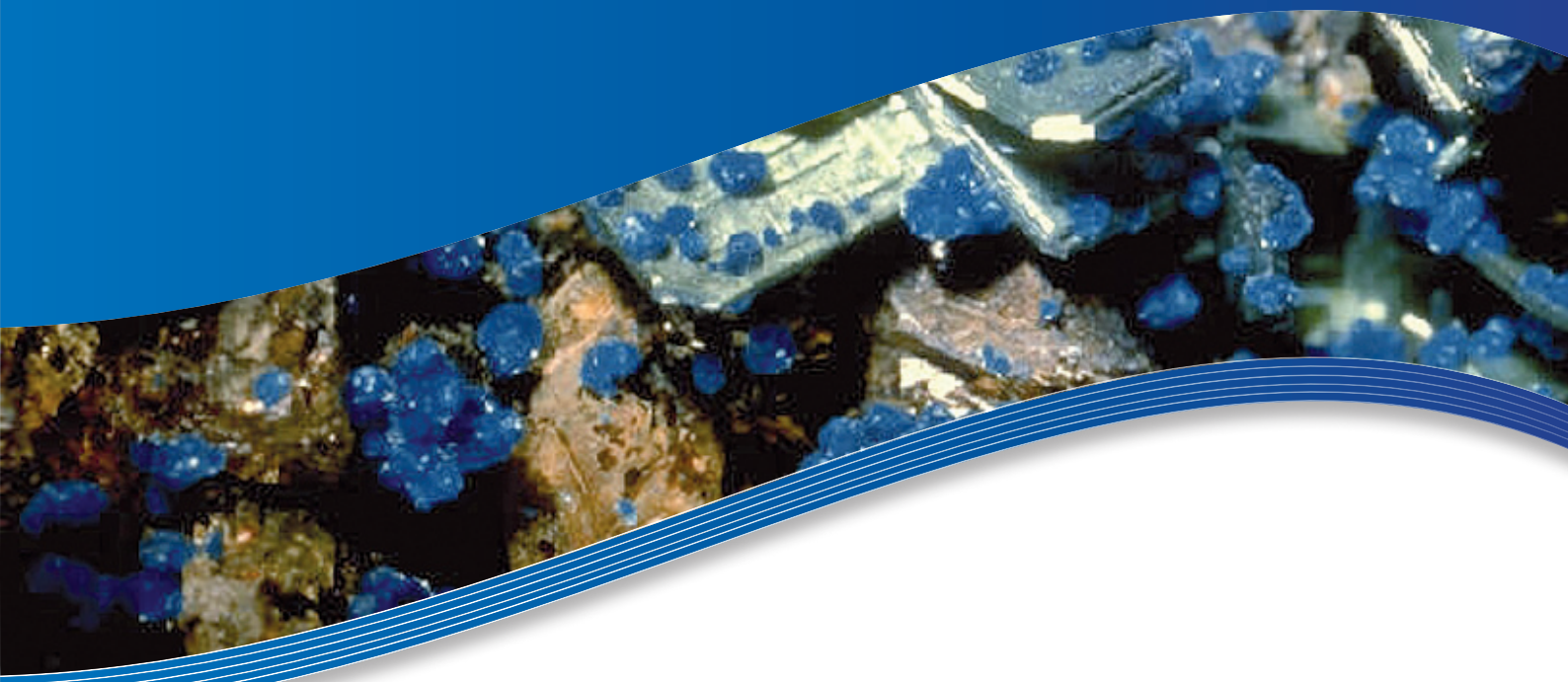
2012 NEA Annual Report



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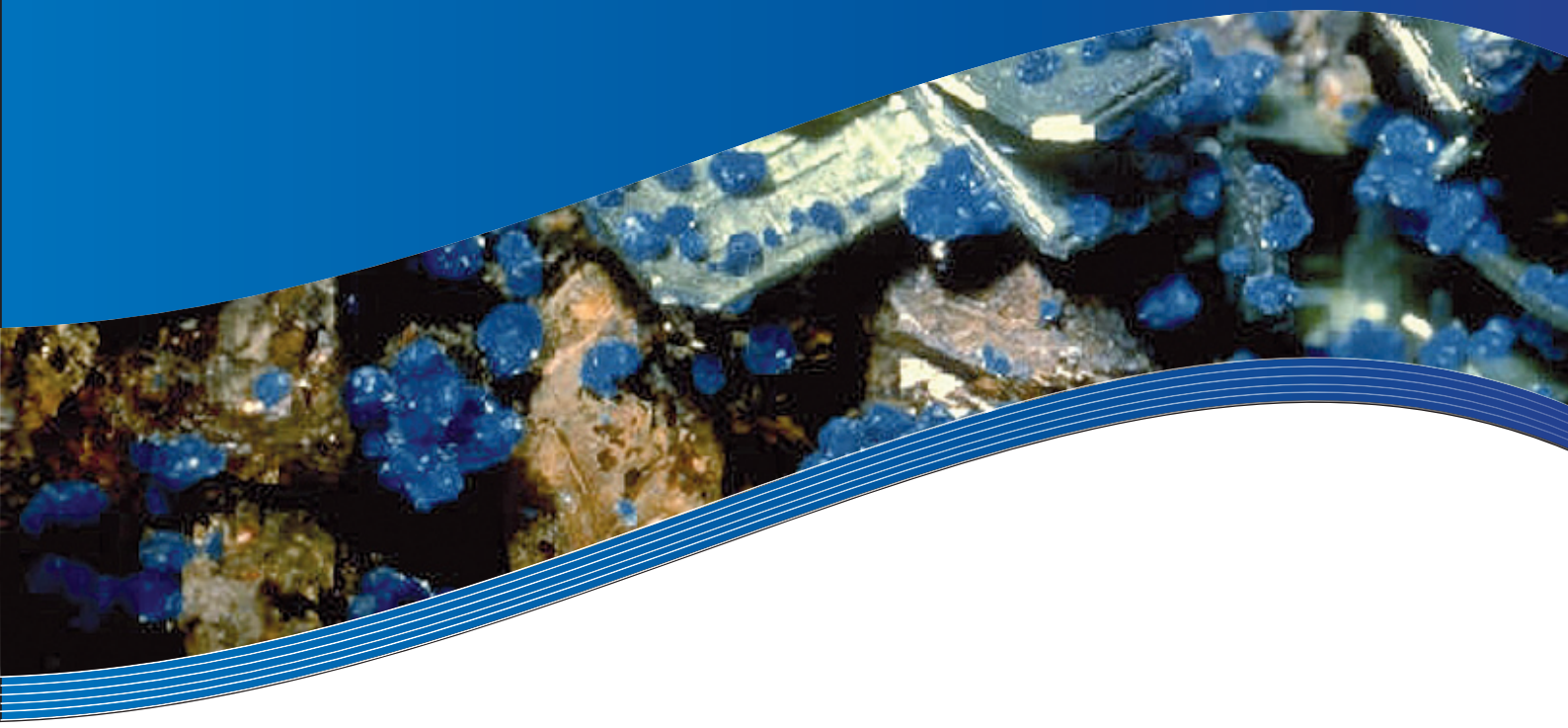
NUCLEAR ENERGY AGENCY

2012 NEA Annual Report



NUCLEAR ENERGY AGENCY

Organisation for Economic Co-operation and Development

The NEA in Brief – 2012

Governing body:
the Steering Committee for Nuclear Energy

30	member countries (23 in the Data Bank)
54	years of international service
7	standing technical committees
71	working parties and expert groups
21	international joint projects funded by participants
78	professional and support staff (NEA and the Data Bank combined)
€ 10.4	million budget for the NEA, supplemented by voluntary contributions
€ 3.0	million budget for the Data Bank, supplemented by voluntary contributions
48	publications produced

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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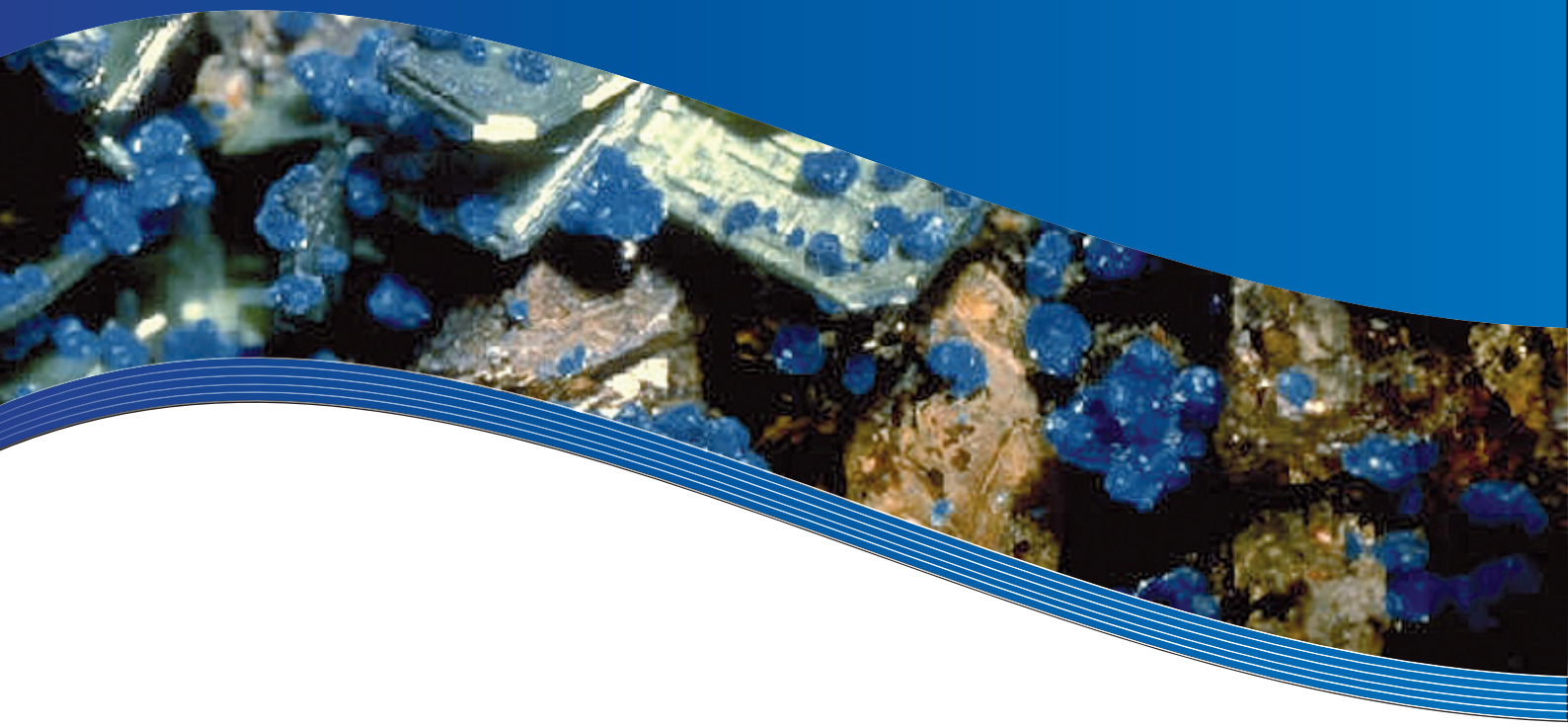
The European Commission (EC) takes part in the work of the NEA. A co-operation agreement is in force with the International Atomic Energy Agency (IAEA). The NEA also maintains contacts with several non-member countries as well as the nuclear industry and a number of civil society organisations.



Message from the Director-General

2012 was marked by a number of significant events and developments for the Agency. The first concerned laying the foundations for an enlargement of the NEA membership.

After two decades of increasingly important co-operation with the NEA, notably in the area of nuclear safety and technology development, on 26 April 2012 the Steering Committee for Nuclear Energy examined the application of the Russian Federation to the NEA and its Data Bank, and agreed on the great value of accession of this major player in the nuclear energy field. Member countries fully supported this enhanced co-operation on the basis of the mutual benefit it would provide, and the contribution it would make to further reinforcing nuclear safety worldwide and the sharing of best practices on all aspects of nuclear energy and its fuel cycle. The OECD Council subsequently approved the application and on 23 May 2012, during the OECD Council Meeting at Ministerial Level, an official exchange of letters took place to formalise accession as from 1st January 2013. This marked a very significant step in the continuing development of the NEA and in strengthening the depth and breadth of its work.

Throughout 2012, the NEA continued to work diligently on the follow-up to the Fukushima Daiichi nuclear power plant accident. As shown in the pages that follow, this work was spearheaded by the Committee on Nuclear Regulatory Activities (CNRA), the Committee on the Safety of Nuclear Installations (CSNI) and the Committee on Radiation Protection and Public Health (CRPPH), with all NEA committees involved in their respective areas of expertise. A report highlighting the activities of the NEA member countries and the Agency to identify key issues and to implement lessons learnt is under preparation for release in 2013. It will cover specific activities and outcomes in such areas as regulatory infrastructure, accident management, defence-in-depth, emergency preparedness and planning, crisis communications, radiological protection, decontamination and recovery, and liability and compensation regimes.

The Agency also continued to offer its direct assistance to the Japanese authorities. Immediately following the accident, this primarily concerned the development and implementation of national safety reviews and stress tests as well as the main elements to achieve effective regulatory reform, and was then extended to best practices in the remediation of land contaminated with radioactive materials, the planning and effective management of decontamination activities, and the long-term planning for the decommissioning of the Fukushima Daiichi nuclear power plant. These too will be reflected in the NEA report.

Finally, two years after the accident, perspectives concerning the future of nuclear power are becoming clearer. Now that nuclear regulators and power plant operators have had the possibility to assimilate some of the major lessons learnt, to implement a number of enhanced safety measures and to consider the implications of the accident in terms of additional safety features which could be necessary in some specific locations, many member countries are confirming a continuing role for nuclear power. Although many of them are also facing a financial crisis, and the availability and price of alternative energy sources, such as gas, are influencing the market, the importance of diversification of energy sources for security of electricity supply and of low-carbon technologies to help mitigate climate change are maintaining nuclear energy at the core of a number of energy policy discussions. As events have shown, the safety of this energy source will always remain the highest priority, and a precondition to its use. The work of the NEA in this regard, reflected in the *2012 Annual Report*, constitutes a very important contribution to the safety of both today's and tomorrow's reactors.

Luis E. Echávarri
NEA Director-General

The Fukushima Daiichi Accident and NEA Follow-up

Nuclear regulation

Immediately following the accident, the NEA began collecting information and sharing it among member countries. A web page was established to provide an overview of member countries' national follow-up activities. The NEA response to the Fukushima accident is being co-ordinated among the three NEA standing technical committees that address regulation and safety: the Committee on Nuclear Regulatory Activities (CNRA), the Committee on Radiation Protection and Public Health (CRPPH) and the Committee on the Safety of Nuclear Installations (CSNI). After the initial development of area-specific responses, a joint meeting of the three committees' bureaus was held to establish a shared way forward. The CNRA is leading the integrated post-Fukushima co-ordination of NEA nuclear safety activities. Each committee has determined the specific direction of its work while building upon the shared mandate of protecting public health and safety, and the environment.

The CNRA established a Senior-level Task Group on Impacts of the Fukushima Accident (STG-FUKU) on 23 March 2011 to identify regulatory and safety concerns as well as activities that would benefit from international collaboration; to carry out timely exchanges of information; and to maintain awareness and co-ordination of activities in other organisations. The CSNI and the CRPPH are represented on the STG-FUKU.

The STG-FUKU has been tasked with co-ordinating and monitoring the NEA's safety-related activities in response to the accident where an issue may be within the mandate of more than one standing technical committee. This includes CSNI activities related to a reassessment of the defence-in-depth philosophy; a reassessment of accident management issues; the development of a thorough understanding of the accident progression; and a review of precursor events to identify other areas that could have a similar impact on safety as the Fukushima Daiichi accident. In addition, the CSNI has undertaken activities to review approaches to considering internal and external hazards; to assess plant robustness and defence-in-depth considerations; to assess safety management in view of human and organisational issues; to study the implications of severe environmental conditions on human performance during emergency response; and to conduct research on severe accident progression and management. Activities within the scope of the CRPPH include evaluating offsite emergency preparedness issues, in particular: licensee, government and regulatory body command and control linkages during emergency response; the availability of onsite or offsite equipment and measurement capabilities; the co-ordination of recommendations among countries for the protection of their citizens; the comparison of release and dose calculations; and the roles and authorities of different organisations associated with emergency preparedness activities in different countries.

In 2012, committee-level discussions on the repercussions from and response to the Fukushima Daiichi accident continued. There were specific round-table discussions within both the CSNI and the CNRA on the topic of defence-in-depth, its concept and implementation in light of the Fukushima Daiichi accident. A one-day workshop to be held in Paris on 5 June 2013 on this topic is being organised jointly by the CSNI and the CNRA, and will also involve the CRPPH.

Nuclear safety and stress tests

Following the accident, every country with operating nuclear power plants conducted initial assessments of the continued safe operation of its plants. The reviews found that short-term actions taken by licensees provided assurance of the continued safe operation while more thorough evaluations of

TEPCO, Japan

Fukushima Daiichi NPP before the accident.

TEPCO, Japan

Tsunami wave overrunning the sea walls and flooding the Fukushima Daiichi nuclear power plant on 11 March 2011 (photo taken from unit 5).

the accident and the impact on safety were implemented. In many countries, the longer-term, more thorough evaluations have been called "stress tests", notably in Europe. On 4 October 2012, the European Commission released its Communication on the results of the comprehensive risk and safety assessments of nuclear power plants performed in 15 EU member states, Switzerland and Ukraine.

These efforts were a targeted reassessment of the safety margins of nuclear power plants in light of the severe external events that occurred at the Fukushima Daiichi nuclear power plant. They consisted of evaluations of the responses of a nuclear power plant to severe external events (single and multiple), and a verification of the measures chosen to prevent or mitigate an accident using a defence-in-depth logic that considers the initiating events, the consequential loss of safety functions and severe accident management. It was assumed that there was a sequential loss of the lines of defence following a deterministic methodology regardless of the probability of this loss. The reassessments examined the response of the plants, the effectiveness of preventive measures, the identification of weak points and cliff-edge effects. They also included evaluations of the robustness of the current defence-in-depth approach by looking at the adequacy of existing accident management measures and then identified the potential safety improvements, both technical and organisational, that are being considered to improve the capability of the plants to withstand accidents that may be caused by severe external hazards.

With regard to NEA support to the Japanese authorities on nuclear safety issues, on 17-18 January 2012, an NEA team of international experts met in Tokyo with members of the Japanese Advisory Committee for Prevention of Nuclear Accidents and the special Japanese Task Force for the Reform of Nuclear Safety Regulations and Organisations to foster increased understanding of various national regulatory organisations and approaches to regulatory oversight of nuclear power facilities. Participants discussed different approaches to reforming areas recommended by the Advisory Committee, such as those concerning independence, regulatory oversight, crisis management, human resources and development, new safety regulations, transparency and international aspects for regulatory organisations.

Crisis communication

A significant challenge encountered by both the Japanese authorities and the broader international community was effective communication during the Fukushima Daiichi accident, including with the public. For regulatory authorities, the NEA has a Working Group on Public Communication of Nuclear Regulatory Organisations (WGPC). The WGPC held a special meeting in September 2011 to follow up on lessons learnt from the Fukushima Daiichi accident and organised a Crisis Communication Workshop in Madrid on 9-10 May 2012. The workshop brought together senior-level regulators (11 top regulators

TEPCO, Japan

Emergency Response Headquarters during the Fukushima accident.

attended) and other stakeholders (the media, NGOs, industry, and parliamentary and municipal representatives) to identify efficient approaches and practices to improve crisis communications, to take into account the lessons learnt from the accident, and to collect insights for future guidance on international aspects of regulators' crisis communication programmes. The results from this workshop were used to strengthen the international dimension of the WGPC's Roadmap for Crisis Communication, the new version of which was adopted by the CNRA in December 2012.

Intergovernmental communications are an essential part of developing appropriate national responses to almost any nuclear or radiological emergency situation, and these communications certainly played a key role in responding to the Fukushima Daiichi accident. To assist governments in communicating more effectively, the NEA, through the Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE), collected government decisions (e.g. recommendations for foreign nationals in Japan and recommendations concerning airlines flying to or from Japan) for posting on the IAEA's Incident and Emergency Centre (USIE) website. To maximise learning from this event, the NEA performed an analysis of these decisions, not with respect to the national decisions taken but rather to the types of decisions taken, in order to better understand the quality of information that is needed by governments, and when.

Radiological protection

Because the Japanese government quickly recommended the evacuation of the 78 000 people living within 20 km of the plant, the sheltering of those living between 20 and 30 km from the plant, and the evacuation of a further 10 000 people living to the north-east of the plant in what was determined to be the most contaminated area, health-significant population exposures were avoided.

In 2011 and 2012, Japanese authorities, TEPCO and several other organisations estimated the amount of radioactive material released into the atmosphere by the Fukushima Daiichi accident (see Table 1). They also estimated the amount of radioactive materials released into the ocean (in the vicinity of a port) by the Fukushima Daiichi accident (see Table 2).

