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NEA News

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Nuclear power in the United Arab Emirates: Legal framework and regulatory co-operation

Estimation and comparability of nuclear facility decommissioning costs

and more...

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NUCLEAR ENERGY AGENCY

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The OECD Nuclear Energy Agency (NEA) is an intergovernmental organisation established in 1958. Its primary objective 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. It is a non-partisan, unbiased source of information, data and analyses, drawing on one of the best international networks of technical experts. The NEA has 31 member 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 takes part in the work of the NEA. A co-operation agreement is in force with the International Atomic Energy Agency.

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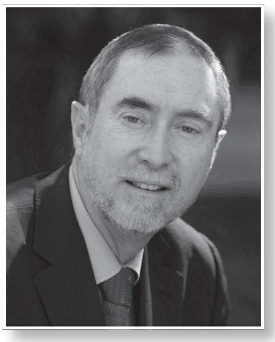
Nuclear power: An important option in energy mixes



Nuclear power remains an important option for many countries to improve energy security, to provide the energy needed for development and to fight climate change. This was one of the main conclusions from the recent International Ministerial Conference on Nuclear Power in the 21st Century, held in St. Petersburg, where participants from around the world agreed that nuclear power has an important role to play given the challenges faced by the international community. Regarding climate change in particular, OECD Secretary-General Angel Gurría further stressed in a conference communiqué, "We are far from achieving our environmental goal of limiting increases in average world temperature. Bolder and more innovative efforts are required, and nuclear energy can and must be part of the solution."

He also made clear in his statement that it is essential to move forward "in a safe and economically competitive manner. Only thus, will it be possible to take advantage of the long-term, carbon-free security of supply and stable prices that nuclear energy has to offer." An absolutely fundamental element in developing nuclear power is nuclear safety. There can be no room for complacency in this regard, and as participants noted in St. Petersburg, the Fukushima Daiichi nuclear power plant accident has in fact led to a strengthening of nuclear safety throughout the world. It is in this context that the international nuclear community must continue working together.

As readers will see in this edition of *NEA News*, the Agency has an extensive programme of international joint research projects. Another of the NEA's strengths is related to economic analyses and is highlighted in the articles addressing the interaction between nuclear energy and renewables in low-carbon electricity systems, and the estimation and comparability of nuclear facility decommissioning costs.

More than two years after the Fukushima Daiichi accident, perspectives concerning the future of nuclear power are becoming clearer, as are the lessons to be learnt. Both regulators and power plant operators have been able to consider the implications of the accident and to take action to enhance plant safety and emergency response systems; safety levels have now risen even higher. The actions taken by NEA member countries and standing technical committees are described in more detail in the new NEA report, *The Fukushima Daiichi Nuclear Power Plant Accident: OECD/NEA Nuclear Safety Response and Lessons Learnt*.

Luis E. Echávarri
NEA Director-General

System effects of nuclear energy and renewables in low-carbon electricity systems

by J.H. Keppler, M. Cometto and R. Cameron*

What are system effects?

Electric power plants do not operate in isolation. They interact with each other and their customers through the electricity grid, as well as with the wider natural, economic and social environment. Electricity production thus generates costs that accrue at the level of the system beyond the perimeter of the individual plant. Attention has been focusing in particular on the system effects of variable renewables, such as wind and solar. Their increasing deployment generates a number of impacts that profoundly affect the structure, financing and operational mode of electricity systems.

While classic externalities such as impacts on the environment or the security of supply also constitute system costs, the current focus is increasingly on "grid-level system costs", the subset of system costs mediated by the electricity grid. Such grid-level system costs include a) the costs of extending and reinforcing transport and distribution grids as well as connecting new capacity to the grid and b) the costs of increased short-term balancing and maintaining the long-term adequacy of electricity supply.

In addition, variable renewables exert a number of dynamic effects that have a profound impact on the operations and structure of electricity markets. Their low marginal costs lead to lower electricity prices and reduce the load factors of dispatchable power generators (the compression effect) with significant impacts on the latter's profitability. At the level of the national economy, the current production structure is no longer optimal, since the new residual demand curves require a different technology mix.

Electricity produced by variable renewables significantly affects the economics of dispatchable power generators, in particular those of nuclear power, both in the short run and the long run. In the short run, if the current structure of the power generation mix were to remain in place, all dispatchable technologies, including nuclear, coal and gas, will suffer due to lower electricity prices and reduced load factors. Due to their relatively low variable costs, existing nuclear power plants will do better than gas and coal plants, which have already been substantially affected by the introduction of variable renewables in several OECD countries. In the long run, however, high fixed-cost technologies such as nuclear will be affected disproportionately by the increased difficulties in financing further investments in volatile low-price environments. The outcome of these competing factors will depend on the amount of variable renewables being introduced, local conditions and the level of carbon prices.

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Nuclear power and system effects

Like all forms of energy production, nuclear power has its own system costs, even if these remain relatively modest in comparison to variable renewables. These costs relate to specific siting requirements, the conditions that nuclear power poses for the outlay and technical characteristics of the surrounding grid, as well as specific balancing requirements due to the size of nuclear power plants. Additional costs due to siting constraints are often borne by nuclear power plants themselves, and only impose limited additional costs on the electricity system as a whole. The specific arrangements in place in OECD countries may be different with regard to the special conditions that nuclear power plants impose on the electrical system in terms of higher requirements for grid stability and security, specific conditions for the grid layout, as well as the interaction between the overall generation system and nuclear plants due to the latter's operational characteristics.

At least as important as the system effects of nuclear plants is their ability to deal with the volatility generated by variable renewables through load following. While most nuclear power plants operate at stable levels close to full capacity, others – notably in France and Germany – have significant experience with load following. In France, nuclear capacity exceeds baseload needs during certain periods, which requires load reductions. In Germany, the great diversity of variable renewables has repeatedly forced prices below the marginal costs of nuclear, including in several instances to negative price levels. The French and the German experiences show that nuclear power has the technical capabilities to engage in load following. The short-term, load-following capabilities of nuclear power plants are thus comparable to those of coal-fired power plants but below those of combined and open cycle gas turbines (see Table 1).

Table 1: A comparative analysis of dispatchable power plants' load-following capacities

	Start-up time	Maximal change in 30 sec	Maximum ramp rate (%/min)
Open cycle gas turbine (OCGT)	10-20 min	20-30%	20%/min
Combined cycle gas turbine (CCGT)	30-60 min	10-20%	5-10%/min
Coal plant	1-10 hours	5-10%	1-5%/min
Nuclear power plant	2 hours - 2 days	up to 5%	1-5%/min

Source: EC JRC, 2010 and NEA, 2011.

Measuring system effects

An assessment of grid-level system costs (including the costs for grid connection, extension and reinforcement, as well as the added costs for balancing and back-up, but excluding the financial costs of intermittency and the impacts on security of supply, the environment, siting and safety), reveals a considerable difference between those of dispatchable technologies and those of variable renewables.

Using a common methodology and a broad array of country-specific data, the grid-level system costs for Finland, France, Germany, the Republic of Korea, the United Kingdom and the United States were calculated for nuclear, coal, gas, onshore wind, offshore wind and solar PV both at 10% and 30% penetration levels.

At less than USD 3 per MWh, the system costs for dispatchable technologies are modest. They are considerably higher for variable technologies and can reach up to USD 80 per MWh for solar. The costs for variable renewables would be lower by USD 10 to USD 20 per MWh if the costs for back-up were not included, assuming that current electricity systems in OECD countries already have sufficient dispatchable capacity to cover demand at all times. While this may be an admissible assumption in the short run, it would not be a correct assumption in the long run when existing capacity will need to be replaced.

Table 2: Grid-level system costs in selected OECD/NEA countries (USD/MWh)

Finland												
Technology	**Nuclear**		**Coal**		**Gas**		**Onshore wind**		**Offshore wind**		**Solar**	
Penetration level	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**
Back-up costs (adequacy)	0.00	0.00	0.06	0.06	0.00	0.00	8.05	9.70	9.68	10.67	21.40	22.04
Balancing costs	0.47	0.30	0.00	0.00	0.00	0.00	2.70	5.30	2.70	5.30	2.70	5.30
Grid connection	1.90	1.90	1.04	1.04	0.56	0.56	6.84	6.84	18.86	18.86	22.02	22.02
Grid reinforcement and extension	0.00	0.00	0.00	0.00	0.00	0.00	0.20	1.72	0.12	1.04	0.56	4.87
Total grid-level system costs	**2.37**	**2.20**	**1.10**	**1.10**	**0.56**	**0.56**	**17.79**	**23.56**	**31.36**	**35.87**	**46.67**	**54.22**

France												
Technology	**Nuclear**		**Coal**		**Gas**		**Onshore wind**		**Offshore wind**		**Solar**	
Penetration level	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**
Back-up costs (adequacy)	0.00	0.00	0.08	0.08	0.00	0.00	8.14	8.67	8.14	8.67	19.40	19.81
Balancing costs	0.28	0.27	0.00	0.00	0.00	0.00	1.90	5.01	1.90	5.01	1.90	5.01
Grid connection	1.78	1.78	0.93	0.93	0.54	0.54	6.93	6.93	18.64	18.64	15.97	15.97
Grid reinforcement and extension	0.00	0.00	0.00	0.00	0.00	0.00	3.50	3.50	2.15	2.15	5.77	5.77
Total grid-level system costs	**2.07**	**2.05**	**1.01**	**1.01**	**0.54**	**0.54**	**20.47**	**24.10**	**30.83**	**34.47**	**43.03**	**46.55**

Germany												
Technology	**Nuclear**		**Coal**		**Gas**		**Onshore wind**		**Offshore wind**		**Solar**	
Penetration level	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**
Back-up costs (adequacy)	0.00	0.00	0.04	0.04	0.00	0.00	7.96	8.84	7.96	8.84	19.22	19.71
Balancing costs	0.52	0.35	0.00	0.00	0.00	0.00	3.30	6.41	3.30	6.41	3.30	6.41
Grid connection	1.90	1.90	0.93	0.93	0.54	0.54	6.37	6.37	15.71	15.71	9.44	9.44
Grid reinforcement and extension	0.00	0.00	0.00	0.00	0.00	0.00	1.73	22.23	0.92	11.89	3.69	47.40
Total grid-level system costs	**2.42**	**2.25**	**0.97**	**0.97**	**0.54**	**0.54**	**19.36**	**43.85**	**27.90**	**42.85**	**35.64**	**82.95**

Republic of Korea

Technology	Nuclear		Coal		Gas		Onshore wind		Offshore wind		Solar	
Penetration level	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**
Back-up costs (adequacy)	0.00	0.00	0.03	0.03	0.00	0.00	2.36	4.04	2.36	4.04	9.21	9.40
Balancing costs	0.88	0.53	0.00	0.00	0.00	0.00	7.63	14.15	7.63	14.15	7.63	14.15
Grid connection	0.87	0.87	0.44	0.44	0.34	0.34	6.84	6.84	23.85	23.85	9.24	9.24
Grid reinforcement and extension	0.00	0.00	0.00	0.00	0.00	0.00	2.81	2.81	2.15	2.15	5.33	5.33
Total grid-level system costs	**1.74**	**1.40**	**0.46**	**0.46**	**0.34**	**0.34**	**19.64**	**27.84**	**35.99**	**44.19**	**31.42**	**38.12**

