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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 30 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 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.

For more information about the NEA, see:
www.oecd-nea.org

Cover page photo credits: High voltage line (F. Vuillaume, OECD/NEA); Residents of Kawauchi village, Japan (AFP ImageForum); View of the Halden reactor hall (IFE, Norway); Brokdorf NPP, Germany (GFDL). Page 3 photo credit of Luis Echávarri (M. Lemelle, France).

Contents

Supporting the safety of nuclear energy

Since the March 2011 nuclear accident at the Fukushima Daiichi nuclear power plant in Japan, the NEA and its member governments have been making numerous efforts to support and to further reinforce the safety of nuclear energy. Multiple verification activities and "stress tests" have been implemented in all NEA member countries using nuclear power, and follow-up measures have already begun to be implemented.

In November 2011, an NEA team of international experts met in Tokyo with the Japanese Nuclear and Industrial Safety Agency (NISA) and the Japan Nuclear Energy Safety Organisation (JNES) to foster a better understanding of other NEA member countries' post-Fukushima national safety reviews ("stress tests"), international guidance and review methodologies. The programme included a technical experts' meeting for sharing information on national reviews, an international seminar on stress tests with the Japanese nuclear industry and the public, and a meeting with an advisory committee supporting the regulatory reviews of licensee analyses as part of the Japanese stress tests. Experts from Japan, Finland, France, Korea, the United Kingdom, the United States and the International Atomic Energy Agency (IAEA) took part. Presentations can be consulted on the NEA Fukushima information exchange page of the NEA website.

In terms of recovery from the accident, on 16 October 2011, an International Symposium on Decontamination – Towards the Recovery of the Environment was held in Fukushima Prefecture. Organised by the Ministry of Environment of Japan with the collaboration of the NEA and the IAEA, the symposium, in which I participated, provided a 400+ audience of Japanese government experts, local elected officials and members of the Japanese public with an overview of NEA member countries' experience in these important areas as well as experience from other countries.

In the area of nuclear regulation, the NEA will send experts to Japan to support the elaboration of the new nuclear safety regulatory framework and the establishment of the new regulatory authority. The Japanese government aims to have an updated framework before the end of the year and a new regulatory authority at the end of March 2012. The senior NEA experts supporting Japan will include members of the NEA Committee on Nuclear Regulatory Activities (CNRA).

Two new working groups have been established at the NEA in relation to the Fukushima Daiichi nuclear accident: the CNRA Senior-level Task Group on Impacts of the Fukushima Accident and the NEA Committee on Radiation Protection and Public Health (CRPPH) Expert Group on Radiological Protection Aspects of the Fukushima Accident. Other established NEA groups and committees are examining safety, communication and radiological protection aspects of severe accident management and post-accident recovery, as well as liability and compensation issues (see in particular the article on page 9). In the year to come, the Agency will continue to analyse the various aspects of the accident and to share internationally the lessons that can be learnt.

Luis E. Echávarri
NEA Director-General

Carbon pricing and the competitiveness of nuclear power

by J.H. Keppler and C. Marcantonini*

A recent NEA study entitled *Carbon Pricing, Power Markets and the Competitiveness of Nuclear Energy* assesses the competitiveness of nuclear power against coal- and gas-fired power generation in liberalised electricity markets with either CO_2 trading or carbon taxes. It uses daily price data for electricity, gas, coal and carbon from 2005 to 2010, which encompasses the first years of the European Emissions Trading System (EU ETS), the world's foremost carbon trading framework. The study shows that even with modest carbon pricing, competition for new investment in electricity markets will take place between nuclear energy and gas-fired power generation, with coal-fired power struggling to be profitable. The data and analyses contained in the study provide a robust framework for assessing cost and investment issues in liberalised electricity markets with carbon pricing, even in the post-Fukushima context. A summary of the publication's[1] main elements is provided below.

Overview

Pricing schemes for greenhouse gas emissions are increasingly becoming a reality as more countries look to ensure emission reduction targets. The accident at the Fukushima Daiichi nuclear power plant in Japan in March 2011 has of course questioned a number of assumptions in the nuclear power industry and in the energy industry at large. Nevertheless, the reality of climate change and of measures to reduce greenhouse gas emissions, among which carbon pricing is the most prominent and likely to be the most efficient, will not go away. In addition, the powerful trend in OECD countries towards more liberalised power markets will continue. Hence, the basic question of the study regarding the impact of carbon pricing on the competitiveness of nuclear energy compared to coal- and gas-fired power generation in a context of liberalised electricity markets remains as valid as ever.

This study is the first to assess the competitiveness of different power generation technologies under carbon pricing on the basis of empirical data. It analyses daily data from European power and carbon markets during a period stretching from July 2005 to May 2010, thus encompassing the first five years of the EU ETS (see Figure 1). Nevertheless, many of the conclusions are applicable to other OECD regions to the extent that power market liberalisation has taken hold. The study also provides calculations of the levelised cost of electricity (LCOE) for all three OECD regions, which constitute an important benchmark for cost competitiveness in regulated power markets.

The study consistently adopts the viewpoint of a private investor seeking to maximise the return on his/her invested funds. It concludes that competition in electricity markets is being played out between nuclear energy and gas-fired power generation, with coal-fired power generation no longer being competitive once carbon pricing is introduced (see Figure 2). Whether nuclear energy or natural gas comes out ahead in this competition depends on a number of assumptions.

How realistic is the NEA's carbon price analysis after Fukushima?

This NEA study works with a first-of-a-kind (FOAK) case and an industrial maturity case for Generation III+ reactors which can be interpreted as the upper and lower bounds of the future investment costs for nuclear energy. The precise cost of future reactors will be difficult to determine for some time for two reasons. Firstly, deployment of the new Generation III and III+ reactors will generate economies of scale, but how much precisely is difficult to say. Secondly, the accident at the Fukushima Daiichi nuclear power plant has triggered regulatory reviews of safety features that will be required for existing as well as new nuclear power plants. Although it is too soon to draw conclusions from the lessons learnt at Fukushima, and while there might be some impact in terms of added costs, there is reason to think that it may be limited given that Generation III+ reactors already have a number of safety features such as multiple (up to four) independent cooling systems, cooling systems that work with natural convection (passive cooling), core catchers and strong outer containment domes (in addition to the interior reactor containment vessel) able to withstand high pressures. In other words, the assumptions of this study would seem to remain a valid range for new European nuclear reactors in the coming years.