Table 1: Estimates of radioactive releases into the atmosphere

	Amount released (PBq[1])			
	Rare gas	I-131	Cs-134	Cs-137
TEPCO (24 May 2012)[2]	~500	~500	~10	~10
Japan Atomic Energy Agency, Nuclear Safety Commission (12 April 2011-12 May 2011)	-	150	-	13
Japan Atomic Energy Agency, Nuclear Safety Commission (22 August 2011)	-	130	-	11
Japan Atomic Energy Agency (6 March 2012)	-	120	-	9
Nuclear and Industrial Safety Agency (12 April 2011)	-	130	-	6.1
Nuclear and Industrial Safety Agency (6 June 2011)	-	160	18	15
Nuclear and Industrial Safety Agency (16 February 2012)	-	150	-	8.2
Releases from the Chernobyl nuclear power plant accident	6 500	1 800	-	85

1. 1 PBq (peta Becquerel) = 1 000 trillion Bq = 1 015 Bq.
2. The value estimated by TEPCO is rounded off to one decimal place and was originally reported in Bq.

Sources: www.tepco.co.jp/en/press/corp-com/release/2012/1204659_1870.html and www.tepco.co.jp/en/press/corp-com/release/betu12_e/images/120524e0201.pdf.

Table 2: Estimates of radioactive releases into the ocean

	Period of assessment	Released amount in PBq		
		I-131	Cs-134	Cs-137
TEPCO (Central Research Institute of Electric Power Industry)	26 March 2011-30 September 2011[1]	11	3.5	3.6
Japan Atomic Energy Agency	21 March 2011-30 April 2011[2]	11.4	-	3.6

1. The amount released from 21 March 2011, when the measurement of the concentration of radioactive materials in seawater near the water discharge canals was started, to 25 March 2011, was tentatively calculated to be about 0.1 PBq for Cs-137. The ratio of I-131 and Cs-137 suggests the predominance of releases into the atmosphere.
2. Includes the releases into the atmosphere.

Source: www.tepco.co.jp/en/press/corp-com/release/betu12_e/images/120524e0202.pdf.

Since the time of the accident, the status of contaminated areas has evolved. Based on a decision by the Japanese government once the safety of the plant was considered stable, and following the government's recovery plan of 26 December 2011, access to certain previously restricted areas has been reinstated in a phased manner. Allowing for a transition period and for tasks such as confirmation of infrastructure and security, the areas for which evacuation orders had been issued have been organised into three areas responding to the annual cumulative doses since April 2012 as follows:

1. 1mSv~20 mSv:	Areas for which evacuation orders are ready to be lifted.
2. 20mSv~50 mSv:	Areas in which residents are not permitted to live.
3. 50 mSv~:	Areas where it is expected that residents will face difficulties in returning for a long time.

In response to the accident, the Fukushima prefectural government developed and implemented the Fukushima Health Survey to facilitate suitable healthcare in the future. The results from this survey will be used to estimate individual external exposures received between 11 March 2011 and 11 July 2011. These estimates will be used as basic data in health exams scheduled to be conducted for former residents of evacuated areas, as well as for future long-term health care. The survey is being conducted in the form of a self-report questionnaire.

This health survey was first issued to the residents of three towns (Namie, Iitate and Kawamata) near the Fukushima Daiichi nuclear power plant and was then extended to all residents of Fukushima prefecture. By 5 December 2012, the health survey had been sent to 361 906 residents in Fukushima prefecture. For 354 736 residents (all residents except for radiation workers), this survey showed that most received less than a few mSv of exposure. The highest effective dose was 25 mSv as shown below.

Table 3: Health survey of effective dose rates
(5 December 2012)

Effective dose (mSv)	Number of residents excluding radiation workers
Less than 1 mSv	234 929
1 to 2 mSv	101 738
2 to 3 mSv	15 464
3 to 4 mSv	1 122
4 to 5 mSv	527
5 to 10 mSv	838
10 to 15 mSv	106
More than 15 mSv	12
Total	**354 736**
Maximum effective dose	25 mSv

Source: Fukushima Prefecture website.
www.pref.fukushima.jp/imu/kenkoukanri/20121227kihontyousa.pdf.

Radiation workers showed somewhat higher doses during this time period.

In addition to this estimate of public doses, according to a TEPCO press release on 27 December 2012, approximately 24 940 workers (TEPCO and contractor) participated in response activities at the Fukushima Daiichi nuclear power plant from March 2011 to November 2012. Those who participated in onsite recovery activities in March 2011 and April 2011 received the highest exposures. To date, 167 workers have received over 100 mSv with the highest dose being 678.8 mSv.

There were no cases of immediate radiation sickness in workers or in members of the public. This was as expected based on current scientific understanding, as such effects appear only after exposures of greater than 1 000 or 2 000 mSv. The NEA continues to provide the experience of its other member governments to assist the Japanese authorities with recovery.

Final exposures to the public will be determined as time passes, and the Japanese government has initiated a long-term health programme to provide regular surveillance of those exposed.

Decontamination and recovery

The most significantly contaminated areas are mostly in Fukushima prefecture, although contamination can be measured in many areas of Japan. The Japanese government has initiated a vast programme of decontamination and recovery, focusing on those areas where estimated doses to people living there would exceed 1 mSv in a year. The Japanese central government itself is taking charge of areas where people have been evacuated (where estimated annual doses would be greater than 20 mSv). Municipalities, with support from the Japanese government, are responsible for developing and implementing decontamination programmes where the populations still living in the areas are estimated to be exposed to doses between 1 and 20 mSv per year. Although technically challenging, the rehabilitation of living conditions in these affected areas is achievable, but only through extensive involvement of the exposed populations themselves in identifying local priorities, customs and needs.

The NEA has been supporting Japanese recovery efforts through a series of workshops and seminars intended to provide examples of extensive experience in stakeholder involvement to the Japanese government from other NEA member country governments, in particular those which have been addressing the consequences of the Chernobyl accident for the past 25 years. For example, the NEA participated in the organisation of a symposium on the Experience and Technology of Russia, Ukraine and Belarus on Remediation and Restoration of Environments, which took place in Tokyo on 4 February 2012, and organised a one-day session on stakeholder involvement in Fukushima City on 5 February 2012.

In addition, the NEA has supported and participated in four dialogues organised by the International Commission on Radiological Protection (ICRP), which have brought together affected stakeholders from Fukushima prefecture and the Tokyo area with international experts from France, Norway and Belarus with extensive post-Chernobyl experience. The meetings, held in November 2011, February 2012, July 2012 and November 2012, were hosted by municipalities in Fukushima prefecture. Participants discussed their concerns regarding general, agricultural and food distribution issues, as well as education and information issues. The experience from these meetings is being summarised by various Japanese NGOs involved in the process. The NEA will continue to participate in and support these meetings, the next of which is scheduled to take place in March 2013.

The NEA also participated in the International Symposium on Remediation of Site Contamination Caused by the Fukushima Accident in Fukushima in May 2012, organised by the Society for Remediation of Radioactive Contamination in the Environment and co-organised by the Ministry of the Environment of Japan. At the symposium, the NEA presented the Agency's extensive decommissioning and waste management experience.

Nuclear Power in 2012

Nuclear energy development

Worldwide reviews of the safety of nuclear facilities were the main activity in 2012 as NEA member countries tested the ability of nuclear facilities to withstand beyond-design-basis events (in particular severe earthquakes and flooding) in response to the 2011 accident in Japan at the Fukushima Daiichi nuclear power plant. Nuclear energy development was delayed overall, but varied across regions and according to national policies. In Asia and the Middle East, new construction and projects moved ahead, while low natural gas prices and the global financial crisis continued to limit nuclear energy development elsewhere.

At the end of 2012, there were 331 reactors in operation in the NEA's 30 member countries. The construction of two new reactors was completed in the Republic of Korea (Shin-Wolsong 1 and Shin-Kori 2), while two reactors reached the end of their operational lifetime and were shut down in the United Kingdom, and one was closed in Canada because the operator decided not to make the investment required to extend its operational lifetime. At the end of 2012, nuclear electricity generating capacity in NEA countries constituted about 81% of the world total; production accounted for some 20% of their total electricity supply.

Significant developments that occurred in NEA member countries included:

- In Belgium, the coalition government announced in July that all seven reactors in the country were to be closed by 2025 after about 40 years of operation, with the exception of the Tihange 1 reactor which, owing to security of energy supply concerns, will be allowed to operate for 50 years.
- In Canada, Bruce Power reactors 1 and 2 (laid up since the 1990s) were returned to service. Refurbishment of the Point Lepreau reactor was completed. In addition, an environmental assessment of the construction of up to four new reactors at Darlington concluded that the project will not result in any significant adverse environmental impacts.
- In the Czech Republic, the state power company ČEZ received bids in July for the construction of two additional reactors at the Temelin site, with the winning bid expected to be announced in 2013.
- In Finland, cost overruns and delays continued to plague the construction of the Olkiluoto 3 reactor. E.ON announced its intention to sell its 34% stake in the Fennovoima nuclear power consortium formed to build a new reactor in Pyhajoki as from 2015.

2012 nuclear data summary (as of 31 December 2012)

	Operational reactors	Installed capacity (GWe net)	Uranium requirements (tonnes U)	Nuclear share of electricity production (%)
Belgium	7	5.9	1 030	50.5*
Canada	19	13.5	1 650*	17.0*
Czech Republic	6	3.8	670	35.3
Finland	4	2.7	370	32.6
France	58	63.1	2 000	77.8
Germany	9	12.1	1 700	16.2
Hungary	4	1.9	435*	43.2*
Japan	50	44.2	6 400*	18.1*
Mexico	2	1.4	180	3.5
Netherlands	1	0.5	60	4.4
Republic of Korea	23	20.7	4 200	29.6
Slovak Republic	4	1.8	375	54.5
Slovenia	1	0.7	150	34.7
Spain	8	7.5	940	20.5
Sweden	10	9.4	1 470*	39.6*
Switzerland	5	3.2	120*	39.4*
United Kingdom	16	9.2	1 435*	17.8*
United States	104	101.4	22 865*	19.7*
Total (OECD)	**331**	**303.0**	**52 340**	**20.7***

* 2011 data. Operational = connected to grid.

Shares of uranium resources and production			
	Resources (%)*	Production (%)**	Production (tU)**
Australia	31.0	12	7 000
Canada	9.0	16	9 000
United States	3.8	3	1 600
Namibia	5.3	8	4 250
Niger	5.0	8	4 300
South Africa	5.5	1	600
Kazakhstan	12.1	37	20 900
Russian Federation	8.9	5	3 000
Uzbekistan	2.1	4	2 500
Ukraine	1.9	2	900
Others	15.4	4	2 150
Total	**100.0**	**100**	**56 200**

* Identified resources recoverable at less than USD 130/kgU (2011 data). ** 2012 estimates.

- In France, the newly elected president announced his intention to reduce the country's reliance on nuclear power for electricity production from 75% to 50% by 2025, beginning with the closure of the country's oldest nuclear power plant (Fessenheim) by end of 2016. A national debate on energy policy was launched in November 2012.
- In Japan, a new independent Nuclear Regulation Authority was created while the role of nuclear power in the country's energy mix continued to be the subject of intense debate. All but two of the country's 50 operational reactors had not been brought back into service, increasing the country's reliance on imported energy sources (mainly natural gas).
- In the Republic of Korea, two reactors were added to the grid and construction was initiated at Shin Ulchin 1, but nuclear development plans were delayed as government approvals took longer than expected and incidents occurred at certain operating reactors.
- In Poland, the first Transboundary Strategic Environmental Impact Assessment was carried out as part of the country's developing nuclear power programme. The launch of a tender for the country's first nuclear power plant was postponed while formal arrangements for the project, including the involvement of a strategic partner and debt financing, were finalised.
- In Sweden, Vattenfall submitted an application to build reactors to replace those that would reach the end of their operational lifetime in the 2020s, stating that undertaking the application process was required to compile all the information needed to make an investment decision, expected within ten years.
- In Switzerland, the government released a national energy strategy for public consultation that outlines an energy roadmap to 2050 featuring reduction in demand and expansion of hydroelectric and renewable energy sources as a way of gradually reducing and eventually abandoning nuclear power.
- In Turkey, the government advanced plans for the construction of two additional nuclear power plants after finalising arrangements for the construction of four units at the first nuclear power plant, Akkuyu on the Mediterranean coast, which will be built, owned and operated by the Russian Federation.
- In the United Kingdom, EDF Energy was awarded the first new site preparation licence for a nuclear power plant in 25 years for the planned Hinkley Point expansion, as industry continues to advance toward the construction of 16 GWe of nuclear generating capacity by 2025.
- In the United States, the first new nuclear reactor licences in three decades were issued for four reactors. Construction at the Vogtle and VC Summer sites was initiated while a plan to complete construction of the partly built Bellefonte 1 was approved. Work continued to complete construction of the Watts Bar 2 reactor. In parallel, in June the Nuclear Regulatory Commission (NRC) suspended all reactor licensing decisions pending completion, targeted for no later than September 2014, of a new waste confidence environmental impact statement and rule made necessary after a Court of Appeals found that aspects of its 2010 revised waste confidence rule regarding long-term storage of spent fuel did not satisfy the NRC's National Environmental Policy Act obligations.

Reassessments of nuclear power safety were also undertaken outside NEA member countries, notably in China, which has the most rapidly expanding nuclear power programme worldwide. After an initial pause in licensing additional reactors following the Fukushima accident, near the end of 2012 the Chinese government announced that permits would once again be issued for the construction of new reactors, but for the moment only on coastal locations and at a slower rate than previously planned. One reactor was connected to the grid outside the NEA area in 2012 (in Ningde, China) and construction was initiated on six reactors (four in China, all in the latter part of the year, and one each in the Russian Federation, which will be an NEA member as from 1 January 2013, and the United Arab Emirates).

Uranium production, conversion and enrichment

Preliminary, unofficial data indicate that global uranium production increased by about 3% in 2012, principally owing to increased production in Kazakhstan and, to a lesser extent, in Namibia and Niger. Uranium was produced in seven NEA member countries in 2012, although France, Germany and Hungary contributed only very small amounts as part of mine remediation activities. Australia (12%), Canada (16%), the Czech Republic (<1%) and the United States (3%) together accounted for a significant share of world production. Production in NEA countries amounted to approximately 17 850 tonnes of uranium (tU) in 2012, an increase of about 6% from 2011, covering roughly 35% of NEA member country uranium requirements. Remaining requirements were met by other producing countries and secondary sources (material derived from dismantling warheads, excess commercial inventories and reprocessed uranium).

Uranium conversion facilities were in operation in Canada, France, the United Kingdom and the United States. Construction of additional conversion capacity continued in France, with limited production initiated in 2012 with the idea of gradually building to nominal capacity by 2016. In the United States, the Metropolis conversion facility entered into an extended shutdown in May 2012 in order to implement upgrades required by the regulator to strengthen the facility's resistance to earthquakes and tornadoes.

Two recently constructed, high-efficiency uranium centrifuge enrichment plants (AREVA's Georges Besse II plant in France and URENCO's facility in the United States) continued commercial operation through 2012, with capacity expansions currently underway at both facilities. AREVA Enrichment Services decided to delay construction of its proposed centrifuge Eagle Rock Enrichment Facility at Idaho Falls in the United States. Development of the US Enrichment Corporation's American Enrichment Plant continued at a reduced pace pending a US Department of Energy loan guarantee decision. The GE-Hitachi Global Laser Enrichment project received a construction and operating licence for a potential commercial production facility at the site of the existing Paducah gas diffusion enrichment plant. The Paducah gas diffusion plant is expected to close in 2013, and the feasibility of re-enriching about 100 000 tonnes of high assay enrichment tails stored on the site using laser enrichment is being investigated. The EURODIF Georges Besse gas diffusion enrichment plant was closed in June 2012 after 33 years of uninterrupted operation.

AREVA, France

Georges Besse II.

Nuclear safety and regulation

As described earlier in this report, a number of activities have been undertaken by the international community to identify and to address the lessons learnt from the Fukushima Daiichi nuclear power plant accident. Preliminary safety assessments were promptly conducted by every regulatory authority in countries with established nuclear power programmes to evaluate the safety of their operating nuclear power plants under similar severe conditions. These preliminary safety assessments concluded that the existing nuclear power plants were safe for continued operation while longer-term programmes were implemented to assess safety enhancements to improve the protection of public health and the environment. The lessons learnt have emphasised the importance of continuing to enhance the safety of nuclear power plants by, for example, ensuring the robustness of their designs to withstand severe natural phenomena and other hazards; applying defence-in-depth approaches to ensure that mitigative strategies are in place to address the loss of electrical power and ultimate heat sink; developing and sustaining strong safety cultures in operating organisations and regulatory bodies; and understanding the importance of effective communication during a crisis. Accordingly, NEA member countries have been actively engaged in assessing and implementing actions in response to the lessons learnt and in developing comprehensive approaches for regulatory bodies to consider as they enhance their regulatory framework in response to the Fukushima Daiichi accident.

At the same time, several countries are also licensing and constructing new reactors. A number of initiatives have been undertaken to share experience related to the regulation of new reactors, including an NEA workshop on the safety of new reactors, held in Atlanta in the United States in October 2012, or are continuing, such as the Multinational Design Evaluation Programme (MDEP) to improve the efficiency of the design review of new nuclear reactors. International collaborative efforts are yielding improvements in regulatory practices as well as enhanced knowledge and understanding of new technology. The initiatives are seeking to reinforce nuclear safety worldwide, by promoting convergence on safety practices and combining the expertise of participating regulatory authorities, while improving and expediting the safety review of new designs. The lessons learnt from the Fukushima Daiichi accident will also impact the design requirements of new reactors.

New approaches, new concepts and new technology often present new issues for nuclear safety. The development and validation of new analytical tools and research is necessary to support the identification and resolution of new or unique safety issues based on the technology of advanced designs. Regulatory and safety practices for advanced designs have the greatest potential for international harmonisation and should be pursued to the extent practical. Likewise, international collaborative projects and cost-sharing have significant potential for mutual gains.

Radioactive waste management

Significant efforts are being expended in NEA member countries in the field of radioactive waste management. Many countries are establishing or updating their national waste management plans, some in order to prepare for the entry into force of the directive adopted by the Council of the European Union on 19 July 2011. Under this directive, the member states of the European Union are asked to establish, maintain and implement comprehensive national programmes covering the management of all spent fuel and radioactive waste from generation to disposal. The directive also calls for provisions for ensuring and reinforcing transparency and public participation in decision making. In several countries, there have been amendments to legislation during 2011-2012.

In the United States, the Blue Ribbon Commission on America's Nuclear Future released its recommendations to the US Administration on the management of spent fuel and high-level waste in January 2012. The report confirms the international finding that geological disposal is the only practicable final solution for such waste and calls for a programme that will lead to a national repository within a few decades. The approach to be taken should be staged, adaptive and consent-based. The Swedish industry submitted a licence application to begin implementation of the industrial programme of spent fuel disposal in Sweden in the municipality of Östhammar. The Finnish industry submitted a licence to start constructing a spent fuel repository in the municipality of Eurajoki. Progress was made in France, where a national debate was announced for 2013 on the industrial development of a specified area in the Meuse/Haute Marne departments for a geological repository of high-level and long-lived, intermediate-level waste.

In Switzerland, the siting process for deep disposal of radioactive waste has moved into its second phase. In Canada, a number of local communities have expressed interest in pursuing a dialogue with industry on a spent fuel repository. Efforts are now focusing on conducting the detailed studies required in the interested communities. News is awaited from the United Kingdom as to whether communities that participated in a first pre-siting stage will issue an expression of continued interest. In the Czech Republic, the siting process for a spent fuel repository is now restarting under the guidance of a multi-stakeholder Working Group on Transparency, an advisory body to the government.

In Germany, discussions are ongoing as to whether to restart the siting programme for a geological repository for high-level waste. In Japan, the high-level waste management programme has been delayed pending post-Fukushima discussions. Elsewhere, the Fukushima Daiichi accident does not seem to have had any significant influence on radioactive waste management programmes or on relationships between the waste management institutions and civil society.

Overall, there has been good progress in both technical and societal development of geological disposal but, in many countries, the timing of the implied decision-making processes makes it necessary to consider storage for extended periods of time, notably in Germany, Japan, Spain and the United States.

Progress has also been made in the low-level waste area. In Belgium, a licence application for a surface disposal facility at Dessel was in its final stages of preparation. In Canada, a regulatory process is underway for approval of a deep geological repository for low- and intermediate-level waste in Ontario. In Hungary, excavation was completed of two more disposal chambers in the Bátaapáti repository. As decommissioning programmes are implemented, the rate of production of very low-level and low-level waste will increase, and waste management organisations will need to accommodate this increase in activity, for example through the extension of existing disposal facilities.