United Kingdom

Technology	Nuclear		Coal		Gas		Onshore wind		Offshore wind		Solar	
Penetration level	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**
Back-up costs (adequacy)	0.00	0.00	0.06	0.06	0.00	0.00	4.05	6.92	4.05	6.92	26.08	26.82
Balancing costs	0.88	0.53	0.00	0.00	0.00	0.00	7.63	14.15	7.63	14.15	7.63	14.15
Grid connection	2.23	2.23	1.27	1.27	0.56	0.56	3.96	3.96	19.81	19.81	15.55	15.55
Grid reinforcement and extension	0.00	0.00	0.00	0.00	0.00	0.00	2.95	5.20	2.57	4.52	8.62	15.18
Total grid-level system costs	**3.10**	**2.76**	**1.34**	**1.34**	**0.56**	**0.56**	**18.60**	**30.23**	**34.05**	**45.39**	**57.89**	**71.71**

United States

Technology	Nuclear		Coal		Gas		Onshore wind		Offshore wind		Solar	
Penetration level	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**
Back-up costs (adequacy)	0.00	0.00	0.04	0.04	0.00	0.00	5.61	6.14	2.10	6.85	0.00	10.45
Balancing costs	0.16	0.10	0.00	0.00	0.00	0.00	2.00	5.00	2.00	5.00	2.00	5.00
Grid connection	1.56	1.56	1.03	1.03	0.51	0.51	6.50	6.50	15.24	15.24	10.05	10.05
Grid reinforcement and extension	0.00	0.00	0.00	0.00	0.00	0.00	2.20	2.20	1.18	1.18	2.77	2.77
Total grid-level system costs	**1.72**	**1.67**	**1.07**	**1.07**	**0.51**	**0.51**	**16.30**	**19.84**	**20.51**	**28.26**	**14.82**	**28.27**

Establishing estimates for grid-level system costs also allows for a calculation of the total costs of electricity supply with and without variable renewables. This calculation can be done by comparing electricity costs for various levels of renewable energy penetration with a reference case having only dispatchable technologies. The analysis shows that introducing variable renewables at up to 10% of the total electricity supply will increase total per MWh cost between 5% and 50%, depending on the country, whereas satisfying 30% of demand might increase per MWh costs from anywhere between 16% and 180% (the latter is the case for solar energy in Finland).

Internalising system effects through improved regulatory frameworks

The introduction of large amounts of variable renewables creates a radically new situation in electricity wholesale markets, which in turn requires rapid adaptation on the part of all actors. In particular, it calls for the creation of new institutional, regulatory and financial frameworks that would allow the emergence of markets that remunerate so-called "flexibility services", which include the provision of short-term balancing services and, in particular, sufficient amounts of dispatchable long-term capacity. There are essentially four dimensions in which one may consider providing the necessary balancing and capacity services to ensure the balance between demand and supply in electricity systems with a significant share of variable renewables:

- short-term spinning reserves and long-term capacity provided by dispatchable power generators such as nuclear, coal or gas;
- interconnections to spread demand and supply imbalances over larger areas;
- storage to ensure the availability of short-term power reserves when needed;
- demand-side management (DSM) to curb demand in case of supply shortfalls.

Given the current market environment, capacity mechanisms could play a particular role in remunerating dispatchable capacity purely for its availability in times of need. Such remuneration could be administered through capacity payments, markets with capacity obligations or subscriptions to long-term, fixed-price contracts for guaranteed portions of the output of dispatchable plants, whether in the form of contracts-for-differences or feed-in tariffs (FITs).

The system effects of variable renewables also require a rethinking of the mechanisms through which subsidies are administered. The combination of fixed FITs and grid priority for renewables means that renewable generators have no interest in adjusting their load to market conditions. More efficient mechanisms would be feed-in premiums (FIPs) or an obligation for all providers, including producers based on variable renewables, to feed stable hourly bands into the system.

Policy recommendations

Variable renewables are creating a market environment in which dispatchable technologies can no longer finance themselves through revenues in "energy only" wholesale markets. This has serious implications for the security of electricity supplies. Only the subdued demand for electricity in the current low-growth environment of OECD countries has allowed for the temporary deferral of more serious stresses in the market.

The magnitude of both technical and pecuniary system costs implies that they can no longer be borne in a diffuse and unacknowledged manner by operators of dispatchable technologies as an unspecific system service.

While future studies will undoubtedly refine the results of this study, current research has already identified four main policy recommendations:

Recommendation 1 – Ensure the transparency of power generation costs at the system level. Failure to do so will rebound in terms of unanticipated cost increases in overall power supply for many years to come.

Recommendation 2 – Implement regulatory frameworks to minimise system costs and favour their internalisation. Four approaches merit consideration in this context:

- recognise and adequately compensate dispatchable operators for decreased revenues due to the compression effect;
- ensure that all operators, including those of renewables, feed stable hourly bands of electricity into the grid for the effective internalisation of the system costs in relation to balancing and adequacy;
- allocate the costs of grid extension and connection to the appropriate operators since costs for grid reinforcement and interconnections are difficult to allocate to any one technology;
- closely monitor the implications of carbon emissions for different back-up provision strategies and propose internalisation through a robust carbon tax.

Recommendation 3 – Recognise the value of dispatchable low-carbon technologies such as nuclear in complementing the introduction of variable renewables. While nuclear power has some system costs of its own, it remains the only major dispatchable low-carbon source of electricity apart from hydropower, which is in limited supply.

Recommendation 4 – Develop flexibility resources that allow the co-existence of nuclear energy and variable renewables in future low-carbon systems. This will require increasing load-following abilities of dispatchable low-carbon back-up including nuclear, expanding storage, rendering demand more responsive and increasing international interconnections.

Stakeholder involvement: A central theme in radiological protection

by H.B. Okyar, C. Mays, E. Lazo and M. Siemann*

Throughout the world, civil society stakeholders are gaining a stronger voice in many types of decision making concerning the applications and effects of ionising radiation. This cultural shift is supported by the Aarhus Convention, which guarantees a citizen's right of access to information and judicial redress, as well as the right to participate in environmental decision making. Even in cases where this international treaty is not invoked, it is clear that professionals in radiological protection, in radioactive waste management and in nuclear safety fields must continuously develop their sensitivity to the needs of the public. The NEA has long supported these professionals in improving their understanding, practice and ultimately their service to society.

The NEA Committee on Radiation Protection and Public Health (CRPPH) began considering the importance of stakeholder involvement in radiological protection decision making in the early 1990s. Initially, stakeholder involvement simply consisted of informing and hopefully convincing the public of decisions that had already been taken (the so-called "decide-announce-defend" approach). But in 1998, the question was asked: "Should society be made to fit into radiological protection decisions or should radiological protection be integrated into society's decisions addressing radiological issues?" Discussions around this question first took place at the Villigen series of workshops on stakeholder involvement in 1998, where it was agreed that radiological protection decisions clearly should be viewed as a supporting component of societal decisions. The CRPPH has since been working actively to promote an exchange of experience among its members with respect to involving various stakeholders in radiological protection decision-making processes and to exploring the various aspects and processes that result in acceptable and sustainable radiological protection decisions. Today, this ongoing exploration is a central element in many of the CRPPH's activities.

Science and values in radiological protection decision making

The radiological protection community has gone to great lengths over the past 20 years to inform the public about radiological risks, to stress that such risks are relatively small in absolute terms and to highlight the ubiquitous nature of radiation exposure. Yet in parallel, studies on stakeholder involvement have emphasised not only the importance of scientific understanding in radiological protection decision making, but also the weight of social values in driving decisions to an even greater extent than scientific fact. There is increasing recognition that social values must be taken into account, and moreover, that they are best identified through dialogue with interested and affected stakeholders. Since the early 1990s, the CRPPH has organised meetings and international workshops and established expert groups to address issues relating to stakeholder involvement. The latest in this series were three large workshops held in Finland, in France and most recently in Japan, to examine how diverse social values and uncertainties in science are weighed when making radiological protection decisions.

The "Science and Values" workshops were launched in 2008 to better understand the significance of the different components of decision making and to examine approaches that more clearly and transparently articulate both science and values, with the goal of improving the system of radiological protection. The third workshop took place in Tokyo, Japan in November 2012 and used questions arising from the Fukushima Daiichi nuclear power plant accident as mechanisms to better understand the science and values aspects of decisions. This third workshop gave the floor to a broad panel of radiological protection officials from Asian countries, who reported on their challenges and solutions in the aftermath of the accident. Decision making involving professionals, local officials and community leaders was studied through an in-depth discussion of self-help behaviours in the context of the decontamination of an elementary school in the Fukushima prefecture. Other topics reviewed were low-dose/dose-rate exposures and public health, and non-cancer effects. The full report of this workshop is available online.

The NEA is also sponsoring and co-organising a series of innovative Dialogue Initiatives in Fukushima, under the aegis of the International Commission on Radiological Protection (ICRP). Six structured dialogues have been held to date. They bring together representatives from many stakeholder categories to explore issues important to recovery: evacuation, early return

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and reconstruction; contamination of food; radiation monitoring; and education, for example. During these dialogues between international radiological protection professionals and inhabitants of the communities affected by the Fukushima Daiichi nuclear power plant accident, it became evident that people do not expect experts to make definitive statements about whether living conditions are "safe" or "unsafe". Instead, people who feel affected by the accident ask specialists to help them improve their knowledge base so that they can better understand the possible radiological consequences related to their own decisions. This, once again, underlines the paradigm shift in the area of radiological protection, in which the professional acts less as the reigning expert and more as a specialist at the service of society.

The NEA recognises the value of lessons that continue to emerge from the Fukushima Daiichi accident and the importance of supporting officials and affected inhabitants. The NEA will continue offering knowledge and assistance where requested, working for and with stakeholders in such vital activities as *post hoc* dose assessment, health surveillance, off-site decontamination, restoration of lifestyle and confidence building.

ICRP Recommendations and International Basic Safety Standards

Throughout the development of the latest ICRP General Recommendations in Publication 103, and the subsequent revision of the International Basic Safety Standards (BSS), the NEA, the ICRP and the IAEA have been engaged in stakeholder discussions in order to provide relevant input from governmental stakeholders and to help ensure that the ICRP recommendations and the international BSS are practical and viable. As part of this work, the NEA held five Asian Regional Workshops on the Evolution of the System of Radiological Protection to make certain that Asian views were well incorporated into these documents. These efforts were an example of the direct involvement of stakeholders, undertaken in this case together with the ICRP and the IAEA.

