.

During 2015, the CADAK Project entered its second three-year phase with a focus on exchanging experiences on condition monitoring methods and their use for cables implemented in NPPs. Another focus task during this new phase is to exchange and compare the main lessons learnt from member countries' cable experiments. Six countries are participating in the second phase of the CADAK Project.

The CODAP

The Component Operational Experience, Degradation and Ageing Programme (CODAP) started in 2011, building on two earlier NEA projects: the Piping Failure Data Exchange (OPDE) Project that ran from 2002 to 2011 and produced an international database on piping service experience applicable to commercial nuclear plants, and the Stress Corrosion Cracking and Cable Ageing Project (SCAP), which ran from 2006 to 2010 to assess stress corrosion cracking (SCC) and degradation of cable insulation, both of which have implications for nuclear safety and for plant ageing management.

The objectives of the CODAP include:

- collect information on passive metallic component degradation and failures of the primary system, reactor pressure vessel internals, main process and standby safety systems, support systems (i.e. ASME code classes 1, 2 and 3, or equivalent), and components not related to safety (non-code) but with significant operational impact;
- establish a knowledge base for general information on component and degradation mechanisms such as applicable regulations, codes and standards, bibliographies and references, R&D programmes and proactive actions, information on key parameters, models, thresholds and kinetics, fitness for service criteria, and information on mitigation, monitoring, surveillance, diagnostics, repair and replacement;
- develop topical reports on degradation mechanisms in close co-ordination with the CSNI WGIAGE.

During the first phase of the CODAP, a status report and two technical reports based on the analysis of the events collected in the database were published. In 2015, 11 countries agreed to continue with a second, three-year phase of the programme.

The FIRE Project

The Fire Incidents Records Exchange (FIRE) Project started in 2002. A third phase of the project began in 2010 for a duration of four years with 12 countries participating, followed by a fourth transitional phase that began in 2014 with the same partners. The main purpose of the project is to collect and analyse, on an international scale, data related to fire events in nuclear environments. The specific objectives are to:

- define the format for, and collect fire event experience (through international exchange) in, a quality-assured and consistent database;
- collect and analyse fire events data over the long term so as to better understand such events, their causes and their prevention;
- generate qualitative insights into the root causes of fire events that can then be used to derive approaches or mechanisms for their prevention or for the mitigation of their consequences;
- establish a mechanism for the efficient feedback of experience gained in connection with fire events, including the development of defences against their occurrence, such as indicators for risk-based inspections;
- record event attributes to enable quantification of fire frequencies and risk analysis.

The structure of the database has been well defined and arrangements have been made in all participating countries to collect and to validate data. The quality-assurance process is in place and has proven to be efficient on the first set of data provided. An updated version of the database, which now contains more than 400 records, is provided to participants every year. The fourth transitional phase was used to consolidate future plans for the project and the appointment of a new operating agent. This new operating agent continues to develop the access database for event analysis.

An open summary report of the third phase of the project was issued in 2015 and a topical report based on analyses of the database for combinations of fire with other fire events was approved for publication at the end of 2015. The report has been held up as a good example of the added value that can be gained through the analysis of data in the database.

Two meetings of the project steering body were held in 2015, at which time the members defined a four-year work programme for a new fifth phase. The agreement is being circulated for signature among the existing 12 members.

The ICDE Project

The International Common-cause Data Exchange (ICDE) Project collects and analyses operating data related to common-cause failures (CCF) that have the potential to affect several systems, including safety systems. The project has been in operation since 1998, and was extended with a new phase 7 agreement covering 2015 to 2018.

The ICDE Project comprises complete, partial and incipient common-cause failure events. It

currently covers the key components of the main safety systems, such as centrifugal pumps, diesel generators, motor-operated valves, power-operated relief valves, safety relief valves, check valves, control-rod drive mechanisms, reactor protection system circuit breakers, batteries and transmitters. These components have been selected because several probabilistic safety assessments have identified them as major risk contributors in the case of common-cause failures.

Qualitative insights from data will help reduce the number of CCF events that are risk contributors, and member countries use the data for their national risk analyses. Additional activities in the area of quantification are under discussion. Reports have been produced for pumps, diesel generators, motor-operated valves, safety and relief valves, check valves and batteries. Data exchange for switchgear and breakers and reactor-level measurement was completed. The following ICDE Project reports were issued in 2015 using information from the database:

- “ICDE Workshop on Collection and Analysis of Common-cause Failures due to External Factors”.
- “Collection and Analysis Collection and Analysis of Emergency Diesel Generator Common-cause Failures Impacting Entire Exposed Population”.

In 2015, the ICDE Steering Group met in April and October. Further work was identified based on the interest of member countries and resulted in an agreement on a new phase 7 of the ICDE Project.

Secretariat-serviced body

Multinational Design Evaluation Programme

The Multinational Design Evaluation Programme (MDEP) is a multinational initiative to develop innovative approaches to leverage the resources and knowledge of national regulatory authorities who are engaged in new reactor power plant design activities. The main objective of MDEP is to enable increased co-operation and establish reference regulatory practices to enhance the safety of new reactor designs. Enhanced co-operation among regulators strengthens the effectiveness and efficiency of the regulatory design reviews. Current MDEP co-operation areas include five design-specific working groups (EPR, AP1000, APR1400, ABWR and VVER) and three cross-cutting, issue-specific working groups (vendor inspection co-operation, digital instrumentation and control, and mechanical codes and standards). These working groups address a broad spectrum of challenges that can arise during the regulation of new reactor design, construction and commissioning. Active, constructive engagement among member regulators has led to a productive year in terms of sharing information. MDEP members are regulators from Canada, China, Finland, France, Hungary, India, Japan, Korea, Russia, South Africa, Sweden, Turkey, the United Arab Emirates, the United Kingdom and the United States. The International Atomic Energy Agency is involved in generic MDEP activities to support consistency and co-ordination.

2015 highlights

In 2015, the MDEP Policy Group (PG) took the important decision to extend MDEP co-operation an additional five years beyond 2018 to continue co-operation in its current form, while providing for periodic assessments. The focus of new co-operation will be on design-specific working groups. The issue-specific group activities will be phased out by transferring these activities to existing NEA committees. Future cross-cutting issues that are needed to support more than one design-specific group

will be handled by ad hoc groups under the supervision of the MDEP Steering Technical Committee.

The Policy Group has approved the inclusion of an initial phase of new reactor operation to be part of the scope of design-specific working group activities. All design-specific groups have incorporated co-operation on design-related issues encountered during the initial phase of operation in their programme of work.

MDEP design-specific working groups have been drafting position papers to address the impact of the Fukushima Daiichi accident on new reactor designs. The EPR Working Group completed its position paper, which is available online. The other four design-specific working groups have submitted draft position papers to the Steering Technical Committee, which will be working on a common position addressing all reactors in MDEP.

Co-operation on commissioning activities are part of all the design-specific working groups' programmes of work. The EPR and AP1000 working groups are particularly active in this area as they are overseeing 12 new reactor constructions worldwide. All design working groups are working on a common position to develop a generic framework that would accept first plant only tests (FPOT) for a specific design by developing a set of conditions to ensure that successful FPOT tests performed on a first reactor would be acceptable for subsequent similar reactors being commissioned in member regulator countries. MDEP and the CNRA Working Group on the Regulation of New Reactors (WGRNR) will be holding a joint workshop on commissioning in Korea in March 2016.

The PG has eliminated associate membership status so as to simplify membership in MDEP, making all MDEP members full members subject to the same rights and commitments. The Hungarian Atomic Energy Authority (HAEA) has been accepted as the 15th member of MDEP. The country's initial focus will be to participate in the VVER design-specific working group.

For more information on the MDEP structure, and publicly available technical reports and common positions, see www.oecd-nea.org/mddep.

Human Aspects of Nuclear Safety

The goal of the NEA in this sector is to assist member countries in their efforts to enhance focus and attention on areas impacting nuclear safety that have been highlighted as critical elements leading to all past nuclear power plant accidents – including Fukushima Daiichi. This sector also includes issues associated with effective public communication and stakeholder engagement regarding nuclear safety, waste management and related issues. The staff works closely with all NEA committees and relevant expert groups in this area, most prevalently the Committee on the Safety of Nuclear Installations (CSNI), the Committee on Nuclear Regulatory Activities (CNRA) and the Radioactive Waste Management Committee (RWMC).

Highlights

- The Working Group on Public Communication of Nuclear Regulatory Organisations completed its North American workshop, hosted by the US Nuclear Regulatory Commission.
- A tri-committee workshop on “The Challenges and Enhancements to the Safety Culture of a Regulatory Body” was completed and supported the development of a new guidance document on the safety culture of nuclear safety regulatory organisations.
- A new report regarding best practices towards ensuring effective human performance under extreme conditions was issued in 2015, drawing from lessons learnt from the Fukushima Daiichi experience.
- Two new reports were issued by the Forum on Stakeholder Confidence regarding the development of effective working relationships with stakeholder groups and local communities. A flyer was also issued on how stakeholder involvement can be improved.

Nuclear regulators and public communication

The NEA Working Group on Public Communication of Nuclear Regulatory Organisations (WGPC) focuses on exchanging information, methods and experiences in the field of public communication of regulatory matters.

In 2015, the WGPC issued a report on the “Communications Strategies of Nuclear Regulatory Organisations” (NROs). This report discusses the importance of NROs defining a communications strategy in order to communicate with various stakeholders, including the public, and of developing a

strategy that will enable them to manage expectations, ensure consistent messaging, improve productivity and measure outcomes. The group continues to focus its efforts on helping NROs to plan, conduct and evaluate public meetings by describing strategies and approaches that member countries can use to ensure successful and productive meetings.

In parallel, the WGPC continues to expand its co-operation with stakeholders across three continents. After the success of a first European workshop held in Paris in 2014, the group organised a second workshop in Washington DC, United States, in April 2015, which brought together



The NEA WGPC North American workshop with NEA Director-General William D. Magwood, IV, United States Nuclear Regulatory Agency Chairman Steven Burns and participants, April 2015, Washington, DC.