Decommissioning plans continue to be updated regularly in NEA countries and new projects have been started. For instance, Italy began the second phase of decommissioning of a fuel fabrication plant. Furthermore, as the accident at Fukushima Daiichi has led some countries to phase out nuclear energy production at a faster pace or not to renew the lifetime extensions of nuclear power plants, this will soon result in an increase in decommissioning activities for which preparations need to be made. Experience shows 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

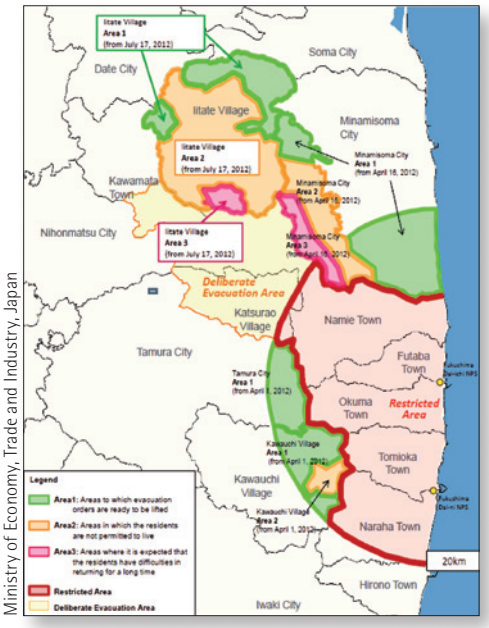
The most significant radiological protection events of 2012 continued to be those resulting from the accident at the Fukushima Daiichi nuclear power plant. An overview is provided on page 7, but the impact on the system of radiological protection is still being assessed.

The early phase of the accident raised several questions which are now being studied nationally and internationally. The early availability of information is, in any accident situation, a difficult issue fraught with uncertainties, and this proved to be the case during the Fukushima Daiichi accident.

This concerned not only the availability of information coming from the accident site, but also the sharing of information and of accident assessment considerations among countries working to protect their citizens in Japan. Discussions are underway regarding how to be better prepared to provide information and to communicate effectively and efficiently among relevant national authorities. As part of these discussions, the designation of emergency planning zones is also a key issue. Before the Fukushima Daiichi accident, most evacuation zones around nuclear installations were around 2-10 km in radius. Now, with long-duration and multi-unit accident scenarios being reconsidered, the size of emergency planning zones is being re-evaluated.

Various aspects of recovery planning, at both the national and international levels, are also being re-evaluated as a result of the Fukushima Daiichi accident. National approaches and criteria for the return of evacuated populations to their homes, workplaces and businesses are being reconsidered in view of the large areas of significant contamination in Japan, and the large-scale decontamination efforts that continue to be undertaken. Post-Chernobyl international approaches to the management of food and goods coming from contaminated territories resulted in some confusion during the Fukushima Daiichi accident and are being reviewed. The overall costs of a large-scale nuclear accident, including such aspects as social detriment, are also being re-evaluated to facilitate recovery and liability planning.

As these emergency and recovery management issues are discussed nationally and internationally, they are also being considered by the International Commission on Radiological Protection (ICRP) which is re-evaluating its two 2009 recommendations addressing the protection of people in emergency exposure situations and during post-accident recovery (Publications 109 and 111 respectively), and by the International Atomic Energy Agency (IAEA) and several co-sponsoring organisations which are updating the 2002 IAEA requirements document on emergency management (IAEA GS-R-2). In all these areas, experience from Fukushima Daiichi strongly suggests the need for stakeholder involvement in planning and implementing both emergency and recovery management.



Restricted areas and areas to which evacuation orders have been issued (as of 15 April 2012).

Nuclear science

Enhancing the capacity of light water reactors (LWRs) to withstand an accident has become a topic of increasingly detailed technical discussion. Programmes of work at national and international level are being initiated to study alternative fuel and cladding materials with enhanced capability to retain radioactive nuclides during extreme events. While there is broad consensus on the desired characteristics of these alternative materials (avoidance of hydrogen production and exothermic reactions with steam, increased thermal conductivity, higher melting point, etc.), the net benefits of moving away from the well-established zircaloy/uranium dioxide fuel design is open to much debate. It is clear that such a move could only be sanctioned and supported after an extensive testing and simulation programme.

Regarding simulation, there are an increasing number of studies being reported where the evolution of the reactor cores at Fukushima Daiichi Units 1 to 3 has been modelled and compared with plant information as it continues to become available. These analyses are starting to provide a detailed picture of how the accident progressed, providing insights into the role played by the fuel and cladding designs as well as other aspects of the plant design such as pressure/containment vessels and pressure venting arrangements. This type of severe accident modelling will provide crucial information needed to optimise recovery plans at the reactor sites. It is also relevant to the development of new fuel designs by providing a means to quantify the effectiveness of such designs in reducing the consequences of this type of accident.

Research activities in support of advanced reactor systems are set to continue with further refinement of established design concepts over the next few years. For future reactor systems, there has been a continued trend towards the study and development of systems and fuel designs which help minimise waste arising. Some proposed fuel designs include the presence of significant quantities of minor actinides as part of transmutation strategies, and there continues to be interest in the possibility of switching from the current uranium/plutonium fuel cycle to a thorium/uranium-233 approach. Notwithstanding the current dedication of resources to Fukushima-related analyses, interest in advanced nuclear systems remains strong, and the lessons emerging from analysis of the accident may be expected to steer the development of some parts of the associated research programmes.

Noting the various drivers to seek improved fuel and material performance, it seems likely that this will continue to be a key issue. With the closure of many of the world's high fluence irradiation facilities, there may be increasing reliance on detailed computer modelling of material performance, including the application of multi-scale modelling methods.

Many of the technical areas referred to above have seen a steady decline in the number of technical experts actively involved in research programmes. With continued high rates of retirement, the need to train, educate and develop a new generation of technical specialists is likely to become increasingly acute.

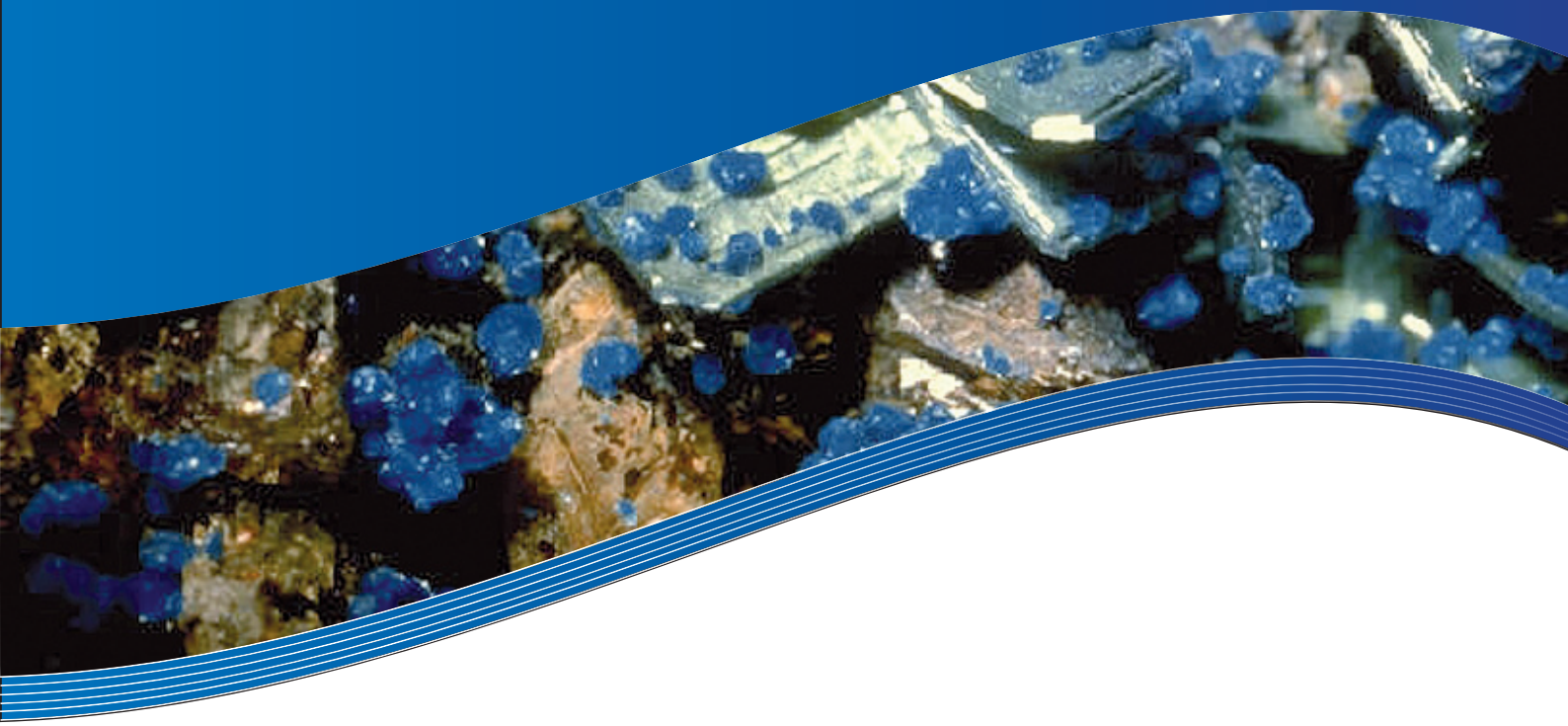
Nuclear law

Ensuring that adequate and equitable compensation is made available to victims who suffer injury or damage as a result of a nuclear accident occurring at a nuclear installation or during the transport of nuclear substances remains a primary concern of NEA member countries. Following the Fukushima Daiichi accident in Japan, the international nuclear law community concentrated on assessing and learning from the liability and compensation issues faced by the Japanese government. The accident also gave rise in several countries to a thorough review of nuclear laws and regulations, mainly regarding nuclear safety, which sometimes led to their modification or streamlining and, exceptionally, to a planned nuclear phase-out. Several countries also considered or implemented legislation to strengthen or improve their regulatory organisations responsible for licensing and oversight of nuclear installations and materials.

The NEA member countries that signed the 2004 Protocols to amend the Paris Convention on Third Party Liability in the Field of Nuclear Energy (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, provisions that 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 than ever before. A majority of the signatories to both protocols are now ready to deposit their instruments of ratification of these protocols. It is expected that Belgium, Italy and the United Kingdom will adopt ratification and implementing legislation which should allow the 2004 Protocols to enter into force by the end of 2013. Belgium has, however, already adopted transitory legislation in 2011 which transposes the compensation levels provided in the 2004 Protocols. Some signatories, such as Spain and Finland, have adopted temporary amendments to their nuclear liability legislation which increase the existing amounts of liability while waiting for such protocols to come into force.

In addition, countries that are not signatories to the above-mentioned conventions continue to modernise their third party liability regimes. The United Arab Emirates, the first country to start the construction of its first nuclear power plant in 27 years, ratified in 2012 the 1997 Protocol to amend the 1963 Vienna Convention on Civil Liability for Nuclear Damage (Vienna Convention) and the 1988 Joint Protocol, which establishes a link between the Paris and Vienna Conventions. The 1997 Convention on Supplementary Compensation for Nuclear Damage has been ratified by only four countries (Argentina, Morocco, Romania and the United States). This convention will enter into force 90 days after the date on which at least five states with a minimum of 400 000 "units" of installed nuclear capacity (or roughly 400 000 MWth of installed capacity as defined in the convention) have done the same.

Technical Programmes



Nuclear Development and the Fuel Cycle

Nuclear Development Committee (NDC)

The NDC continues to support member countries in economic assessments of nuclear energy, including the direct and indirect costs of nuclear power generation and the economics of the fuel cycle, as well as in the reliable application of nuclear technology and the examination of nuclear power's potential to mitigate greenhouse gas emissions and enhance security of supply.

Highlights

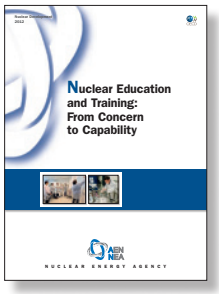
- *Nuclear Energy and Renewables: System Effects in Low-carbon Electricity Systems* was published in November. Analysing data from six OECD countries, the study finds that the system costs of variable renewables are significant and should be more transparently included in the costs of electricity production.
- *Nuclear Energy Today, 2nd Edition*, was released in December and provides an up-to-date overview of the issues associated with the use of nuclear energy.
- *Market Impacts of Converting to Low-enriched Uranium Targets for Medical Isotope Production* assesses the economic and capacity impacts of converting from the use of highly enriched uranium to low-enriched uranium targets for molybdenum-99/technetium-99m production.
- *Nuclear Education and Training: From Concern to Capability* reviews the ten years since the publication of *Nuclear Energy and Training: Cause for Concern?* and concludes that a sustainable situation has not yet been reached.
- *The Role of Nuclear Energy in a Low-carbon Energy Future* analyses the contribution that nuclear power makes to the reduction of greenhouse gas emissions and the challenges that need to be overcome by the nuclear sector in the future.

Policy and strategic issues

The impact of the Fukushima Daiichi accident on the future development of nuclear energy has been closely followed by the Agency, with revisions being made to projections of nuclear growth to 2030 and 2050. In this context, there is growing interest in the role of small modular reactors. The NEA will continue to consider the issues of new build, financing and project management in 2013-2014.

Interest remains in using nuclear energy to mitigate climate change and the NEA Secretariat contributed to two side events at the Rio+20 conference in Brazil, jointly with the International Atomic Energy Agency (IAEA).

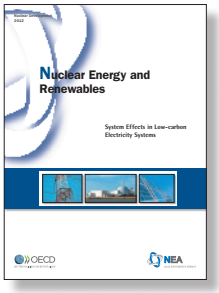
Strains on human resources continue to be high in the nuclear industry, exacerbated by the increasing rate of retirement as the workforce ages. With few major breakthroughs in addressing the demographic downturn of an ageing workforce, concerns regarding the availability of sufficient skilled manpower and adequate infrastructures still remain. This situation has been assessed in the NEA study *Nuclear Education and Training: From Concern to Capability* published in April. To encourage mobility of the workforce, the report also proposes a draft job taxonomy for adoption by both member and developing countries.



The NEA also participated in the International Energy Agency (IEA) in-depth energy policy reviews of Finland, Germany and Sweden. NEA involvement brings expertise on nuclear energy to the teams conducting the reviews, thus ensuring that they are as comprehensive as possible. The Agency also provided input to the *World Energy Outlook 2012* and revision of *Energy Technology Perspectives*, also released in 2012.

Economics and financing

The Working Party on Nuclear Energy Economics (WPNE) continued to provide advice on key economic issues meriting investigation on an international level. Under its oversight, the Secretariat produced the study *Nuclear Energy and Renewables: System Effects in Low-carbon Electricity Systems* in November.



While nuclear power has some system costs of its own, notably in terms of grid reinforcement and specific requirements for the reliability of external power supplies, it can provide back-up and balancing services due to its good flexibility and ability

to follow changes in electrical load. System effects refer to the costs above plant-level costs to supply electricity at a given load and level of security of supply. The report focuses on "grid-level system costs", the subset of system costs mediated by the electricity grid, which include i) the costs for extending and reinforcing transport and distribution grids as well as for connecting new capacity to the grid, and ii) the costs for increased short-term balancing and for maintaining the long-term adequacy of electricity supply. System costs are increasingly capturing the attention of electricity industry experts and decision-makers due to the large system costs of decentralised, intermittent renewables such as wind and solar. Not accounting for system costs means adding implicit subsidies to already sizeable explicit subsidies. As long as this situation continues, dispatchable technologies will increasingly not be replaced as they reach the end of their operating lifetimes, thereby weakening security of supply.

The existence of sizeable system costs implies that significant changes will be needed to generate the flexibility required for an economically viable coexistence of nuclear energy and renewables in increasingly decarbonised electricity systems. This includes carbon prices, long-term contracts and capacity mechanisms in order to provide adequate incentives for investment in dispatchable low carbon technologies such as nuclear.

Two other important studies were pursued in 2012 on the economics of the back end of the fuel cycle and the economics of long-term operation of nuclear power plants. The former study will be concluded in 2013, and considers the cost of final disposal for three scenarios relating to the once-through cycle, partial recycling and a cycle involving fast reactors.

The study on the economics of long-term operation (LTO) of nuclear power plants was published in December. The study found that in nearly all cases, the continued operation of nuclear power plants for at least ten more years is profitable, even taking into account the additional costs of post-Fukushima modifications. The preliminary estimates of the economic impact of post-Fukushima modifications are about 10-17% of the initially projected LTO investment. Despite the economic attractiveness of LTO, there are several risks and uncertainties that can influence the utilities' decision to extend the operational lifetime of a plant, such as public acceptance, changes in national policies or security concerns.

Data and resources

Published in July by the NEA in co-operation with the IAEA, *Uranium 2011: Resources, Production and Demand,* commonly referred to as the "Red Book", shows that uranium resources and production have been on the rise and that the security of uranium supply is assured for the long term. Total identified resources have increased by 12% since 2009. Despite nuclear phase-out policies in three countries in western Europe and delays in nuclear development in other countries as a result of the Fukushima accident, projections developed in the Red Book indicate that demand for uranium is expected to continue to rise in the foreseeable future.

Nuclear Energy Data 2012, an annual publication that aims to keep member countries abreast of the latest nuclear power developments in OECD countries, was published in September. The 2012 edition has been written in light of the real and potential impacts of the Fukushima Daiichi accident.

Security of supply of medical radioisotopes

The NEA continued its efforts related to improving the global security of supply of molybdenum-99 (^{99}Mo) and its decay product, technetium-99m (^{99m}Tc), which is the most widely used medical radioisotope. The High-level Group on the Security of Supply of Medical Radioisotopes (HLG-MR) completed work on capacity and cost impacts from converting to the use of low-enriched uranium (LEU) targets for ^{99}Mo production with the release of a report entitled *The Supply of Medical Radioisotopes: Market Impacts of Converting to Low-enriched Uranium Targets for Medical Isotope Production*. Evidence presented in the report indicates that governments have a role in encouraging manufacturers to convert to LEU fuel and targets in order to mitigate proliferation and security risks and ensure a long-term, secure supply of this important medical isotope.

As a direct action to monitor implementation of the principles of the HLG-MR policy approach, the NEA has undertaken a review of the ^{99}Mo/^{99m}Tc supply chain by means of a self-assessment by supply chain participants. The objectives of the review are to analyse and report on progress made by supply chain participants in implementing the HLG-MR policy approach, with a particular focus on full-cost recovery, outage reserve capacity and the role of governments in the market. A report on the self-assessment will be issued in 2013.

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Nuclear Safety and Regulation

Committee on Nuclear Regulatory Activities (CNRA)

The CNRA contributes to developing a consistent and effective regulatory response to current and future challenges, addressing in particular operational experience feedback, inspection practices, the regulation of new reactors and public engagement concerning safety in the use of nuclear energy.

Highlights

- The CNRA senior task group continued to co-ordinate NEA activities to implement lessons learnt from the Fukushima Daiichi accident.
- Two workshops were held on the safety of new reactors (Atlanta, United States, October 2012) and on inspection practices (Baden, Switzerland, May 2012).
- Crisis communication and transparency were important areas of focus for identifying key programme elements for nuclear regulatory organisations.
- Emphasis continued to be placed on identifying and applying lessons learnt and commendable practices in the areas of operating experience and inspection practices.

Regulatory impacts of the Fukushima Daiichi accident

The task group of senior-level regulators that was formed in March 2011 continued to provide a dedicated forum for the timely and efficient exchange of information on national activities and safety reviews in response to the Fukushima Daiichi accident. It also continued to identify areas of concern for member countries that would benefit from an international collaborative effort. Several activities have been undertaken in this context (see page 6 for further details).

Operating experience

The Working Group on Operating Experience (WGOE) focuses its activities on follow-up actions regarding national trends and lessons learnt from national events submitted to the joint NEA/IAEA International Incident Reporting System for Operational Experience (IRS). The IRS is the only international system providing regulators with information about lessons learnt from safety-significant events at nuclear power plants (NPPs). The group completed a report on regulatory activities concerning "Maintaining and Transferring Knowledge on Operating Experience".

Regulation of new reactors

The Working Group on the Regulation of New Reactors (WGRNR) is reviewing regulatory activities concerning siting, licensing and oversight of new commercial NPPs. Given that sharing information about the licensing process, construction experience and inspection practices will be helpful to all countries, a construction experience programme (ConEx) has been developed. The ConEx objectives are to identify deficiencies associated with NPP design and construction, to assess the adequacy of, and to supplement if necessary, regulatory activities to detect and correct such events, and to disseminate information to ensure appropriate regulatory attention is given to lessons learnt from past events. A web-based interface has been provided and member countries have begun submitting information. The first ConEx report assessing the construction experience information from 2008 to 2011 was issued in 2012.

A report was completed on the regulation of site selection and preparation aimed at reviewing the various practices used by regulators. It is based on a survey covering different aspects of the regulation of nuclear sites. In 2012, the WGRNR initiated a follow-up activity related to new plant siting including changes or enhancements as a result of the Fukushima Daiichi accident. A survey was prepared covering such siting topics as: multi-unit sites, site layout considerations, consideration of external hazards and combinations of hazards, population density, emergency preparedness integration activities with siting, social acceptability, and assessments to examine the nuclear power plant design parameters and how they are affected by the site characteristics.

A study was undertaken on recent regulatory experiences describing licensing structures, the resources and skills needed to perform design reviews, assessments and construction oversight, the types of training needed for these activities and the various licensing processes. Answers to the survey were collected in 2012 and an assessment of the responses to identify best practices in design reviews is underway.

These three areas, licensing structure, site-related and construction activities, formed the basis of a workshop held in October in Atlanta, United States, and hosted by the US Nuclear Regulatory Commission (NRC). Participants also visited the Vogtle construction site where the first NPP is being constructed in the US after more than 30 years.