INEX-3 and INEX-4

Since the Three Mile Island accident in 1979, and even more so since the Chernobyl accident in 1986, the NEA has been actively studying international aspects of nuclear emergency management through the development and conduct of international nuclear emergency exercises (INEX). The first exercises in the series (INEX-1, INEX-2 and INEX-2000), which took place between about 1993 and 2001, addressed the national and international aspects of responses in the early phases of a nuclear emergency. INEX-3 and INEX-4, in 2005/2006 and 2010/2011 respectively, addressed the later phases, focusing on consequence management. The involvement of stakeholders in emergency planning and in consequence management was a particularly important part of these exercises. However, participating countries indicated that it was a formidable task to find stakeholders to participate in emergency planning at the level of detail and commitment that is needed to ensure the smooth implementation of countermeasures and of post-accident consequence management. These countries also recognised the need to include a broad spectrum of stakeholders, in particular representatives from the farming and food distribution sectors – in the case of a scenario with agricultural implications – to facilitate market stability. A full summary of the results of INEX-4 was published in January 2013, and a topical session was organised in May 2013 based on the themes arising from the questionnaire sent to countries conducting the INEX-4 exercise. The CRPPH is currently discussing the objectives to be tested during the INEX-5 exercise, likely to be held in 2015/2016.

Emergency management and recovery lessons from the Fukushima Daiichi accident

With the experience gained from the INEX series descibed above, the NEA has embarked on a collection of experiences from its members with a tailored survey on emergency communications, approaches to establishing national criteria (or protocol) for monitoring incoming products (i.e. from the accident country) and technical assessments of accident situations as a result of lessons learnt from the Fukushima Daiichi accident. Fourteen NEA countries responded to the survey, conducted from January to March 2013. The survey results and Fukushima lessons learnt were discussed with member countries during a CRPPH Working Party on Nuclear Emergency Matters (WPNEM) Joint Topical Session in May 2013. Issues related to stakeholder involvement (decisions on emergency planning and preparedness, zone definition, evacuation and shelter criteria, and stipulations for ending evacuation and shelter and for allowing evacuees to return home) are always paramount in this regard due to their potential social impact. The views of the CRPPH and WPNEM membership on current approaches to, or the criteria for, decision making were gathered through a survey and served as the basis for updating the NEA report on *Short-term Countermeasures in Case of a Nuclear or Radiological Emergency*. The updated report was approved and will be published in 2013.

Conclusion

The NEA has made stakeholder involvement in radiological protection decision making one of its flagship issues as well as one of its strengths as an international nuclear organisation. The lessons learnt over the past 20 years serve not only to help identify areas that could be addressed by further studies, but also to better refine working approaches and mechanisms so as to be more efficient in radiological protection work carried out for and with stakeholders. The NEA will continue to reach out to institutional, academic and civil society stakeholders on the national and international levels in order to foster a more inclusive radiological protection culture in the service of public health.

Nuclear power in the United Arab Emirates: Legal framework and regulatory co-operation

by X. Vásquez-Maignan*

As part of a decision to diversify its energy mix, the United Arab Emirates (UAE) has begun construction of its first nuclear power plant. In that context, it has also taken a number of important steps to integrate itself into the international regime for nuclear safety.

Development of the UAE nuclear programme

In 2008, the UAE adopted the *Policy on the Evaluation and Potential Development of Peaceful Nuclear Energy*, after assessing available options to meet the growing energy needs of the country. The option chosen would cover in particular the energy needs of desalination plant projects, which are a highly energy-consuming solution to drinking water scarcity in the region. This assessment of the available options led the UAE government to conclude that "nuclear power generation emerged as a proven, environmentally promising and commercially competitive option which could make a significant base-load contribution to the UAE's economy and future energy security." Once the decision was taken, the government of the UAE began to actively adopt and implement the necessary policies and actions to launch a nuclear power programme. Indeed, the UAE took steps to implement its nuclear programme at a remarkable pace, implementing the following measures in 2009 alone:

- **Adoption of the UAE's Federal Law No. 6 of 2009 on the peaceful uses of nuclear energy:** this law enabled the development of a system for licensing and control of nuclear material and established the UAE's Federal Authority for Nuclear Regulation (FANR) to oversee the nuclear energy sector in the UAE and to promote the highest standards of nuclear safety, nuclear security and radiological protection. The law also provides for a system of licensing and control of nuclear material in accordance with criteria established by the International Atomic Energy Agency (IAEA). It prohibits the development, construction or operation of uranium enrichment or spent fuel reprocessing facilities in the UAE. Instead, the UAE will obtain nuclear fuel from international suppliers, in line with a co-operation agreement signed with the United States on 15 January 2009. The law further establishes a system of civil and criminal penalties for violations, including unauthorised use, theft, transport or trade in nuclear materials.

FANR

Abu Dhabi Public Forum in April 2013 on the FANR's role in ensuring the safe, secure and peaceful uses of nuclear energy in the UAE.

- **Establishment of the Federal Authority for Nuclear Regulation (FANR):** the FANR was established as an independent legal entity with full legal competence, as well as financial and administrative independence. It is in charge of regulating and licensing nuclear activities in the UAE, which in addition to the nuclear power programme, includes radioactive material and radiation sources used in medicine, research, oil exploration and other industries. It determines all matters relating to the control and supervision of the nuclear sector in the UAE, in particular nuclear safety and security, radiological protection and safeguards. The FANR shall ensure compliance with all obligations entered into by the UAE under the relevant international treaties, conventions or agreements.

- **Establishment of the Emirates Nuclear Energy Corporation (ENEC):** the ENEC is the organisation in charge of implementing the UAE nuclear energy programme. It will be the owner and operator of future nuclear power plants in the UAE and will also serve as the investment arm of the Government of Abu Dhabi, making strategic investments in the nuclear sector, both domestically and internationally.

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- **Awarding of the first contract for nuclear power plants in the UAE:** the ENEC awarded a contract to a consortium led by the Korea Electric Power Corporation (KEPCO) to supply the UAE with four APR1400s, which are advanced, third-generation light water reactors.

In July 2012, after completing its environmental and safety review of the ENEC's application, the FANR issued a construction licence to the ENEC to build two nuclear power reactors at the Barakah site in the western region of the Abu Dhabi Emirate. The ENEC is expected to apply for an operating licence in 2015 to support the anticipated operation of the units in 2017-2018.

The UAE, a member of the IAEA since 15 January 1976, entered into a Comprehensive Safeguards Agreement (CSA) on 9 October 2003 and an Additional Protocol to the CSA on 20 December 2010. Before the adoption of its nuclear policy, it had also acceded to nuclear-related international instruments, such as the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (both entered into force in the UAE on 2 November 1987). The UAE has continued to move forward with its international commitments and has recently acceded to the Convention on Nuclear Safety and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (both entered into force in the UAE on 29 October 2009). The UAE has also joined international nuclear liability instruments, more specifically the 1997 Protocol to Amend the 1963 Vienna Convention on Civil Liability for Nuclear Damage (the "Revised Vienna Convention") and the 1988 Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention (the "Joint Protocol"), with the former entering into force in the UAE on 29 August 2012 and the latter on 29 November 2012.

The UAE nuclear liability regime

Since ordinary common law is often not well-suited to deal with the particular problems associated with nuclear energy, a special regime for nuclear third party liability is necessary. The drafters of existing nuclear liability conventions (i.e. the 1960 Paris Convention on Third Party Liability in the Field of Nuclear Energy, the 1963 Vienna Convention and the 1997 Convention on Supplementary Compensation for Nuclear Damage) set out to provide adequate compensation to the public for damage resulting from a nuclear accident. In addition, these special regimes were intended to ensure that nuclear operators, who are in the best position to offer assurance on the safety of their nuclear installations and transport activities, assume full liability in case of an accident while not being exposed to an excessive liability burden.

Following its accession to the Revised Vienna Convention and the Joint Protocol, the UAE adopted the Federal Law by Decree No. 4 of 2012 concerning civil liability for nuclear damage in August 2012 (the "UAE Nuclear Liability Law"), which incorporates the basic principles that form the foundation of the nuclear liability conventions:

- *Strict liability:* the operator of a nuclear installation is held liable, regardless of fault; therefore, to claim compensation, a person suffering damage caused by a nuclear accident is not required to prove negligence or any type of fault on the part of the operator.
- *Exclusive liability:* liability is legally channelled solely to the operator of the nuclear installation; no other person or entity may be held liable.
- *Limitation of liability in amount:* only a few states (for example, Japan and Germany) apply the concept of unlimited liability to the operator of a nuclear installation. The operator's liability under the UAE Nuclear Liability Law shall not exceed 450 million Special Drawing Rights (SDRs).
- *Congruence of liability and coverage:* the operator must maintain insurance or provide other financial security to cover its liability for nuclear damage in such amount, of such type and in such terms as required by the state where the nuclear installation is located. Under the UAE Nuclear Liability Law, the operator is required to maintain insurance or provide other financial security up to 450 million SDRs; in the event that the operator is not able to obtain the required coverage for certain risks, the UAE government will cover such risks.
- *Limitation of liability in time:* a time limit is set for the submission of claims against the operator of the nuclear installation. Pursuant to the UAE Nuclear Liability Law, actions for compensation may only be brought against the operator or the entity providing financial security within three years from the date that the person suffering damage had knowledge or ought to have had knowledge of the damage and the operator liable for the damage. The right to compensation will be extinguished if the claim is not brought within 30 years for loss of life and personal injury, and within 10 years for other types of damage from the date of a nuclear accident.
- *Equal treatment:* the nuclear liability regimes (whether international or national) must be applied without any discrimination based on nationality, domicile or residence.
- *Unity of jurisdiction:* the courts of the countries where the nuclear accident occurred must have exclusive jurisdiction. Pursuant to the UAE Nuclear Liability Law, the Federal Courts in Abu Dhabi will have sole jurisdiction for actions that may be brought in accordance with the UAE Nuclear Liability Law.

The definition of "nuclear damage" provided under the UAE Nuclear Liability Law is consistent with the definition provided by the Revised Vienna Convention, and the FANR is the competent authority to implement the UAE Nuclear Liability Law, including by issuing rules and regulations relating to the application of the provisions of such law. The provisions of the UAE Nuclear Liability Law do not impede the rights or obligations of any person to obtain compensation under any health insurance, employee or other occupational disease compensation scheme.

The FANR joins the Multinational Design Evaluation Programme (MDEP)

On 24-26 September 2012, the FANR participated in its first MDEP meeting as a new associate member on the occasion of the MDEP Steering Technical Committee meeting held in Beijing, China.

The MDEP was launched in 2006 by the US Nuclear Regulatory Commission (NRC) and the French Nuclear Safety Authority (ASN) with the aim of developing innovative approaches to leverage the resources and knowledge of national regulatory authorities reviewing new reactor designs. The NEA acts as the Technical Secretariat for the MDEP. The IAEA participates in many of the MDEP activities, including harmonisation efforts.

The full MDEP membership includes national regulatory authorities from Canada, China, Finland, France, India, Japan, the Republic of Korea, the Russian Federation, South Africa, Sweden, the United Kingdom and the United States. The FANR is the first associate member to join the MDEP. MDEP associate membership status is intended for national regulatory authorities of interested countries that already have commitments for new build or firm plans to have commitments in the near future for a new reactor design. They may participate in the working group addressing the specific design and issue(s) of interest and, as approved by the MDEP Policy Group, a representative may attend the Steering Technical Committee meetings.