45 participants from 11 countries, including media and communication experts, government officials, non-governmental organisations and industry representatives from North America. The third workshop will be held in April 2016 in Tokyo, Japan to gather views from Asian countries.

Senior-level Task Group on the Safety Culture of the Regulatory Body

A guidance “green booklet” on the *Safety Culture of an Effective Nuclear Regulatory Body* was finalised by the Senior-level Task Group on the Safety Culture of the Regulatory Body (STG-SCRB) in 2015. The booklet identifies and describes five principles and their associated attributes that underpin and support the safety culture of an effective nuclear regulatory body. These principles are related to leadership for safety; individual responsibility and accountability; co-operation and open communication; a holistic approach and continuous improvement; and learning and self-assessment. The booklet also addresses some of the challenges to regulatory bodies’ safety culture which must be recognised, understood and overcome. A CNRA/CSNI/CRPPH Workshop on “The Challenges and Enhancements to the Safety Culture of a Regulatory Body” took place in June 2015 in Paris. The workshop proceedings were issued, and the green booklet is scheduled for publication in early 2016.



CNRA/CSNI/CRPPH Workshop on Challenges and Enhancements to the Safety Culture of the Regulatory Body in June 2015.

Human and organisational factors

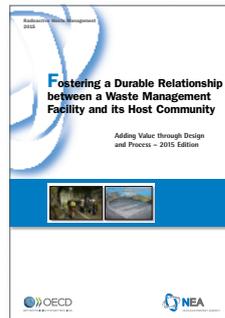
The NEA Working Group on Human and Organisational Factors (WGHO) constitutes a unique international forum addressing safety management issues such as human and organisational factors and human performance in nuclear facilities.

In 2015, a workshop was held on sharing best practices in relation to conducting validation tests on the performance of integrated systems such as reactor control rooms. A WGHO report was also issued on ensuring effective human performance under extreme conditions, similar to those experienced during the Fukushima Daiichi accident. One of the basic conclusions of the report is that organisations

need to look beyond reliability and develop resilience or flexibility to support human performance in extreme situations.

Forum on Stakeholder Confidence

In 2015, the NEA Forum on Stakeholder Confidence (FSC) met for the 16th time. FSC participants focused on developing the Forum’s new programme of work, which emphasises the concept of added value for radioactive waste disposal and stakeholder confidence in waste transport. The group, which reports to the RWMC, also discussed the forthcoming FSC national workshop and community visit, which will take place on 7-9 September 2016 in Switzerland.



Two reports were published in 2015 on *Fostering a Durable Relationship between a Waste Management Facility and its Host Community: Adding Value through Design and Process – 2015 Edition* and *Stakeholder Involvement Decision Making: A Short Guide to Issues, Approaches and Resources*, as well as a flyer on improving stakeholder involvement.

Collaboration with the European Commission continued and led to the release of a report highlighting the work of the FSC since its creation 16 years ago entitled *The OECD Nuclear Energy Agency’s Forum on Stakeholder Confidence, Radioactive Waste Management and Public Participation: A Synthesis of its Learnings and Guiding Principles*.



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Radioactive Waste Management

The goal of the NEA in this sector is to assist member countries in the development of safe, sustainable and broadly acceptable strategies for the long-term management of all types of radioactive materials, with particular emphasis on the management of long-lived waste and spent fuel considered as waste, and on the decommissioning of disused nuclear facilities. The staff works closely with the Radioactive Waste Management Committee (RWMC) and its expert groups in this area.

Highlights

- The RWMC Regulators' Forum held a workshop in September to examine challenges that regulators face in siting and licensing the construction and operation of radioactive waste repositories.
- The proceedings of the International Conference and Debate on Radioactive Waste Management and Constructing Memory for Future Generations were released.
- The Integration Group for the Safety Case (IGSC) held an international workshop on scenario development in June to continue enhancing safety cases of radioactive waste disposal systems.
- The WPDD organised the "International Conference on Decommissioning: Strategies, Practices and Challenges" in Moscow and published a study on *The Practice of Cost Estimation for Decommissioning of Nuclear Facilities*.

Knowledge management activities

The 33 members of the Preservation of Records, Knowledge and Memory (RK&M) across Generations initiative (RK&M) met twice in 2015 to examine mechanisms to transmit information on radioactive repository sites, including archives or small-sized time capsules, and to study ways to deter intrusions (i.e. markers). They also continued to develop the key information file (KIF), a document that will provide an international, standardised structure for synthesising key information about each national repository. The RK&M initiative published in 2015 the *Radioactive Waste Management and Constructing Memory for Future Generations: Proceedings of the International Conference and Debate, 15-17 September 2014, Verdun, France*.

Regulators' Forum (RF)

With many radioactive waste management programmes advancing towards the construction and operation of disposal facilities, the RWMC-RF organised a workshop in September to examine the challenges faced by regulators when reviewing construction and operation licence applications for radioactive waste repositories. Experience gained at the different developmental stages of national waste management programmes prompted intense debate about the challenges faced by regulators in both the siting process and future operations of disposal facilities.

In 2015, the RWMC-RF also evaluated the issue of the "transfer of responsibilities", for example in relation to long-term legal liabilities and oversight of radioactive waste disposal facilities. In June, a tri-bureau meeting was held with the RWMC, the Committee on Radiation Protection and Public Health (CRPPH) and the Nuclear Law Committee (NLW) to review the

liabilities of the different stakeholders involved in nuclear activities. Participants at the meeting concluded that a joint expert group should be established to assess the appropriate nuclear liability regimes to be applied to radioactive waste disposal projects in NEA member countries.

International Conference on Geological Repositories

Building upon the success of previous conferences held in Denver (1999), Stockholm (2003), Berne (2007) and Toronto (2012), the NEA and the French National Radioactive Waste Management Agency, Andra, are co-organising the 2016 ICGR, which will bring together high-level decision-makers from regulatory and local government bodies, waste management organisations and public stakeholder communities to review current perspectives of geological repository development. The theme of the conference, "continued engagement and safe implementation of repositories", is designed to promote information and experience sharing, particularly in policy development and regulatory frameworks. Repository safety, planning and implementation of repository programmes with societal involvement, as well as ongoing work within different international organisations, will also be addressed at the conference, which is currently scheduled to take place on 6-9 December 2016.

The safety case for geological disposal

In 2015, the Integration Group for the Safety Case (IGSC) carried out a series of workshops and technical meetings to continue the enhancement of safety cases for radioactive waste disposal. In early 2015, the IGSC

started a new initiative to assess effective approaches to communicating scientific information with non-technical stakeholders. In June 2015, the group held a workshop to discuss scenario development methods used in NEA member countries and to review the contribution of scenarios to recent safety cases.

The first edition of the IGSC Sourcebook, a tool to co-ordinate ongoing work activities on safety case development at the NEA, the IAEA and the European Commission was completed in 2015. The sourcebook provides the foundation for a positive and mutually respectful working relationship between international organisations, and its provision for periodic review and feedback will enhance the work planning process, which takes into account the specific needs of member countries.

The scientific supporting groups of the IGSC – the Clay Club, the Salt Club and the Expert Group on Operational Safety (EGOS) – have achieved good progress in their pursuit of robust scientific data for safety assessment. In 2015, the Clay Club finalised its *Clay Catalogue of Characteristics of Argillaceous Rocks*, and publication is anticipated in early 2016. The Salt Club's focus in 2015 continued to be on developing its catalogue of features, events and processes (FEP) for geological disposal, a comprehensive study of specific mechanical behaviours of rock salts including their dilatant behaviours and creep at low deviatoric stresses, and the impacts of microbial activity on geological repositories in rock salts.

Operational safety issues of geological repositories remain a key interest of the IGSC, with a renewed mandate in 2015 focusing on specific operational safety activities, including waste acceptance criteria for radioactive waste disposal and continued work on the creation of an NEA database on operational hazards.

Radioactive Waste Repository Metadata Management (RepMet)

The RepMet initiative held its third meeting in May, followed by a fourth meeting in October. RepMet aims to promote a better understanding of the identification and administration of metadata – a key aspect of data management – to support national programmes in managing their radioactive waste repository data, information and records in a way that is both harmonised internationally and suitable for long-term management and use.

At the beginning of 2015, participating waste management organisations (WMOs) completed a questionnaire to provide data on the collection and storage for low- and intermediate-level waste (L/ILW) in their national programmes. The RepMet group decided to develop a conceptual data model for the processing library using elements of the questionnaire as a starting point. Participants at the fourth meeting discussed and checked the flexibility of the data model developed, and established a way forward to complete the library with data and metadata attributes. The working session confirmed the robustness of the proposed data model.

Decommissioning

The 16th annual meeting of the Working Party on Decommissioning and Dismantling (WPDD) was held on 23-25 November 2015. Participants discussed the interests and needs of NEA member countries and the future programme of work, identifying decommissioning cost analyses as a key theme. The meeting included a joint special session on the “Decommissioning Scene in Far East Asia”. The International Conference on Decommissioning of Nuclear Facilities: Strategies, Practices and Challenges was also successfully organised by the NEA in Moscow on 9-11 November 2015, with support from Rosatom.

The WPDD Decommissioning Cost Estimation Group (DCEG) published a study on *The Practice of Cost Estimation for Decommissioning of Nuclear Facilities*. The study offers a useful reference for the practitioner and for training programmes and covers current practices and standards in a number of NEA member countries.

In 2015, a new WPDD Task Group on Preparing for Decommissioning during Operation and after Final Shutdown (TGPFD) was launched. The WPDD Task Group on Radiological Characterisation and Decommissioning (TG-RCD) carried out a survey to identify important issues in radiological characterisation for decommissioning resulting from waste and materials management processes.