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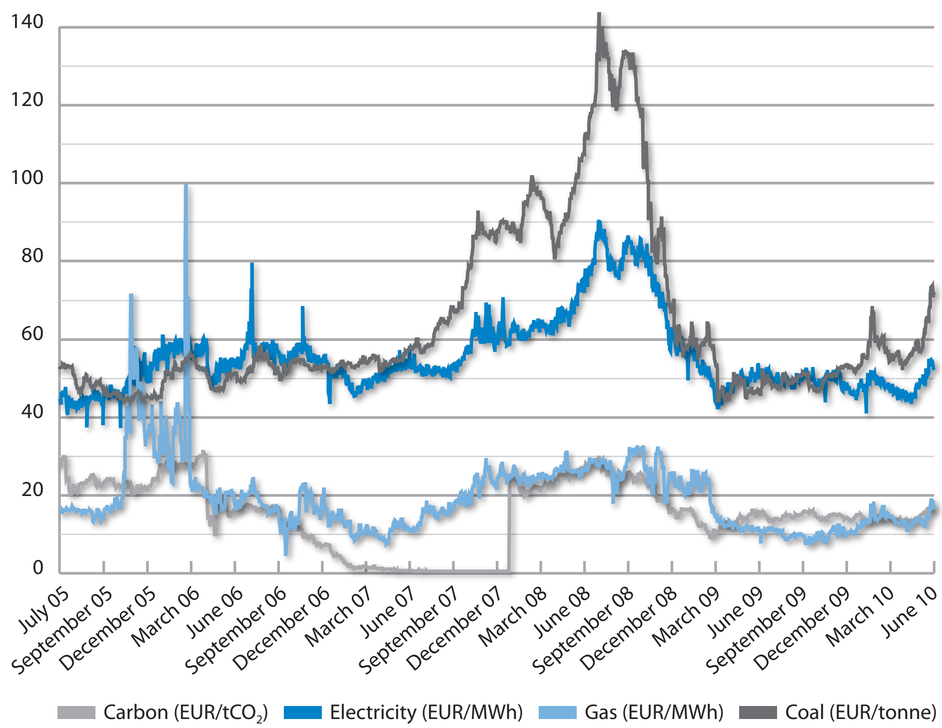
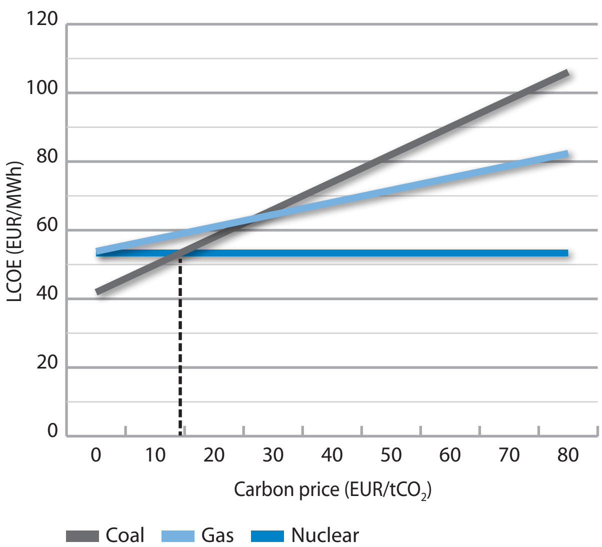
Figure 1: European prices for electricity, carbon, gas and coal (2005-10)



In order to assess the profitability of different options for power generation, the study employs three methodologies: a profit analysis looking at historic returns over the past five years, an investment analysis projecting the conditions of the past five years over the lifetime of plants, and a carbon tax analysis (differentiating the investment analysis for different carbon prices) looking at the issue of competitiveness from different angles.

Figure 2: Carbon pricing and the competitiveness of nuclear energy in OECD Europe

LCOE of different power generation technologies at a 7% discount rate



Source: Adapted from IEA/NEA, 2010.

They show that the competitiveness of nuclear energy depends on a number of variables which in different configurations determine whether electricity produced from nuclear power or from combined-cycle gas turbines (CCGTs) generates higher profits for its investors. They are:

1. *Overnight costs:* the profitability of nuclear energy as the most capital-intensive of the three technologies depends heavily on its overnight costs. This is a characteristic that it shares with other low-carbon technologies such as renewable energies, but the latter are not included in this comparison. The study reflects the importance of capital costs[2] by working with a first-of-a-kind (FOAK) case and an industrial maturity case, where the latter's capital cost is two-thirds of the former's.

2. *Financing costs:* these have a very large influence on the costs and profitability of nuclear energy. Nevertheless, the study does not concentrate on this well-known point but works (except for one illustrative case) with a standard capital cost of 7% real throughout the study.

3. *Gas prices:* what capital costs are to the competitiveness of nuclear energy, gas prices are to the competitiveness of gas-fired power generation, which spends a full two-thirds of its lifetime costs on fuel. If gas prices are low, gas-fired power generation is very competitive indeed. If they are high, nuclear energy is far ahead. The study reflects this fact by working with a low gas price case and a high gas price case in addition to the base case scenario.

4. *Carbon prices:* low and medium-high carbon prices, up to EUR 50 per tonne of CO_2 (tCO_2) increase the competitiveness of nuclear power. However, high carbon prices do not unequivocally improve the competitiveness of nuclear power in a market environment. As carbon pricing makes coal with its high carbon content the marginal fuel, the revenues of gas increase faster than its cost, with an overall increase in profitability that matches that of nuclear and can surpass it at very high carbon prices.
5. *Profit margins* or "mark-ups" are the difference between the variable costs of the marginal fuel and the electricity price, and are a well-known feature of liberalised electricity markets. They have a very strong influence on the competitiveness of the marginal fuel, either gas or coal, for which they single-handedly determine profits. The level of future profit margins can thus determine the competitiveness between nuclear energy and gas.
6. *Electricity prices:* in a liberalised electricity market, prices are a function of the costs of fossil fuels (natural gas and coal), carbon prices and mark-ups. The higher they are, the better nuclear energy fares, both absolutely and relatively. This is also due to the fact that higher electricity prices go along with higher prices for fossil fuels and carbon.
7. *Carbon capture and storage (CCS):* the standard investment and carbon tax analyses do not assume the existence of pervasive CCS for coal-fired power plants. However, an alternative scenario does and it shows that CCS will remarkably strengthen the relative competitiveness of nuclear energy against gas-fired power generation. The profitability of gas declines significantly once it substitutes for coal as the marginal fuel at high carbon prices.