The MDEP pools the resources of these nuclear regulatory authorities for the purposes of 1) co-operating on safety reviews of designs of nuclear reactors that are under construction and undergoing licensing in several countries, and 2) exploring opportunities and potential for harmonisation of regulatory requirements and practices. It also produces reports and guidance documents that are shared internationally beyond the MDEP membership. The MDEP is a unique forum with a growing influence on new nuclear reactor projects.

Further reading

- For more information on the UAE's *Policy on the Evaluation and Potential Development of Peaceful Nuclear Energy*, see www.enec.gov.ae/nuclear-energy-in-the-uae/uae-nuclear-energy-policy/.
- The UAE's Nuclear Liability Law came into force on the date of its publication in the UAE official Gazette on 26 August 2012. An official English translation of the law is available at: http://fanr.gov.ae/En/AboutFANR/OurWork/Documents/Federal-Law-by-Decree-No-4-of-2012-Concerning-Civil-Liability-for-Nuclear-Damage-English.pdf. For additional information, see www.fanr.gov.ae/En/MediaCentre/News/Pages/UAE-Issues-Nuclear-Liability-Law.aspx.
- The report on the UAE Nuclear Liability Law is based on a communication issued by the FANR on 15 October 2012. For more information, see www.fanr.gov.ae/En/MediaCentre/News/Pages/UAE-Issues-Nuclear-Liability-Law.aspx.
- The 1963 Vienna Convention on Civil Liability for Nuclear Damage, the Revised Vienna Convention and the Joint Protocol were established under the auspices of the IAEA. For the texts of the conventions, see www.iaea.org/Publications/Documents/Conventions/index.html.
- The Paris Convention was established under the auspices of the OECD Nuclear Energy Agency (NEA). For more information, see www.oecd-nea.org/law/paris-convention.html.
- For more information on the MDEP, see: www.oecd-nea.org/mdep/.

Estimation and comparability of nuclear facility decommissioning costs

by C. Pescatore, B. Hedberg and I. Rehak*

It is now common practice to prepare decommissioning plans and associated cost estimates for nuclear power plants and other nuclear facilities even before the start of construction. Typically these plans and estimates are updated regularly during the time a plant is in operation, in the transition period after shut down and during decommissioning. Specific requirements regarding the content of these plans are usually set out within national regulations, which have their basis in national legislation.

Transparent, solid cost estimates have a number of important functions. They provide a rationale for the chosen decommissioning strategy, a basis for assessing the cost-effectiveness of decommissioning activities and a means of ensuring the necessary funds are available to cover the actual cost of decommissioning. Practices for estimating decommissioning costs vary across countries and projects. There is also a great deal of difference in reported decommissioning costs, including for those of similar projects. Governments are working to harmonise and improve cost estimates, as well as the comparability and reporting of costs.

Status of cost estimates for decommissioning

Most countries have established requirements for cost estimates and reporting. For nuclear power plants and other commercial facilities, legal requirements include the preparation of a decommissioning plan and associated cost estimates, with periodic updates every three to five years.

National regulations include both administrative and substantive requirements. The substantive requirements generally relate to a breakdown and justification of the boundary conditions and assumptions used to calculate cost estimates. Examples of boundary conditions include the year of the estimate, possible site end states, characteristics of the facility and waste clearance limits, as well as the expected decommissioning activities. The latter may include facility characterisation, transitioning from operation to dismantling, waste processing, legacy waste disposition, spent fuel disposition, storage, transport and other materials management activities. Examples of assumptions include assessments of the labour market and contingency costs. In some countries, substantive requirements stipulate the use of present value costs and means for handling escalation.

Nuclear safety regulators play an important role in the review and approval of decommissioning plans and, in some cases, in decommissioning cost estimates and funding plans. Some regulators require a cost-benefit analysis or the equivalent to assess alternative decommissioning technologies and techniques. Reviewing cost estimates regularly and comparing them with the actual cost of decommissioning activities ensure the quality of these estimates, particularly in light of the time frame for active decommissioning, which can occur several years or even decades after the initial estimate was made.

The majority of countries have adopted an internally consistent formal structure for estimating and reporting costs. The methodology, however, can vary from country to country. In most cases, a cost breakdown is used to sort estimates into activity-dependent and period-dependent costs. These cost breakdowns can be used to divide decommissioning financing into tranches, with the figures for the immediate tranches likely to be more reliable than those from the later tranches. Several countries have reflected this degree of reliability by specifying various contingency factors for the different tranches of the project.

Contingencies and uncertainties

In preparing and managing cost estimates, the concepts of "contingency" and "uncertainty" are important. "Contingency" addresses potential increases in the defined cost of an activity item and is specific to that item. When increases occur, these are mainly due to the novelty of some of the tasks. The overall budget for completed projects usually allows for between 10 to 30% of the overall cost for contingencies. "Uncertainty" is used to refer to cost variations from causes outside the control of the project, such as currency exchange rate fluctuations, unexpected inflation rates, regulatory changes or the availability of new technologies or disposal routes. The effect of uncertainty on project

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costs can be much greater than that of contingency factors. Various approaches are used to deal with uncertainty, and each country may use a different combination of tools, such as numerical simulations or scenario analyses.

Challenges in comparing the costs of decommissioning projects

The most significant cost elements and their ranking as cost drivers in the actual decommissioning of plants that have not undergone a major accident are, in decreasing order:

- scope of work through to the endpoint of the site;
- regulatory requirements, including detail of reporting and clearance levels;
- stakeholders' demands;
- characterisation of physical, radiological and hazardous materials inventory;
- waste processing, storage and the availability of final disposition facilities;
- disposition of spent nuclear fuel and onsite storage prior to emplacement in a permanent repository;
- clean structure disposition and availability of the site for new infrastructure developments;
- contingency application and use in estimates;
- availability of experienced personnel with knowledge of the plant;
- approximate duration of the dismantling and clean-up activities.

Most of these elements are outside the control of the project and thus can be affected by uncertainty factors. Unless these elements and their history are specified in comparative tables, the proposed figures for the costs of decommissioning projects should not be taken at face value. The cost of decommissioning projects could also vary with the number of facilities or units on the same site and with the degree of experience of personnel involved in previous decommissioning activities. These factors will affect the efficiency of processes or alternative strategies.

Habitual sources of variability therefore make it challenging to compare entire project costs across projects and countries. In general, only a range of values can be provided, with no indication of median or average cost values. Comparisons can be made only by benchmarking the cost ranges of specific decommissioning activities rather than benchmarking entire projects.

Progress in the harmonisation of cost reporting and cost comparability

The NEA, the European Commission (EC) and the International Atomic Energy Agency (IAEA) have developed an international cost structure to facilitate cost reporting, transparency and comparability. Based on the 1999 publication *Nuclear Decommissioning: A Proposed Standardised List of Items for Costing Purposes*, the new *International Structure for Decommissioning Costing (ISDC) of Nuclear Installations* breaks down decommissioning projects into a series of technical and non-technical activities. Its general cost platform outlines typical decommissioning activities and cost categories. The ISDC publication also provides guidance in establishing a basis for estimates (e.g. assumptions, boundary conditions, end points, costing methodology), includes a detailed guide for preparing structured cost estimates and provides an example that can be followed.

Additional international guidance based on an Earned Value Management System (EVMS) is under preparation by the NEA Working Party on Decommissioning and Dismantling. The EVMS has now been adopted in many large government programmes and in some commercial projects as an effective tool for cost control.

Conclusions

The most important considerations in ensuring stable and more accurate decommissioning cost estimates include: avoiding changes in project scope, fixing regulatory standards during the planning phase to avoid delays during active decommissioning and ensuring the accurate characterisation of materials and soil. Ultimately, it is difficult to compare cost estimates for entire projects, and the proposed figures should not be taken at face value unless all boundary conditions and assumptions have been made clear. In the end, it would appear that benchmarking the costs of specific activities is preferable to benchmarking those of entire projects. An International Structure for Decommissioning Costing (ISDC) of Nuclear Installations is now available and allows for better comparability of the costs of specific activities. Industry, governments and regulators are invited to make use of the ISDC and to participate in improving guidelines, for example, through the activities of the NEA Working Party on Decommissioning and Dismantling.

Reference

NEA, IAEA, EC (2012), *International Structure for Decommissioning Costing (ISDC) of Nuclear Installations*, OECD, Paris. Available at www.oecd-nea.org.

Nuclear power and climate change: The cost of adaptation

by H. Paillère*

For more than a decade, the international community has been voicing concern over growing greenhouse gas (GHG) emissions, which are believed to be the largest contributor to global warming and more generally to climate change. According to the Intergovernmental Panel on Climate Change (IPCC),[1] an increase in the frequency of heat waves and droughts is expected in many parts of the world, as is that of storms, flooding and cold episodes. The potential consequences of this projected climate change have prompted calls to reduce the use of fossil fuels and to promote low-carbon energy sources such as renewables and nuclear power.

At the same time, there has also been growing concern that without a rapid decrease in GHG emissions, climate change could occur at such a scale that it will have a significant impact on major economic sectors including the power generation sector. Although the expanded use of renewables will reduce emissions from the power sector, it will also increase the dependence of distribution systems and electricity production on climatic conditions. Thermal power plants, such as fossil fuel and nuclear, will be affected primarily by the diminishing availability of water and the increasing likelihood of heat waves, which will have an impact on the cooling capabilities and power output of plants. In its 2012 edition of the *World Energy Outlook*,[2] the IEA underlined the need to address an additional challenge, the water-energy nexus: water needs for energy production are set to grow at twice the rate of energy demands over the next decades. It has thus become clear that the availability of water for cooling will be an important criterion for assessing the viability of energy projects.

Given the long operating life of nuclear reactors (60 years for Generation III designs), the possible impact of climate change on the operation and safety of nuclear power plants needs to be addressed at the design and siting stages in order to limit costly adaptation measures during operation. The availability of water for cooling will likely become the major criterion for siting new nuclear power plants. Existing reactors, on the other hand, may require more significant investments to deal with variations in climatic and hydrological conditions that exceed the initial design values at the sites, especially if long-term operation is considered.

Many countries are also implementing more severe environmental and regulatory constraints. Such constraints may impose operational limitations on the use of thermoelectric plants and add considerable cost to power plant retrofits, which will in turn influence the electricity generation cost of these plants. Measures can be developed to improve the resilience of nuclear power plants, but investment decisions will depend on an assessment of the risks posed by climate change and the possible consequences in terms of losses in power generation.

The NEA recently launched a project under the auspices of the Nuclear Development Committee (NDC) entitled "Climate change: Assessment of the vulnerability of nuclear power plants and the cost of adaptation". The project will assess:

- The level of vulnerability of nuclear power plants to future climatic challenges. Case studies involving different types of extreme weather (e.g. heat waves, droughts, floods, ice storms) will be carried out, and the cost of outages (or partial outages) resulting from these events will be assessed.
- The level of adaptation of nuclear power plants to extreme weather conditions, and the plant or fleet management approaches involved, as well as their associated cost.
- The possible consequences of climate change on nuclear power plants' contribution to the security of a country's energy supply.