Radioactive waste inventorying and reporting

The RWMC Expert Group on Radioactive Waste Inventorying and Reporting (EGIRM) developed a universal radioactive waste and spent fuel inventory presenting scheme as a tool to provide a unified format to present national inventories. In 2015, the group developed and tested the methodology for application to spent fuel and high-level waste after spent fuel reprocessing.

Fukushima waste management and decommissioning

The Expert Group on Fukushima Waste Management and Decommissioning R&D (EGFWMD) continued to provide advice on the management of large quantities of on-site waste at the Fukushima Daiichi NPP and to share experiences with the international community. The expert group advises the Japanese government on waste management and decommissioning at the Fukushima Daiichi NPP.



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Joint Projects

The CPD

The NEA Co-operative Programme for the Exchange of Scientific and Technical Information Concerning Nuclear Installation Decommissioning Projects (CPD) is a joint undertaking of a limited number of organisations actively executing or planning the decommissioning of nuclear facilities. The objective of the CPD programme, launched in 1985 and operating under Article 5 of the NEA Statute, is the exchange and sharing of information from operational experience in decommissioning nuclear installations which is useful for current and future projects. Initially consisting of 10 decommissioning projects in 8 countries, the programme has since grown to the present 67 projects (39 reactors and 28 fuel cycle facilities) in 13 NEA member countries, one non-member economy and the European Commission. A revised agreement among participants that founded the basis of the programme came into force on 1 January 2014 and will run until 31 December 2018.

Information exchange also ensures that best international practice is made widely available and encourages the application of safe, environmentally friendly and cost-effective methods in all decommissioning projects. Biannual meetings of the Technical Advisory Group (TAG) are held, during which the site of one of the participating projects is visited, and positive and less positive examples of decommissioning experience are openly exchanged for the benefit of all.

Although part of the information exchanged within the CPD is confidential and restricted to programme participants, experience of general interest gained under the programme's auspices is released for broader use. In this context, the CPD Task Group on Recycling and Reuse of Materials continues to review the various national and international approaches for the management of low-level radioactive waste from decommissioning.

The TDB Project

The Thermochemical Database (TDB) Project was initiated in 1984 by the NEA Radioactive Waste Management Committee to fulfil a need for a high-quality database for modelling purposes in the safety assessments of radioactive waste repositories. The project's current mandate runs to March 2018. Fifteen organisations from twelve countries participate.

The project has thus far produced 13 volumes of internationally recognised and quality-assured thermodynamic data. Work is currently in progress to complete four reviews – on iron (second volume), on molybdenum, on ancillary data and a second update of the uranium, americium, neptunium, plutonium, and technetium volumes – as well as two state-of-the-art reports on thermodynamic considerations for cement minerals and on high ionic strength systems. The renewal of the TDB electronic database is also ongoing.

Phase 5 of the TDB project began in April 2014. The core of the TDB-5 programme of work comprises:

- the update of the phase 2 actinide volumes, including technetium;
- the preparation of a state-of-the-art report on thermodynamic considerations for cement minerals;
- the preparation of a state-of-the-art report on thermochemical extrapolation of data to non-standard state temperatures pending the outcome of an initiation report;
- the preparation of a state-of-the-art report on thermodynamic considerations for actinide elements in high ionic strength aqueous solutions.



US Nuclear Regulatory Commission

Decommissioning works.

Radiological Protection

The goal of the NEA in this sector is to assist member countries in the regulation, implementation and further development of the system of radiological protection by identifying and effectively addressing conceptual, scientific, policy, regulatory, operational and societal issues. The staff works closely with the Committee on Radiation Protection and Public Health (CRPPH) and its expert groups in this area.

Highlights

- A CRPPH/RWMC joint topical session was organised on underground safety in radioactive waste repositories.
- The 4th “Science and Values” workshop was held in Moscow, Russia.
- The CRPPH continued to support the ICRP Dialogue Initiative meetings, with a summary meeting in December 2015, following the 12th and final Dialogue Initiative.
- A proposal was refined for a CRPPH joint undertaking on organ dose variability with gender, age and body mass index.
- The INEX-5 exercise was initiated, with 22 participating countries.
- The exchange of information and experience in occupational radiation protection at nuclear power plants within the ISOE programme continued with its ALARA symposia series in Brazil, Japan and the United States.

Radiological protection consequences of the Fukushima Daiichi accident

The importance of government support for recovery efforts has emerged as a key lesson of the Fukushima Daiichi accident, as has stakeholder trust in government. Recovery hinges on stakeholders’ choices on whether to stay or go, return or not, and such choices can be based on an individual’s level of understanding of the prevailing circumstances, including radiological conditions, social aspects such as work, schools, health care and infrastructure, social networks, available shops and support facilities. As such, it is important that stakeholder concerns be addressed by scientific, social and governmental experts so that choices are based on realistic and scientifically sound information.

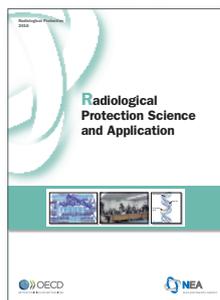
The International Commission on Radiological Protection (ICRP) dialogues with stakeholders have clearly demonstrated that those people who wish to stay in affected territories, or to return to these territories, have developed a positive attitude towards the future, accepting that post-accident normality has become the normality. Considerations such as family history, local cultural ties, infrastructure and work, as well as age and family structure, all act as important input into such decisions. NEA staff participated in the ICRP Dialogue Symposium meeting in December, summarising the 12 dialogues and presenting lessons from discussions, which will be compiled in a final report.

Evolution of the international system of radiological protection

The ICRP is in the process of updating its two publications on emergency and recovery management (Publications 109 and 111), which are expected to be released in 2017. The NEA has been participating in

this work to ensure that the document reflects NEA member experience and CRPPH views. The CRPPH view that radiological protection concerns and management approaches are driven by prevailing circumstances has been reinforced through this work and other experiences over the years. When planning and implementing protective decisions, for example, it is seen as essential to begin with a clear understanding of the radiological and non-radiological conditions. In fact, prevailing circumstances, and the ability to control the source of exposure and manage exposure pathways under the prevailing circumstances, provide a central rationale for identifying the type of situation – planned, existing or emergency exposure situation – as well as an individual’s tolerability of exposures (the selection of the appropriate band for dosimetric criteria). The Fukushima accident has demonstrated that the focus on “numeric criteria”, particularly on 20 mSv/a and 1 mSv/a, has caused some concern and misunderstanding. It is for this reason that a renewed focus on the prevailing circumstances, with discussions on the ICRP Framework tools that can best address the prevailing circumstances, may help to refocus affected stakeholders on actions rather than on numeric criteria.

Radiological protection science



The CRPPH Expert Group on Radiological Protection Science (EGRPS) completed its update of the Committee’s 1998 and 2007 reports on the implications of radiological protection science. The report, to be published in early 2016, suggests that radiological, epidemiological and biological research continue to

broadly support the assumption that radiological risks exist even at doses less than 100 mSv, and that one of the models that can be used to estimate the dose/risk curve is linear, with no threshold.

Radiological protection science and policy judgement

Radiological protection decisions are a combination of science and judgement, and making these two elements more transparent in decision making would help improve the acceptability and sustainability of decisions. The CRPPH is addressing such issues through a series of “Science and Values” workshops in radiological protection, the first three of which were held in 2008, 2009 and 2012. The fourth workshop was held in Moscow on 9-11 June 2015. Workshop participants addressed the science and value aspects of three topics: the medical surveillance of workers and post-accident victims, the use of dose measurements for the assessment of risks and the communication of low-dose risks.

Nuclear emergency management

Following the Fukushima Daiichi accident, a consensus has evolved in international fora that there is a need to enhance international communication and the exchange of information relevant to national emergency management decisions. International harmonisation and co-ordination of protective measures is particularly important at the regional level to help ensure a balanced response. The co-ordination of national responses is an important factor when accidents directly affect several countries in a region, or even when they affect only one country.

Since the Fukushima Daiichi accident, many actions have been taken at national and international levels concerning emergency response and recovery plans. The International Nuclear Emergency Exercise (INEX) series is an opportunity for participating

countries to test and demonstrate the value of changes implemented as a result of the Fukushima Daiichi accident. INEX-5 has been designed to test new actions, measures and approaches developed at the regional and international levels to enhance communication and information exchange, and cross border co-ordination.

INEX-5 addresses the emergency management aspects of notification, communication and interfaces among countries and international organisations (IOs). While the INEX-5 scenario involves a release of radioactivity from an NPP, the exercise material has been developed to enable NPP and non-NPP countries to conduct regional, multi-participant, table-top exercises, with independent exercises remaining an option.

In this framework, the NEA has encouraged INEX-5 participating countries to take part in a regional exercise (whether their own or someone else’s) with neighbours and those further afield in order to investigate how countries can improve these aspects should they be required. An important outcome of the exercise will be the identification of good practices, as well as key needs for future work that would benefit from international co-operation.

The INEX-5 exercise is being conducted from September 2015 to June 2016, with an initial plan to hold the post-exercise evaluation workshop in spring 2017. INEX-5 is open to all countries (both NEA member and non-member countries) as well as to interested IOs. At the end of 2015, 22 countries had communicated their intent to participate in INEX-5.



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Joint Project

The ISOE

Since its creation in 1992, the Information System on Occupational Exposure (ISOE), sponsored jointly by the NEA and the IAEA, has been facilitating the exchange of data, analysis, lessons and experience in occupational radiological protection (RP) at nuclear power plants worldwide. It maintains the world's largest occupational exposure database and a network of utility and regulatory authority RP experts. The new ISOE terms and conditions, covering the period 2012-2015, came into force on 1 January 2012 and have been revised seven times since then, mostly to incorporate new members. As of 31 December 2015, the ISOE programme includes the participation of 76 utilities from 29 countries, and 22 regulatory authorities from 20 countries. Authorities from the United Arab Emirates and the Republic of Belarus joined the ISOE in 2015.