The particular configuration of these seven variables will determine the competitive advantage of the different power generation options. The profit analysis shows that during the five-year period studied, nuclear energy made very substantive profits due to carbon pricing. These profits are far higher than those of coal and gas, even though the latter did not have to pay for their carbon emission permits during the 2005-10 period. Operating an existing nuclear power plant in Europe today is very profitable.

The conclusion that an existing nuclear power plant is highly profitable under carbon pricing is independent of the particular carbon pricing regime both in absolute and relative terms. Given that nuclear power would not have to acquire carbon permits under any regime, its profits would not change as long as electricity prices stay the same. Profits would change instead for coal- and gas-fired generation. The switch to auctioning permits under the EU ETS in 2013, which will oblige emitters actually to pay for their emissions, will thus increase the competitive advantage of nuclear energy due to carbon pricing. Substituting an emissions trading scheme characterised by volatile prices with a stable carbon tax equivalent to the average trading price would actually increase the volatility of profits for coal and gas and thus increase the relative competitiveness of nuclear energy even further. Contrary to the opinion that nuclear would be better served by a stable tax, the empirical evidence indicates that nuclear energy does at least as well under carbon trading, including when carbon prices are volatile.

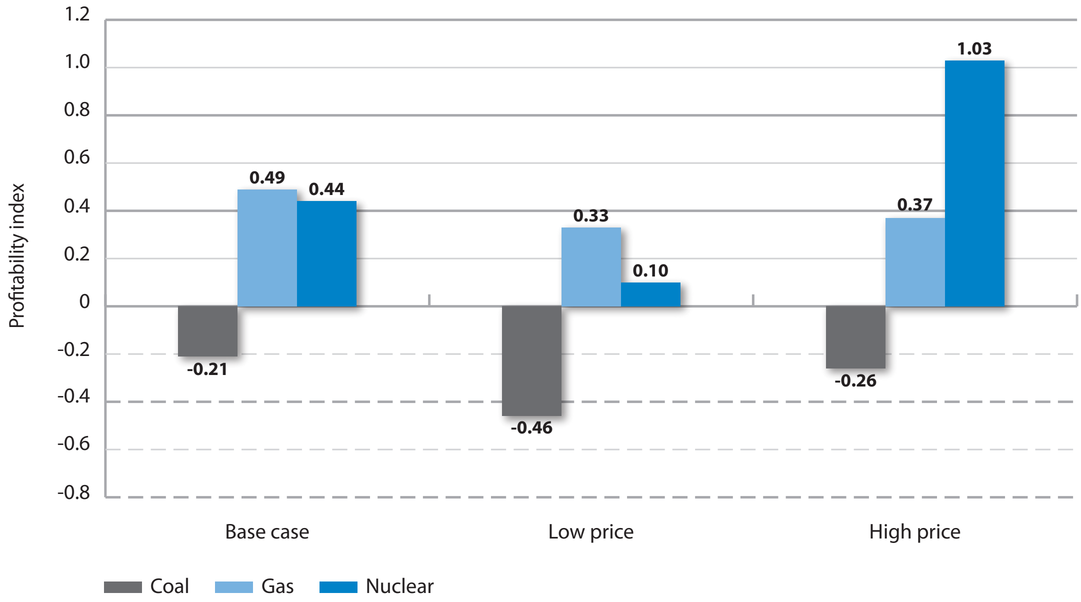
However, the profit analysis does not consider investment costs. It is more difficult to summarise the results for the investment and the carbon tax analysis, which both take into account the investment costs and compute the costs and benefits over the lifetime of the different plants. Again, a new coal plant is highly unlikely to be a competitive or even a profitable technology option under the price conditions prevailing during the 2005-10 period once it has to pay for its carbon emissions. Concerning the competition between nuclear energy and gas-fired power generation measured in terms of an appropriately defined profitability index (PI), one needs to differentiate and to specify the particular configuration of the seven variables presented above. If they are grouped into three broad categories – investment costs, electricity prices as a function of gas, and carbon prices and CCS – then one may summarise the results of the study in the following manner:

Nuclear energy is competitive with natural gas for baseload power generation as soon as one of the three categories – investment costs, prices or CCS – acts in its favour. It will dominate the competition as soon as two out of three categories act in its favour.

It is important to recall that, according to the study's parameters, a new nuclear power plant being commissioned in 2015 would produce electricity until 2075. While final appreciations are the prerogative of each investor, there is a very strong probability that gas prices will be considerably higher than today and that coal-fired power plants will be consistently equipped with carbon capture and storage during that period.

The competition between nuclear energy and gas-fired power generation remains characterised by the dependence of each technology's profitability on different scenarios. Gas, which is frequently the marginal fuel, makes modest profits in many different scenarios, which limits downside as well as upside risk. The small size of its fixed costs does not oblige it to generate very large profit margins. High electricity prices are not necessarily a source of significant additional profits as they frequently result precisely from high gas prices. Nuclear energy is in the opposite situation, where its profitability depends almost exclusively on electricity prices. Its high fixed costs and low and stable marginal costs mean that its profitability rises and falls with electricity prices (see Figure 3).

Figure 3: Profitability index in different electricity price scenarios
7% real discount rate, industrial maturity case and average 2005-10 carbon price



Carbon pricing will, of course, increase the competitiveness of nuclear energy against coal and to a lesser extent against gas. In the competition between nuclear energy and gas, carbon pricing will favour nuclear, in particular in a range up to EUR 50 tCO_2 (the five-year EU ETS average was slightly over EUR 14). Beyond that range, coal-fired power generation will consistently set electricity prices and gas-fired power plants will thus earn additional rents faster than their own carbon costs increase. This may, at very high carbon prices, enable gas to surpass nuclear energy (see Figure 4).

While coherent at the level of the modelling exercise, it should be said that market behaviour and cost conditions at carbon prices above EUR 50 tCO_2 are quite uncertain, and results for any configuration in that range should be considered with caution. One would, for instance, expect that high carbon prices applied consistently over time would generate a number of dynamic effects and technological changes, such as a faster penetration of carbon capture and storage (CCS). This would substantially alter results by enhancing the relative competitiveness of nuclear against gas (see Figure 5).