New entrants

On 26-27 June 2012, the NEA facilitated a mission with the IAEA Regulatory Cooperation Forum (RCF) to meet with government officials in Vietnam. The purpose of the mission was to discuss international requirements, experiences and best practices for regulatory bodies that Vietnam may consider as it moves forward with planned enhancements to Vietnam's Atomic Law that would clarify the authorities, roles and responsibilities within the governmental structure for regulatory oversight as Vietnam embarks on its new nuclear power programme.

Meetings were held with the Deputy Prime Minister of Vietnam and senior government officials from the seven ministries with regulatory responsibilities for nuclear power. During these meetings, the mission participants shared their insights on regulatory independence and technical and regulatory competencies within their own frameworks.

Regulatory inspection practices

The Working Group on Inspection Practices (WGIP) continued its efforts on the inspection of licensee maintenance programmes and licensee emergency arrangements. The 11th WGIP workshop was hosted by ENSI, the Swiss Federal Nuclear Safety Inspectorate, in Baden, Switzerland, on 21-25 May 2012. The workshop addressed inspection of ageing and equipment qualification, inspection of operator competency and inspection of licensee's oversight of contractors. As typical of a WGIP workshop, pre-workshop questionnaires were completed by countries and the lead working group member prepared a presentation to open the discussions. Preparations were made for the 12th WGIP workshop, which is to be hosted by the US NRC in spring 2014. Topics will include inspection of licensee's outage activities, with a subtopic on inspection of licensee's fire protection programmes, event response inspections and post-Fukushima inspections.

Nuclear regulators and public communication

The activities of the Working Group on Public Communication of Nuclear Regulatory Organisations (WGPC) focused on crisis communication, which is needed whenever a nuclear event has a media impact. Based on a survey of practices in member countries, a roadmap for crisis communication of nuclear regulatory organisations (NRO) was established early 2011 describing the main aspects to be addressed before, during and after a crisis. The roadmap was assessed by NRO communicators in member countries after the Fukushima Daiichi accident and was found to be relevant in cases where the major impact of the event remained within the country. It was also found, however, that the international dimension for cases of wider impact needed further development. In this respect, a new survey was prepared and a workshop bringing together senior regulators, NRO communicators and stakeholders (politicians, media, NGOs and industry) was convened on 9-10 May 2012 in Madrid and addressed the specific needs of crisis communication in the international dimension. The workshop attracted 170 participants from 32 countries; proceedings are in preparation. Other areas of WGPC work include the use of social media and the development of communication plans.

Committee on the Safety of Nuclear Installations (CSNI)

The CSNI contributes to maintaining a high level of safety performance and safety competence by identifying emerging safety issues through the analysis of accidents and their management, ageing and structural integrity, fuel and fuel cycle safety, contributors to risk and human factors. The committee also facilitates the establishment of international joint research projects when useful.

Highlights

- CSNI activities focused on continued follow-up to the Fukushima Daiichi accident. The committee and its working groups discussed possible new technical tasks to respond to some of the preliminary lessons learnt and closely co-operated with the CNRA and the CRPPH in a cross-committee integrated response to the accident.
- In total, eight new tasks were approved in 2012 to address one or more technical lessons learnt from the Fukushima Daiichi accident.
- At the end of 2012, a total of 17 international joint research and 4 database projects were ongoing.

Analysis and management of accidents

The activities of the Working Group on Analysis and Management of Accidents (WGAMA) have focused on the thermal-hydraulics of the reactor coolant system; in-vessel behaviour of degraded cores; containment behaviour and protection; computational fluid dynamics (CFD); and fission product release, transport, deposition and retention.

During 2012, further progress was made on best-estimate methods and uncertainty evaluations with a new benchmarking activity (Post-BEMUSE Reflood Input Uncertainty Methods) launched on quantifying the uncertainty of the physical models in system thermal-hydraulic computer codes which will include five phases. Meetings related to Phases I and II took place in February and June 2012 respectively.

Regarding computational fluid dynamics (CFD), work is progressing on the consolidation of best practice guidelines for CFD application to nuclear reactor safety (NRS) problems, CFD code assessment for NRS problems, CFD extension to two-phase flow problems, benchmarking activities and the organisation of workshops. A new CFD benchmark exercise was undertaken on turbulent flow in a customised rod bundle with spacer grids and completed in September 2012. The results of this benchmark were presented during the workshop on Experimental Validation and Application of CFD and Computational Multifluid Dynamics (CMFD) Codes to Nuclear Reactor Technology (CFD4NRS-4), organised in the Republic of Korea on 10-12 September 2012.

Regarding knowledge transfer, the NEA held the 3rd THICKET seminar on 25-29 June 2012. This seminar series, organised with the support of the European Commission (EC) and the IAEA, is dedicated to transferring competence, knowledge and experience gained through CSNI activities in the field of thermal-hydraulics over the past three decades. This time, new topics such as best-estimate methods and uncertainty evaluation, computational fluid dynamics, safety margin assessment and application and OECD/NEA project outcomes were added to the programme.

Work also continued on in-vessel behaviour of degraded cores. A new activity is progressing on code benchmarking to assess the ability of computer codes to simulate in-vessel core melt progression and degraded core coolability on the basis of three severe accident sequences involving safety systems failure or delayed operation. In 2012, there were two meetings related to this benchmarking activity, which is expected to be completed in 2014. In parallel, the work on the Containment Code Validation Matrix approached completion at the end of 2012 with a draft report distributed for independent review. The activity on a state-of-the-art report addressing molten corium concrete interaction and ex-vessel molten core coolability was launched in April 2012, and progressed with a technical meeting in November 2012; the state-of-the-art report is expected to be completed at the end of 2013.

Finally, the WGAMA submitted several proposals to the CSNI regarding Fukushima-related issues. All the proposals were approved and concern: i) a status paper on filtered containment venting; ii) an international benchmarking project on fast running software tools to model fission product releases during accidents at nuclear power plants; iii) a status paper on hydrogen generation, transport and risk assessment; and iv) a status report on spent fuel pools under loss of cooling accident conditions.

Ageing and structural integrity of reactor components

The main topics addressed by the Working Group on Integrity of Components and Structures (WGIAGE) concern the integrity and ageing of metal components and concrete structures, and the seismic behaviour of structures and components.

In 2011, the WGIAGE finalised the report that documents the main findings and conclusions of the 2010 activity on improving the robustness of assessment methodologies of structures impacted by missiles (IRIS-2010). In 2012, a post-IRIS-2010 round robin was initiated to give the opportunity to participants to update and improve blind simulations.

In view of the increasing interest in safe, long-term operation of existing nuclear power plants, an activity is being conducted to identify technical areas of common interest concerning age-related degradation of materials in safety-related systems, structures and components (SSCs) during NPP long-term operation (60 years) and to capture operating experience associated with degradation in buried tanks and piping.

In 2012, a Fukushima-related activity on metallic component margins under high seismic loads was initiated to quantify the existing margins in seismic analysis of safety-class components for high seismic loads. The group continues to review current practices in member countries regarding the definition of seismic input from far- and near-field sources and its control point, with a view to providing recommendations on their harmonisation in the future.

Risk assessment

The main mission of the Working Group on Risk Assessment (WGRISK) is to advance the understanding and utilisation of probabilistic safety assessment (PSA) as a tool to support nuclear safety decision making in member countries. The activity on PSA knowledge transfer is progressing as scheduled, with the objective of developing an understanding of the current needs and ongoing activities in member countries on PSA knowledge transfer, including related international activities, and supporting the dissemination of lessons learnt and best practices. A comprehensive questionnaire was circulated to WGRISK members, the IAEA and the EC, and the resulting report was approved by the CSNI.

The activities on PSA for the design and commissioning of new NPPs and on PSA for advanced reactors seek to identify and characterise current practices in this area and to identify key technical issues, current approaches to addressing them, associated lessons learnt and issues requiring further work. In addition, the proceedings of a joint workshop including PSA for new and advanced reactors were issued. A common report based on the outcome of this joint workshop and on specific surveys on PSA for new and advanced reactors was approved.

Work has continued on the development of best practice guidelines on failure mode taxonomy for reliability assessment of digital instrumentation and control (I&C) systems for PSA with the aim of developing technically sound and feasible failure mode taxonomy for such reliability assessments, and providing best practice guidelines on the use of taxonomy in modelling, data collection and qualifi-

cation of digital I&C reliability. Two workshops were organised in 2012, and the guidelines are expected to be submitted for CSNI approval in June 2013.

Regarding information exchange on the use and development of PSA, a report on "The Use and Development of PSA in NEA Member Countries" was updated and approved.

The activity on the use of data from OECD/NEA projects (such as the FIRE and the ICDE projects described on pages 40-41) continued its work to identify and characterise current uses of such data and associated products in support of PSA, and to ensure better interaction and co-ordination among the projects. Two surveys based on questionnaires distributed to WGRISK and data project members were discussed during a meeting on 15-16 October 2012.

Fuel safety

The Working Group on Fuel Safety (WGFS) is addressing the systematic assessment of the technical basis for current safety criteria and their applicability to high burn-up, as well as to the new fuel designs and materials being introduced.

The results of the examination of the mechanical testing of fuel cladding for radioactivity-initiated accident (RIA) applications methods are summarised in the report on "Mechanical Testing for RIA Applications". The group concluded that there are two reasons to develop separate-effects mechanical tests: to derive stress-strain curves applicable to RIA loading and to determine failure strains typical of cladding failures under RIAs. The report is scheduled to be issued in 2013. The second task on RIA benchmarking continues and should be completed in 2013.

In 2012, an activity was started on leaking fuel impacts and practices, with the aim of discussing and reviewing current practices in member countries and drawing conclusions to help decision making on the specification of reactor operation conditions with leaking fuel rods.

Human and organisational factors

The Working Group on Human and Organisational Factors (WGHOF) constitutes a unique international forum for addressing safety management including safety culture, human and organisational factors, and human performance in nuclear facilities. In 2012, work continued on two ongoing tasks. The first, a joint WGHOF/WGRISK task, aims to investigate key attributes of human reliability analysis (HRA) in nuclear risk assessments. Using the attributes scale developed, a number of well-known HRA techniques will then be evaluated. A final report is intended to be produced by the end of 2013. The other ongoing task is directly related to the Fukushima Daiichi accident and concerns human performance and intervention under extreme conditions. The task group will investigate human and group performance, including decision making under conditions applicable to severe accident situations, and draw out lessons and best practices to be applied to the operation of nuclear facilities. The intention is to review such practices both within and outside the nuclear industry, namely in other high hazard sectors.

In 2012, two new WGHOF reports were produced: a technical opinion paper (TOP) on *Nuclear Licensee Organisational Structures, Resources and Competencies: Determining Their Suitability* and a workshop proceedings on "Licensee Leadership and Management for Safety, Including Safety Culture".

Fuel cycle safety

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

The joint NEA/IAEA Fuel Incident Notification and Analysis System (FINAS) is the only international system providing regulators and government bodies with information about lessons learnt from safety-significant events at fuel cycle facilities. The FINAS web-based system has been in operation since 2008. In total, 154 events have been registered. The FINAS will be migrated in 2013 to the NUCLEUS system, where other IAEA databases have been brought together.

After completion of the technical opinion paper on *Ageing Management of Nuclear Fuel Cycle Facilities,* the group started preparations for a workshop on the safety of long-term interim storage facilities to be held in Munich, Germany, in May 2013. The scope of the workshop is to discuss and review current national activities, plans and regulatory approaches for the safety of long-term interim storage facilities dedicated to spent nuclear fuel (SF) and high-level waste (HLW), as no final repository for SF from commercial reactors or HLW is in operation to date, and many NEA member countries have expressed their intention to plan for long-term interim storage.

Sump clogging

At the end of 2010, a Task Group on Sump Clogging was established to update the state-of-the-art report on the "Knowledge Base for Emergency Core Cooling System Recirculation Reliability", taking into account progress in relevant R&D that has occurred since its initial publication in 1996. Special emphasis has been placed on chemical effects and downstream effects as well as long-term core cooling which were identified as main concerns during a joint CNRA/CSNI workshop held at the end of 2008. Drafts have been prepared and commented by the task group members. The final report is expected to be submitted for approval in 2013.

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Radioactive Waste Management

Radioactive Waste Management Committee (RWMC)

The RWMC is assisting member countries in the development of safe, sustainable and broadly acceptable strategies for the long-term management of all types of radioactive waste, in particular long-lived waste and spent fuel considered as waste, and for the decommissioning of obsolete nuclear facilities.

Highlights

- The NEA organised and helped carry out two international peer reviews: one on the Swedish industry's safety case for a deep geological repository for spent nuclear fuel in Sweden and the other on key safety aspects of a surface disposal facility for low-level waste in Belgium.
- The RWMC Regulators' Forum and the Integration Group for the Safety Case (IGSC) held an international workshop on preparing for the construction and operation of geological repositories.
- The RWMC issued a collective statement on the current status and prospects of estimating the decommissioning costs of a nuclear facility and their comparability.
- The RWMC agreed to launch the "Salt Club" among member countries which have rock salt as one potential host formation for a geological repository.
- Several publications were completed, notably on the evolving role of regulators and trends over the past decade, and a cost control guide for decommissioning projects.

Strategic activities

Meeting societal requirements and expectations is a prerequisite to implementing geological repositories, and local and regional governance levels play an essential role in decision-making processes. The 4th International Conference on Geological Repositories, ICGR-2012, reaching out to political and opinion leaders, fostered information sharing on policy development, safety, regulatory frameworks, planning and implementation of repository programmes with societal involvement, and work underway within international organisations. Geological disposal was confirmed in this forum, attended by 200 participants from 15 countries, to be a technically feasible and safe option for the long-term management of radioactive waste. Entitled "National Commitment – Regional and Local Involvement", conference participants recognised that implementing this management approach is not only a technical or scientific issue. A collective statement was issued under the same title by the RWMC.

To assist programmes in preparing for the approaching industrialisation phase, the IGSC and the RWMC Regulators' Forum held a joint workshop in January 2012 to discuss the challenges that implementers and regulators may face, particularly when applying for construction and operation licences of geological repositories. Important issues that have been observed across the various national programmes independently of their developmental stages were summarised.

International peer reviews

A key activity in the field of radioactive waste management is the organisation of independent, international peer reviews of national studies and projects. In 2012, the NEA organised i) a review of the post-closure radiological safety case of SKB in support of the application for a general licence to construct and operate a spent fuel geological repository in Östhammar, Sweden; and ii) a review of key aspects of the safety case being developed by Ondraf/Niras for its licence application to construct and operate a surface disposal facility for short-lived, low- and intermediate-level radioactive waste in Dessel, Belgium.

The review for Sweden concluded that the SKB's post-closure radiological safety report, SR-Site, is sufficient and credible for the licence application. The safety report is also considered to be well-structured with good traceability and justification of the safety conclusions.

The review for Belgium noted that the key aspects of the Belgian safety report are credible and robust, and that international best practice has been observed and taken into account when applicable. Many recommendations were made for improving the documentation.

Implementers, regulators and local communities of both countries have indicated that international peer reviews are an effective means to evaluate the completeness and robustness of the proposed projects.

Records, knowledge and memory

As radioactive waste disposal programmes approach the siting and operational stages, the preservation of records, knowledge and memory (RK&M) across generations constitutes one of the pillars of confidence

in safety and security, and a foundation for robust decisions by future generations. These aspects should thus be addressed early on in national programmes. The new RWMC initiative on RK&M held its second workshop in 2012. Participants included representatives of institutions involved in waste management as well as social scientists.

Safety case for geological disposal

Early in 2012, with the support of the RWMC Regulators' Forum (RF), the IGSC held a workshop on Preparing for Construction and Operation of Geological Repositories – Challenges to the Regulator and the Implementer. The workshop provided an important opportunity for regulators and implementers to discuss the challenges they face when preparing for a licence application.

At its 2012 annual meeting, the IGSC reviewed how to manage uncertainties in safety cases. The discussion concluded that a systematic approach with good traceability of uncertainties is not only an effective method, but will also enhance confidence as the programme continues to evolve.

The Salt Club, officially established in April 2012, has been mandated to develop and exchange scientific information on rock salt as a host rock formation for deep geological repositories for high-level and long-lived radioactive waste. The Salt Club prepared its 2012-2014 work programme and some of its scientific activities have started. A workshop on Natural Analogues for Safety Cases of Repositories in Rock Salt was held in Braunschweig, Germany, in September 2012.

The NEA Clay Club held its 5th international workshop on Clays in Natural and Engineered Barriers for Radioactive Waste Confinement in October in Montpellier, France. Over 500 participants discussed the role of natural and artificial clay barriers for radionuclide confinement. The next annual meeting is planned to be hosted by the Honorobe Underground Research Laboratory in Japan.

To continue to provide the latest information on safety case development and relevant scientific data, the IGSC developed or updated various documents in 2012. These include the safety case brochure, the underground research laboratory brochure, the sorption project report, the cementitious material project report and various information flyers.

Forum on Stakeholder Confidence

The Forum on Stakeholder Confidence (FSC) held its 13th regular meeting in the Czech Republic immediately followed by its 9th national workshop and community visit. The workshop was entitled "Deliberating together on geological repository siting; expectations and challenges in the Czech Republic". More than 50 international delegates from 13 NEA member countries dialogued with some 60 national stakeholders, concerned citizens and elected representatives of the seven granitic sites currently considered to be suitable for investigation in view of a future facility. Significant delegations of Swedish, Belgian and Hungarian stakeholders, who have hosted FSC activities in the past, took an active part in the workshop discussions. In particular, they participated in a local debate which was also open to dozens more local Czech citizens. The debate clarified the challenges addressed by townships engaged in multi-year deliberations on repository hosting.

Decommissioning

The Working Party on Decommissioning and Dismantling (WPDD) held its yearly meeting in Penrith, United Kingdom. Participants received information on the UK national decommissioning scene, and visited decommissioning projects at Sellafield.

The WPDD received a report from the task group on identifying and summarising best practice for radiological characterisation at different stages of decommissioning. The task group organised a workshop in April 2012, at the Studsvik site in Sweden in co-operation with the Swedish regulator and three Swedish decommissioning companies. Over 120 participants attended from 23 countries and 4 international organisations. Participants shared current practices, lessons learnt and innovation in radiological characterisation for the safe decommissioning of nuclear sites and facilities.

The WPDD approved the cost control guide completed by its Decommissioning Cost Estimation Group (DCEG). The guide provides a practical, user-friendly approach to implementing cost controls for major decommissioning programmes by minimising project budget and schedule overruns. The DCEG has started work on developing a methodology for peer reviews of decommissioning project costs to further improve transparency and auditability of decommissioning costing.

The International Co-operative Programme for the Exchange of Scientific and Technical Information Concerning Nuclear Installation Decommissioning Projects (CPD) continued its work which currently covers 59 active decommissioning projects (35 reactors and 24 fuel facilities) in 12 member countries, one non-OECD economy and the European Commission (see Joint Projects and Other Co-operative Projects for more information).

The CPD has accepted the Tokyo Electric Power Company (TEPCO) amongst its members. Four additional decommissioning projects have also been accepted: the Waste Storage Facility #56 at Cadarache (CEA, France); Fukushima Daiichi NPP (TEPCO, Japan); Brunsbüttel NPP (Vattenfall Europe Nuclear Energy GmbH, Germany); and the MR/FRT Research Reactors (NRC, Kurchatov Institute, Russia).

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Radiological Protection

Committee on Radiation Protection and Public Health (CRPPH)

The objective of the CRPPH is to facilitate the understanding and implementation of a system of radiological protection that addresses regulator and practitioner needs, and more appropriately positions scientific radiological protection considerations within the broader context of social judgment and risk governance.

Highlights

- A co-ordinated programme of Fukushima-related activities was established, focusing on contributions to the organisation of workshops in Japan, stakeholder engagement and recovery management, the management of emergency situations, the framework for post-accident trade in food and commodities, and the operational protection of severe accident management workers.
- The CRPPH agreed to work with the International Atomic Energy Agency (IAEA) and several other international organisations to revise the IAEA Safety Requirements for Preparedness and Response for a Nuclear or Radiological Emergency, GS-R-2.
- Several events were organised: a workshop on good practice in effluent management, the 3rd Workshop on Science and Values in Radiological Protection Decision Making and the 6th Asian Regional Conference on the Evolution of the System of Radiological Protection in Japan.
- A study was finalised on the radiological management of transient nuclear power plant workers and on integrated risk management in nuclear power plants.
- A report assessing the results of the International Nuclear Emergency Exercise 4 (INEX-4) was completed.

Radiological protection consequences of the Fukushima Daiichi accident

Following the Fukushima Daiichi accident, the CRPPH established a framework to make its experience available to the Japanese government and at the same time, to start collecting lessons learnt from the accident. To this end, a number of activities were launched under CRPPH auspices, in particular in areas of its traditional strength, namely the evolution of the system of radiological protection, stakeholder involvement in radiological protection decision making, emergency management and occupational exposure. The Committee's work in this area has been co-ordinated internally by a specially mandated expert group, within the NEA through active contacts with the Committee on Nuclear Regulatory Activities (CNRA) and the Committee on the Safety of Nuclear Installations (CSNI), and internationally through the Inter-Agency Committee on Radiation Safety.