Four supporting ISOE Technical Centres (Asia, Europe, North America and the IAEA) manage the system's day-to-day technical operations of analysis and exchange of information and experience. The ISOE occupational exposure database contains information on occupational exposure levels and trends at 482 reactor units (401 operating units and 81 units in cold shutdown or at some stage of decommissioning) in 29 countries, thus covering about 91% of the world's operating commercial power reactors. The ISOE database, publications and annual symposia, along with the ISOE Network

website, facilitate the exchange among participants of operational experience and lessons learnt in the optimisation of occupational radiological protection.

In 2015, the ISOE programme continued to concentrate on the exchange of data, analysis, good practices and experience in the area of occupational exposure reduction at nuclear power plants, and on improving the quality of its occupational exposure database. The ISOE regional Technical Centres continued to support their members through specialised data analyses and benchmarking visits. Key outcomes of work during 2015 included the preparation of the ISOE Strategic Programme Plan for 2016-2019; establishment of a new Working Group on Radiological Protection Aspects of Decommissioning Activities in Nuclear Facilities (WGDECOM); development of several new, standard, push-button database analyses; and the signing of a Technical Co-operation Agreement with Enresa (Spain) to facilitate the exchange of information and experience on the optimisation of occupational radiation protection in the operation and decommissioning of nuclear power plants.

The ISOE programme organised an International ALARA Symposium in Brazil (26-27 May) and two regional ALARA Symposia in North America (United States, 12-14 January) and Asia (Japan, 9-10 September).

Nuclear Science

The goal of the NEA in this sector is to help member countries identify, collate, develop and disseminate the basic scientific and technical knowledge required to ensure the safe, reliable and economic operation of current and next-generation nuclear systems. The staff works closely with the Nuclear Science Committee (NSC) and its expert groups in this area.

Highlights

- Three reports, *Introduction of Thorium in the Nuclear Fuel Cycle*, *Review of Integral Experiments for Minor Actinide Management*, and the *Handbook on Lead-bismuth Eutectic Alloy and Lead Properties, Materials Compatibility, Thermal-hydraulics and Technologies* were released in 2015.
- The NEA established an Expert Group on Liquid Metal Technology.
- The Agency released a benchmark report in 2015 on the determination of nuclide composition and neutron multiplication factor of BWR spent fuel for burn-up credit and criticality control of damaged nuclear fuel.
- Two state-of-the-art reports were issued on multi-scale modelling of nuclear fuels and primary radiation damage in materials.
- A new Nuclear Data Sensitivity Tool (NDaST) was developed, combining the capabilities of the database for ICSBEP (DICE) with the nuclear data viewing tool JANIS.

Reactor physics

An important focus of nuclear science activities relates to the development and validation of calculation methods for the analysis of reactor transients. Methods for modelling transients in light water reactors are being compared for a range of designs including pressurised water reactors (PWRs), boiling water reactors (BWRs) and the Russian-designed VVER-1000. In 2015, studies have moved from the analysis of separate effect tests to the assessment of uncertainties based on explicitly coupled multi-physics measurement data such as those obtained from the Oskarsham BWR instability event.

In a broader context, coupled multi-physics computational methods continue to evolve to meet the needs of designers, operators and safety regulators, by improving predictive accuracy and by extending their capability to model more complex scenarios. Novel multi-physics simulation tools are now being developed to include coupled behaviours linked to fuel performance and coolant chemistry. To be used to their full potential by the nuclear science community, these tools will require a more complex array of validation tests reflecting the multiple lengths and timescales involved, as well as the number of physical phenomena being simulated. Recognition of this has led research and industry experts from across the NEA nuclear science community to form a new Expert Group on Multi-physics Experimental Data, Benchmarks and Validation (EGMPEBV) comprising two task forces.

Throughout 2015, the EGMPEBV concentrated its efforts on producing two reports to act as common

terms of reference for both task forces, the “Definition of the Scope of Multi-Physics Applications” and the “Summary Report on the Current Status and Expected Needs for Validation of Multi-Physics Modelling and Simulation Tools”.

The nuclear science programme has also continued to build its databases of high-quality benchmarks. In 2015, a review was initiated with the aim of identifying any significant gaps in the current databases, along with the characteristics of experimental facilities that could be used to carry out experiments required to meet current and future needs of the code user community.

Fuel cycle physics and chemistry

Activities in this area cover all aspects of the fuel cycle from the front to back end, and deal with issues arising from various existing and advanced systems including fuel cycle scenarios, innovative fuels and materials, separation chemistry and waste disposal.

A number of expert groups are currently finalising their activities, with for example the release of an updated *Handbook on Lead-bismuth Eutectic Alloy and Lead Properties, Materials Compatibility, Thermal-hydraulics and Technologies*, and the Expert Group on Liquid Metal Technology (EGLM) replacing the Expert Group on Heavy Liquid Metal Technology (EGHLM) to include an activity on liquid sodium. The Expert Group on Advanced Fuel Cycle Scenarios (AFCS) has launched two new activities: a benchmark study on transuranic waste (TRU) management scenarios and a benchmark on dose rate calculations for irradiated fuel assemblies.

The final drafts of the “State-of-the-art Report on Separation Chemistry” by the Expert Group on Fuel Recycling Chemistry (FRC) and “Uncertainty of Input Parameters on Nuclear Fuel Cycle Scenario Studies” by the AFCFS are currently being reviewed for release. Phase II of the benchmark on thermal-hydraulic loop models for lead-alloy-cooled advanced energy systems has been completed and the report is in preparation.

Nuclear criticality safety

The NEA Working Party on Nuclear Criticality Safety (WPNCS) currently oversees five associated expert groups. The WPNCS is responsible for the co-ordination and maintenance of the International Criticality Safety Benchmark Evaluation Project (ICSBEP) database and the Spent Fuel Composition and Assay Database (SFCOMPO). In 2015, the capture and verification of publicly available experimental assay data in SFCOMPO-2.0 continued, and an “Evaluation Guide for the Evaluated Spent Nuclear Fuel Assay Database” was finalised.

Benchmark activities continue to examine the rigorous treatment of uncertainty propagation in different criticality safety problems. In 2015, the specifications for two new benchmarks were defined for the establishment of correlations in experimental uncertainties and for a blind benchmark on mixed oxide fuel (MOX) damp powders aimed at providing a realistic test of consistency of various criticality assessment methods.

Materials science

Activities in the field of materials science span multi-scale modelling and simulation, as well as R&D supporting current nuclear fuels and innovative fuel designs. The NEA Working Party on Multi-scale Modelling of Fuels and Structural Materials for Nuclear Systems (WPMM) issued two state-of-the-art reports in 2015. The first assesses the scientific and technological bases for the multi-scale modelling of fuels in support of current fuel optimisation programmes and innovative fuel designs, and the second looks at primary radiation damage in materials, reviews the current understanding in the field and proposes a new standard for the displacement damage model to incorporate in-cascade defect production efficiency and mixing effects. In parallel, a new activity was initiated in 2015, aimed at establishing a state of the art in modelling experimental techniques for characterising irradiation defects in structural materials.

The Expert Group on Reactor Fuel Performance (EGRFP) initiated a benchmark on pellet-cladding mechanical interaction (PCMI) with fuel performance codes. More than 20 organisations participate in this benchmark, which also foresees a comparison of simulation results with experimental data provided by the Halden reactor. The Expert Group on Accident-tolerant Fuels for LWRs (EGATFL) made substantial progress in the definition of state-of-the-art knowledge on fundamental properties and behaviour under normal operations and accident conditions for

innovative core materials and components (fuels, cladding, advanced control rods and BWR channel box) with enhanced accident tolerance. Analysed materials include innovative fuels (enhanced uranium oxide, high density fuels such as uranium silicide/nitride, fully encapsulated ceramic fuel) and cladding materials (coated and improved zirconium alloys, advanced steels, silicon carbide [SiC] and SiC/SiC composites and refractory metals) compatible with current generation II, III and III+ reactors, with the aim of enhancing tolerance in accidental conditions entailing prolonged loss of cooling.

Knowledge management

To maintain the scientific and technical capabilities required to develop new nuclear facilities, work in this area focuses particularly on the transfer of knowledge and skills between generations. Several years ago, the NEA Nuclear Science Committee launched a programme establishing well-structured and highly accessible databases to preserve and evaluate information from reactor physics (IRPhE), criticality safety (ICSBEP), shielding (SINBAD), fuel performance (IFPE) and isotopic composition of spent fuel (SFCOMPO). The maintenance and updating of these databases are performed in close collaboration with the NEA Data Bank.

A new nuclear data sensitivity tool (NDaST) was developed, combining the capabilities of the ICSBEP (DICE) database with the nuclear data viewing tool JANIS to show how proposed changes in nuclear data could impact the thousands of criticality benchmarks collected in the ICSBEP handbook. An update was also made to the structure and data for the research and test facility database that contains major characteristics and the status of research and test facilities in the field of nuclear science and technology. The collection and overview of literature related to validation approaches and identification of experimental needs in neutronics, thermal-hydraulics, material studies, fuel behaviour and coupled multi-physics methods continued, as did improvements in NEA databases (DICE, IDAT, SFCOMPO, SINBAD, IFPE).