Figure 4: Evolution of profitability indices in the base case scenario
Constant profit margin of EUR 10,
7% real discount rate and industrial maturity case

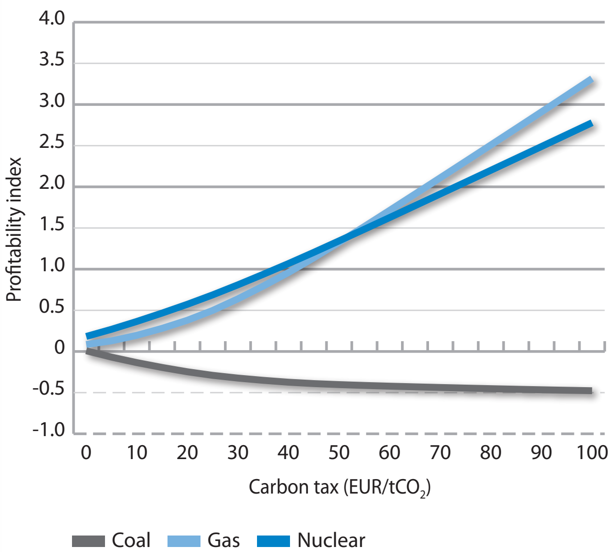
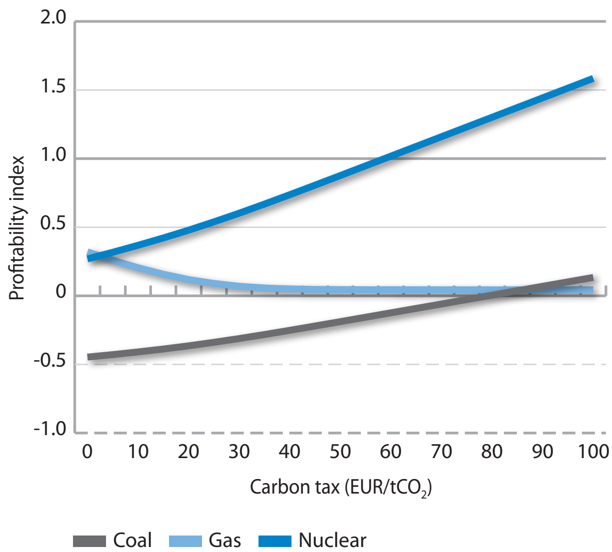


Figure 5: Evolution of profitability indices in the CCS base case scenario
Constant profit margin of EUR 10,
7% real discount rate, industrial maturity case
and coal with carbon capture



For investors, it is thus important that they make their own assessment of the probability of different capital costs and price scenarios. If nuclear succeeds in limiting overnight costs and electricity prices in Europe stay high, nuclear energy is by far the most competitive option. With high overnight costs and low electricity prices, only a strong logic of portfolio diversification could motivate an argument in its favour. As far as prices are concerned, it is likely that European electricity prices will remain high or even increase in the foreseeable future. The progressive exit from both fossil fuels and nuclear energy in Germany, Europe's biggest market, will inevitably push electricity prices higher, which in conjunction with carbon pricing opens opportunities for nuclear energy in other European countries. Similar dynamics may also assert themselves in the United States, where ambitious greenhouse gas reduction targets also ensure a floor under electricity prices.

A high electricity price scenario is thus likely, but by no means assured. In this context, policy makers need to be aware of the fact that the profitability of nuclear energy in liberalised electricity markets depends on specific electricity price scenarios. It is thus not unthinkable that risk-averse private investors may opt for fossil-fuel-fired power generation instead of nuclear, even in cases where nuclear energy would be the least-cost option over the lifetime of the plant. Liberalised electricity markets with uncertain prices can lead to different decisions being taken by risk-averse private investors than by governments with a longer-term view. Care has to be taken to reflect the specificities of high fixed cost, low-carbon technologies such as nuclear energy and certain renewables in the process through appropriate measures, for example, long-term contracts for electricity provision. Otherwise, the risk of private and social optimality disconnecting is very real.

An additional aspect of public policy making concerns the profit margins or mark-ups of electricity prices over the variable costs of the marginal fuel which benefit, in particular, the competitiveness of the last fuel in the merit order. Regardless of whether they are an expression of spontaneous or consciously constructed monopoly power, nuclear energy is favoured by limiting these welfare-reducing mark-ups. Market opening and competition in the provision of baseload power favour the competitiveness of nuclear energy.

In the end, the outcome of the competition between nuclear energy and gas-fired power generation (coal-fired power generation being uncompetitive under carbon pricing) depends on a number of key parameters such as investment costs and prices. The profitability of either nuclear energy or gas-fired power generation, however, cannot be assessed independently of the scenario in which they are situated. Given the realities of the large, integrated utilities that dominate the European power market, which need to plan ahead for a broad range of contingencies, the implications are straightforward. Risk minimisation implies that utilities need to diversify their generation sources and to adopt a portfolio approach. Such diversification would not only limit financial investor risk, but also a number of non-financial risks (climate change, security of supply, accidents). Portfolio approaches and the integration of non-financial risks will both be important topics for future research at the NEA and in the wider energy community.

Notes

1. *Carbon Pricing, Power Markets and the Competitiveness of Nuclear Energy* is available from the OECD online bookshop at www.oecdbookshop.org.
2. Capital costs are a function of overnight costs (which include pre-construction or owner's cost, engineering, procurement and construction costs as well as contingency costs) and interest during construction (IDC). The latter depends, of course, on financing costs as discussed under point 2.

Reference

IEA/NEA (2010), *Projected Costs of Generating Electricity: 2010 Edition,* OECD, Paris.