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References

1. IPCC (2007), *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Cambridge University Press, Cambridge.
2. IEA (2012), *World Energy Outlook 2012*, OECD Publishing, Paris.

International nuclear law essentials

The third session of the International Nuclear Law Essentials (INLE) programme will take place on 21-25 October 2013 at the OECD Conference Centre in Paris. The INLE programme has been designed to provide working professionals with an exhaustive and informed understanding of the various interrelated legal issues relating to the safe, efficient, secure and environmentally friendly use of nuclear energy. This intensive and comprehensive course in international nuclear law seeks to accommodate the needs and interests of lawyers working in either the public sector or the private sector, but it may be of interest to scientists, policy-makers and managers as well.

The 2013 INLE programme will be conducted under the leadership of Paul Bowden, Partner at Freshfields Bruckhaus and Deringer LLP, London, United Kingdom. Lectures will be delivered by renowned specialists in nuclear law from international organisations, government and private industry. The INLE programme addresses developments in nuclear law and provides a high-quality, extensive overview of a complex body of laws and legal regimes. The International Nuclear Law Essentials programme builds on the foundation of the annual International School of Nuclear Law that the NEA co-sponsors with the University of Montpellier 1 in France. The five-day programme covers fundamental principles and current developments in such areas as radiological protection, nuclear safety, emergency management, regulatory regimes, management of radioactive waste, the impact of environmental law, liability, compensation and insurance for nuclear damage, non-proliferation and international safeguards, security and physical protection, international trade, and transport of nuclear materials and fuel. The registration fee includes admission to the programme and related social events. Print and electronic reference materials are also provided to INLE participants.

Applicants should have at least one year of relevant professional experience and a basic understanding of nuclear energy fundamentals. All course instruction and discussion will take place in English; all course materials are provided in English. Simultaneous interpretation is not available during the course.

Because the number of participants is limited, applicants should submit an application as soon as possible. For additional information, including application information, please visit the INLE website at: www.oecd-nea.org/law/inle. The NEA Legal Affairs Section can be contacted by e-mail at inle@oecd-nea.org.

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

NEA contributions to the worldwide collection, compilation and dissemination of nuclear reaction data

by E. Dupont*

The NEA Data Bank is an international centre of reference for basic nuclear tools used in the analysis and prediction of phenomena in different nuclear applications. The Data Bank collects and compiles computer codes and scientific data and contributes to their improvement for the benefit of scientists in its member countries. In line with this mission, the Data Bank is a core centre of the International Network of Nuclear Reaction Data Centres (NRDC), which co-ordinates the worldwide collection, compilation and dissemination of nuclear reaction data. The NRDC network was established in 1976 from the earlier Four-Centres' Network created in 1966 by the United States, the NEA, the International Atomic Energy Agency (IAEA) and the former Soviet Union. Today, the NRDC is a worldwide co-operation network under the auspices of the IAEA, with 14 nuclear data centres from 8 countries and 2 international organisations belonging to the network.

The main objective of the NRDC is to preserve, update and disseminate experimental nuclear reaction data that have been compiled for more than 40 years in a shared database (EXFOR). The EXFOR database contains basic nuclear data on low- to medium-energy experiments for incident neutron, photon and various charged-particle-induced reactions on a wide range of isotopes, natural elements and compounds. Today, with more than 140 000 data sets from approximately 20 000 experiments, EXFOR is by far the most important and complete experimental nuclear reaction database in the world and is widely used in the field of nuclear science and technology.

The Data Bank is responsible for the collection and compilation of nuclear reaction data measured in its geographical area.[1] Since 1966, the Data Bank has contributed around 5 000 experiments to the EXFOR database, and it continues to compile new data while maintaining the highest level of quality throughout the database.

NRDC co-ordination meetings are held on a biennial basis. Recent meetings were organised in the United States (Brookhaven, 2004), Austria (Vienna, 2006), Russia (Obninsk, 2008) and Japan (Sapporo, 2010), with the latest meeting in the series hosted by the NEA on 16-19 April 2012.

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Representatives of the International Network of Nuclear Reaction Data Centres (NRDC) during the co-ordination meeting held at the NEA on 16-19 April 2012.

The 2012 NRDC meeting was attended by 23 delegates from 13 data centres representing 8 countries and 2 international organisations. Participants presented a total of 41 working papers to discuss the worldwide compilation of nuclear reaction data, as well as data exchange between centres and nuclear data services to users.

In 2011, the Data Bank reported on recent updates in the EXFOR database for neutron and charged-particle data measured in its geographical area, as well as on the development of in-house checking codes to further improve the overall quality of the database. The Data Bank also reported on the status of the Joint Evaluated Fission and Fusion File (JEFF) project and on the development of its Java-based nuclear information software (NEA, 2012a), which facilitates users' access to the EXFOR experimental database and other large evaluated nuclear data libraries, such as JEFF-3.1.2 (NEA, 2012b).

Note

1. Within the NRDC network, the geographical area of the NEA Data Bank corresponds to member countries at the time of the creation of the network in 1976 (i.e. Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey and the United Kingdom).

References

NEA (2011), "Statistical methods for the verification of databases", *NEA News,* Volume 29, No. 1, OECD, Paris.

NEA (2012a), JANIS 3.4, *A Java-based Nuclear Data Display Program* (DVD), OECD, Paris. For more information, see www.oecd-nea.org/janis.

NEA (2012b), JEFF 3.1.2, *Joint Evaluated Nuclear Data Library for Fission and Fusion Applications* (DVD), OECD, Paris. For more information, see www.oecd-nea.org/dbdata/jeff.

NEA joint projects: nuclear safety, nuclear science, radioactive waste management, radiological protection

Project	Participants	Budget
Behaviour of Iodine Project (BIP-2) Contact: axel.breest@oecd.org Current mandate: April 2011-March 2014	Belgium, Canada, Finland, France, Germany, Japan, Republic of Korea, Spain, Sweden, United Kingdom, United States.	≈€ 300 K /year
Benchmark Study of the Accident at the Fukushima Daiichi Nuclear Power Plant (BSAF) Contact: andrew.white@oecd.org Current mandate: November 2012-March 2014	France, Germany, Japan, Republic of Korea, Russian Federation, Spain, Switzerland, United States.	€ 160 K
Cable Ageing Data and Knowledge (CADAK) Project Contact: axel.breest@oecd.org Current mandate: November 2011-December 2014	Belgium, Canada, France, Japan, Slovak Republic, Spain, Switzerland, United States.	€ 70 K /year
Cabri Water Loop Project Contact: radomir.rehacek@oecd.org Current mandate: March 2000-March 2015	Czech Republic, Finland, France, Germany, Japan, Republic of Korea, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom, United States.	≈€ 74 million
Component Operational Experience, Degradation and Ageing Programme (CODAP) Contact: axel.breest@oecd.org Current mandate: June 2011-December 2014	Canada, Chinese Taipei, Czech Republic, Finland, France, Germany, Japan, Republic of Korea, Slovak Republic, Spain, Sweden, Switzerland, United States.	€ 130 K /year
Co-operative Programme on Decommissioning (CPD) Contact: ivan.rehak@oecd.org Current mandate: January 2009-December 2013	Belgium, Canada, Chinese Taipei, European Commission, France, Germany, Italy, Japan, Republic of Korea, Slovak Republic, Spain, Sweden, United Kingdom, United States.	≈€ 70 K /year
Fire Incidents Records Exchange (FIRE) Project Contact: neil.blundell@oecd.org Current mandate: January 2010-December 2013	Canada, Czech Republic, Finland, France, Germany, Japan, Netherlands, Republic of Korea, Spain, Sweden, Switzerland, United States.	≈€ 84 K /year

NEA joint projects and information exchange programmes enable interested countries, on a cost-sharing basis, to pursue research or the sharing of data with respect to particular areas or issues in the nuclear energy field. The projects are carried out under the auspices, and with the support, of the NEA.

At present, 18 joint projects are being conducted or completed in relation to nuclear safety, one in the area of nuclear science (advanced fuels), two in support of radioactive waste management and one in the field of radiological protection. These projects complement the NEA programme of work and contribute to achieving excellence in each area of research.

Objectives
• Obtain a more detailed and mechanistic understanding of iodine adsorption/desorption on containment surfaces by means of new experiments with well characterised containment paints and paint constituents and novel instrumentation (spectroscopic methods). • Obtain a more detailed and mechanistic understanding of organic iodide formation by means of new experiments with well characterised containment paints and paint constituents and novel instrumentation (chromatographic methods). • Develop a common understanding of how to extrapolate confidently from small-scale studies to reactor-scale conditions.
• Analyse the accident progression of the Fukushima Daiichi NPP utilising the common information database. • Improve the understanding of the severe accident (SA) phenomena which occurred during the accident, through comparison with participants' analysis results and with measured plant data. • Contribute the above results to the improvement of methods and models of the SA codes applied in each participating organisation, in order to reduce uncertainties in SA analysis and to validate the SA analysis codes by using data measured through the decommmissioning process. • Contribute results of the analysis on accident progression, the status in the reactor pressure vessels (RPVs) and the primary containment vessels (PCVs) and the status of debris distribution to a future debris removal plan.
• Establish the technical basis for assessing the qualified life of electrical cables in light of the uncertainties identified following initial (early) qualification testing. • Investigate the adequacy of the safety margins and their ability to address the uncertainties.
• Extend the database for high burn-up fuel performance in reactivity-induced accident (RIA) conditions. • Perform relevant tests under coolant conditions representative of pressurised water reactors (PWRs). • Extend the database to include tests done in the Nuclear Safety Research Reactor (Japan) on BWR and PWR fuel.
• Collect information on passive metallic component degradation and failures of the primary system, reactor pressure vessel internals, main process and standby safety systems, and support systems (i.e. ASME Code Class 1, 2 and 3 or equivalent), as well as non safety-related (non-code) components with significant operational impact. • Establish a knowledge base for general information on component and degradation mechanisms such as applicable regulations, codes and standards, bibliography 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 NEA/CSNI Working Group on Integrity of Components and Structures (WGIAGE).
Exchange scientific and technical information amongst decommissioning projects for nuclear facilities, based on biannual meetings of the Technical Advisory Group, to ensure that the safest, most environmentally friendly and economical options for decommissioning are employed.
• Collect fire event experience (by international exchange) in the appropriate format and in a quality-assured and consistent database. • Collect and analyse fire events data over the long term with the aim of better understanding such events, their causes and their prevention. • Generate qualitative insights into the root causes of fire events which 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 including the development of defences against their occurrence, such as indicators for risk-based inspections. • Record characteristics of fire events in order to facilitate fire risk analysis, including quantification of fire frequencies.