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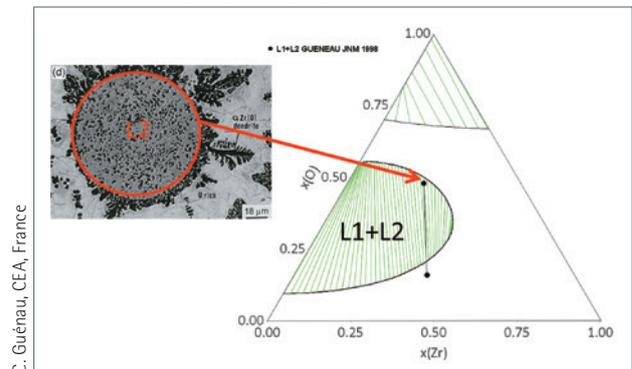
Joint Project

The TAF-ID Project

The Thermodynamics of Advanced Fuels – International Database (TAF-ID) Project was established in January 2013 and is supported by nine organisations in six NEA member countries. It is devoted to establishing a comprehensive, internationally recognised and quality-assured database of phase diagrams and thermodynamic properties of advanced nuclear fuels to meet the specialised requirements for the development of advanced fuels for a future generation of nuclear reactors. The specific technical objectives of the programme are to:

- predict the solid, liquid and/or gas phases formed during fuel/cladding chemical interaction under normal and accident conditions;
- improve the control of the experimental conditions during the fabrication of the fuel materials at high temperature, for example, by predicting the vapour pressures of the elements (particularly of plutonium and the minor actinides);
- predict the evolution of the chemical composition of fuel under irradiation versus temperature and burn-up.

The six countries taking part in this project are: Canada (CNL, RMCC, UOIT), France (CEA), Japan (JAEA, CRIEPI), Korea (KAERI), the Netherlands (NRG) and the United States (DOE).



C. Guénau, CEA, France

Miscibility gap in liquid state.

A new release of the TAF-ID database was issued in 2015 to the project signatories, for a total of seven new binary and ternary systems related to fission products, corium and metal fuels. A second version of this database, containing only data which have already been published in the open literature on oxide-carbide and metal fuels, is also publicly available, free of charge. This second version will be accessible to all NEA member countries, upon request to the NEA and after signature of a non-disclosure agreement.

Data Bank

The goal of the NEA in this sector is to provide the premier international centre of reference for basic nuclear tools, such as computer codes and nuclear data, used for the analysis and prediction of phenomena in the nuclear field; and to provide a direct service to its users by developing, improving and validating these tools and making them available as requested.

Highlights

- The Task Force on the Future Programme of the Data Bank reported its recommendations to the Data Bank Management Committee in June 2015. The report was endorsed by the Data Bank Management Committee and the Nuclear Science Committee and presented to the NEA Steering Committee for its consideration of the recommendations.
- Nine workshops or training courses on the most popular computer codes were organised by the computer program services as part of NEA Data Bank knowledge management activities.
- Work on two new applications, the Nuclear Data Sensitivity Tool (NDaST) and the Nuclear Data Evaluation Cycle (NDEC), was initiated in 2015.

Computer program services

The Data Bank collection contains more than 2 200 computer programs and 350 integral experiments covering all areas related to reactor design, dynamics, safety and radiation shielding, material behaviour and nuclear waste applications. A total of 12 new or new versions of computer programs and 3 integral experiments were added to the collection in 2015.

More than 950 computer program and 1 800 integral experiment packages were dispatched upon request to Data Bank participating countries in 2015. The current co-operative arrangement between the United States Department of Energy and the NEA authorises the NEA Data Bank to issue user licences and distribute US computer codes to Data Bank participating countries.

The number of officially nominated establishments using the Computer Program Service in NEA Data Bank participating countries is 825. Detailed information about material available from the computer program services can be accessed via the NEA website at www.oecd-nea.org/dbprog/.

Knowledge transfer

As an important complement to the Computer Program Service, the Data Bank organises workshops and training courses on the use of the most popular computer programs. Over 100 participants attended 9 workshops or training courses in 2015, covering computational radiation physics, criticality safety and radiation shielding, radiation transport using Monte-Carlo codes and sensitivity/uncertainty analysis.

Preservation of information from integral experiments

The Data Bank has established a number of databases containing information from integral experiments.

These data are especially important for the validation and benchmarking of computation methods and programs used in Data Bank participating countries to model nuclear systems. The databases maintained and updated by the Data Bank in co-operation with other sectors of the NEA are SINBAD (integral shielding experiments), International Fuel Performance Experiments (IFPE), International Criticality Safety Benchmark Evaluation Project (ICSBEP), CSNI Code Validation Matrix for LWR LOCAs and transients (CCVM) and International Reactor Physics Benchmark Experiments (IRPhE). More than 1 800 copies of these databases were distributed in 2015. The most popular of the databases was SINBAD, with more than 650 experiments distributed, followed by CCVM and IFPE.

Nuclear data services

The Data Bank maintains large databases containing bibliographic, experimental and evaluated nuclear data, which are made available online to scientists and engineers in participating countries. An important nuclear data activity of the Data Bank is the development of the JANIS software, designed to facilitate the visualisation, comparison and manipulation of nuclear data. In 2015, JANIS 4.0 was revised and updated according to user feedback. TENDL2014 has been processed into the JANIS database, and a roadmap has been defined with the objective of a major release at the International Conference on Nuclear Data for Science and Technology (ND2016).

The recent development of the Nuclear Data Evaluation Cycle (NDEC) platform is at the centre of an initiative undertaken by the Data Bank to strengthen its role as a reference centre in the verification, benchmarking and validation of nuclear data. The objective is to provide better nuclear data services to Data Bank participating countries in general and

to serve the Joint Evaluated Fission and Fusion (JEFF) Nuclear Data Library project more specifically.

The Data Bank contribution to the compilation of measured neutron and charged-particle-induced reaction data continues with the help of external consultants and in close co-operation with a number of nuclear reaction data centres worldwide, under the auspices of the Nuclear Data Section of the IAEA. In 2015, the number of updates in the EXFOR database implemented by the Data Bank (or currently peer-reviewed by other data centres) amounted to 85 entries for neutron-induced reactions and 116 for charged-particle-induced reactions.

International nuclear data evaluation co-operation

The Data Bank co-operates closely with the NSC Working Party on International Nuclear Data Evaluation Co-operation (WPEC). The WPEC was established to promote an international framework for co-operative activities among the major evaluation projects, in close co-operation with the IAEA. The aim is to review worldwide progress in nuclear data evaluation and measurement activities, the status of joint actions and future challenges.

Ongoing subgroup (SG) activities focus on “Improved fission product yield evaluation methodologies” (SG37) and “Developing a modernised nuclear data format structure” (SG38). These have been extended for one year in order to complete the work and prepare final reports. An extensive activity has been carried out on “Methods and approaches to provide feedback from nuclear and covariance data adjustment for the improvement of nuclear data files” (SG39) and the “Collaborative international evaluated library organisation pilot project (CIELO)” (SG40). The first meeting on “Improving nuclear data accuracy of ^{241}Am and ^{237}Np capture cross-sections (INDA)” (SG41) focused on the ^{241}Am capture cross-section. A new activity on “Thermal scattering kernel $S(\alpha,\beta)$: Measurement, evaluation and application” (SG42) has been initiated as a result of interest in revisiting and revising the existing thermal neutron scattering data in the existing cross-section libraries. Further information on recent WPEC reports is available at www.oecd-nea.org/science/wpec.

The Joint Evaluated Fission and Fusion File Project

The Joint Evaluated Fission and Fusion File (JEFF) project is a collaborative effort among Data Bank participating countries to produce common sets of evaluated nuclear data, mainly for fission and fusion applications. The latest version of the JEFF general purpose neutron library, JEFF-3.2, was released in March 2014. Since June 2015, the JEFF Project began a new and restructured mandate for the period 2015-2018, which will focus on delivering the next JEFF-3.3 release.

Two Nuclear Data Weeks were organised in April and December 2015 at the Institut Curie in Paris to

review recent achievements and outline planned actions so as to meet nuclear data challenges associated with the multi-year JEFF work plan. More information on the JEFF project is available at www.oecd-nea.org/dbdata/jeff.

The Thermochemical Database Project

The Thermochemical Database (TDB) Project was initiated in 1984 by the NEA Radioactive Waste Management Committee to fulfil the need for a high-quality database for modelling purposes in the safety analyses of radioactive waste repositories. Phase 5 was initiated in April 2014 and runs to April 2018. A total of 15 organisations from 12 countries participate and fund this project independently through budgetary and in-kind contributions.

The TDB project has produced 13 volumes of internationally recognised and quality-assured thermodynamic data. Work is currently in progress to complete four reviews – on iron (second volume), on molybdenum, on ancillary data and a second update of the uranium, americium, neptunium, plutonium, and technetium volumes – as well as two state-of-the-art reports on thermodynamic considerations for cement minerals and on high ionic strength systems. The renewal of the TDB electronic database is also ongoing.

In-house computer services

The Data Bank provides support for NEA in-house computer services including Internet and data servers connected to a fast network. The computer services also develop software or software tools in relation to JANIS, DICE, IDAT, ISOE and SFCOMPO, and maintain collaborative platforms for the Multinational Design Evaluation Programme (MDEP), the Generation IV International Forum (GIF) and the Thermochemical Database (TDB) Project. In addition, work on two new applications, the Nuclear Data Sensitivity Tool (NDaST) and the Nuclear Data Evaluation Cycle (NDEC), was initiated in 2015. Both applications are in their early stages and will continue to be developed in 2016.

During the second half of 2015, a considerable amount of the computer service staff's time was dedicated to the relocation of the NEA data centre to the Boulogne building.



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Legal Affairs

The goal of the NEA in this sector is to help create sound national and international legal regimes required for the peaceful uses of nuclear energy, including international trade in nuclear materials and equipment, to address issues of liability and compensation for nuclear damage, and to serve as a centre for nuclear law information and education. The Office of Legal Counsel works closely with the Nuclear Law Committee (NLC) in this area.