Fukushima: liability and compensation

by X. Vásquez-Maignan*

On 11 March 2011, Japan endured one of the worst natural disasters in its history when a massive earthquake struck the Pacific coast of the country and was followed by a tsunami which led to considerable loss of lives. It also led to a major accident[1] at the Fukushima Daiichi nuclear power plant. Soon afterwards, the operator of the plant, Tokyo Electric Power Company (TEPCO), assumed responsibility and liability for the nuclear accident. On 28 April 2011, TEPCO established a dedicated contact line to provide consulting services for financial compensation related to the damage caused.[2]

Third party nuclear liability principles

The compensation procedure set up by TEPCO complies with the Japanese legislation governing third party liability for nuclear activities. Even though Japan is not party to any of the international nuclear liability conventions, it has solid national third party liability legislation whose main principles are as follows:

- The operator of the nuclear power plant where the nuclear accident occurred is strictly liable (which means that the operator is held liable regardless of fault, negligence or intention to harm).
- The operator is exclusively liable for the damages (i.e., no other person may be held liable for the damages caused by the nuclear accident).
- The operator's liability is not limited in amount.
- The operator is obliged to financially secure its liability up to a certain amount (JPY 120 billion for nuclear power plants, or approximately EUR 1.16 billion or USD 1.57 billion as of 27 September 2011).
- Where nuclear damage exceeds the financial security amount, the government may help a nuclear operator to compensate the damage to the extent authorised by the National Diet.
- All rights of action are fully extinguished 20 years following the date of the tort and the actions must be brought within three years from the date at which the person suffering damage had knowledge both of the damage and of the person liable.
- The victims may refer their claims directly to the operator concerned, to a local court or to the Dispute Reconciliation Committee for Nuclear Damage Compensation (the Reconciliation Committee), which the Japanese Ministry for Education, Culture, Sport, Science and Technology (MEXT) may establish following an accident and whose function is, on the one hand, to draft instructions to establish the scale of the nuclear damage as well as to actually assess them and, on the other hand, to mediate disputes concerning compensation claims.

In the case of the Fukushima accident, MEXT established the Reconciliation Committee in early April 2011.

Nuclear damage

According to the Act on Compensation for Nuclear Damage (the Compensation Act), nuclear damage means "any damage caused by the effects of the fission process of nuclear fuel, or of the radiation from nuclear fuel… however, any damage suffered by the nuclear operator who is liable for such damage… is excluded."

Damages to the operator concerned are explicitly excluded, with the operator having to assume the loss or damage to his own property (such as the nuclear installation itself). The purpose is to avoid the financial security being used to compensate the operator to the detriment of the victims.

As the law does not clearly define the nature of the damages to be compensated by the operator, the Reconciliation Committee has adopted guidelines that are not legally binding to determine the type of damages which give right to compensation. The "Preliminary guidelines for determination of the scope of nuclear damage due to TEPCO's Fukushima Daiichi and Daini nuclear power stations" adopted on 28 April 2011 defined the damages resulting from instructions issued by the central and local governments which may be compensated (e.g. evacuation instructions; restrictions of marine areas; restrictions of shipments of agricultural products and marine products).

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Summary of liability and compensation	
National third party liability legislation	Nuclear power plant operator subject to strict, unlimited liability and required to financially secure JPY 120 billion (EUR 1.16 billion) per site. Can be completed by government funds if approved by the Diet.
Indemnity agreement	Amount paid by the government to TEPCO: JPY 120 billion (EUR 1.16 billion).
Nuclear Damage Compensation Facilitation Corporation Established September 2011	Amount received by TEPCO from the Nuclear Damage Compensation Facilitation Corporation: JPY 558.7 billion (EUR 5.39 billion).
TEPCO	Estimated provisional compensation paid thus far: – JPY 52 billion (EUR 0.5 billion) to households; – JPY 43 billion (EUR 0.4 billion) to individuals for evacuation fees; – JPY 63 billion (EUR 0.6 billion) to farmers, fishermen and small- and medium-sized companies.

The "Second Guidelines" adopted on 31 May 2011 provide the method of calculating the damages listed in the first guidelines and define additional types of damages, such as damage suffered by workers, bankruptcies, costs of decontamination measures and damage caused by unfounded rumors. On 5 August 2011, the Reconciliation Committee adopted the "Interim guidelines governing nuclear disaster compensation due to the accident at Fukushima Daiichi and Daini Power Plants" pursuant to which TEPCO has drawn up the procedure to pay the "permanent compensation" amounts (as opposed to the "provisional compensation" which were paid up until recently as a measure of urgency).

Despite the official mandate of this Committee, it is the Japanese courts that will have the final decision on what qualifies as nuclear damage. However, in the past, out-of-court settlements have been successful in Japan thanks to the guidelines of the committees and the help of local governments. On 30 September 1999, a criticality accident took place in a uranium processing facility of JCO Co. Ltd. at Tokai-mura. As a result, approximately 8 000 claims were raised, most of which were compensated in out-of-court settlements according to the compensation guidelines.

As regards the Fukushima accident, it will be a challenge to distinguish damages directly linked to radiation exposure risks from those that were caused by the earthquake and tsunami. Evacuations were ordered, at first, to protect the population from the inundation, and one major difficulty will be to draw a clear line between victims of the natural disaster and those who have suffered nuclear damage in a stricter sense.

Exoneration of liability

The Compensation Act provides that the operator may be exempted from liability when "…the damage is caused by a grave natural disaster of an exceptional character…". Where this exoneration applies, the government shall take, pursuant to the Compensation Act, "the necessary measures to relieve victims and to prevent the damage from spreading".

In light of the massive earthquake and the ensuing tsunami which led to the Fukushima accident, the question arises of a potential exoneration of TEPCO's liability. However, the government's current position does not suggest that TEPCO will be exonerated from liability due to the "exceptional" character of this natural disaster. When the Compensation Act was enacted, the conditions for the exemption due to natural disasters were described in the Congress as a "huge natural disaster beyond all expectations of humankind". As an earthquake-prone archipelago, Japan has a rather unique perception of what qualifies as a "grave natural disaster of an exceptional nature". For example, the earthquake in Kobe on 17 January 1995, which registered at 6.9 on the Richter scale and resulted in over 5 000 deaths, did not qualify as a grave natural disaster of an exceptional character.

Courts in civil proceedings will decide if the earthquake of 11 March 2011 qualifies as a natural disaster beyond all expectations of humankind, but only if TEPCO decides to invoke this exemption against claimants. TEPCO's latest statements do not suggest that it will invoke the application of this provision in its favour.

Liability amount

Pursuant to the Compensation Act, the operator has an unlimited liability and must maintain financial security either through i) a private nuclear liability insurance contract (the most common means of financial security) combined with an indemnity agreement to be entered into with the government for non-insurable risks (for which the operator shall pay a fee to the government), ii) a deposit (in cash or in security) or iii) any other arrangement approved by MEXT.