NEA joint projects

Project	Participants	Budget
Fire Propagation in Elementary, Multi-room Scenarios (PRISME-2) Project Contact: neil.blundell@oecd.org Current mandate: July 2011-June 2016	Belgium, Canada, Finland, France, Germany, Japan, Spain, Sweden, United Kingdom.	€ 7 million
Halden Reactor Project Contact: radomir.rehacek@oecd.org Halden contact: Fridtjov.owre@hrp.no Current mandate: January 2012-December 2014	Belgium, Czech Republic, Denmark, Finland, France, Germany, Hungary, Italy, Japan, Kazakhstan, Norway, Republic of Korea, Russian Federation, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom, United States.	≈€ 55 million
High Energy Arcing Fault Events (HEAF) Project Contact: neil.blundell@oecd.org Current mandate: July 2012-December 2015	Canada, France, Germany, Japan, Republic of Korea, Spain, United States.	Costs covered by the US NRC and in-kind contributions from the participants.
Hydrogen Mitigation Experiments for Reactor Safety (HYMERES) Project Contact: axel.breest@oecd.org Current mandate: October 2012-September 2016	Canada, China, Czech Republic, Finland, France, Germany, India, Russian Federation, Spain, Sweden, Switzerland.	€ 4 million
Information System on Occupational Exposure (ISOE) Contact: halilburcin.okyar@oecd.org Current mandate: January 2012-December 2015	Armenia, Belgium, Brazil, Bulgaria, Canada, China, Czech Republic, Finland, France, Germany, Hungary, Italy, Japan, Lithuania, Mexico, Netherlands, Pakistan, Republic of Korea, Romania, Russian Federation, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Ukraine, United Kingdom, United States.	≈€ 500 K /year
International Common-cause Failure Data Exchange (ICDE) Project Contact: axel.breest@oecd.org Current mandate: April 2011-March 2014	Canada, Czech Republic, Finland, France, Germany, Japan, Republic of Korea, Spain, Sweden, Switzerland, United Kingdom, United States.	≈€ 120 K /year
Loss of Forced Coolant (LOFC) Project Contact: neil.blundell@oecd.org Current mandate: April 2011-March 2014	Czech Republic, France, Germany, Hungary, Japan, Republic of Korea, United States.	€ 3 million

Objectives
• Answer questions concerning smoke, fire and heat propagation inside a plant, by means of experiments tailored for code validation purposes for fire modelling computer codes. • Undertake experiments related to smoke and hot gas propagation, through a horizontal opening between two superimposed compartments. • Provide information on heat transfer to cables and on cable damage. • Provide information on the effectiveness of fire extinguishing systems.
Generate key information for safety and licensing assessments and aim at providing: • extended fuel utilisation: basic data on how the fuel performs, both under normal operation and transient conditions, with emphasis on extended fuel utilisation in commercial reactors; • degradation of core materials: knowledge of plant materials behaviour under the combined deteriorating effects of water chemistry and nuclear environment, also relevant for plant lifetime assessments; • man-machine systems: advances in computerised surveillance systems, virtual reality, digital information, human factors and man-machine interaction in support of control room upgradings.
Perform experiments to obtain scientific fire data on the high energy arcing faults phenomena known to occur in nuclear power plants through carefully designed experiments: • use data from the experiments and past events to develop a mechanistic model to account for the failure modes and consequence portions of HEAFs; • improve the state of knowledge and provide better characterisation of HEAFs in fire probabilistic risk assessment (PRA) and US National Fire Protection Association NFPA 805 license amendment request applications; • examine the initial impact of the arc to primary equipment and the subsequent damage created by the initiation of an arc (e.g. secondary fires).
Improve the understanding of hydrogen risk phenomenology in containment in order to enhance modelling in support of safety assessments that will be performed for current and new nuclear power plants.
• Collect, analyse and exchange occupational exposure data and experience from all participants. • Provide broad and regularly updated information on methods to improve the protection of workers and on occupational exposure in nuclear power plants. • Provide a mechanism for dissemination of information on these issues, including evaluation and analysis of the data assembled and experience exchanged, as a contribution to the optimisation of radiation protection.
• Provide a framework for multinational co-operation. • Collect and analyse common-cause failure (CCF) events over the long term so as to better understand such events, their causes and their prevention. • Generate qualitative insights into the root causes of CCF events which can then be used to derive approaches or mechanisms for their prevention or mitigation of their consequences. • Establish a mechanism for the efficient feedback of experience gained in connection with CCF phenomena, including the development of defences against their occurrence, such as indicators for risk-based inspections. • Generate quantitative insights and record event attributes to facilitate the quantification of CCF frequencies in member countries. • Use the ICDE data to estimate CCF parameters.
To perform three integral tests in the high-temperature engineering test reactor (HTTR) in order to: • provide experimental data to clarify the anticipated transient without scram (ATWS) in the case of an LOFC with occurrence of reactor re-criticality; • provide experimental data to validate the key assumptions in computer codes predicting the behaviour of reactor kinetics, core physics and thermal-hydraulics related to protective measures for safety; • provide experimental data to verify the capabilities of these codes regarding the simulation of phenomena coupled between reactor core physics and thermal-hydraulics.

NEA joint projects

Project	Participants	Budget
Primary Coolant Loop Test Facility (PKL-3) Project Contact: abdallah.amri@oecd.org Current mandate: April 2012-December 2015	Belgium, China, Czech Republic, Finland, France, Germany, Hungary, Italy, Japan, Republic of Korea, Slovak Republic, Spain, Sweden, Switzerland, United States.	€ 4.6 million
Rig of Safety Assessment (ROSA-2) Project Contact: abdallah.amri@oecd.org Current mandate: April 2009-March 2013	Belgium, China, Czech Republic, Finland, France, Germany, Hungary, Japan, Netherlands, Republic of Korea, Spain, Sweden, Switzerland, United Kingdom, United States.	€ 2.7 million
Sandia Fuel Project (SFP) Contact: radomir.rehacek@oecd.org Current mandate: July 2009-February 2013	Czech Republic, France, Germany, Hungary, Italy, Japan, Norway, Republic of Korea, Spain, Sweden, Switzerland, United Kingdom, United States.	€ 4 million
Source Term Evaluation and Mitigation (STEM) Project Contact: axel.breest@oecd.org Current mandate: July 2011-June 2015	Canada, Czech Republic, Finland, France, Germany, Republic of Korea, United States.	€ 3.5 million
Studsvik Cladding Integrity Project (SCIP-2) Contact: axel.breest@oecd.org Current mandate: July 2009-June 2014	Czech Republic, Finland, France, Germany, Japan, Norway, Republic of Korea, Russian Federation, Spain, Sweden, Switzerland, United Kingdom, United States.	€ 1.5 million /year
Thermochemical Database (TDB) Project Contact: tdb@oecd.org Current mandate: February 2008-January 2014	Belgium, Canada, Czech Republic, Finland, France, Germany, Japan, Republic of Korea, Spain, Sweden, Switzerland, United Kingdom, United States.	≈€ 441 K /year
Thermodynamics of Advanced Fuels – International Database (TAF-ID) Project Contact: simone.massara@oecd.org Current mandate: January 2013-December 2015	Canada, France, Japan, Republic of Korea, United States.	≈€ 100 K /year
Thermal-hydraulics, Hydrogen, Aerosols, Iodine (THAI-2) Project Contact: neil.blundell@oecd.org Current mandate: August 2011-July 2014	Canada, Czech Republic, Finland, France, Germany, Hungary, Japan, Netherlands, Republic of Korea, Sweden, United Kingdom.	€ 3.6 million

Objectives
• Investigate safety issues relevant for current PWR plants as well as for new PWR design concepts. • Focus on complex heat transfer mechanisms in the steam generators and boron precipitation processes under postulated accident situations.
• Provide an integral and separate-effect experimental database to validate code predictive capability and accuracy of models. In particular, phenomena coupled with multi-dimensional mixing, stratification, parallel flows, oscillatory flows and non-condensable gas flows are to be studied. • Clarify the predictability of codes currently used for thermal-hydraulic safety analyses as well as of advanced codes presently under development, thus creating a group among OECD/NEA member countries who share the need to maintain or improve technical competence in thermal-hydraulics for nuclear reactor safety evaluations.
• Study potential accident conditions and perform a highly detailed thermal-hydraulic characterisation of full-length, commercial pressurised water reactor (PWR) fuel assembly mock-ups. • Provide data for the direct validation of appropriate codes. • Address applicability to other fuel designs, once the basis of the BWR data is provided to the project participants.
Improve the general evaluation of the source term, and in particular: • perform experiments to study the stability of aerosol particles under radiation and the long-term gas/deposits equilibrium in a containment. • conduct a literature survey on the effect of paint ageing. • perform experiments to study ruthenium transport in pipes.
• Generate high-quality experimental data to improve the understanding of the dominant failure mechanisms for water reactor fuels and devise means for reducing fuel failures. • Achieve results of general applicability (i.e. not restricted to a particular fuel design, fabrication specification or operating condition). • Achieve experimental efficiency through the judicious use of a combination of experimental and theoretical techniques and approaches.
Produce a database that: • contains data for elements of interest in radioactive waste disposal systems; • documents why and how the data were selected; • gives recommendations based on original experimental data, rather than on compilations and estimates; • documents the sources of experimental data used; • is internally consistent; • treats all solids and aqueous species of the elements of interest for nuclear waste storage performance assessment calculations.
Make available a comprehensive, internationally recognised thermodynamic database and associated phase diagrams on nuclear fuel materials for the existing and future generation of nuclear reactors.
Address remaining questions and examine experimental data relevant to nuclear reactor containments under severe accident conditions concerning: • release of gaseous iodine from a flashing jet; • deposition of molecular iodine on aerosol particles; • hydrogen combustion during spray operation; • onset of passive autocatalytic recombiner (PAR) operation under extremely low oxygen conditions.

New publications

General interest

Annual Report 2012

NEA No. 7144. 60 pages.

Nuclear Energy Today

Second Edition

NEA No. 6885 (ISBN 978-92-64-99204-7). 120 pages.

Meeting the growing demand for energy, and electricity in particular, while addressing the need to curb greenhouse gas emissions and to ensure security of energy supply, is one of the most difficult challenges facing the world's economies. No single technology can respond to this challenge, and the solution which policy-makers are seeking lies in the diversification of energy sources.

Although nuclear energy currently provides over 20% of electricity in the OECD area and does not emit any carbon dioxide during production, it continues to be seen by many as a controversial technology. Public concern remains over its safety and the management of radioactive waste, and financing such a capital-intensive technology is a complex issue. The role that nuclear power will play in the future depends on the answers to these questions, several of which are provided in this up-to-date review of the status of nuclear energy, as well as on the outcome of research and development on the nuclear fuel cycle and reactor technologies.

Economic and technical aspects of the nuclear fuel cycle

Nuclear Energy and Renewables

System Effects in Low-carbon Electricity Systems

NEA No. 7056 (ISBN 978-92-64-18851-8). 252 pages. Executive summary also available.