Discussing stakeholder involvement in post-nuclear emergency management.

With nearly two years of post-accident experience, the CRPPH identified concrete activities to support its members in a co-ordinated fashion with other ongoing Fukushima-related activities. These included the collection of emergency and recovery management lessons, developing a report on the implementation of new International Commission on Radiological Protection (ICRP) recommendations in post-accident and recovery activities, actively participating in and supporting two ICRP dialogues with stakeholders in Japan, and the development of a framework for trade in food and goods coming from contaminated territories.

Evolution of the international system of radiological protection

With the completion and approval of the new international Basic Safety Standards (BSS) with the IAEA and the six other co-sponsoring organisations (EC, FAO, ILO, PAHO, UNEP and WHO), the focus of the evolution of the system of radiological protection turned to emergency and recovery management. Following the 2009 recommendations of the ICRP in these areas, the IAEA agreed that its 2002 IAEA Safety Requirements for Preparedness and Response for a

Nuclear or Radiological Emergency, GS-R-2, should be updated. The NEA, as a co-sponsor of GS-R-2, agreed to participate in the updating of the document with a view to co-sponsoring the new version.

The CRPPH also continued its efforts to provide the ICRP with practical user feedback on draft documents, analysing a new draft ICRP recommendation on Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste, in co-operation with the NEA Radioactive Waste Management Committee (RWMC). The NEA will publish, jointly with the ICRP, a flyer briefly summarising this ICRP recommendation in plain language, in particular to facilitate the explanation of these somewhat complex concepts to a more general public.

Radiological protection science and policy judgment

Radiological protection decisions are a combination of science and judgment, and making these two elements more transparent in decision making will most likely improve the acceptability and sustainability of decisions. The CRPPH is addressing these issues through a series of science and values workshops, the first two having been held in 2008 and 2009. The third workshop on Science and Values in Radiological Protection was held in Japan in November 2012. Further details on this workshop can be found on page 50 in the section on Nuclear Energy and Civil Society.

Operational radiological protection from a policy perspective

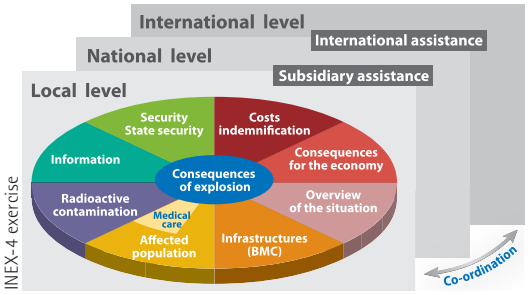
The CRPPH Expert Group on Occupational Exposure (EGOE) prepared a report on the management of total risk and on radiological protection aspects of transient worker exposure management. The EGOE met in January and October 2012 to finalise the draft report, which will be submitted to the CRPPH for approval in May 2013.

The CRPPH Expert Group on Best Available Techniques (EGBAT) completed most of its work during 2012, holding a workshop on Good Practice in Effluent Management in January. As a result of the workshop, a series of questions regarding approaches to good practice were generated and turned into a questionnaire for participants. Questionnaire responses will be used to finalise the draft expert group report on good practice in effluent management for nuclear power plant new build, due to be issued in late 2013.

Nuclear emergency and recovery management

In terms of system evolution, the CRPPH agreed to investigate how the new ICRP recommendations for emergency management and for post-accident rehabilitation were being implemented, with a view to assist members in updating their own approaches and to provide practical feedback to the ICRP. An expert group of the Working Party on Nuclear Emergency Matters (WPNEM) is preparing a report on the evolution of national emergency management programmes in response to the new ICRP recommendations which should be issued in the first half of 2013. Also in the area of emergency management implementation, in early 2013 the WPNEM will complete the update of its 2003 report on short-term countermeasure criteria currently used by NEA member countries.

The INEX-4 exercise, which was undertaken in 2011-2012 by 17 countries (including 4 non-NEA countries), focused on consequence management and transition to recovery in response to malicious acts involving the release of radioactive materials in an urban setting. The exercise summary report was completed and submitted to the CRPPH Working Party on Nuclear Emergency Matters for approval at its November 2012 meeting. The report will be finalised with a joint topical session with the CRPPH on INEX-4 results in May 2013.



Comprehensive problem identification.

Occupational exposure at nuclear power plants

The sharing of operational lessons and experience, as well as the collection, analysis and exchange of occupational exposure data continue to be addressed by the Information System on Occupational Exposure (ISOE), an NEA joint project in the field of radiological protection which is co-sponsored by the IAEA. In 2012, the ISOE continued its efforts to share dose reduction experience among participants, and to co-ordinate projects to improve optimisation of worker radiological protection at nuclear power plants by providing online data collection and detailed analysis of data through its MADRAS module. Further details on the ISOE programme are provided on page 42.

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Nuclear Science

Nuclear Science Committee (NSC)

The aim of the NEA nuclear science programme is to help member countries identify, pool, develop and disseminate basic scientific and technical knowledge used to ensure safe and reliable operation of current nuclear systems, as well as to develop next-generation technologies. The main areas covered are reactor physics, fuel cycle physics and chemistry, criticality safety and material science.

Highlights

- The 6th Workshop on Uncertainty Analysis in Modelling LWR transients (UAM-6) was held in May.
- A special workshop on accident tolerant fuels was held in December.
- A test version of the new database tool (IDAT) for the International Reactor Physics Experiments (IRPhE) database was released for evaluation by a selected group of database users.
- Two benchmark reports were published on fuel cycle issues.
- The 12th Information Exchange Meeting on Partitioning and Transmutation (IEMPT) was held in October in Prague, Czech Republic.

The main objective of the NEA nuclear science programme is to validate models and data used in member countries for predicting the behaviour and performance of different nuclear systems by comparing calculated and experimental results in international benchmark exercises. In addition, it organises specialists' meetings and workshops and produces state-of-the-art reports as necessary.

Reactor physics

A significant part of NEA work related to reactor physics is devoted to the propagation of uncertainties in the modelling of coupled core neutronics/thermal-hydraulics effects in a reactor. A number of benchmarks based on measured data, such as the Russian-designed reactor (VVER-1000) coolant transient benchmark, the pressurised water reactor (PWR) and the boiling water reactor (BWR) benchmarks, are used to validate the models. These activities have now grown to cover the field of fuel performance modelling with a view to providing knowledge and methods for sensitivity and uncertainty analysis that can be integrated in the state of the art of reactor computation.

Several benchmark exercises devoted to advanced reactor systems are also underway covering reactor transient calculations, for example in a pebble bed modular reactor (PBMR) and a sodium-cooled fast reactor (SFR), and fuel depletion calculations in a high-temperature, gas-cooled reactor (HTGR).

In addition to the above-mentioned activities, work in this area also addresses fuel performance as well as radiation transport and shielding and involves the development of experimental databases. The NEA has established corresponding databases containing experimental data used extensively in member countries to validate modelling codes and associated data.

The database of International Reactor Physics Experiments (IRPhE) has grown significantly in the last few years. In response, the NEA initiated a project to develop a database tool for IRPhE to improve user access, based on the DICE tool already available for accessing data contained in the International Criticality Safety Benchmark Experiment Project (ICSBEP) handbook. Demonstrations of a development version of the tool (IDAT) were made *inter alia* at the IRPhE technical review group meeting in 2012. A prototype version will be included in the 2013 issue of IRPhE handbook (on DVD).

Fuel cycle physics and chemistry

The main activities in this area are undertaken under the Working Party on Scientific Issues of the Fuel Cycle (WPFC). A new Expert Group on Fuel Recycling Chemistry was formed, replacing the one on chemical partitioning. This new group is currently working on a report on minor actinide separations. Several other reports were issued or finalised:

- "Benchmark Studies on Nuclear Fuel Cycle Transition Scenarios Analysis Codes" provides a comparative study of existing codes in term of capabilities, modelling and results.
- "Benchmarking of Thermal-Hydraulic Loop Models for Lead-Alloy-Cooled Advanced Energy Systems (Phase I)" addresses thermal-hydraulic behaviours in lead-alloy-cooled systems under steady state, forced and natural convection.
- A state-of-the-art report on "Innovative Structural Materials" has been finalised and will be issued at the start of 2013.

Nuclear criticality safety

The different expert groups within the Working Party on Nuclear Criticality Safety (WPNCS) carry out international benchmark exercises on burn-up

credit criticality, criticality excursions analyses and uncertainty analyses for criticality safety assessments, and work on the evaluation of assay data of spent nuclear fuel.

The WPNCS is also responsible for co-ordinating activities of the International Criticality Safety Benchmark Evaluation Project (ICSBEP) and the Spent Fuel Isotopic Composition Database (SFCOMPO). In 2012, the NEA started a major restructuring effort of the SFCOMPO database. This database aims at providing functional access to all available experimental assay data and, in the longer run, to the fully evaluated assay data sets, essential for the validation of depletion codes and, by extension, for many criticality safety assessments of waste management and disposal operations.

In addition, ongoing studies related to burn-up credit, the safety approach that accounts for the reduction in reactivity of spent nuclear fuel due to the change in its composition after irradiation, have recently revisited the case of spent fuel assemblies from boiling water reactors in follow-up to the Fukushima accident. Other benchmark activities which concern the rigorous treatment of uncertainties in different criticality safety assessment methodologies are underway.

The activities of the Expert Group on Advanced Monte Carlo Techniques were restarted. The group is focusing on developing best practices and recommendations for the good transfer of Monte Carlo technologies to criticality safety practitioners.

Material science

Substantial progress was made on three out of five state-of-the-art reports on multi-scale modelling of fuel and cladding materials:

- an assessment of the possibilities and limits of numerical methods applied to multi-scale modelling of materials and the means to link them;
- a critical review of recent progress and bottlenecks for future development of fuels;
- an assessment of the use of a multi-scale modelling approach to describe the changes induced by irradiations in structural nuclear materials.

The completion of two other reports is now rescheduled for 2013: an assessment of primary radiation damage characterisation and the limitations of the Norgett Robinson and Torrens (NRT)-dpa standard to propose a new parameter to better describe radiation damage; and a validation and benchmark of multi-scale modelling methods.

An international workshop on innovative accident tolerant fuels for LWRs was held in December. As part of R&D efforts to enhance the safety of current Generation II/III plants in the post-Fukushima context, this workshop aimed at sharing information on innovative solutions to increase grace time in severe accident conditions initiated by prolonged loss of cooling and/or heat sink. A precise work programme for this activity will be developed in 2013.

Integral experiments for minor actinide management

The main objectives of this activity are to assess the availability of minor actinide nuclear data, to evaluate the target accuracies of these data in applications such as transmutation in light water, fast and accelerator-driven subcritical reactors, and, if appropriate, to make recommendations on additional differential and integral experiments needed to meet the target accuracies. A review of existing nuclear data and integral experiments for minor actinide management has been performed, as well as an assessment of the accuracy of the available data. A discussion of the need for further measurements is ongoing, with the final report due to be issued in 2013.

Knowledge preservation

In order to assist member countries in the development of new nuclear facilities, and in the context of marked change in the composition of their skills base as a generation of highly experienced nuclear scientists and engineers retires, the NEA Nuclear Science Committee launched, some years ago, 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.

The contents of the above-mentioned databases were as follows in 2012:

- the IRPhE handbook included 56 series of reactor physics experiments performed at 32 reactor facilities;
- the ICSBEP handbook included 4 708 critical or subcritical configurations;
- the SINBAD database contained 46 radiation shielding, 31 fusion neutronic shielding and 23 accelerator shielding experiments;
- the IFPE database contained information on 1 452 rods/samples from various sources, comprising BWR, AGR, PHWR, PWR and VVER reactor systems;
- the SFCOMPO database contained 246 samples from 14 commercial reactors and is being restructured to improve user access to the data.

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Data Bank

The Data Bank operates as an international centre of reference for its member countries with respect to basic nuclear tools, such as computer codes and nuclear data, used for the analysis and prediction of phenomena in the nuclear field. It provides a direct service to its users by acquiring, developing, improving and validating these tools and making them available upon request.

Highlights

- Seven workshops and training courses on the most popular computer codes were organised as part of the knowledge management activities of the NEA Data Bank.
- The Computer Program Service sent out its 100 000th package since its inception in 1964.
- A new version of the nuclear data display program, JANIS 3.4, was released online and on DVD together with an exhaustive compilation of cross-section curves and tabulated key quantities; the compilation is known as the "JANIS Book".
- The JEFF-3.1.2 General Purpose Library was released online and on DVD with special purpose files and application libraries.

Computer program services

The Data Bank collection contains more than 2 500 computer programs and 400 integral experiments covering all areas from reactor design, dynamics, safety and radiation shielding to material behaviour and nuclear waste applications. Twenty-eight new versions of computer programs and 32 integral experiments were added to the collection in 2012.

A total of 1 019 computer program packages were dispatched upon request in 2012 to the Data Bank member countries and, through the co-operative agreement between the NEA Data Bank and the International Atomic Energy Agency (IAEA), to authorised non-OECD member countries having access to these services. The current co-operative arrangement between the United States Department of Energy and the NEA, signed in 2006, authorises the NEA Data Bank to issue user licenses and distribute the US computer codes to the Data Bank member countries.

On 5 March, the Data Bank sent out its 100 000th package since the Computer Program Service started in 1964. The package was sent to the Korean Institute of Nuclear Safety. It was a program contributed by the US Energy Science and Technology Software Centre.

The number of officially nominated establishments using the Computer Program Service in NEA Data Bank member countries is 937, and 77 establishments in other countries.

Detailed information about material available from the Computer Program Services can be accessed via the NEA website at www.oecd-nea.org/dbprog/. News on updates is provided in an electronic newsletter.

Knowledge transfer and preservation of information from integral experiments

As an important complement to the Computer Program Service, the Data Bank organises workshops and training courses on the utilisation of the most popular computer programs. Seven workshops/training courses were organised during 2012, attended by more than 100 participants. Subjects covered many different areas including computational radiation physics, criticality safety and radiation shielding, radiation transport using Monte-Carlo codes and sensitivity/uncertainty analysis.

Under the scientific guidance of the NEA Nuclear Science Committee, the Data Bank verifies, preserves and disseminates well-documented integral data in the following areas: integral shielding experiments (SINBAD), International Fuel Performance Experiments (IFPE), the International Criticality Safety Benchmark Evaluation Project (ICSBEP) and the International Reactor Physics Benchmark Experiments (IRPhE). More than 1 000 sets were distributed upon request in 2012.

The Data Bank also assists other parts of the NEA, especially in the area of knowledge preservation. In co-operation with the NEA Nuclear Safety Division, experimental data from several international joint projects are maintained and distributed.

Nuclear data services

Using the Java-based nuclear information software (JANIS), designed by the Data Bank to facilitate the visualisation, comparison and manipulation of nuclear data libraries, users can locally or remotely access a comprehensive choice of evaluated (e.g. ENDF/B, JEFF, JENDL), experimental (EXFOR) and bibliographical (CINDA) data sets.

In June 2012, JANIS 3.4 was released online and on DVD, together with the most recent evaluated nuclear data libraries. Using the latest version of the JANIS software and database, the Data Bank also made available a compilation of cross-section curves and tabulated key values for neutron-, photon- and

light-charged-particle-induced reactions below 200 MeV. This compilation, known as the JANIS Book, provides a global overview of the quality and completeness of experimental and evaluated nuclear data. More information is available at www.oecd-nea.org/janis.

The Data Bank is a founding member of the international network of Nuclear Reaction Data Centres (NRDC) and in April 2012 hosted the biennial NRDC co-ordination meeting with the participation of 23 delegates from 13 data centres representing 8 countries and 2 international organisations. The Data Bank is responsible for the compilation in the EXFOR database of experimental reaction data measured in member countries. In 2012, the NEA contributed 123 entries for neutron- and 248 entries for charged-particle-induced reaction data following a specific NRDC effort to improve the coverage of proton- and deuteron-induced reaction data in the EXFOR database.

The JEFF Project

The Joint Evaluated Fission and Fusion File (JEFF) project is a co-operative effort among NEA Data Bank member countries to produce a common set of evaluated nuclear data, mainly for fission and fusion applications.

The JEFF Report 23 (JEFF-3.1 validation report) was completed and is due to be published shortly. The report covers the integral validation of the JEFF-3.1 library for thermal reactors, fuel cycle, storage and reprocessing, fusion and other applications.

The latest version of the JEFF Evaluated Nuclear Data Library in the 3.1 series, JEFF-3.1.2, was released in February 2012. In particular, this release includes new hafnium evaluations and more complete photon-production data for fission products in the general purpose file. Of particular note, following the adoption of JEFF-3.1.1 by the French nuclear industry, it is the foreseen that JEFF-3.1.2 will be adopted by the nuclear industry in the United Kingdom.

Another major update of the JEFF library, JEFF-3.2, was also under preparation in 2012. In addition to the neutron file, this update will include a revision of the special purpose files for light-charged-particle-induced reactions, activation, fission yields and radioactive decay data. The final contents of the JEFF-3.2 test file were defined at the end of 2012. These take into account several improvements in major isotope evaluations which have been made in recent years, including new evaluations for major actinides (uranium, plutonium and americium isotopes). The release of JEFF-3.2 is scheduled for the end of 2013 following a phase of further integral validation.

More information on the JEFF project is available at www.oecd-nea.org/dbdata/jeff.

International nuclear data evaluation co-operation

The NEA Working Party on International Nuclear Data Evaluation Co-operation (WPEC) reviews worldwide progress in the field of nuclear data evaluation, measurement and related topics with the objective of improving the quality and completeness of evaluated nuclear data files. It also provides a worldwide framework for co-operative activities between major nuclear data evaluation projects in the form of short-term subgroups.

The current WPEC subgroup activities focus on meeting nuclear data needs for advanced reactor systems, methods for the combined use of integral experiments and covariance data, evaluation of plutonium-239 in the resonance region, scattering angular distributions in the fast energy range and on the reporting and usage of experimental data for evaluation in the resolved resonance region.

Two new subgroups were established in 2012. The first will focus on improved fission product yield evaluation methodologies, whereas the second will define a modern nuclear database structure beyond the current Evaluated Nuclear Data Format (ENDF).

More information on recent WPEC reports is available at www.oecd-nea.org/science/wpec.

The Thermochemical Database (TDB) Project

The Data Bank works together with the NEA Radiological Protection and Radioactive Waste Management Division on a thermochemical database project examining the key elements required for geochemical modelling of deep geological repositories. Teams of international experts are carrying out critical reviews of bibliographic references and have set up a quality-assured database. Further details are provided in the section on Joint Projects and Other Co-operative Projects (see page 34).

In-house computer services

The Data Bank is responsible for NEA in-house computer services comprising internet and data servers connected to a fast network. In 2012, the NEA internet server registered 1.4 million visits, during which four million web pages were browsed and some 13.5 terabytes were downloaded. The computer services also develop software, such as JANIS, DICE, IDAT and ISOE, and maintain collaborative platforms for the Multinational Design Evaluation Programme (MDEP), Generation IV International Forum (GIF) and Thermochemical Database (TDB) projects.

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Legal Affairs

Nuclear Law Committee (NLC)

The NLC promotes the development, strengthening and harmonisation of nuclear legislation governing the peaceful uses of nuclear energy in member countries and selected non-member countries. It supports the adoption, implementation and modernisation of national and international nuclear liability regimes. Under its supervision, the NEA analyses and disseminates information on nuclear law through a regular publications programme and two education programmes (the International School of Nuclear Law and the International Nuclear Law Essentials).

Highlights

- Signatories to the 2004 Protocols to revise the Paris Convention and the Brussels Supplementary Convention made good progress towards preparing for the ratification and implementation of the provisions of those protocols into their national legislation, including finding ways to financially secure those nuclear risks for which operators are unable to obtain private insurance.
- The NLC held special sessions on nuclear third party liability issues arising from the Fukushima Daiichi accident, as well as on legal aspects of the reform and independence of regulatory bodies.
- The second session of International Nuclear Law Essentials (INLE) was held in June, and the 12th session of the International School of Nuclear Law was held in co-operation with the University of Montpellier 1 in late August to early September.
- Two issues of the *Nuclear Law Bulletin* (NLB) were prepared and included articles on the revision of the IAEA International Basic Safety Standards, India's civil nuclear liability regime, international efforts against nuclear trafficking, the status of decommissioning in Italy, the Nuclear Power Plant Exporters' Principles of Conduct, the "MCP Altona" incident involving the transport of uranium, conflict of law issues related to Switzerland's participation in the nuclear third party liability regime under the Paris Convention, and the impact of the Additional Protocol on comprehensive safeguards agreements and a strengthened IAEA safeguards system.

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 amongst member countries. Those countries which are party to the Paris and Brussels Supplementary Conventions on nuclear third party liability worked towards implementing the 2004 Protocols amending those conventions. A few are still facing delays in implementation because, among other reasons, private nuclear risk insurers are unable to provide full coverage for certain risks which nuclear operators are obliged to assume under the revised conventions. Such risks include the cost of reinstating an impaired environment and claims instituted more than ten years after the occurrence of a nuclear incident.