The six units at Fukushima Daiichi are treated as one site; the same applies to the four units at Fukushima Daiini. As a result, the financial security amounts to JPY 120 billion for each site.

Should damages exceed the JPY 120 billion of financial security, the operator still remains liable (unlimited liability). However, in that event and if approved by the National Diet, the government shall give the nuclear operator concerned such aid as required to compensate the (excess) damage when the government deems it necessary in order to attain the purpose of the Compensation Act.

Compensation of the Fukushima victims

As the Fukushima accident will have consequences which will exceed JPY 120 billion, on 13 May 2011 the Japanese government issued a framework for government financial support to TEPCO in which it recognises its social responsibility and essentially aims to minimise the burden to be placed on the public. This plan was then submitted to and approved by the National Diet on 3 August 2011 under the bill for the "Establishment of a Nuclear Damage Compensation Facilitation Corporation" (the Facilitation Corporation). This corporation, established in September 2011, will manage a fund which shall receive contributions from the government and the Japanese nuclear installation operators, and will support operators in providing compensation to victims of nuclear accidents. The operator requesting such support will be required to implement cost-cutting measures as a pre-requisite to benefit from this fund and will be expected to pay back over the years the amounts received.

On 28 October 2011, TEPCO applied in order to benefit from the Facilitation Corporation financial support and submitted to that effect a business plan with cost-cutting measures which was approved on 4 November 2011. According to TEPCO, on 15 November 2011 it received JPY 558.7 billion (EUR 5.39 billion or USD 7.2 billion) from the Facilitation Corporation pursuant to the approval of its business plan. Furthermore, on 22 November 2011 it received JPY 120 billion from the government under the indemnity agreement for non-insurable risks.

TEPCO has been paying "provisional compensation" amounts to the victims, but as from October 2011, "permanent compensation" shall be paid pursuant to new procedures that were established by TEPCO on 30 August 2011[3] (for the procedure applicable to damages suffered by individuals) and on 21 September 2011[4] (for the procedure applicable to damages suffered by sole proprietors and corporations).

According to the press, TEPCO has so far paid about JPY 52 billion (EUR 0.5 billion or USD 0.7 billion) in "provisional compensation" to 56 400 households, and an additional JPY 43 billion (EUR 0.4 billion or USD 0.56 billion) to individuals for fees they had paid to be evacuated. It has also paid about JPY 63 billion (EUR 0.6 billion or USD 0.8 billion) to farmers, fishermen and small- and medium-sized companies as "provisional compensation".[5]

Notes

1. For the technical description of the event, see *NEA News* No. 29.1.
2. www.tepco.co.jp/en/index-e.html.
3. www.tepco.co.jp/en/press/corp-com/release/11083007-e.html.
4. www.tepco.co.jp/en/press/corp-com/release/11092109-e.html.
5. *Reuters,* 26 September 2011.

NEA international peer reviews of post-accident protection policy

by T. Lazo*

For many years, the NEA has offered international peer reviews of national, high-level radioactive waste management policies and approaches. Until recently, this service had not been requested in the area of radiological protection. However, the 3rd International Nuclear Emergency Exercise (INEX-3, 2005-2006) addressed post-accident consequence management for the first time in a broad, international sense, and helped generate significant national reflections in this area. In particular, in 2005 the French government began an extensive programme of post-emergency consequence management planning, resulting in a draft national policy to address such situations. The Finnish government used the INEX-3 exercise as a vehicle to discuss post-emergency consequence management with a broad group of governmental and private stakeholders, and also began to develop national policy in this area. In order to further refine national efforts, the French Nuclear Safety Authority (ASN) invited the NEA to perform in April 2011 its first international peer review in the radiological protection area focusing on its post-emergency consequence management policy under development. Finnish experts participated in this peer review team, and as a result, subsequently invited the NEA to perform an international peer review of its developing policy in this area in September 2011. These draft national policies and their international peer reviews are briefly presented below.

Methodology

In order to perform these international peer reviews, the NEA developed an approach based on the methodology used for peer reviews of high-level radioactive waste management policies. Once a member country has requested the review of a specific policy, generally a policy document that is being drafted or is in the process of being revised, an international peer review team is formed. The team is usually composed of four to six experts in the field being assessed, as well as one or two members of the NEA Secretariat. The independence of the team members from the development of the document being reviewed is verified, and validated by the organisation requesting the review. The organisation requesting the review covers the travel costs for the international peer review team members as well as the travel costs and working time of the NEA Secretariat.

The document to be reviewed is provided to the NEA and the international peer review team members who then perform a preliminary review of the document and submit questions of clarification to the requesting organisation through the NEA Secretariat. These questions are used by the requesting organisation as preliminary feedback, but also as an indication of which national experts will be most needed for discussions with the international peer review team. The team then meets on site with members of the requesting organisation to discuss details of the document. This includes a word-by-word, line-by-line review of the document, noting questions, identifying areas requiring clarification and providing suggestions for changes to the text. Each question and suggested change is accompanied by a clear rationale as to why the team feels the comment is necessary. At the end of the two- to three-day meeting, the team will have produced a list of general comments, as well as an annotated version of the document including all comments and suggestions. The team then holds a short seminar for the requesting organisation in order to present its preliminary results. The team's final report, presenting general and specific comments on the text, is prepared by the NEA Secretariat, approved by the international peer review team members, and submitted to the requesting organisation. With the permission of the requesting organisation, the report is made available to the full membership of the NEA Committee on Radiation Protection and Public Health (CRPPH) for information.

It should be noted that the members of the peer review team provide comments based on their experience with their own national approaches. It is not the intention of these reviews to perform a comparison against an existing standard, for example the IAEA Safety Standards.