This report addresses the increasingly important interactions of variable renewables and dispatchable energy technologies, such as nuclear power, in terms of their effects on electricity systems. These effects add costs to the production of electricity, which are not usually transparent. The report recommends that decision-makers should take into account such system costs and internalise them according to a "generator pays" principle, which is currently not the case. Analysing data from six OECD/NEA countries, the study finds that including the system costs of variable renewables at the level of the electricity grid increases the total costs of electricity supply by up to one-third, depending on technology, country and penetration levels. In addition, it concludes that, unless the current market subsidies for renewables are altered, dispatchable technologies will increasingly not be replaced as they reach their end of life and consequently security of supply will suffer. This implies that significant changes in management and cost allocation will be needed to generate the flexibility required for an economically viable coexistence of nuclear energy and renewables in increasingly decarbonised electricity systems.

Nuclear Energy Data 2012/*Données sur l'énergie nucléaire 2012*

NEA No. 7058 (ISBN 978-92-64-17785-7). 84 pages.

Nuclear Energy Data is the OECD Nuclear Energy Agency's annual compilation of statistics and country reports documenting the status of nuclear power in the OECD area. Information provided by member country governments includes statistics on installed generating capacity, total electricity produced by all sources and by nuclear power, nuclear energy policies, fuel cycle developments, and projected generating capacity and electricity production to 2035, where available. Following the accident at the Fukushima Daiichi nuclear power plant in March 2011, total nuclear generating capacity and electricity generation declined, principally because of the permanent shutdown of 12 reactors (8 in Germany and 4 in Japan) and the prolonged shutdown of reactors in Japan. The Fukushima Daiichi accident also prompted safety reviews of existing nuclear facilities and led some governments to adopt nuclear phase-out plans. Other governments remained committed to maintaining nuclear power in the energy mix, in some cases pursuing plans to either increase nuclear generating capacity or, as in the cases of Poland and Turkey, to add nuclear generating capacity for the first time. Further details on these and other developments are provided in the publication's numerous tables, graphs and country reports.

The Economics of Long-term Operation of Nuclear Power Plants

NEA No. 7054 (ISBN 978-92-64-99205-4). 114 pages.

Refurbishment and long-term operation (LTO) of existing nuclear power plants (NPPs) today are crucial to the competitiveness of the nuclear industry in OECD countries as existing nuclear power plants produce baseload power at a reliable cost. A number of nuclear power plants, most notably 73 units in the United States (up to 2012), have been granted lifetime extensions of up to 60 years, a development that is being keenly watched in other OECD countries. In many of these (e.g. France, Switzerland), there is no legal end to the operating licence, but continued operation is based on the outcomes of periodic safety reviews.

This study analyses technical and economic data on the upgrade and lifetime extension experience in OECD countries. A multi-criteria assessment methodology is used considering various factors and parameters reflecting current and future financial conditions of operation, political and regulatory risks, the state of the plants' equipment and the general role of nuclear power in the country's energy policy.

The report shows that long-term operation of nuclear power plants has significant economic advantages for most utilities envisaging LTO programmes. In most cases, the continued operation of NPPs for at least ten more years is profitable even taking into account the additional costs of post-Fukushima modifications, and remains cost-effective compared to alternative replacement sources.

The Supply of Medical Radioisotopes

Market Impacts of Converting to Low-enriched Uranium Targets for Medical Isotope Production

NEA No. 7129 (ISBN 978-92-64-99197-2). 64 pages.

The reliable supply of molybdenum-99 (^{99}Mo) and its decay product, technetium-99m (^{99m}Tc), is a vital component of modern medical diagnostic practices. At present, most of the global production of ^{99}Mo is from highly enriched uranium (HEU) targets. However, all major ^{99}Mo-producing countries have recently agreed to convert to using low-enriched uranium (LEU) targets to advance important non-proliferation goals, a decision that will have implications for the global supply chain of ^{99}Mo/^{99m}Tc and the long-term supply reliability of these medical isotopes.

This study provides the findings and analysis from an extensive examination of the ^{99}Mo/^{99m}Tc supply chain by the OECD/NEA High-level Group on the Security of Supply of Medical Radioisotopes (HLG-MR). It presents a comprehensive evaluation of the potential impacts of converting to the use of LEU targets for ^{99}Mo production on the global ^{99}Mo/^{99m}Tc market in terms of costs and available production capacity, and the corresponding implications for long-term supply reliability. In this context, the study also briefly discusses the need for policy action by governments in their efforts to ensure a stable and secure long-term supply of ^{99}Mo/^{99m}Tc.

Uranium 2011: Resources, Production and Demand

NEA No. 7059 (ISBN 978-92-64-17803-8). 488 pages. Executive summary available in English, French and Russian.

In the wake of the Fukushima Daiichi nuclear power plant accident, questions are being raised about the future of the uranium market, including as regards the number of reactors expected to be built in the coming years, the amount of uranium required to meet forward demand, the adequacy of identified uranium resources to meet that demand and the ability of the sector to meet reactor requirements in a challenging investment climate. This 24th edition of the "Red Book", a recognised world reference on uranium jointly prepared by the OECD Nuclear Energy Agency and the International Atomic Energy Agency, provides analyses and information from 42 producing and consuming countries in order to address these and other questions. It offers a comprehensive review of world uranium supply and demand as well as data on global uranium exploration, resources, production and reactor-related requirements. It also provides substantive new information on established uranium production centres around the world and in countries developing production centres for the first time. Projections of nuclear generating capacity and reactor-related requirements through 2035, incorporating policy changes following the Fukushima accident, are also featured, along with an analysis of long-term uranium supply and demand issues.

Nuclear safety and regulation

Challenges in Long-term Operation of Nuclear Power Plants

Implications for Regulatory Bodies

NEA No. 7074 (ISBN 978-92-64-99187-3). 32 pages.

Nuclear power reactors have become a major source of electricity supply in many countries and, based on the experience of safe and reliable operation, many operators have sought and received authorisation for long-term operation beyond the period assumed in the plant's design. Acceptance of a nuclear power plant for long-term operation must be based on evidence that the plant will operate safely over the extended period of service. This requires an assessment of the current and projected condition of the plant and, in particular, of the systems that perform fundamental safety functions, to ensure that these systems will continue to perform their safety functions during the extended operating period. Programmes for long-term operation must be informed by operating experience and must also consider and assess environmental impacts.

This guidance document is intended to assist regulatory organisations in assessing and approving the long-term operation safety assessments submitted by operators. It outlines the fundamental principles that should govern decisions on authorisation for long-term operation. It also describes regulatory challenges and considerations that may arise in an assessment of a plant for long-term operation.

Crisis Communication: Facing the Challenges

Workshop Proceedings, Madrid, Spain, 9-10 May 2012

NEA No. 7067. 240 pages.

As manifested by an increasingly globalised media, a nuclear accident anywhere quickly becomes a potential concern for people everywhere. It is therefore of prime importance that nuclear regulators' communication strategies take into consideration the expectations and concerns of the public and provide sound information not only for the people of the affected country, but also for citizens worldwide. Public trust is a key element in being able to do so effectively and of particular importance when there are consequences for people or the environment. International co-operation can play a fundamental role in helping to improve crisis communication on national and global scales in the event of a nuclear accident or radiological emergency. These proceedings contain the papers, recommendations and conclusions of the workshop, which was attended by over 180 experts from 27 countries and 6 international organisations.

CSNI Technical Opinion Papers No. 15

Ageing Management of Nuclear Fuel Cycle Facilities

NEA No. 6990 (ISBN 978-92-64-99181-1). 40 pages.

Managing the ageing of fuel cycle facilities (FCFs) means, as for other nuclear installations, ensuring the availability of required safety functions throughout their service life while taking into account the changes that occur with time and use. This technical opinion paper identifies a set of good practices by benchmarking strategies and good practices on coping with physical ageing and obsolescence from the facility design stage until decommissioning. It should be of particular interest to nuclear safety regulators, fuel cycle facilities operators and fuel cycle researchers.

CSNI Technical Opinion Papers No. 16

Defence in Depth of Electrical Systems

NEA No. 7070. 48 pages.

As all safety systems in the majority of existing nuclear power plants use the preferred power supply, any voltage surges in these systems could lead to common-cause failures. In the event of an unusual electrical system transient, it is essential that safety-related equipment be isolated or protected from the fault in order to ensure its ability to safely shut down the reactor and remove decay heat.

Based on the analysis of the voltage surges observed at Forsmark-1 in 2006 and Olkiluoto-1 in 2008, this technical opinion paper summarises the current state of knowledge of in-plant and external grid-related challenges to nuclear power plant safety-related electrical equipment. It will be of particular interest to nuclear safety regulators, nuclear power plant operators and grid system regulators and operators.

Nuclear Fuel Safety Criteria Technical Review

Second Edition

NEA No. 7072 (ISBN 978-92-64-99178-1). 80 pages.

Most of the current nuclear fuel safety criteria were established during the 1960s and early 1970s. Although these criteria were validated against experiments with fuel designs available at that time, a number of tests were based on unirradiated fuels. Additional verification was performed as these designs evolved, but mostly with the aim of showing that the new designs adequately complied with existing criteria, and not to establish new limits.

In 1996, the OECD Nuclear Energy Agency (NEA) reviewed existing fuel safety criteria, focusing on new fuel and core designs, new cladding materials and industry manufacturing processes. The results were published in the *Nuclear Fuel Safety Criteria Technical Review* of 2001. The NEA has since re-examined the criteria. A brief description of each criterion and its rationale are presented in this second edition, which will be of interest to both regulators and industry (fuel vendors, utilities).

Nuclear Power Plant Operating Experience

from the IAEA/NEA International Reporting System for Operating Experience 2009-2011

NEA No. 7120 (ISBN 978-92-64-99193-4). 60 pages.

The application of lessons learnt from the International Reporting System for Operating Experience (IRS) is an essential element for enhancing the safe operation of nuclear power plants (NPPs) throughout the world. The IRS provides a mechanism for the exchange of information related to the incident, actions taken, root cause analysis and lessons learnt. This feedback on how to adequately remedy, or avoid, possible challenges and precursors is of paramount importance to operational safety. The IRS improves international awareness of potential challenges, actual incidents and "precursors" in NPP operations. The heightened awareness generated by feedback from operating experience has resulted in numerous improvements to equipment, procedures and training in many NPPs. The application of operational feedback also benefits the design of the next generation of NPPs. Operating experience has demonstrated that design modification issues documented in IRS reports can have a significant impact on safety. The IRS is jointly operated and managed by the OECD Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA).

核設施除役

可行且有成功案例 (Chinese translation of Decommissioning of Nuclear Facilities)

NEA No. 7126. 8 pages.

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

NEA No. 7082 (ISBN 978-92-64-99183-5). 24 pages.

Disposal in engineered facilities built in stable, deep geological formations is the reference solution for permanently isolating long-lived radioactive waste from the human biosphere. This management method is designed to be intrinsically safe and final, meaning that it is not dependent on human presence or intervention in order to fulfil its safety goal. Selecting the site of a waste repository brings up a range of issues involving scientific knowledge, technical capacity, ethical values, territorial planning, community well-being and more. Bringing to fruition the multi-decade task of siting and developing a repository demands a strong national commitment and significant regional and local involvement.