Highlights

- The Inaugural Session of the 9th mandate of the European Nuclear Energy Tribunal was held under NEA auspices in July. The tribunal consists of seven independent judges appointed for five years by decision of the OECD Council and has jurisdiction over disputes between states parties to the Paris Convention or the Brussels Supplementary Convention concerning the interpretation or application of these conventions.
- Signatories to the 2004 protocols to revise the Paris Convention and the Brussels Supplementary Convention continued to make progress towards the ratification and implementation of those protocols into their national legislation.
- The NLC expanded its activities to include discussions on nuclear safety issues from a legal perspective, while continuing to address environmental and public participation matters and to focus on nuclear liability, some aspects of which are being examined in conjunction with other standing technical committees, such as the RWMC and the CRPPH.
- Two issues of the Nuclear Law Bulletin (NLB) were published and included articles on the entry into force of the Convention on Supplementary Compensation for Nuclear Damage, the Vienna Declaration on Nuclear Safety and nuclear regulatory reform over time.
- The 15th session of the International School of Nuclear Law was held in co-operation with the University of Montpellier from late August to early September.
- A number of online national reports on the regulatory and institutional frameworks governing nuclear activities in OECD and NEA member countries have been updated in co-operation with the relevant national delegations.

Development and harmonisation of nuclear legislation

Ensuring adequate and equitable compensation for third party damage caused by a nuclear incident continued to attract the highest level of attention among member countries. Those countries that are party to the Paris Convention on Third Party Liability in the Field of Nuclear Energy (the Paris Convention) and the Brussels Convention Supplementary to the Paris Convention (the Brussels Supplementary Convention) worked towards implementing the 2004 protocols amending those conventions. A few are still facing delays in implementation because, *inter alia*, private nuclear risk insurers are unable to provide full coverage for certain risks that nuclear operators are obliged to assume under the revised conventions.

At the NLC meeting in June 2015, presentations on national developments in nuclear law were given by member countries (including Japan, the Slovak Republic and the United States) and five invitees (Argentina, India, Romania, the United Arab Emirates and Viet Nam). The IAEA and the EC reported on matters of special interest under their respective auspices, and several issues regarding

the interpretation and implementation of the Paris Convention were addressed, including the proposal to exclude from the scope of the convention low-level radioactive waste disposal facilities. This exclusion is intended to avoid the imposition of disproportionate obligations on operators in relation to the actual risks posed by the installations.

The NLC continued to address the legal implications of the Fukushima Daiichi accident and organised sessions on decommissioning challenges and on nuclear liability aspects of transport. It also assessed proposals to include in its discussions nuclear safety issues from a legal perspective, including the licensing frameworks for lifetime extensions and the legal frameworks for judicial challenges to licensing decisions. Finally, the committee continues to address the implementation of the Aarhus and Espoo Conventions as related to nuclear activities. A representative of the United Nations Economic Commission for Europe (UNECE) reported on the application of the Espoo Convention to activities related to nuclear energy and the initiative of states parties to this convention to elaborate good practice recommendations that would support the application of the convention to activities related to nuclear energy.



The 2015 ISNL session was attended by 57 participants from 30 countries.

The NEA continued to contribute to the work of the International Expert Group on Nuclear Liability (INLEX) established by the IAEA, the International Nuclear Law Association and the World Nuclear Association.

Nuclear law publication programme

The NLB is a unique international publication for both professionals and academics in the field of nuclear law, providing comprehensive information on nuclear law developments. It features topical articles written by renowned legal experts, covers legislative developments worldwide and reports on relevant case law, international agreements and the activities of intergovernmental organisations. The 95th and 96th issues of the NLB were published in 2015, with articles addressing topics such as the entry into force of the Convention on Supplementary Compensation for Nuclear Damage, the Vienna Declaration on Nuclear Safety and nuclear regulatory reform over time. As from 2014, all issues of the NLB are available free online at www.oecd-nea.org/law/nlb.

Country profiles on the regulatory and institutional framework for nuclear activities in member countries are available at www.oecd-nea.org/law/legislation/. The NEA website also provides a list of latest legislative developments, which tracks recent changes in nuclear-related legislation (see www.oecd-nea.org/law/legislation/updates.html). The NEA continues its concerted efforts to update the legislation information and is grateful for the support of OECD and NEA member countries. In 2015, updates were posted for the Czech Republic, Denmark, Greece, Poland and Slovenia, and the Office of Legal Counsel is actively working with six other countries on their respective updates.

Nuclear law education programmes

The fourth session of International Nuclear Law Essentials (INLE), an intensive, one-week programme

on the international nuclear law framework as well as the major issues affecting the peaceful uses of nuclear energy, was held on 16-20 March 2015 at the OECD Conference Centre in Paris, France. This year's INLE brought together a diverse group of professionals from 16 countries and 4 continents for a series of master lectures by 23 speakers, including NEA Director-General William D. Magwood, IV and Stephen G. Burns, Chairman of the United States Nuclear Regulatory Commission, on topics related to nuclear safety, security, non-proliferation and liability. More information on the INLE may be obtained at www.oecd-nea.org/law/inle/.

The 15th session of the International School of Nuclear Law (ISNL), a unique academic programme organised by the NEA and the University of Montpellier, was held from 24 August to 4 September 2015. Over the past 15 sessions, the ISNL has provided a high-quality educational experience to more than 750 participants from around the world. This session attracted 57 participants from 30 countries, including participants sponsored by the IAEA. The programme brings together leading experts in nuclear safety, security, liability, non-proliferation and safeguards to provide an in-depth exploration of the legal aspects of the use and oversight of nuclear energy. Participants enrolled in the ISNL are able to apply for a university diploma in international nuclear law recognised by the University of Montpellier. Further information may be obtained at www.oecd-nea.org/law/isnl/.



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General Information

Information and Communications

The goal of the NEA in this sector is to provide member governments and other major stakeholders with information resulting from NEA activities and to enhance awareness and understanding of the scientific, technical, economic and legal aspects of nuclear activities as well as awareness of the NEA itself.

Highlights

- The Agency produced 24 publications and 46 technical reports in 2015. Overall dissemination and downloads remained very strong.
- Seventeen press and news releases were issued in 2015, including on the NEA Workshop on Challenges and Enhancements to the Safety Culture of the Regulatory Body, the extension of the GIF Framework Agreement, the visit of the Parliamentary Vice-Minister Mamoru Fukuyama and new senior appointments at the NEA.
- Online networking platforms and multimedia tools such as videos and webinars were increasingly used throughout the year to communicate the Agency's latest publications, news and events.
- The NEA participated in the 21st Conference of the Parties (COP21) of the UN Framework Convention on Climate Change (UNFCCC). In co-operation with the IAEA, the NEA also held two side-events on "Why the Climate Needs Nuclear Energy" on 10-11 December 2015.

The NEA is an intergovernmental agency specialised in studying the scientific, technical and economic aspects of nuclear energy. It strives to provide high-quality, factual information in a timely manner to its member countries as well as to other interested parties wishing to learn about nuclear energy's multiple aspects and the results of the Agency's work.

Relations with the media

Relations with the media in 2015 covered a wide variety of topics and questions regarding the development and use of nuclear power. Seventeen press and news releases were issued in 2015, notifying the media, for example, of the NEA presence at COP21, new senior appointments at the NEA, the visit to the NEA of the National Nuclear Emergency Response Technical Assistance Center of the China Atomic Energy Authority (CAEA), the NEA Workshop on Challenges and Enhancements to the Safety Culture of the Regulatory Body, the visit of the Parliamentary Vice-Minister Mamoru Fukuyama, the Steering Committee Policy Debate on the health effects of low-dose radiation and the extension of the GIF Framework Agreement. These press and news releases are available in the online NEA news section at www.oecd-nea.org/news.

Over the course of the year, numerous interviews with the NEA Director-General and senior staff were conducted, and articles were printed in specialised publications and the international press such as *POWER* magazine ("William D. Magwood, IV on Nuclear Power's Present and Future"), the *Eurosafe Tribune* ("International cooperation: the whys and hows") *Reuters*, *World Nuclear News* and *Scientific American*. Significant efforts were also employed to ensure efficient internal and external co-ordination and communication, including with the OECD, the IEA and the IAEA.

Publications

In 2015, the Agency produced 24 publications, with all material posted free of charge on the NEA website in line with the NEA publications policy. The list of publications is provided on page 57. A total of 46 NEA technical reports were also issued under the unclassified "R" series, directly downloadable from the substantive areas' web pages.

The most accessed online reports during the course of the year included *Nuclear Site Remediation and Restoration during Decommissioning of Nuclear Installations: A Report by the NEA Co-operative Programme on Decommissioning* (16 623 downloads), *Uranium 2014: Resources, Production and Demand* (15 068 downloads), *Review of Integral Experiments for Minor Actinide Management* (12 444 downloads) and *NEA News 2014, Volume 32.1/32.2* (12 101 downloads).

The Agency's specialised journal, *NEA News*, keeps NEA correspondents and other interested professionals abreast of significant findings and advances in the Agency's programme of work. It provides feature articles on the latest developments in the nuclear energy field, as well as updates on NEA work, news briefs and information about NEA publications and forthcoming events.

In 2015, *NEA News* covered such topics as nuclear new build, nuclear liability amounts on the rise for nuclear installations, gas generation in deep geological repositories, the NEA Benchmark Study of the Accident at the Fukushima Daiichi Nuclear Power Station (BSAF), the NEA Thermochemical Database (TDB) Project, a clean environment approach to uranium mining and why the climate needs nuclear energy. *NEA News* is available free of charge on the Agency's website at www.oecd-nea.org/nea-news/.

Online communication

The NEA's online presence and use of new media technologies play a key role in communicating the work and accomplishments of the Agency. Website traffic remained steady in 2015, with an average of over 5 000 visitors per day or 1.9 million visits on an annual basis. The website sections that attracted the most views were, in order of magnitude: the NEA Monthly News Bulletin, News, Publications and the NEA Data Bank's Java-based Nuclear Data Information System (JANIS).

Online networking platforms have helped strengthen communication of NEA activities. The Agency maintains a regular presence on Facebook and LinkedIn, and can be followed on Twitter @OECD_NEA. In 2015, the NEA increased the frequency of its posts and engagement on all three platforms. The Agency's social media profile continued to grow rapidly with a 60.8% increase in the number of followers on LinkedIn, a 38% increase on Twitter and a 33% increase on Facebook. The Agency has also started to integrate video into its digital communications strategy and revived its YouTube profile. As a result, these channels have helped increase the visibility of NEA results, publications and events.