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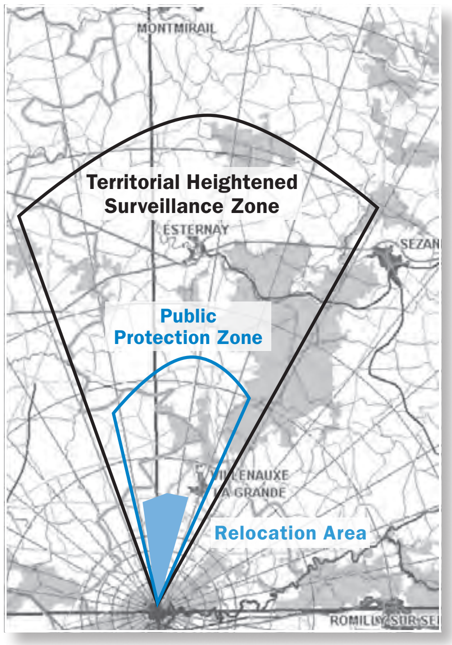
French policy for managing the transition to the post-accident phase

The first radiological protection peer review was requested by the French Nuclear Safety Authority (ASN). The ASN was tasked in 2005 with developing French policy for the management of the post-accident phase of a nuclear or radiological accident situation. To accomplish this, the *Comité directeur pour la gestion de la phase post-accidentelle d'un accident nucléaire ou d'une situation d'urgence radiologique* (CODIRPA: Steering Committee for the management of the post-accident phase of a nuclear or radiological incident) was established. This work mobilised more than 200 people, including members of relevant national administrations and their local representatives, utility and industrial representatives, technical service organisations, nuclear safety authorities from countries bordering France, NGOs and local elected officials. As a result of this work, the ASN developed a guide for exiting the emergency phase, describing French policy for this process, and began transposing this generic guide to the specific needs of four pilot-project areas, each being home to a nuclear installation or other radiological risk.

To complement activities addressing policy at the national level, several dialogues were engaged with organisations and officials from local government, relevant services from the agricultural ministry and civil society representatives in order to test ideas and approaches against local realities. In this context, the NEA was requested by the ASN to organise an international peer review of the CODIRPA Guide for Exiting the Emergency Phase. The review was to provide the ASN with comments on the CODIRPA Guide in order to help the ASN improve its policy in this area and to finalise the guide.

The CODIRPA Guide is a broad, national-level document that is intended to serve as a framework within which procedures and plans can be developed in detail for each area in France where such plans are needed. For example, each French region that is home to a nuclear power plant, a radioactive waste management facility or a research laboratory using radionuclides is required to have an emergency management plan. The intention of the CODIRPA project is to provide a common framework such that national-level assistance can be optimised, and that inter-regional plans can be complementary and compatible.

Simply stated, the CODIRPA policy is based on the establishment of "zones" that bound the management of consequences of a nuclear or radiological incident. The Public Protection Zone (ZPP) is identified as the area that has been or could be contaminated as a result of the accident to such an extent that populations living in the area will be required to shelter for some period. In those cases, bans on the consumption of locally grown food and milk, and entering the area will also be implemented. Beyond this zone, the French define a Territorial Heightened Surveillance Zone (ZST), where contamination levels that have occurred or might occur do not warrant sheltering, but do require food monitoring and other bans. The key to this policy is that these zones are established based on predictive assessments, and are intended to evolve as information (e.g. contamination measurements, food monitoring, etc.) becomes available, as well as to form the framework within which particular protective actions will be developed.



CODIRPA, France

The zoning strategy of the French CODIRPA policy.

The international peer review team found that the CODIRPA work was well-constructed and presented very useful and innovative thinking on the important question of consequence management during the period of transition following the emergency phase. The team broadly agreed with the principles presented in the guide, in particular the use of zoning as a central strategy for managing a constantly evolving situation. It was noted that the implications of the Fukushima accident on emergency preparedness and on post-accident consequence management would need to be assessed and appropriately taken into account.

Finnish intervention policy

The Finnish Radiation and Nuclear Safety Authority (STUK) is in the process of developing new guidance on intervention policy for protective measures for the early and intermediate phases of any nuclear or radiological emergency situation, including malicious acts. During the preparation of this guidance, feedback and comments from public- and private-sector organisations were solicited at national, regional and local levels, and experts from the STUK responsible for preparing the draft policy worked extensively with stakeholders to achieve an approach that is broadly viewed as acceptable. The usefulness of this guidance was tested during the INEX-4 exercise conducted in Finland (mid-2011), as well as during the Finnish response to the Fukushima accident in terms of evaluating measures for recommendations to Finnish citizens potentially exposed to fallout from the Fukushima accident, and in terms of issuing advice and monitoring goods imported from Japan. In order to continue to refine this guidance and the Finnish approach to its implementation, the STUK requested that the NEA perform an international peer review.

The key to the Finnish policy is the use of operational intervention levels, or OILs. Operational intervention levels are defined as some physically measurable quantity (e.g. dose rate, surface contamination level, airborne contamination level) that has been measured or is predicted to be possible, above which it is recommended to implement a specific countermeasure, such as sheltering or taking stable iodine tablets. Accordingly, should a nuclear or radiological accident occur such that gaseous and/or liquid radioactive material has been or could be released, and if a dose rate, in micro-Sieverts per hour, exceeds a given OIL, or if models suggest that it will exceed a given OIL, then the countermeasure associated with this OIL should be implemented. The OILs are calculated to ensure that individuals who might be exposed under such circumstances would not receive an annual dose higher than a selected value. As such, this approach is based on implementing a series of countermeasures within areas where contamination levels may breach, or have already exceeded, a particular level.