This collective statement by the Radioactive Waste Management Committee of the OECD Nuclear Energy Agency recognises the advances made towards greater transparency and dialogue among the diverse stakeholders concerned and identifies the fundamental elements needed to support national commitment and to foster territorial involvement. It concludes that technical and societal partners can develop shared confidence in the safety of geological repositories and jointly carry these projects forward.

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

NEA No. 6993 (ISBN 978-92-64-99185-9). 236 pages.

Deep geological repositories of radioactive waste are designed and licensed based on a model of long-term safety which does not require the active presence of man. During the period of stepwise development of such repositories, reversibility of decisions and retrievability of the waste are widely thought to be beneficial. Reversibility and retrievability are not requirements for long-term safety. They are instead about implementing a process that responds to ethical and precautionary obligations without compromising safety. How are the concepts of reversibility and retrievability understood in the various nuclear countries? How do they appear in national waste management legislation, regulation and operational programmes, and how can they be implemented?

The "R&R" project of the OECD Nuclear Energy Agency (NEA) culminated in an International Conference and Dialogue on Reversibility and Retrievability in December 2010. This open meeting brought together regulators, policy makers, elected officials, experts in social sciences, and representatives of civil society and stakeholder groups in addition to waste management professionals. These proceedings include the texts of 50 presentations and the "International Retrievability Scale" – a tool to support dialogue with stakeholders and to help establish a common international framework.

Stakeholder Confidence in Radioactive Waste Management

An Annotated Glossary of Key Terms

NEA No. 6988. 64 pages.

The OECD Nuclear Energy Agency (NEA) Forum on Stakeholder Confidence (FSC) Annotated Glossary is a review of concepts central to societal decision making about radioactive waste management. It records the evolution in understanding that has taken place in the group as the FSC has worked with these concepts over time. This should be a useful resource not only for new FSC participants but also for others: this annotated glossary forms a good reference handbook for future texts regarding societal aspects of radioactive waste management and its governance.

The Evolving Role and Image of the Regulator in Radioactive Waste Management

Trends over Two Decades

NEA No. 7083 (ISBN 978-92-64-99186-6). 28 pages.

In the area of radioactive waste management, the regulator or safety authority has emerged in recent years as a principal actor in the eyes of civil society. This study shows how regulators are increasing their interaction with society while still retaining – or reinforcing – their independence and how they play their role within the stepwise licensing and decision-making processes now adopted in most countries. Safety is ensured by a "regulatory system", in which a host of players, including local stakeholders, have a vital role to play. The technical regulator has come to be considered as the "people's expert", concentrating knowledge useful to local communities as they deliberate the hosting of a waste storage or disposal facility.

This report provides a useful update on the changing role of the regulator as well as insights that will be helpful to the many countries that are considering, or are preparing for, storage or disposal of radioactive waste either in near-surface facilities or deeper underground. While it focuses on the developments in waste management and disposal, the trends it describes are probably relevant throughout the nuclear field.

The Long-term Radiological Safety of a Surface Disposal Facility for Low-level Waste in Belgium

An International Peer Review of Key Aspects of ONDRAF/NIRAS' Safety Report of November 2011 in Preparation for the License Application

NEA No. 7086 (ISBN 978-92-64-99196-5). 100 pages.

An important activity of the OECD Nuclear Energy Agency (NEA) in the field of radioactive waste management is the organisation of independent, international peer reviews of national studies and projects. This report provides an international peer review of the long-term safety strategy and assessment being developed by the Belgian Agency for Radioactive Waste and Enriched Fissile Materials, ONDRAF/NIRAS, as part of the licence application for the construction and operation of a surface disposal facility for short-lived, low- and intermediate-level radioactive waste in the municipality of Dessel, Belgium. The review was carried out by an International Review Team comprised of seven international specialists, all of whom were free of conflict of interest and chosen to bring complementary expertise to the review. To be accessible to both specialist and non-specialist readers, the review findings are provided at several levels of detail.

The Post-closure Radiological Safety Case for a Spent Fuel Repository in Sweden

An International Peer Review of the SKB License-application Study of March 2011

NEA No. 7084 (ISBN 978-92-64-99191-0). 156 pages.

Sweden is at the forefront among countries developing plans for a deep geological repository of highly radioactive waste. There is no such repository in operation yet worldwide, but Sweden, Finland and France are approaching the licensing stage. At the request of the Swedish government, the NEA organised an international peer review of the post-closure radiological safety case produced by the Swedish Nuclear Fuel and Waste Management Company (SKB) in support of the application for a general licence to construct and operate a spent nuclear fuel geological repository in the municipality of Östhammar. The purpose of the review was to help the Swedish government, the public and relevant organisations by providing an international reference regarding the maturity of SKB's spent fuel disposal programme *vis-à-vis* best practices in long-term disposal safety and radiological protection. The International Review Team (IRT) consisted of ten international specialists, who were free of conflict of interest with the SKB and brought complementary expertise to the review. This report provides the background and findings of the international peer review. The review's findings are presented at several levels of detail in order to be accessible to both specialist and non-specialist readers.

Radiological protection

原子力緊急事態の事後管理におけるステークホルダー関与の実践と経験

(Japanese translation of Practices and Experience in Stakeholder Involvement for Post-nuclear Emergency Management)

NEA No. 7128. 24 pages.

Nuclear law

Japan's Compensation System for Nuclear Damage

As Related to the TEPCO Fukushima Daiichi Nuclear Accident

NEA No. 7089 (ISBN 978-92-64-99200-9). 244 pages.

Following the TEPCO Fukushima Daiichi nuclear power plant accident, extraordinary efforts were undertaken in Japan to implement a compensation scheme for the proper and efficient indemnification of the affected victims. This publication provides English translations of key Japanese legislative and administrative texts and other implementing guidance, as well as several commentaries by Japanese experts in the field of third party nuclear liability.

The OECD Nuclear Energy Agency (NEA) has prepared this publication in co-operation with the government of Japan to share Japan's recent experience in implementing its nuclear liability and compensation regime. The material presented in the publication should provide valuable insights for those wishing to better understand the regime applied to compensate the victims of the accident and for those working on potential improvements in national regimes and the international framework for third party nuclear liability.

Nuclear Law Bulletin No. 89 and No. 90

Volumes 2012/1 and 2012/2

ISSN No. 0304-341X. Approximately 250 pages. 2013 subscription price (2 issues per year): € 125, US$ 166, £ 99, ¥ 16 000.

The *Nuclear Law Bulletin* 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. Published twice a year in both English and French, it features topical articles written by renowned legal experts, covers legislative developments worldwide and reports on relevant case law, bilateral and international agreements as well as regulatory activities of international organisations.

Feature articles in Issue No. 89 include: "Global nuclear law in the making? Joint exercise of public powers in the nuclear field: the case of the revision of the International Basic Safety Standards", "Italian decommissioning in the post-referendum era", "Through the looking glass: placing India's new civil liability regime for nuclear damage in context" and "Legal aspects of the control and repression of illicit trafficking of nuclear and other radioactive materials".

Feature articles in Issue No. 90 include: "A common high standard for nuclear power plant exports: overview and analysis of the Nuclear Power Plant Exporters' Principles of Conduct", "The MCP Altona incident: the Canadian regulatory response and framework for the export of uranium", "Conflict of law issues related to Switzerland's participation in the Paris Nuclear Third Party Liability Regime", and "The impact of the Additional Protocol and Strengthened Safeguards: effects on the International Atomic Energy Agency and on states".

Nuclear science and the Data Bank

Chemical Thermodynamics of Tin

Volume 12

NEA No. 6354 (ISBN 978-92-64-99206-1). 644 pages.

This volume is the 12th in the OECD Nuclear Energy Agency (NEA) "Chemical Thermodynamics" series. It is based on a critical review of the thermodynamic properties of tin, its solid compounds and aqueous complexes, carried out as part of the NEA Thermochemical Database Project Phase III (TDB III). The database system developed at the OECD/NEA Data Bank ensures consistency not only within the recommended data sets of tin, but also among all the data sets published in the series. This volume will be of particular interest to scientists carrying out performance assessments of deep geological disposal sites for radioactive waste.

Homogeneous versus Heterogeneous Recycling of Transuranics in Fast Nuclear Reactors

NEA No. 7077 (ISBN 978-92-64-99177-4). 92 pages.

Fuel transuranics (TRU) multi-recycling is a mandatory feature if both the resource sustainability and the waste minimisation objectives for future fuel cycles are to be pursued. The resulting TRU transmutation can be implemented in fast neutron spectrum reactors according to two main options commonly referred to as the homogeneous and heterogeneous modes.

In this study, the two alternatives have been compared in terms of reactor core feasibility, fuel development and impact on the fuel cycle. The multi-criteria analysis indicates that there are major challenges in minor actinide-loaded fuel development, its experimental validation and possibly in its reprocessing. Both modes of recycling have an impact on the overall fuel cycle, even if at different stages, for example complex target fabrication and handling in the case of heterogeneous recycling and full core fuel fabrication in the case of homogeneous recycling. The study finds that an economic evaluation according to specific implementation scenarios should still be undertaken.

International Handbook of Evaluated Criticality Safety Benchmark Experiments (DVD)

NEA No. 7080 (ISBN 978-92-64-99192-7).

International Handbook of Evaluated Reactor Physics Benchmark Experiments (DVD)

NEA No. 7140.

Janis 3.4 (DVD)

A Java-based Nuclear Data Display Program

NEA No. 7116.

Structural Materials for Innovative Nuclear Systems (SMINS-2)

Workshop Proceedings, Daejon, Republic of Korea, 31 August-3 September 2010

NEA No. 6896 (ISBN 978-92-64-99209-2). 444 pages.

Materials research is a field of growing relevance for innovative nuclear systems, such as Generation IV reactors, critical and sub-critical transmutation systems and fusion devices. For these different systems, structural materials are selected or developed taking into account the specificities of their foreseen operational environment. Since 2007, the OECD Nuclear Energy Agency (NEA) has begun organising a series of workshops on Structural Materials for Innovative Nuclear Systems (SMINS) in order to provide a forum to exchange information on current materials research programmes for different innovative nuclear systems. These proceedings include the papers of the second workshop (SMINS-2) which was held in Daejon, Republic of Korea on 31 August-3 September 2010, and hosted by the Korea Atomic Energy Research Institute (KAERI).

Validation of the JEFF-3.1 Nuclear Data Library

JEFF Report 23

NEA No. 7079. 76 pages.

The Joint Evaluated Fission and Fusion (JEFF) Project is a collaborative effort among OECD Nuclear Energy Agency (NEA) Data Bank member countries to develop a reference nuclear data library for use in different energy applications. These data can be used to help improve the safety and economy of existing installations, as well as to design advanced nuclear reactors and their associated fuel cycles, including radioactive waste management. The JEFF-3.1 library contains several different data types, including neutron and proton interaction data, neutron activation data, radioactive decay data, fission yield data and thermal scattering data. This report describes the initial validation of the complete JEFF-3.1 library for thermal reactors, fuel cycle, storage and reprocessing, fusion technology and intermediate energy applications. It will be useful for scientists and engineers in national laboratories, universities and industry who use basic nuclear data, and is particularly suitable for those who work with application libraries based on JEFF-3.1.

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