Webinars were an integral part of the NEA's online communications work in 2015 as well. The NEA, along with the IEA, hosted two webinars to disseminate the findings from the latest editions of the *Technology Roadmap: Nuclear Energy and the Projected Costs of Generating Electricity*. The NEA also hosted the Workshop on Challenges and Enhancements to the Safety Culture of the Regulatory Body which was broadcasted live on the NEA website.

Subscriptions to the NEA Monthly News Bulletin have remained constant with approximately 20 000 subscribers. Distributed free of charge, the bulletin includes monthly updates on NEA work, activities and newly released reports. Subscription requests can be submitted at www.oecd-nea.org/bulletin/. Current and archive issues can be viewed at www.oecd-nea.org/general/mnb/.

Online interaction with NEA delegates continues to expand. Most NEA committees and their working groups rely extensively on electronic communication such as password-protected extranet pages, e-mail discussion lists or online collaborative work spaces. The Delegates' Area of the NEA website also continues to provide an important service for many NEA committees and working groups. This section of the website provides authorised users with official NEA documents, information about NEA committee and expert group mandates and contacts, information about standing technical committee co-ordination, as well as access to the presentations and background notes prepared for the Steering Committee and its policy debates.

Public affairs and visibility in international fora

The NEA co-sponsored several international events during 2015, including:

- Winter Certificate Course on Nuclear Law, New Delhi, India, 12-16 January;
- International Expert's Meeting on Strengthening Research and Development Effectiveness in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant (IEM8), Vienna, Austria, 16-20 February;
- Joint International Conference on Mathematics and Computation (M&C), Supercomputing in Nuclear Applications (SNA) and the Monte Carlo (MC) Method, Nashville, Tennessee, United States, 19-23 April;
- 2015 International Congress on the Advances in Nuclear Power Plants (ICAPP), Nice, France, 3-6 May;
- 2015 International Congress on the Advances in Nuclear Fuel Cycles and Systems (GLOBAL), Paris, France, 20-24 September;
- Fourth International Workshop on Nuclear Data Evaluation for Reactor Applications (WONDER 2015), Aix-en-Provence, France, 5-8 October;
- International Conference on Global Emergency Preparedness and Response, Vienna, Austria, 19-23 October;
- 2015 Workshop on Sampling and Characterisation – From Sampling to Analysis, Montpellier, France, 17-19 November.

The NEA officially launched its new brochure on *Nuclear Energy: Combating Climate Change* at COP21. In co-operation with the IAEA, the NEA also held two side-events on "Why the Climate Needs Nuclear Energy" on 10-11 December 2015. The side-events benefited not only from good co-operation among the NEA, the OECD and the IAEA, but also from a lively exchange with an interested and receptive audience. NEA representatives were present throughout the Conference at the OECD pavilion and the exhibition booth.

On 6 November 2015, NEA Director-General William D. Magwood, IV spoke at the White House Summit on Nuclear Energy and highlighted the role of nuclear energy in combating climate change. He also delivered key messages at the 16th Ministerial Level Meeting of the Forum for Nuclear Cooperation in Asia (FNCA) in Tokyo, Japan, on 8 December 2015, the European Nuclear Young Generation Forum 2015 (ENYGF) in Paris, France, on 24 June 2015 and the 48th Japan Atomic Industrial Forum (JAIF) Annual Conference in Tokyo, Japan, on 13 April 2015.

The NEA was also represented at the 62nd Nuclear Energy Assembly, the World Nuclear Association (WNA) New Build Licensing Conference, the 30th KAP (Korea Atomic Power) Annual Conference, the International Congress on Advances in Nuclear Power Plants (ICAPP 2015), the Annual Conference of the Canadian Nuclear Society (CNS), the Platts European Nuclear Power Conference, the WNA Symposium 2015 and Global 2015: Nuclear Fuel Cycle for a Low-Carbon Future.



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Organisational Structure of the NEA

The Nuclear Energy Agency (NEA) is a semi-autonomous body of the Organisation for Economic Co-operation and Development. OECD member countries wishing to participate in the activities of the Agency must make a formal request to join. Of the 34 OECD member countries, 31 were members of the NEA in 2015:

Australia	Germany	Luxembourg	Slovenia
Austria	Greece	Mexico	Spain
Belgium	Hungary	Netherlands	Sweden
Canada	Iceland	Norway	Switzerland
Czech Republic	Ireland	Poland	Turkey
Denmark	Italy	Portugal	United Kingdom
Finland	Japan	Russia	United States
France	Korea	Slovak Republic	

The NEA is governed by the **Steering Committee for Nuclear Energy**. This committee is primarily made up of senior officials from national atomic energy authorities and associated ministries. It oversees and shapes the work of the Agency to ensure its responsiveness to member countries' needs, notably in establishing the biennial programmes of work and budgets. It approves the mandates of the seven standing technical committees.

In 2015, the members of the **Bureau of the Steering Committee** for Nuclear Energy were:

- Mrs Marie-Elise HOEDEMAKERS (Netherlands), Chair
- Dr Kwang-Yong JEE (Korea), Vice-Chair
- Mr Frédéric JOURNÈS (France), Vice-Chair
- Mr Richard STRATFORD (United States), Vice-Chair
- Dr Hiroshi YAMAGATA (Japan), Vice-Chair
- Dr Marta ŽIAKOVÁ (Slovak Republic), Vice-Chair

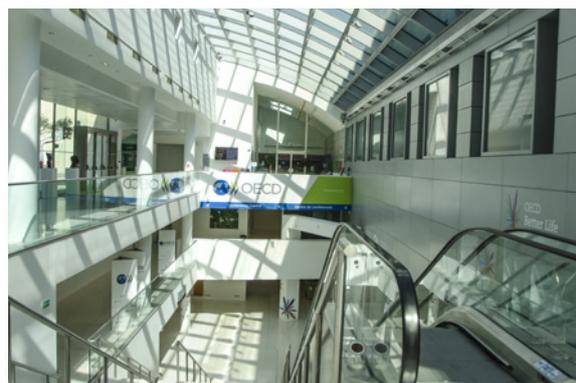
The **standing technical committees** are primarily composed of member country experts and technical specialists. These committees constitute a unique feature and important strength of the NEA, providing flexibility for adapting to new issues and helping to achieve consensus rapidly. Their main areas of work are listed in the chart on the next page.

The Steering Committee for Nuclear Energy and the Agency's seven standing technical committees are serviced by the **NEA Secretariat**, composed in 2015 of 109 professional and support staff from 17 countries. Professional staff are often specialists from national administrations and research institutes, bringing their experience to the Agency for two to five years on average.

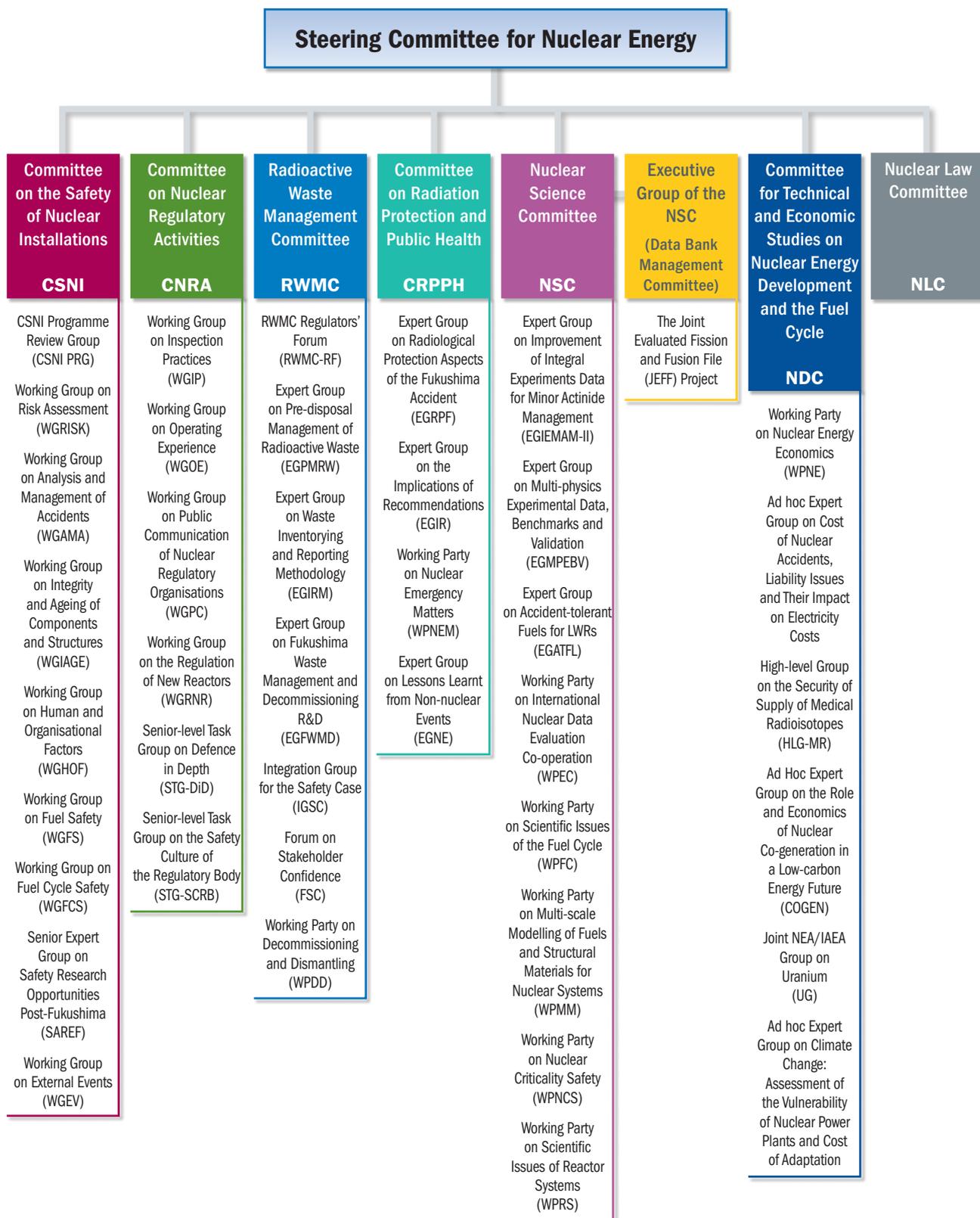
Participation in the work of the Agency by non-member countries is an established practice. Experts from selected **partner countries**, including China and India, take part in NEA activities on an invitee basis.