During its meetings in March and November 2012, the NLC held special sessions on legal aspects related to the Fukushima Daiichi accident. Mr. Toyohiro Nomura, Professor at Gakushuin University and member of the Dispute Reconciliation Committee for Nuclear Damage Compensation, Mr. Shigekazu Matsuura, Director for Nuclear Liability and Deputy Director of Nuclear Liability Office at the Research and Development Bureau of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and Mr. Taro Hokugo, Project Researcher at the Research Promotion Department of the Policy Alternatives Research Institute of the University of Tokyo, described Japan's nuclear liability system and its application to the accident at the Fukushima Daiichi nuclear power plant, providing a detailed overview of the compensation process.

In addition, during the March 2012 meeting of the NLC, Indian experts were invited to give a presentation on the nuclear liability regime in India. A special session on the reform and independence of nuclear regulatory bodies was held during the November 2012 meeting. During this special session, delegates of member countries that had recently undertaken regulatory reform initiatives (such as Japan, Korea and the United Kingdom) gave extensive presentations. The delegate from the Russian Federation explained the Russian regulatory system, and experts from the International Atomic Energy Agency (IAEA) Regulatory Activities Section of the Division of Nuclear Safety and the NEA Nuclear Safety Division explained their related ongoing activities.

The NEA Secretariat participated in the informal expert group which has been set up by the European Commission to analyse the potential for harmonisation across the EU of national legislation regarding nuclear liability. The aim is to ensure legal coherence within the EU in line with international principles.

The 2012 session of the ISNL took place at the University of Montpellier 1 and was attended by 55 participants from 29 countries.

The main objectives are to improve victims' protection in the different member states and to address the impact of diverging financial guarantee obligations. The group intends to provide recommendations for a potential Commission proposal under Article 98 of the Euratom Treaty. The NEA Secretariat has also contributed to the work of the International Expert Group on Nuclear Liability (INLEX) established by the IAEA Director-General.

Nuclear law publication programme

The 89th and 90th issues of the *Nuclear Law Bulletin* (NLB) were prepared. The NLB is a unique international publication for both professionals and academics in the field of nuclear law. It provides subscribers with authoritative and comprehensive information on nuclear law developments. With two issues a year in English and French, it features topical articles written by renowned legal experts, covers legislative developments worldwide and reports on relevant case law, international agreements as well as activities of intergovernmental organisations. All but the latest three editions of the NLB are freely available online at www.oecd-nea.org/law/nlb. A subscription to the Bulletin is available through the OECD bookshop at www.oecdbookshop.org.

Country profiles on the regulatory and institutional framework for nuclear activities in OECD member countries are available at www.oecd-nea.org/law/legislation/. The NEA website also proposes a listing of "Latest legislative developments", which tracks recent nuclear legislative events. The listing can be found at www.oecd-nea.org/law/legislation/updates.html.

Nuclear law education programmes

The 12th session of the International School of Nuclear Law (ISNL), a unique academic programme organised by the NEA and the University of Montpellier 1, was held from 27 August to 7 September 2012. Over the past twelve sessions, the ISNL has provided a high-quality educational experience to more than 600 participants from around the world. This session attracted 55 participants from approximately 30 countries. The programme brings together leading experts in nuclear safety, security, non-proliferation and safeguards to provide an in-depth exploration of the legal aspects of the use and oversight of nuclear energy. A special panel session focused on the impact of the Fukushima Daiichi accident on international nuclear safety, radiological protection and emergency management instruments. Participants enrolled in the ISNL have the opportunity of applying for a University Diploma in International Nuclear Law recognised by the University of Montpellier 1. This diploma is also recognised within the ECTS (European Credit Transfer and Accumulation System). Further information may be obtained at www.oecd-nea.org/law/isnl/.

In June, the NEA hosted the second session of the International Nuclear Law Essentials (INLE) programme. Some 23 participants from 14 countries participated in this one-week comprehensive course covering various aspects of international nuclear law. Built on the success of the International School of Nuclear Law, the INLE is designed to provide focused, relevant and practical training to mid- to senior-level professionals. Renowned experts from international organisations, governments and private industry led lectures, discussions and case studies. The following topics were addressed: introduction to nuclear law; international radiological protection standards; nuclear accident notification and assistance; nuclear safety; nuclear regulatory activities; management of spent fuel and radioactive waste; nuclear activities and environmental law; liability, compensation and insurance for nuclear damage; non-proliferation of nuclear weapons and international safeguards for nuclear materials; nuclear security: physical protection, illicit trafficking and terrorism; international trade in nuclear material and equipment; nuclear project development and contracting; and transport of nuclear materials and fuel. More information is available at www.oecd-nea.org/law/inle/.

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Joint Projects and Other Co-operative 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 100 organisations in 19 countries. The project benefits from 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.

In 2012, the project started its 19th three-year cycle. Work in the fuel area 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 complement the work done at laboratory scale in other institutions, notably in Japan and the United States. A workshop was held in May 2012 to summarise and review the whole history and results of the Halden LOCA experiments, assimilating current understanding of key LOCA phenomena including high burn-up fuel fragmentation, relocation and fuel particle dispersal, which for the first time were being observed in Halden tests.

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 were studied. The experimental programme on the effect of water chemistry variants on fuel and reactor internals materials has been continuing. Tests to investigate the cracking behaviour of reactor internals materials in boiling and pressurised water reactors 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 *inter alia* the use of the Halden Virtual Reality Centre. Progress has been made in the area of human reliability assessment (HRA), aiming 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 regular meetings of the Halden Programme Group, and two meetings of the Halden Board of Management in 2012.

The BIP-2

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

- quantification of the relative contributions of homogeneous bulk aqueous phase processes, homogeneous aqueous phase processes in paint pores and heterogeneous processes on surfaces to organic iodine formation;
- the measurement of adsorption/desorption rate constants on containment surfaces as a function of temperature, relative humidity and carrier-gas composition;
- the provision of Radioiodine Test Facility (RTF) data from five RTF experiments to participants, for use in collaborative model development and validation.

The final report was approved as a CSNI public report in December 2011.

A three-year follow-up project, BIP-2, started in April 2011 and attempts 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 quantifying the rates of formation for methyl iodide from irradiated paint, the mechanism is not understood. Therefore, the objective of BIP-2 is to identify

the mechanisms involved in these two processes. A mechanistic understanding applied to models for these phenomena improves our ability to explain results to regulatory agencies, and justifies application of these results to ranges outside the tested conditions (e.g., extrapolation to a wider selection of materials and to larger-scale experiments and containment conditions).

The specific technical objectives for BIP-2 are:

- 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 on how to extrapolate confidently from small-scale studies to reactor-scale conditions.

The BSAF

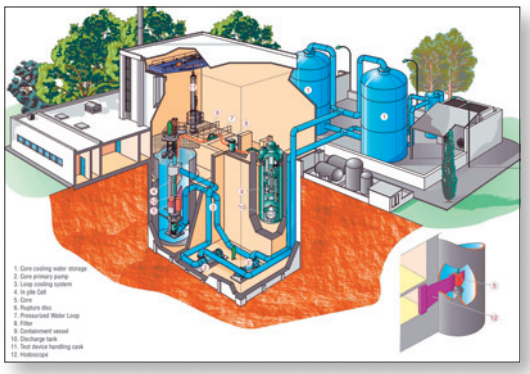
The Benchmark Study of the Accident at the Fukushima Daiichi Nuclear Power Station (BSAF) was established among eight NEA member countries as a new joint research project in 2012. The BSAF is intended to improve severe accident (SA) codes, and to analyse accident progression and current core status in 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 the Japan Atomic Energy Agency (JAEA), the operating agent, in collaboration with other Japanese institutions such as the Institute of Applied Energy (IAE), the Japan Nuclear Energy Safety Organisation (JNES) and the Central Research Institute of Electric Power Industry (CRIEPI), and is supported by the Tokyo Electric Power Company (TEPCO) and other Japanese industry partners. The project 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 will be applied in the NEA benchmark exercise. The range of analysis for this first phase will include: conducting 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 (or reactor scram), and analysing in full a number of key phenomena including, but not limited to, initial transient from rated condition to core heat-up, core heat-up, core melt, release of fission products (FPs) from fuel, behaviour of core internals (core shroud), core status including debris behaviour, molten debris-coolant interaction in the lower plenum (if necessary) and FP transfer.

The first phase of this project is scheduled to run from November 2012 to March 2014.

The Cabri Water Loop Project

The Cabri Water Loop Project, which began in 2000, is investigating the ability of high burn-up fuel to withstand the sharp power peaks that can occur in power reactors due to postulated rapid reactivity insertions in the core (RIA accidents). The project participants, from 13 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. Project execution involves substantial facility modifications and upgrades, and consists of 12 experiments with fuel retrieved from power reactors and refabricated to suitable length. The experimental work is being carried out at 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.



IRSN, Cadarache, France

Cabri reactor with water loop scheme.

Two tests (still using the sodium loop) were carried out with high burn-up fuel cladded with zirconium-niobium material. Fuel that had been in service in Spanish and French reactors, respectively with ZIRLO and M5 cladding, 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 assessment process of the refurbishment works conducted over the last few years on the Cabri research reactor was completed and an authorisation to refuel the CABRI core was received from the French nuclear regulatory authority in March 2012.

The Cabri tests are being complemented by additional reactivity-initiated accident (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, will be carried out under both cold and hot coolant conditions, and with both BWR and PWR fuel.

A meeting of the Cabri Technical Advisory Group was held in April 2011 and the meeting of the Project Steering Committee in February 2011. The next meetings are planned for 2013.

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 the ageing infrastructure 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 is a three-year programme currently supported by five countries and to be conducted at a facility in the United States. Other countries have shown interest in the project. The project aims to conduct experiments in 2013 to explore the basic configurations, failure modes and effects of HEAF events. The equipment to be tested and considered in this study 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 first meeting of the project was held in September 2012 to define an experimental test matrix, experimental conditions and parameters to be investigated.

The LOFC Project

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

The objectives of the proposed project are to conduct integrated large-scale tests of LOFC in the HTTR reactor, to examine 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;
- provide experimental data for validation of the most important safety aspects regarding reactor kinetics, core physics and thermal-hydraulics;
- provide experimental data to verify the capabilities of the codes regarding the simulation of phenomena coupled between reactor core physics and thermal-hydraulics.

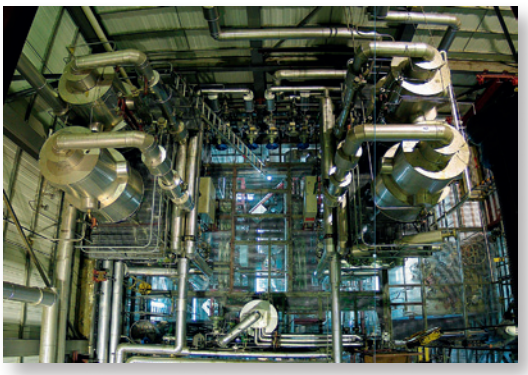
These goals will be achieved by using the HTTR to perform three test cases. The comparison of their results will provide the incremental performance availability within the vessel cooling system (VCS) range. The LOFC tests will be initiated by tripping all three helium gas circulators (HGCs) of the HTTR while deactivating reactivity control to disallow reactor scram due to abnormal reduction of primary coolant flow rate. They will address ATWS with occurrence of reactor re-criticality, and will be conducted with and without active function of the VCS.

A second meeting of the project's steering bodies was held in 2012 during which participants discussed the analyses of the first test. The latter will be used for benchmarking calculations by participants. Due to the HTTR reactor shutdowns after the March 2011 earthquake, the project was extended by one year until March 2014 to allow completion of the remaining tests.

The PKL-2 Project

The PKL-2 Project, which ran from July 2007 to December 2011, consisted of eight experiments carried out in the *Primär Kreislauf* (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 for current PWRs as well as for new PWR design concepts, and focused on complex heat transfer mechanisms in the steam generators and boron precipitation processes under postulated accident situations.

In 2011, participants discussed the preparation and the results of the counterpart test with the ROSA-2 Project addressing small break LOCA with accident management procedures. In October 2012, a second and concluding analytical workshop was organised jointly with the ROSA-2 Project to discuss progress in reactor coolant system (RCS) thermal-hydraulic modelling with systems codes and initial results achieved in modelling with computational fluid dynamics (CFD) codes. A proposal for a follow-up programme prepared by AREVA with side experiments at ROCOM, PMK and PACTEL (Finland) was discussed and, based on the interest expressed by most participants, a draft agreement for a new phase (PKL-3 Project) was prepared and began in 2012.



AREVA, France

Top view of the PKL facility in Erlangen.

The PRISME-2 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 (PSA) that remain open are the following: 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.

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 which ran from 2006 to 2011. A final report of the PRISME Project was approved by the CSNI in 2012, and a concluding seminar was held in Aix-en-Provence, France at the end of May 2012. This seminar drew over 60 participants from 29 countries and international organisations. 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. 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 for simulating other fire propagation scenarios in various room configurations with a good degree of confidence.

The first experimental test campaign for the PRISME-2 Project (vertical heat and smoke propagation from one compartment to another) was completed in 2012 at the IRSN experimental facilities in Cadarache. The second test campaign (electrical cabinet and cable fires) is now also well underway. In 2012, meetings of the PRISME-2 management board and programme review group took place in May and November. Additionally, the project's analytical working group has been constituted and has begun a series of benchmark exercises needed to conduct cross-comparisons and validations of code modelling approaches. At least three benchmark exercises will be conducted as part of the PRISME-2 Project.

The ROSA-2 Project

A first Rig-of-safety Assessment (ROSA) Project was carried out from 2005 to 2009 to address issues in thermal-hydraulics analyses relevant to LWR safety using the ROSA large-scale test facility of the Japan Atomic Energy Agency (JAEA). In particular, it focused on the validation of simulation models and methods for complex phenomena that may occur during transients/accidents. The project was supported by safety organisations, research laboratories and industry in 14 countries, and provided an integral and separate-effect experimental database to validate the code predictive capability and accuracy of models. In particular, temperature stratification and coolant mixing during emergency coolant injection, unstable and disruptive phenomena such as water hammer, natural circulation under high core power conditions, natural circulation with superheated steam, primary cooling through steam generator secondary depressurisation, and upper-head break and bottom break LOCA were addressed by the 12 tests carried out. The project was successfully completed and the final report was released on DVD.

JAEA, Japan

The ROSA large-scale test facility (LSTF).

A second phase of the project, called ROSA-2 and using the same large-scale test facility, started in April 2009 with the support of 14 countries. The ROSA-2 Project was scheduled to last for three years (extended by six months due to the Fukushima Daiichi accident) and to consist of six tests on:

- intermediate break LOCAs (for risk-informed, break-size definition and verification of safety analysis codes);
- steam generator tube rupture (SGTR) and SGTR with steam line break (for improvement and new proposals regarding accident management and mitigation/emergency operation).

All six tests have been successfully performed, including two counterpart tests with PKL. The recent participation of China, which joined as an associate member, enabled a seventh test based on an intermediate cold leg break LOCA with full availability of the emergency core cooling system.

As mentioned above, a joint PKL-2/ROSA-2 workshop was organised on 15-19 October 2012 and included a presentation and discussion of the two counterpart tests and the related analytical work.

The SCIP-2

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. The nuclear fuel failure mechanisms studied in the first phase of the project were:

- pellet-cladding interaction (PCI): stress corrosion cracking initiated at the cladding inner surface under the combined effect of the mechanical loading and chemical environment caused by an increase in the fuel pellet temperature following a power increase;
- hydride embrittlement: time-independent fracture of existing hydrides;
- delayed hydride cracking (DHC): time-dependent crack initiation and propagation through fracture of hydrides.

In December 2008, all members of the project steering bodies indicated their interest in continuing the project for another five-year period. SCIP-2 thus began in July 2009 with the participation of 13 countries (two more than in the first phase).

The main objective of SCIP-2 is 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. The major focus will be on cladding failures caused by pellet-cladding mechanical interaction, especially stress corrosion and hydrogen-assisted fracture mechanisms, as well as on the propagation of cladding cracks. Improved understanding based on experiments and analyses is needed in order to reduce the occurrence, or the risk of occurrence, of fuel failures. This understanding is to be applicable to pellet-cladding interaction conditions that can arise during normal operation or anticipated transients, as well as during long-term fuel storage. The proposed programme is intended to complement other international projects in the fuel area. Extensive analyses and theoretical modelling of the fracture mechanisms are to accompany the experimental programme.

In addition to reviewing existing Studsvik ramp data, the project will study the following fuel failure mechanisms:

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

Two meetings of the project steering bodies took place in 2012, as well as a workshop on fuel rod behaviour modelling.

The SERENA Project

The Steam Explosion Resolution for Nuclear Applications (SERENA) Project was launched in 2007 with nine member countries participating to evaluate the capabilities of the current generation of fuel-coolant interaction (FCI) computer codes to predict steam-explosion-induced loads in ex-vessel reactor situations. It includes a limited number of focused tests with advanced instrumentation reflecting a large spectrum of ex-vessel melt compositions and conditions, as well as the required analytical work to bring the code capabilities to a sufficient level for use in reactor case analyses. The objective of the SERENA experimental programme is threefold:

- to provide experimental data to clarify the explosion behaviour of prototypic corium melts;
- to provide experimental data for validation of explosion models for prototypic materials, including spatial distribution of fuel and void during the pre-mixing and at the time of explosion, and explosion dynamics;
- to provide experimental data for the steam explosion in more reactor-like situations to verify the geometrical extrapolation capabilities of the codes.

These goals will be achieved by using the complementary features of the TROI (Korea Atomic Energy Research Institute) and KROTOS (French *Commissariat à l'énergie atomique et aux énergies alternatives)* corium facilities, including analytical activities. The KROTOS facility is more suited for investigating the intrinsic FCI characteristics in one-dimensional geometry. The TROI facility is better suited for testing the FCI behaviour of these materials in reactor-like conditions by having more mass and multi-dimensional, melt-water interaction geometry. The validation of models against KROTOS data and the verification of code capabilities to calculate more reactor-oriented situations simulated in TROI will strengthen confidence in code applicability to reactor FCI scenarios.

The results of two new tests were presented and discussed in 2011, enabling a better specification of the test configurations for the last test which was performed early in 2012. In parallel, analytical activities were undertaken to prepare and to assess these tests, and a benchmark on a reactor case was carried out. A concluding seminar was organised in November 2012, the conclusions of which will be distributed to the CSNI.

The SFP Project

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 supplement earlier results obtained for BWR assemblies. Code validations based on both the PWR and BWR experimental results will considerably enhance the code applicability to other fuel assembly designs and configurations.

The project was scheduled to last three years and to be 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 meeting of the project steering bodies was held in October 2012. A concluding workshop of the project is scheduled in October 2013.

The STEM Project

The Source Term Evaluation and Mitigation (STEM) Project was initiated in 2011 to improve the general evaluation of the source term. The reduction of known uncertainties regarding specific phenomena is expected to help:

- provide better information and tools to emergency teams enabling a more robust diagnosis and prognosis of the progression of an accident and a better evaluation of potential release of radioactive materials;
- investigate phenomena involved in possible complementary mitigation measures, natural or engineered, so as to minimise releases to the environment.

The STEM Project is a four-year programme supported by seven countries and conducted at the IRSN facilities in Cadarache, France. It will address three main issues:

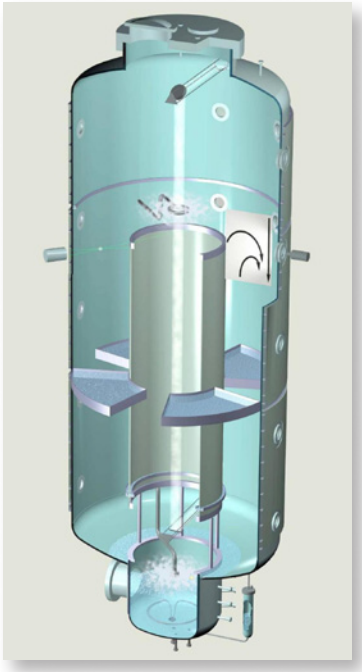
- Radioactive iodine release in the mid- and long-term: in complement to previous programmes, it is proposed to perform experiments to study the stability of aerosol particles under radiation and the long-term gas/deposits equilibrium in a containment.
- Interactions between iodine and paints: no experiments 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: in complement to previous programmes, it is proposed to perform experiments to study ruthenium transport in pipes.

The first meeting of the steering bodies was held in 2011 during which the overall test matrix of experiments to be performed was discussed. The first series of experiments (iodine behaviour under radiation) are dedicated to the analysis of radiation effects and will thus be realised in benches built on the EPICUR facility (Experimental Programme of Iodine Chemistry Under Radiation). The second series of experiments (ruthenium transport) will aim to analyse the chemistry of ruthenium in pipes including the reactor coolant system and in filters. They will be 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 THAI-2 Project

Phase 2 of the Thermal-hydraulics, Hydrogen, Aerosols and Iodine (THAI-2) Project started in July 2011 with the support of ten member countries. It is a follow-up to the THAI Project conducted from 2007 to 2009. The new experiments will also be conducted in the THAI facility operated by Becker Technologies GmbH in Germany. The *Gesellschaft für Anlagen- und Reaktorsicherheit* (GRS) and AREVA NP also support the programme.

The objective of this follow-up project is to address remaining questions and to provide experimental data relevant to high-temperature gas reactor (HTGR) graphite dust transport issues, specific water-cooled reactor aerosol and iodine issues, and hydrogen mitigation under accidental conditions. The project will address open questions concerning the behaviour of: a) graphite dust transport in a generic HTGR geometry, b) release of gaseous iodine from a flashing jet and iodine deposition on aerosol particles, and c) hydrogen combustion during spray operation and passive autocatalytic recombiner operation in case of extremely low oxygen content. Understanding the respective processes is essential for evaluating the challenges posed for next-generation reactors (such as the HTGR), the amount of airborne radioactivity during accidents with core damage (iodine and aerosols) and containment integrity (hydrogen). The programme will



Becker Technologies, Germany

Diagram of the THAI containment vessel.

generate valuable data for evaluating atmospheric flows and subsequently graphite dust transport in a generic multi-compartment geometry. Regarding fission products, the programme will focus on iodine release from a flashing jet and gaseous iodine deposition on aerosols. In terms of hydrogen mitigation, the programme will focus on hydrogen combustion during spray operation and on its effective removal by means of passive autocatalytic recombiners when approaching oxygen starvation. An analytical effort will accompany the experimental programme, mainly consisting of code calculations for pre-test assessments, result evaluations and extrapolation to reactor situations.

Two meetings of the steering bodies were held in 2012 during which the overall test matrix of experiments was modified in view of the new priorities arising from the Fukushima accident. A new test matrix was agreed by the signatories in December 2012.

NUCLEAR SAFETY DATABASES

The CADAK Project

The Cable Ageing Data and Knowledge (CADAK) Project provides a follow-up to the cable ageing part of the Stress Corrosion Cracking and Cable Ageing (SCAP) Project, funded by Japan and operated successfully from 2006 to 2010, due to its relevance for plant ageing assessments and implications for nuclear safety. The objectives of the CADAK Project are 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. This research will investigate the adequacy of the margins and their ability to address the uncertainties.
- Enter for a number of member countries cable data and information in the system, e.g. technical standards being applied in the qualification of cables and inspection methods being used regularly.
- Estimate the remaining qualified lifetime of cables used in nuclear power plants. The cable condition-monitoring techniques shared by the participants within CADAK will become an up-to-date encyclopaedic source to monitor and predict the performance of numerous unique applications of cables.
- Analyse the information collected to develop topical reports in co-ordination with the CSNI Working Group on Integrity and Ageing of Components and Structures.

In late 2012, the CADAK Project was ready to launch the initial version of the CADAK web interface (based on the former SCAP database and knowledge base).

The CODAP

The Component Operational Experience, Degradation and Ageing Programme (CODAP) builds on two recent OECD/NEA projects: the Piping Failure Data Exchange (OPDE) Project which 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, due to their implications for nuclear safety and their relevance for plant ageing management, stress corrosion cracking (SCC) and degradation of cable insulation. Twelve countries are participating in the first phase of the CODAP which started in 2011 and will run until the end of 2014.

The objectives of the CODAP are to:

- 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 pro-active 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 Working Group on Integrity and Ageing of Components and Structures (WGIAGE).

During 2012, two meetings of the Programme Review Group were held. The overall programme of work was discussed, including support from the project Clearinghouse.

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. Twelve countries participate. The main purpose of the project is to collect and to analyse data related to fire events in nuclear environments, on an international scale. The specific objectives are to:

- define the format for, and collect fire event experience (by 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 mitigating 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. Two meetings of the project steering body were held during 2012 with a view to establishing the basis for increased use of the database for probabilistic risk assessments (PRAs).

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 agreement covering 2008-2011. It was also agreed in 2011 to start a new project phase which will run from 2011 to 2014.

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.

In 2012, a report on "Collection and Analysis of Common-cause Failures of Centrifugal Pumps" was completed and approved to be issued as a CSNI report. A total of 353 ICDE events spanning a period from 1975 through 2009 were examined with respect to failure modes, degree of impairment, failure symptoms, failure causes and technical fault aspects. One of the report's conclusions suggests that maintenance and test activities are significantly more effective for preventing complete failures in "failure to run" events than in "failure to start" events. Thus, maintenance and test activities should specifically focus on the prevention of "failure to start" events.

A report on "Collection and Analysis of Common-cause Failures of Control Rod Drive Assemblies (CRDA)" was also completed in 2012 and approved for distribution as a CSNI report. Some 169 ICDE events spanning a period from 1980 through 2003 were examined with respect to root cause, coupling factor, observed population size, corrective action, the degree of failure, affected subsystem and detection method. Most of these failures were caused by core or fuel assembly deformations due to irradiation, thermal, mechanical and hydraulic loading, and their mutual interaction. Communication of operating experience with CCF phenomena is important to ensure that plants can implement the appropriate defences and controls to prevent significant impacts on plant safety.

RADIOACTIVE WASTE MANAGEMENT

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 functioning under an agreement among 23 organisations in 12 NEA member countries, one non-member economy and the European Commission, actively executing or planning the decommissioning of nuclear facilities. The objective of the CPD is to acquire and to share information from operational experience in the decommissioning of nuclear installations that is useful for future projects. It has operated under Article 5 of the NEA Statute since its inception in 1985, and a revised agreement among participants came into force on 1 January 2009 for a five-year period.

The 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. It is based on biannual meetings of the Technical Advisory Group (TAG), 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. Currently 59 projects under active decommissioning (35 reactors and 24 fuel facilities) are included in the information exchange. In 2012, four additional decommissioning projects were accepted: Waste storage facility #56 at Cadarache, CEA, France; the Fukushima Daiichi nuclear power plant, TEPCO, Japan; Brunsbüttel nuclear power plant, KKB, Vattenfall Europe Nuclear Energy GmbH, Germany; and the MR/FRT Research Reactors, NRC, Kurchatov Institute, Russia.

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 Site Remediation and Restoration continues to review the experience, approaches and techniques for nuclear site restoration.

The TDB 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 assessments of radioactive waste repositories. The project's current mandate runs to January 2013, following a one-year extension decided by the TDB Management Board. Sixteen organisations from 13 countries participate.

The project has so far produced 11 volumes of internationally recognised and quality-assured thermodynamic data for the major actinides and fission or activation products. Two reviews concerning tin and iron (Part I) will be published shortly. Three volumes are in preparation on the chemical thermodynamics of molybdenum, iron (Part II) and the ancillary data used in the TDB Project. Related activities will be conducted over the next two years. The preparation of a state-of-the-art report concerning the cement phases started in 2012.

During its annual meeting on 13-14 November 2012, the members of the Management Board defined the programme of work for the next phase of the TDB Project (TDB-5) in view of the needs expressed by the participating organisations, and decided to further extend the mandate of the current phase by an additional year in order to finalise the agreement for the next phase.

RADIOLOGICAL PROTECTION

The ISOE

Since its creation in 1992, the Information System on Occupational Exposure (ISOE), jointly sponsored by 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. As of December 2012, membership comprised 70 participating utilities from 29 countries, and 27 regulatory authorities from 24 countries. The Office of Nuclear Regulation, an agency of the Health and Safety Executive (HSE) of the United Kingdom, has informed the NEA Secretariat of its interest in participating in the ISOE programme as a regulatory authority, and the new regulatory body of Japan, the Nuclear Regulation Authority (NRA), has been invited to the ISOE programme by the Secretariat.

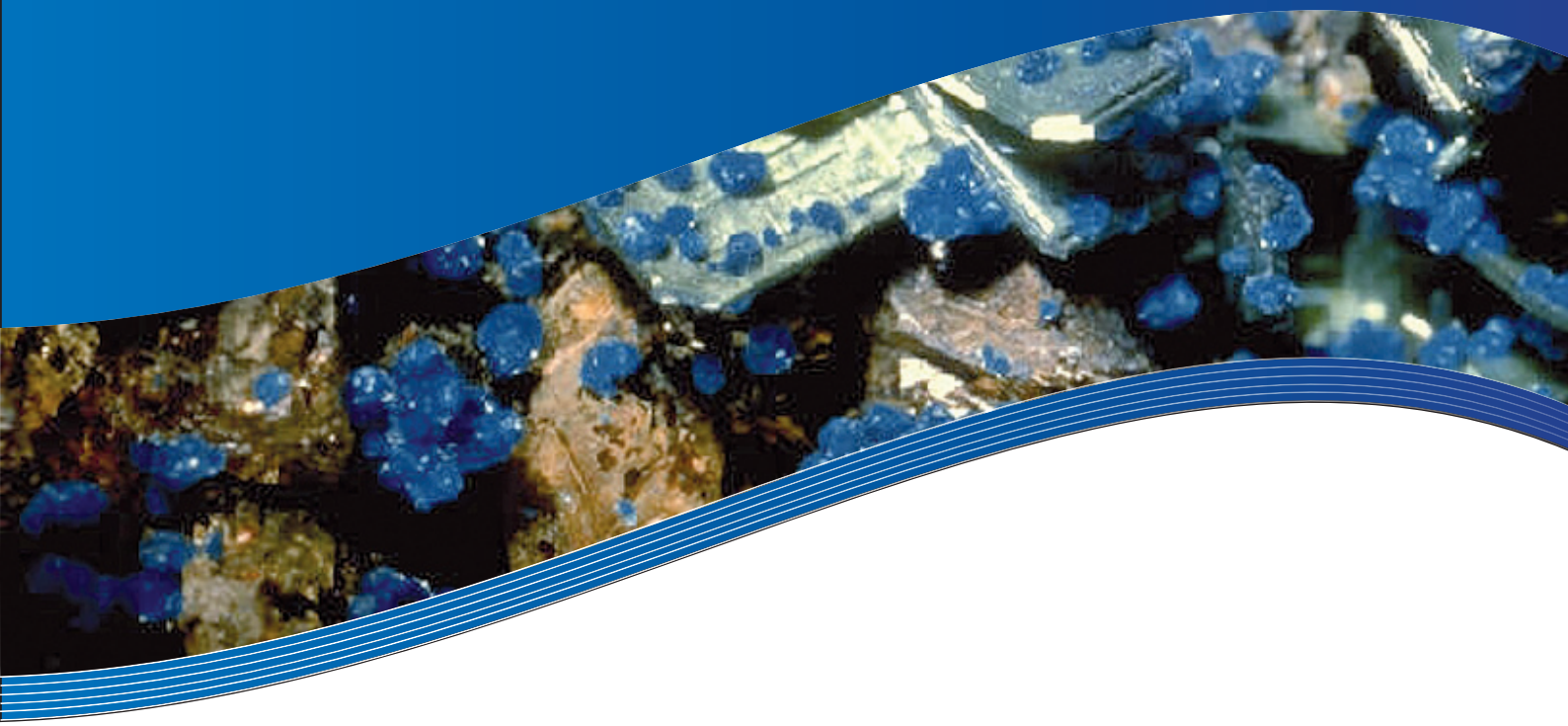
Four supporting ISOE Technical Centres (Europe, North America, Asia and the IAEA) manage the system's day-to-day technical operations of analysis and exchange of information and experience. The ISOE occupational exposure database itself contains information on occupational exposure levels and trends at 482 reactor units in 29 countries (401 operating units and 81 units in cold shutdown or at some stage of decommissioning), 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 2012, the ISOE continued to concentrate on the exchange of data, analysis, good practice and experience in the area of occupational exposure reduction at nuclear power plants, on improving the quality of its occupational exposure database and on migrating ISOE resources to the ISOE Network website (www.isoe-network.net). The four regional ISOE Technical Centres continued to support their regional members through specialised data analyses and benchmarking visits. To improve the effectiveness of the Technical Centres, the ISOE Management Board agreed on the establishment of the ISOE Technical Centres Performance Indicators (TC PIs), which will be implemented in 2013. In 2012, the annual international ISOE Symposium was organised by the North American Technical Centre and a further two regional ALARA symposia were held in Europe and Asia.

The Expert Group on Primary Water Chemistry and Source-term Management (EGWC) was created by the ISOE Management Board at its November 2010 meeting. The objective of the EGWC is to prepare a report on radiological protection aspects of primary water chemistry and source-term management for all reactor types in order to reflect the current state of knowledge, technology and experience in this area. The EGWC met in February and October 2012 and the partial draft final report, which includes detailed chapters on the introduction of strategies and techniques, radiation field measurement techniques, measurement locations and indices, remediation of contamination during outages and radiation protection outcomes, was submitted for review in November 2012.

The Expert Group on Occupational Radiation Protection in Severe Accident Management and Post-Accident Recovery (EG-SAM) was established by the ISOE Management Board in May 2011. The Expert Group comprises 44 members from 18 countries and met twice in 2012. The overarching objective is to contribute to occupational exposure management (providing a view on management of high radiation area worker doses) in Fukushima with the ISOE participants (utilities and regulatory authorities), and to address the experience of a number of ISOE utilities with various RP management approaches in severe accidents. During the November 2012 meeting of the group, it was decided to develop an interim report before the end of 2013 and to finalise the report by organising a workshop in 2014 discussing national experiences. The report will be submitted to the ISOE Management Board for approval.

Technical Secretariat



Generation IV International Forum (GIF)

The present status of nuclear technology is the result of over 50 years of continuous development, making use of experience gained from nearly 15 000 reactor-years of operation. The latest designs of nuclear power plants that are under construction or already in operation, known as Generation III or III+ designs, incorporate the lessons learnt from this experience and offer higher levels of safety and performance, improved fuel efficiency and reduced radioactive waste production compared with earlier designs.

For the longer term, more innovative nuclear energy technologies and fuel cycles, known collectively as Generation IV systems, are being developed through international co-operation. The most important initiative to co-ordinate research and development (R&D) efforts on advanced reactors and fuel cycles is the Generation IV International Forum (GIF). Formed in 2001, GIF brings together 12 countries including Canada, China, France, Japan, the Republic of Korea, the Russian Federation and the United States, as well as Euratom. The aim is to develop systems that offer improved sustainability, economics, safety and reliability, proliferation resistance and physical protection.

Six conceptual nuclear energy systems were selected in 2002 for collaborative R&D, comprising 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). Each of these has reached a different stage of development, depending on the R&D efforts that have been made in the past and the level of commitment each has received from participating countries. Detailed information on these systems can be found in the "Technology Roadmap for Generation IV Nuclear Energy Systems" (2002) and in its update entitled "GIF R&D Outlook for Generation IV Energy Systems" (2009), as well as in the GIF annual reports, all of which are available on the GIF public website (www.gen-4.org).

The NEA provides Technical Secretariat support to the technical bodies in charge of the development of the six systems and the three methodology working groups. The NEA is fully compensated for its support to the GIF through voluntary, financial and in-kind contributions made by individual GIF members.

In 2012, the GIF organised its second symposium, which was embedded in the ANS Winter Meeting in San Diego, California, and brought together more than 200 participants in its open sessions. This symposium marked the ten-year anniversary of the GIF Technology Roadmap, and represented an opportunity for the GIF organisation to reflect on achievements thus far and challenges that lie ahead. An update of the technology roadmap was launched during the year and will be finalised in 2013. Two other initiatives were launched to improve further R&D collaboration within the GIF as well as collaboration between the GIF and other international initiatives or organisations.

In the follow-up to the Fukushima Daiichi accident, the GIF has continued to stress the importance of achieving the highest levels of safety for the Generation IV systems. The GIF is developing in particular safety design criteria that incorporate lessons learnt from the accident. In 2012, the first draft of the SFR safety design criteria was produced. These criteria are expected to be discussed with organisations of regulatory bodies such as the Multinational Design Evaluation Programme (MDEP).

As regards participation in research activities, the participation of the more recent GIF members continued to increase, an example being the new SFR Safety and Operation Project Arrangement which was signed in 2012 by seven members including the Russian Federation and China.

W. Magwood and J. Bouchard, the first two GIF chairs, receiving an award during the ANS Presidential Special Session, Nov. 2012, San Diego, CA, USA.

Multinational Design Evaluation Programme (MDEP)

The Multinational Design Evaluation Programme (MDEP) continues to pursue its work as the construction of new reactors moves forward. While some countries are coming closer to commissioning those reactors, others have joined the MDEP to benefit from the experience already shared regarding regulatory reviews of new designs. MDEP members are the regulators from Canada, China, Finland, France, India, Japan, the Republic of Korea, the Russian Federation, South Africa, the United Kingdom and the United States. The United Arab Emirates (UAE) is an MDEP associate member. The International Atomic Energy Agency (IAEA) is closely involved in generic MDEP activities to ensure consistency with international requirements and practices. In line with international concerns, the MDEP working groups focus on lessons learnt from the Fukushima Daiichi accident and its impact on new reactor designs.

2012 highlights

The MDEP Steering Technical Committee (STC) finalised a self-assessment of MDEP activities, after consultation of MDEP members and several external stakeholders. It was reviewed by the MDEP Policy Group (PG), and the STC is in the process of setting up an action plan to carry out the concluding recommendations.

The PG endorsed an extension of the planning window for MDEP activities, now expected to continue until at least 2018. At the same time, the 2012 and 2013 programmes of work of each of the working groups was approved. This took place against the backdrop of an expansion of MDEP membership and the creation of a new design-specific working group.

Upon requests from members, the PG agreed to create a new design-specific working group for the APR1400. The APR1400 working group held its first meeting in 2012 with Finland, the Republic of Korea, the United States and the UAE as members. A VVER working group is under consideration.

In 2012, India became the first new member of the MDEP since its inception in 2008. Indian representatives joined the EPR working group as well as the issue-specific working groups. The UAE became the first MDEP associate member and joined the APR1400 working group (APR1400WG) and the issue-specific working groups.

Taking into account lessons learnt from the Fukushima accident was a central focus of the design-specific working groups, lead by the STC. The EPR working group mandated experts' subgroups to review in detail the topics which the main group felt the need to address.

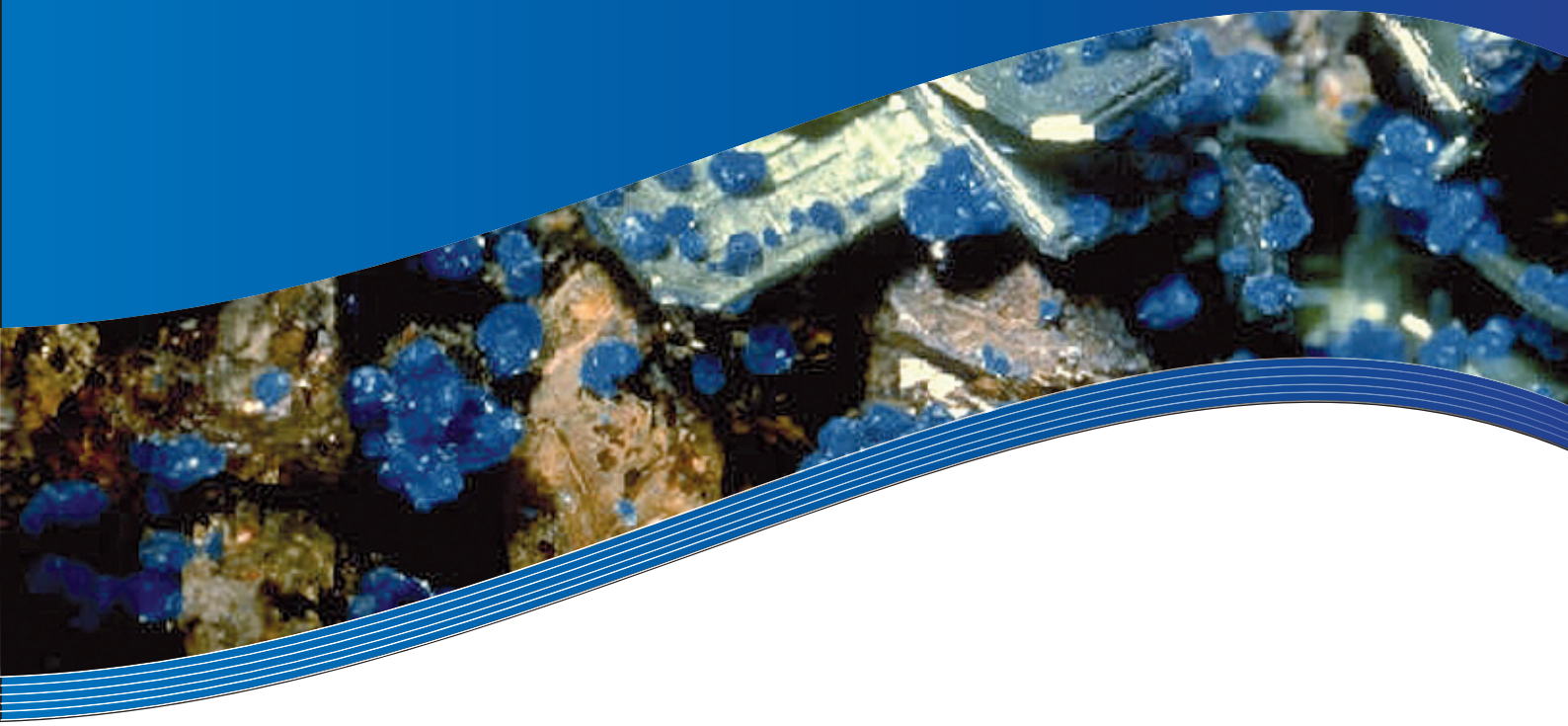
In 2012, the Codes and Standards Working Group (CSWG) released the "Code Comparison Report for Class 1 Nuclear Power Plant Components", written by standard development organisations (SDOs) from Canada, France, Japan, the Republic of Korea, the Russian Federation and the United States. It consists of comparisons of the requirements for Class 1 vessels, piping, pumps and valves between major international codes. Moreover, the SDOs set up a code convergence board which held its first meeting in 2012, with the goal of assessing the possibilities of harmonisation of codes and of minimising divergence in their future versions.