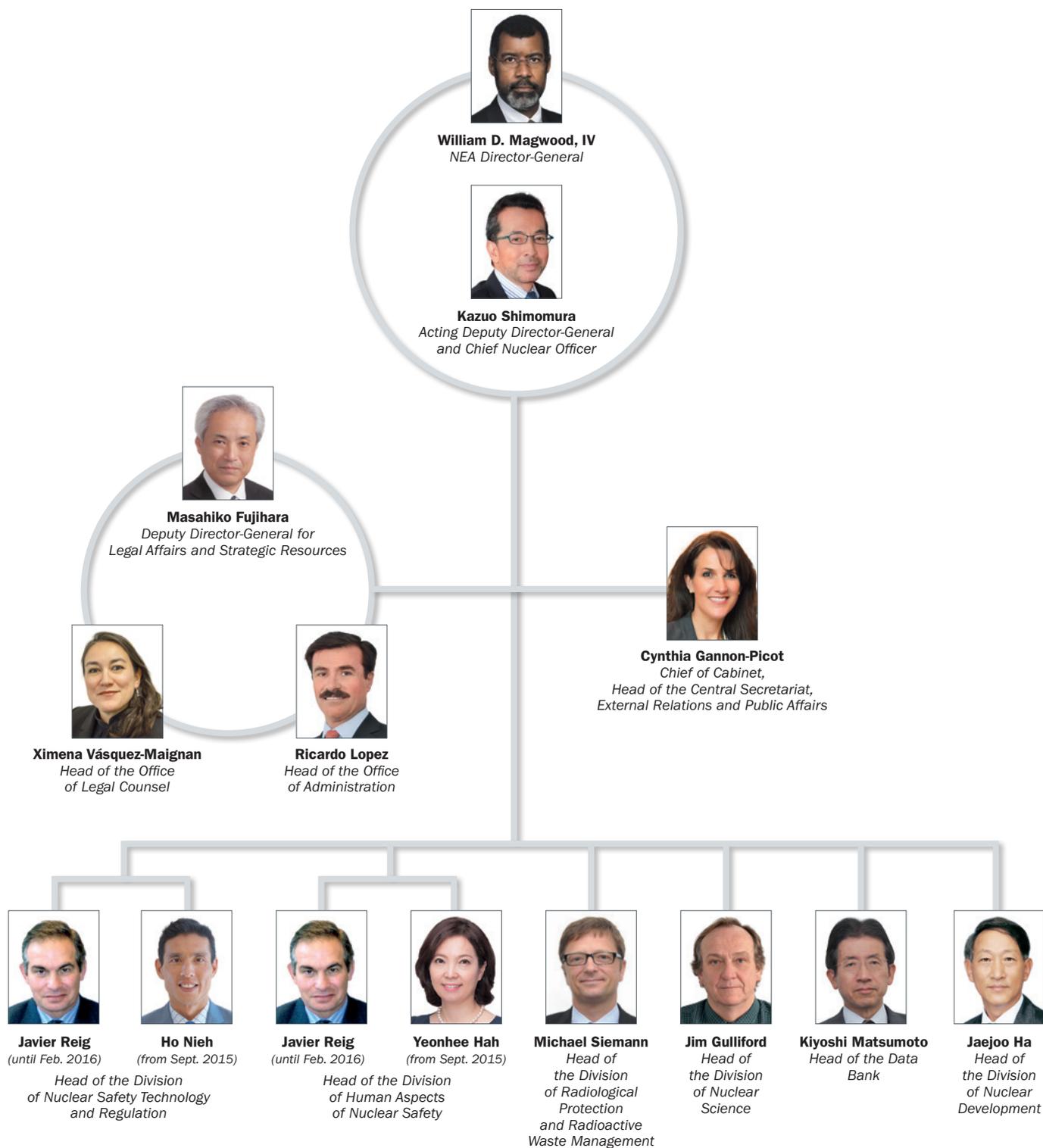
OECD headquarters.



NEA Committee Structure in 2015



NEA Management Structure in 2015



NEA Publications and Brochures Produced in 2015

All NEA publications are available free of charge on the NEA website.



► General interest

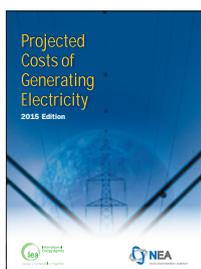
AEN Infos, No. 32.1-32.2
AEN n° 7240. 40 pages.

Annual Report 2014
NEA No. 7238. 60 pages.

Rapport Annuel 2014
AEN n° 7239. 64 pages

NEA News, No. 33.1
NEA No. 7241. 28 pages.

NEA News, No. 33.2
NEA No. 7243. 40 pages.



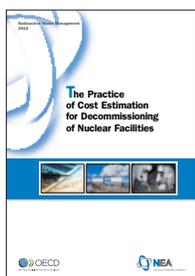
► Nuclear development and the fuel cycle

Nuclear Energy Data 2015/Données sur l'énergie nucléaire 2015
NEA No. 7246. 106 pages.

Nuclear New Build: Insights into Financing and Project Management
NEA No. 7195. 244 pages.

Projected Costs of Generating Electricity – 2015 Edition
(Joint publication with the IEA)
NEA No. 7057. 212 pages.
Full publication on sale (NEA Delegates may contact the NEA).

Technology Roadmap: Nuclear Energy – 2015 Edition
(Joint publication with the IEA)
NEA No. 7257. 64 pages.
Also available in Chinese.



► Radioactive waste management

Fostering a Durable Relationship Between a Waste Management Facility and its Host Community: Adding Value Through Design and Process – 2015 Edition
NEA No. 7264. 66 pages.

Radioactive Waste Management and Constructing Memory for Future Generations
Proceedings of the International Conference and Debate, 15-17 September 2015, Verdun, France
NEA No. 7259. 177 pages.

Stakeholder Involvement in Decision Making: A Short Guide to Issues, Approaches and Resources
NEA No. 7189. 62 pages.

The Practice of Cost Estimation for Decommissioning of Nuclear Facilities
NEA No. 7237. 88 pages.



► Nuclear science and the Data Bank

Handbook on Lead-bismuth Eutectic Alloy and Lead Properties, Materials Compatibility, Thermal-hydraulics and Technologies

NEA No. 7268. 954 pages.

International Handbook of Evaluated Criticality Safety Benchmark Experiments

NEA No. 7281. DVD.

International Handbook of Evaluated Reactor Physics Benchmark Experiments

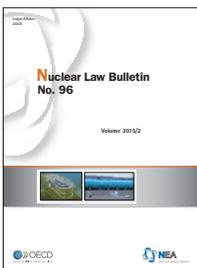
NEA No. 7258. DVD.

Introduction of Thorium in the Nuclear Fuel Cycle: Short- to long-term considerations

NEA No. 7224. 136 pages.

Review of Integral Experiments for Minor Actinide Management

NEA No. 7222. 137 pages.



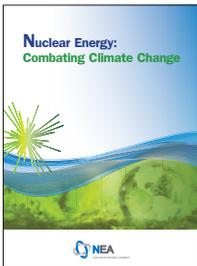
► Nuclear law

Nuclear Law Bulletin No. 95

NEA No. 7252. 157 pages.

Nuclear Law Bulletin No. 96

NEA No. 7254. 116 pages.



► Also available

How can stakeholder involvement be improved? (FSC Flyer)

NEA No. 7262. 4 pages.

Nuclear Energy: Combating Climate Change (brochure)

NEA No. 7208. 19 pages

Nuclear New Build: Insights into Financing and Project Management – Executive Summary

NEA No. 7196. 8 pages.

Perspectives on the Use of Thorium in the Nuclear Fuel Cycle – Extended Summary

NEA No. 7228. 20 pages.

Projected Costs of Generating Electricity – Executive Summary

NEA No. 7279. 8 pages.

The OECD Nuclear Energy Agency (brochure)

8 pages.

L'Agence de l'OCDE pour l'énergie nucléaire (brochure)

8 pages.

Also available in Chinese.



► Publications of Secretariat-serviced bodies

Generation IV International Forum (GIF) Annual Report 2014

124 pages.

Multinational Design Evaluation Programme Annual Report: April 2014-April 2015

56 pages.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where the governments of 34 democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

The OECD member countries are: Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission takes part in the work of the OECD.

OECD Publishing disseminates widely the results of the Organisation's statistics gathering and research on economic, social and environmental issues, as well as the conventions, guidelines and standards agreed by its members.

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1 February 1958. Current NEA membership consists of 31 countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, Russia, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission also takes part in the work of the Agency.

The mission of the NEA is:

- to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes;
- to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information.

The NEA Data Bank provides nuclear data and computer program services for participating countries. In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

Also available in French under the title:

AEN – RAPPORT ANNUEL – 2015

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NEA No. 7293

NEA member countries

(as of 1 January 2016)



Australia



Austria



Belgium



Canada



Czech Republic



Denmark



Finland



France



Germany



Greece



Hungary



Iceland



Ireland



Italy



Japan



Korea



Luxembourg



Mexico



Netherlands



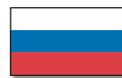
Norway



Poland



Portugal



Russia



Slovak Republic



Slovenia



Spain



Sweden



Switzerland



Turkey



United Kingdom



United States

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