The Vendor Inspection Co-operation Working Group (VICWG) members conducted nine witnessed and joint inspections in 2012, and issued a comparison of quality-assurance requirements among MDEP countries.

All these products are publicly available on the MDEP website (www.oecd-nea.org/mdep), intended to widen communication from the programme.

MDEP Conference on New Reactor Design Activities, 7 May 2012.

General Information



Information and Communications

Nuclear energy decision making and stakeholder participation need to be based on knowledge and understanding. The NEA seeks to provide member governments and other interested parties with a large array of information resulting from the Agency's activities, thereby enhancing awareness and understanding of the scientific, technical and economic aspects of the nuclear option.

Highlights

- A new publications policy was adopted according to which all NEA publications would, as from January 2013, be made available for free download from the Agency's website.
- The Agency produced 48 publications in 2012, of which 7 were put on sale and 41 were distributed free of charge. Overall dissemination and downloads were very strong.
- Eight press releases were issued in 2012 on a wide variety of issues, including on the 2013 accession of the Russian Federation to the NEA and the International Workshop on Crisis Communication.
- Web 2.0 networking channels were used extensively throughout the year to communicate the Agency's latest news and events.

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.

Public affairs and relations with the media

Relations with the media in 2012 covered a wide variety of topics and questions regarding the development of nuclear power. In 2012, media interest in the NEA's activities extended to the Agency's publications, such as *Nuclear Energy and Renewables: System Effects in Low-carbon Electricity Systems*, as well as its continuing response to the Fukushima Daiichi nuclear accident. Over the course of the year, several dozen interviews were organised with senior NEA staff, requested by specialised publications and international press agencies. Significant efforts were also employed to ensure efficient internal and external co-ordination and communication, including with the OECD, the International Energy Agency (IEA) and the International Atomic Energy Agency (IAEA).

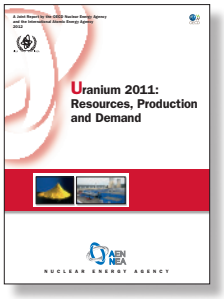
Eight press releases were issued in 2012, notifying the media of, for example, the accession of the Russian Federation to the NEA, which would take effect on 1 January 2013, of new members in the Multinational Design Evaluation Programme (MDEP, see page 45 for further details), the results of an International Workshop on Crisis Communication following Fukushima and the main findings of reports such as *Uranium 2011: Resources, Production and Demand and Nuclear Energy and Renewables: System Effects in Low-carbon Electricity Systems*. These press releases are available in the NEA press room at www.oecd-nea.org/press along with a number of online press kits covering such topics as the Fukushima Daiichi nuclear power plant accident, the decommissioning of nuclear installations, the economics of nuclear power, and nuclear energy and sustainable development.

During the signing ceremony (left) and the press conference (right) for the 23 May 2012 exchange of letters concerning the Russian Federation's accession to the NEA.

Publications

In 2012, the Agency produced 48 publications, of which 7 were put on sale and 41 were distributed free of charge. The list of these publications is provided on page 54. Best sellers included *Uranium 2011: Resources, Production and Demand*, followed by the *Nuclear Law Bulletin* and *Nuclear Energy and Renewables: System Effects in Low-carbon Electricity Systems*. NEA publications will no longer be put on sale as from January 2013 and will be made available free of charge on the NEA website.

The most accessed online reports during the course of the year included *PENELOPE: A Code System for Monte Carlo Simulation of Electron and Photon Transport* (153 191 downloads), *Nuclear Fuel Behaviour in Loss-of-coolant Accident (LOCA) Conditions* (150 301 downloads), *Current Status, Technical Feasibility and Economics of Small Nuclear Reactors* (101 557 downloads) and *Uranium 2009: Resources, Production and Demand* (Japanese version, 90 741 downloads).



NEA News is the Agency's specialised journal, published in English and French, which endeavours to keep 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 2012, *NEA News* covered topics such as the NEA's integrated response to the Fukushima Daiichi nuclear accident and the economic costs of the nuclear phase-out in Germany. The journal is available free of charge on the Agency's website at www.oecd-nea.org/nea-news/.

Internet-based communication

The NEA's online presence plays a key role in communicating the work and accomplishments of the Agency. Website traffic remained steady in 2012 with an average of nearly 4 000 visitors per day or 1.4 million visits on an annual basis. The website sections that attracted the most views were, in order of magnitude: the NEA publications section, the NEA Data Bank's Java-based nuclear data display program JANIS and the NEA press room.

Web 2.0 networking channels are playing an increasingly important role in communicating NEA activities. After establishing a Facebook profile in 2010, the Agency has begun using Twitter, LinkedIn and YouTube to increase visibility of NEA results, publications and events.

Subscriptions to the NEA Monthly News Bulletin have remained constant with approximately 22 000 subscribers. Distributed free of charge, the bulletin includes monthly updates on NEA work and newly-released reports. A sign-up form is available at www.oecd-nea.org/bulletin.

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 on 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 on forthcoming NEA meetings, contact details for other committee members, as well as access to the presentations and background notes prepared for the Steering Committee policy debates.

NEA visibility in international fora

The NEA co-sponsored several international events during 2012, of which some of the main ones included:

- 2012 ISOE International ALARA Symposium, Fort Lauderdale, Florida, United States, 8-11 January;
- 2012 Public Information Materials Exchange (PIME) Conference, Warsaw, Poland, 12-15 February;
- International Congress on Advances in Nuclear Power Plants (ICAPP), Chicago, Illinois, United States, 24-28 June;
- 7th International Youth Nuclear Congress (IYNC), Charlotte, North Carolina, United States, 5-11 August;
- International Conference on Geological Repositories (ICGR 2012), Toronto, Canada, 1-2 October.

The NEA also organised publications and information stands at the OECD Forum in Paris in May, at the Atom'Expo conference in Moscow in June and at the European Nuclear Conference (ENC) in Manchester in December. Several hundred copies of NEA reports and information material were provided at other events.

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Nuclear Energy and Civil Society

Nuclear regulators and the public

Information officers from regulatory bodies meet once a year under the auspices of the Working Group on Public Communication of Nuclear Regulatory Organisations (WGPC) to exchange information and experience related to communication with the public and to carry out related studies. In 2012, the main activity of the WGPC consisted of organising an international workshop with senior regulators, regulatory communicators and stakeholders from civil society in May. One of the main conclusions from this workshop was the need for nuclear regulators to integrate the expectations of the public from other countries in their communication about events in their own countries. In practice, this will mean better co-ordination between nuclear regulatory authorities' public relations and international relations departments.

Forum on Stakeholder Confidence (FSC)

The Forum on Stakeholder Confidence (FSC) held its 13th regular meeting in the Czech Republic immediately followed by its 9th national workshop and community visit. The workshop was entitled "Deliberating together on geological repository siting; expectations and challenges in the Czech Republic". More than 50 international delegates from 13 NEA member countries dialogued with some 60 national stakeholders, concerned citizens and elected representatives of the seven granitic sites currently considered to be suitable for investigation in view of a future facility. Significant delegations of Belgian, Hungarian and Swedish local stakeholders, who have hosted FSC activities in the past, took an active part in the workshop discussions. In particular, they participated in a local debate which was also open to dozens more local Czech citizens. The debate successfully clarified the challenges addressed by townships engaged in multi-year deliberations on repository hosting.

Radiological protection

The importance and implications of stakeholder participation in radiological protection decision making have been addressed by the NEA Committee on Radiation Protection and Public Health (CRPPH) since the early 1990s, beginning with the Committee's 1994 collective opinion, continuing through three stakeholder involvement workshops in 1998, 2001 and 2003, addressing the balance of science and values in radiological protection in two workshops in 2008 and 2009, and specifically looking at stakeholder involvement in post-nuclear emergency management at a workshop in 2010.

The CRPPH had planned to continue this work in 2011 by holding the 3rd Science and Values Workshop to be hosted by the Japanese government, and co-organised by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and the National Institute of Radiological Sciences (NIRS) in co-operation with the nuclear regulatory authority, but the Fukushima Daiichi accident prevented its effective organisation. As a result, the CRPPH reconsidered the workshop programme and organised the workshop in November 2012 in Japan. The third workshop was organised jointly with the 6th Asian Regional Workshop on the Evolution of the System of Radiological Protection. A key aspect of the Asian regional series of workshops has been the contribution of young professionals, so merging the science and values and Asian regional formats resulted in a workshop with presentations by young professionals, as well as science and values plenary and breakout sessions. The topics addressed were the assessment and management of low-dose exposures, the protection of children and non-cancer effects. While the workshop did not directly address the results of the Fukushima Daiichi accident, science and values are clearly central to post-emergency decisions, and as such formed a framework for discussions. A summary report of the workshop will be issued in early 2013.

Some 50 international delegates from 13 NEA member countries at the 9th FSC workshop in the Czech Republic.

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, 30 were members of the NEA in 2012:

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

On 1 January 2013, the Russian Federation became the Agency's 31st member country.

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.

The members of the **Bureau of the Steering Committee** for Nuclear Energy are (as at its autumn 2012 meeting):

- Mr. Richard STRATFORD (United States), Chair
- Ms. Marie-Elise HOEDEMAKERS (Netherlands), Vice-Chair
- Dr. Kwang-Yong JEE (Republic of Korea), Vice-Chair
- Mr. Frédéric MONDOLONI (France), Vice-Chair
- Mr. Kazuo SHIMOMURA (Japan), Vice-Chair
- Ms. Marta ŽIAKOVA (Slovak Republic), Vice-Chair

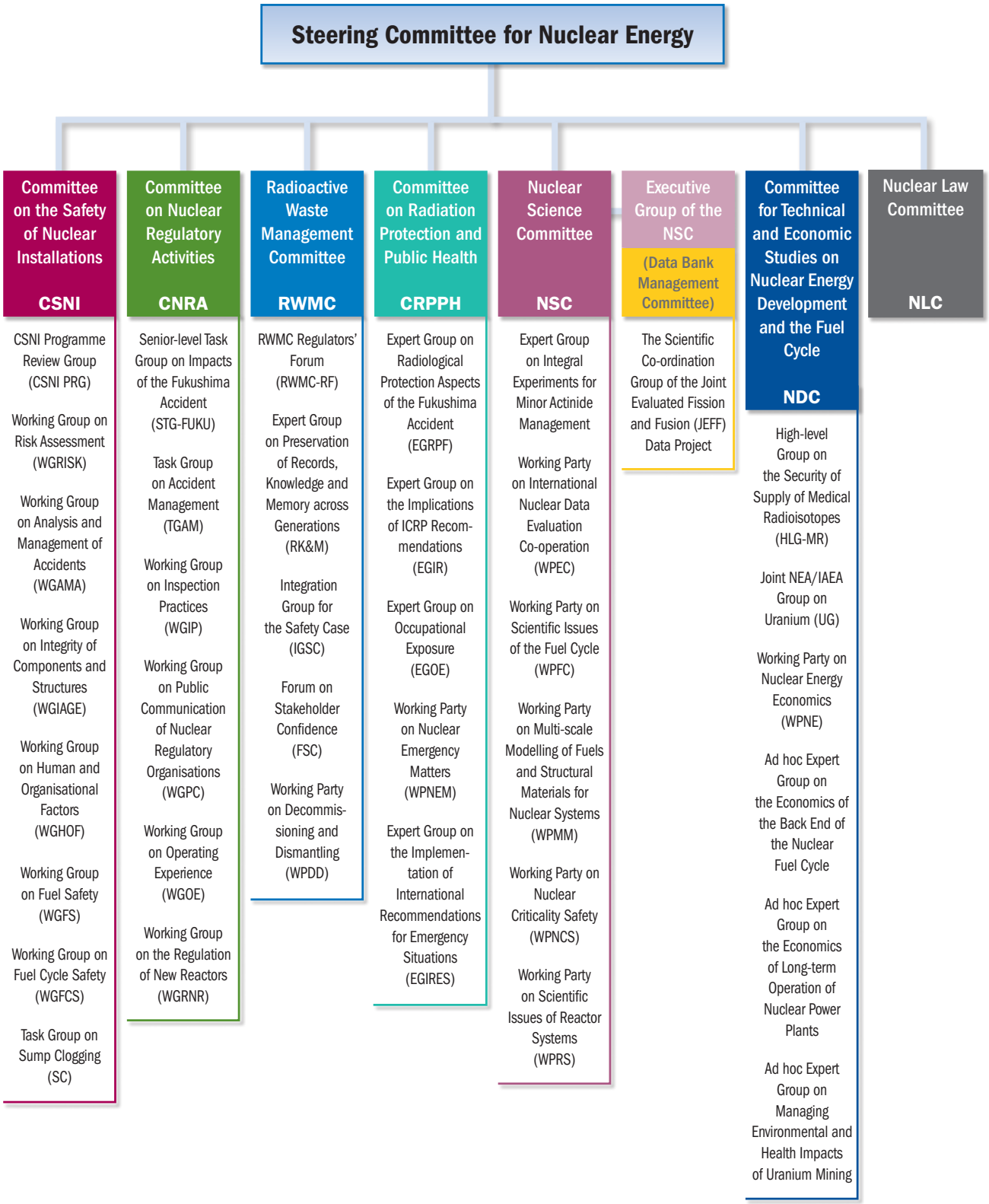
The standing technical committees are primarily composed of member country experts and technical specialists. These committees constitute a unique feature and important strength of the NEA, providing flexibility for adapting to new issues and helping to achieve consensus rapidly. Their main areas of 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 2012 of 78 professional and support staff from 18 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 2012



NEA Secretariat Structure in 2012

Luis Echávarri
Director-General

Uichiro Yoshimura
Deputy Director
Safety and Regulation

Cynthia Gannon-Picot
Head
Central Secretariat, External Relations and Public Affairs
(S. Gas until August 2012)

Ricardo Lopez
Head
Management Support Unit

Steve Burns
Head
Legal Affairs

Thierry Dujardin
Acting Deputy Director-General
and
Deputy Director
Science and Development

Javier Reig
Head of Division
Nuclear Safety

Michael Siemann
Head of Division
Radiological Protection and Radioactive Waste Management

Ron Cameron
Head of Division
Nuclear Development

Jim Gulliford
Head of Section
Nuclear Science

Kiyoshi Matsumoto
Head
Data Bank

NEA Publications and Brochures Produced in 2012

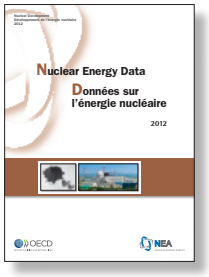
General interest

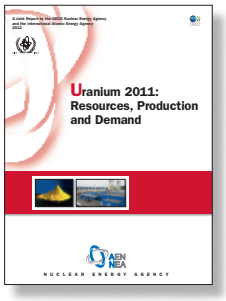
Annual Report 2011
ISBN 978-92-64-99179-8. 56 pages. Free: paper or web.

Rapport annuel 2011
ISBN 978-92-64-99180-4. 56 pages. Gratuit : versions papier ou web.

NEA News, Vol. 30 No. 1
ISSN 1605-9581. 32 pages. Free: paper or web.

AEN Infos, Vol. 30 n° 1
ISSN 1605-959X. 36 pages. Gratuit : versions papier ou web.





Nuclear development and the fuel cycle

Nuclear Education and Training: From Concern to Capability
ISBN 978-92-64-17637-9. 200 pages. Price: € 60, $ 84, £ 54, ¥ 7 800.

Nuclear Energy and Renewables
System Effects in Low-carbon Electricity Systems
ISBN 978-92-64-18851-8. 252 pages. Price: € 60, $ 84, £ 54, ¥ 7 800.

Nuclear Energy Data 2012*/Données sur l'énergie nucléaire 2012*
ISBN 978-92-64-17785-7. 84 pages. Price: € 42, $ 58, £ 37, ¥ 5 400.

Nuclear Energy Today
Second Edition
ISBN 978-92-64-99204-7. 120 pages. Free: paper or web.

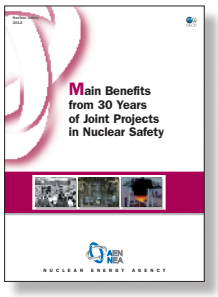
The Economics of Long-term Operation of Nuclear Power Plants
ISBN 978-92-64-99205-4. 114 pages. Free: paper or web.

The Role of Nuclear Energy in a Low-carbon Energy Future
ISBN 978-92-64-99189-7. 92 pages. Web only.

The Supply of Medical Radioisotopes
Market Impacts of Converting to Low-enriched Uranium Targets for Medical Isotope Production
ISBN 978-92-64-99197-2. 64 pages. Free: paper or web.

Uranium 2011: Resources, Production and Demand
ISBN 978-92-64-17803-8. 488 pages. Price: € 140, $ 196, £ 126, ¥ 18 200.

Vers un cycle du combustible nucléaire durable : Évolution et tendances
ISBN 978-92-64-99201-6. 200 pages. Version web.



Nuclear safety and regulation

Challenges in Long-term Operation of Nuclear Power Plants
Implications for Regulatory Bodies
ISBN 978-92-64-99187-3. 32 pages. Free: paper or web.

Défis de l'exploitation à long terme des centrales nucléaires
Implications pour les autorités de sûreté
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Computational Fluid Dynamics (CFD) for Nuclear Reactor Safety Applications
Workshop Proceedings, CFD4NRS-3, Bethesda, Maryland, USA,
14-16 September 2010
CD. Free on request.

CSNI Technical Opinion Papers No. 14
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Determining Their Suitability
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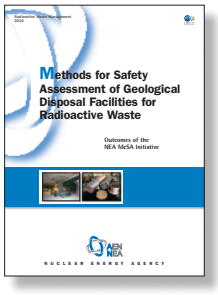
ISBN 978-92-64-99178-1. 80 pages. Free: paper or web.

Nuclear Power Plant Operating Experience
From the IAEA/NEA International Reporting System for Operating Experience:
2009-2011
ISBN 978-92-64-99193-4. 60 pages. Free: paper or web.



Radioactive waste management

Geological Disposal of Radioactive Waste: National Commitment, Local and Regional Involvement
A Collective Statement of the OECD Nuclear Energy Agency Radioactive Waste Management Committee Adopted March 2012
ISBN 978-92-64-99183-5. 24 pages. Free: paper or web.

Stockage géologique des déchets radioactifs : Engagement national, participation locale et régionale
Déclaration collective du Comité de la gestion des déchets radioactifs de l'Agence de l'OCDE pour l'énergie nucléaire, adoptée en mars 2012
ISBN 978-92-64-99184-2. 24 pages. Gratuit : versions papier ou web.

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ISBN 978-92-64-99173-6. 192 pages. Free: paper or web.

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Outcomes of the NEA MeSA Initiative
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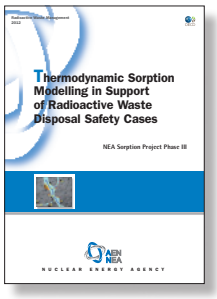

Reversibility and Retrievability in Planning for Geological Disposal of Radioactive Waste
Proceedings of the "R&R" International Conference and Dialogue, 14-17 December 2010, Reims, France
ISBN 978-92-64-99185. 236 pages. Free: paper or web.

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Considerations for National Geological Disposal Programmes
ISBN 978-92-64-99169-9. 28 pages. Free: paper or web.

Réversibilité des décisions et récupérabilité des déchets radioactifs
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Japanese translation of Practices and Experience in Stakeholder Involvement for Post-nuclear Emergency Management
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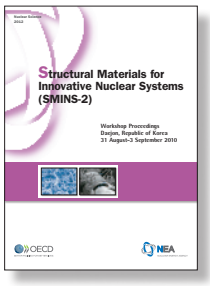

Nuclear science and the Data Bank

Actinide and Fission Product Partitioning and Transmutation
Eleventh Information Exchange Meeting, San Francisco, California, USA, 1-4 November 2010
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JEFF 3.1.2
Joint Evaluated Nuclear Data Library for Fission and Fusion Applications – February 2012
DVD. Free on request.

Structural Materials for Innovative Nuclear Systems (SMINS-2)
Workshop Proceedings, Daejon, Republic of Korea, 31 August-3 September 2010
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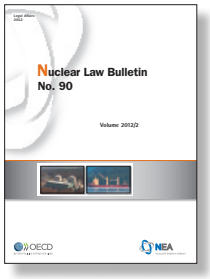

Nuclear law

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ISBN 978-92-64-99200-9. 244 pages. Free: paper or web.

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The OECD Nuclear Energy Agency (NEA) was established on 1 February 1958. As of 1 January 2013, NEA membership consists of 31 countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, the Republic of Korea, the Russian Federation, 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, as well as
- 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:

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NEA No. 7144

NEA member countries

(as of 1 January 2013)

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