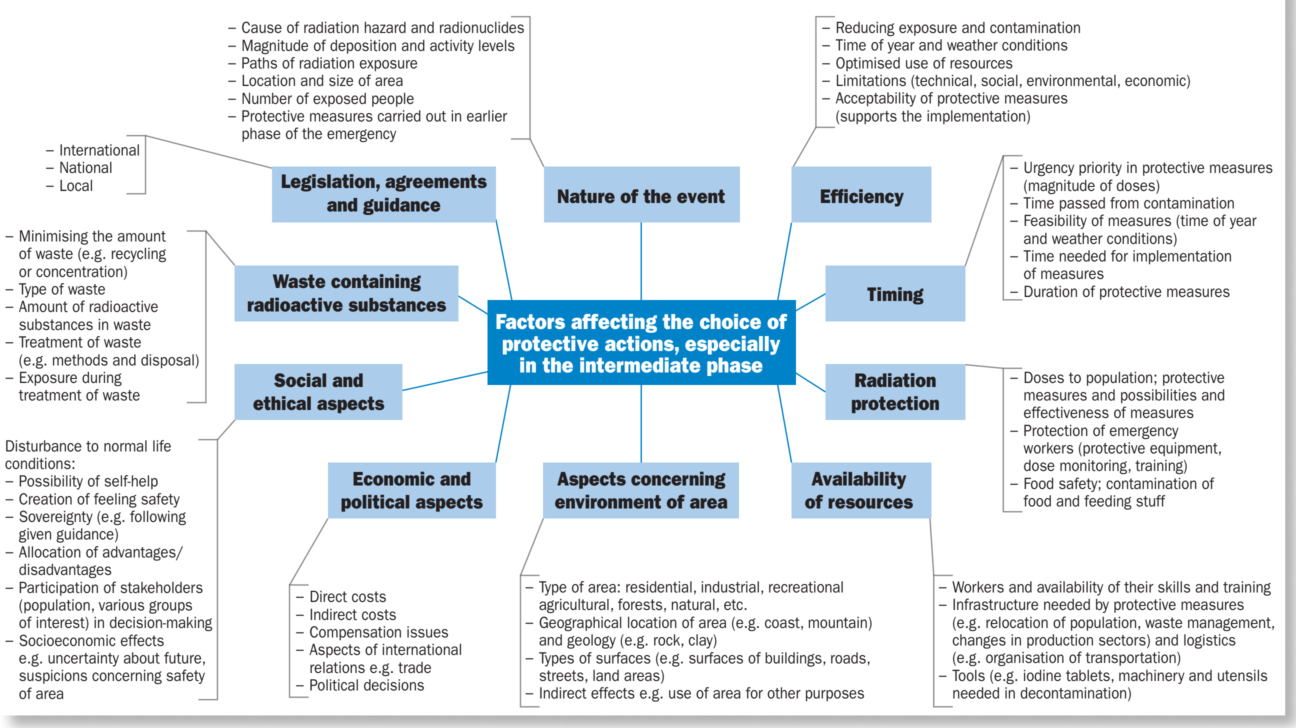
Functionally, the international peer review team found this approach to be very practical and based on a clear operational procedure. The team broadly agreed with the principles presented, in particular the use of OILs as a central strategy for managing a constantly evolving situation. It was noted that a more detailed description of how OILs fit into an overall protection strategy would provide a complete picture of the approach being taken in Finland.

Conclusions

Feedback from both the French ASN and the Finnish STUK suggests that the detailed, external input provided by the international peer review teams have been extremely valuable in refining the content of the guides so that they are more clear, concise, understandable and implementable. It should be recalled that both national policy documents reviewed are far more detailed and extensive than described here. The intent of this article was not to provide a review of the national policies themselves, but rather to give an overview of the review process and the main results of this NEA service to member countries.

In addition to being of value to the organisation that invites the review, the NEA peer review teams felt that their reviews had provided each of them with useful insights that could be of value in their own national approaches. In this context, the NEA is grateful to the ASN and the STUK for having requested these reviews. In order to allow all NEA members to take advantage of the extensive thinking undertaken in France and Finland on the important topic of post-accident consequence management, the results of these reviews will be published as reports of the NEA Committee on Radiation Protection and Public Health and made widely available.

Key elements of the Finnish decision-making process



STUK, Finland

MDEP: producing results in a challenging time for nuclear power

by L. Burkhart*

The Multinational Design Evaluation Programme (MDEP) continues to pool the resources of its ten member countries for the purposes of 1) co-operating on safety reviews of designs of nuclear reactors under construction and undergoing licensing in several countries, and 2) exploring opportunities and potential for harmonisation of regulatory requirements and practices. The International Atomic Energy Agency (IAEA) is closely involved in MDEP activities to ensure consistency with international requirements and practices.

The MDEP involves representatives from the regulatory authorities of Canada's Nuclear Safety Commission (CNSC), China's National Nuclear Safety Administration (NNSA), Finland's Radiation and Nuclear Safety Authority (STUK), France's Nuclear Safety Authority (ASN) with support in working groups from France's Institute for Radiation Protection and Nuclear Safety (IRSN), Japan's Nuclear and Industrial Safety Authority (NISA) with support from Japan's Nuclear Energy Safety Organisation (JNES), the Republic of Korea's Institute of Nuclear Safety (KINS), the Russian Federation's Federal Environmental, Industrial and Nuclear Supervision Service (Rostechnadzor), South Africa's National Nuclear Regulator (NNR), the United Kingdom's Office for Nuclear Regulation (ONR), and the United States' Nuclear Regulatory Commission (NRC). Since the last *NEA News* update on this subject, MDEP regulators with assistance from some of their technical support organisations continue to work together to make regulatory design reviews more focused on safety and to leverage regulatory resources to ensure the safe operation of tomorrow's operating reactors. The events of 11 March 2011 at the Fukushima Daiichi nuclear power plant further highlight the need to continue this effort, and the lesson learnt from Fukushima will be appropriately incorporated into MDEP activities.

The MDEP has been making progress with its stated goals since the pilot project began in 2006 to explore the feasibility of working together in the MDEP, and even more so after the ten-member Policy Group (PG), which consists of the heads of each regulatory authority, approved the MDEP's current mandate and organisational structure. This structure consists of the Steering Technical Committee (STC), which is responsible for the implementation and day-to-day operation of the MDEP, and five working groups. Two working groups focus on co-operation regarding the safety reviews of specific reactor designs. One group is examining AREVA's EPR design (the EPR working group or EPRWG) and involves Canada, China, Finland, France, the United Kingdom and the United States. The other is reviewing Westinghouse Electric Company's AP1000 design (the AP1000WG) and involves Canada, China, the United Kingdom and the United States. Three issue-specific or generic working groups involve all MDEP countries and are exploring the potential to harmonise regulatory requirements and practices in the areas of: 1) vendor inspection co-operation (VICWG), 2) mechanical codes and standards (CSWG), and 3) digital instrumentation and control (DICWG).

Highlights of the progress being made by the MDEP and examples of the Policy Group's goal to communicate activities to other stakeholders, including non-MDEP regulators and other regulatory organisations, reactor vendors and licensees, standards development organisations, and key industry groups, are the MDEP products that were made available on the MDEP public web pages (www.oecd-nea.org/mdep) in March 2011. These products include three issue-specific common positions. The first concerns the digital instrumentation and control area and addresses simplicity in design, the use of software tools and communication independence between safety and non-safety systems. The second is a design-specific common position on the EPR digital instrumentation and control design of important safety systems. The third concerns technical guidelines for the design and safety bases for the large squib valves that will be used in the AP1000 design to initiate passive cooling of the reactor core in emergency conditions. MDEP common positions are generated and discussed by the relevant working group and approved

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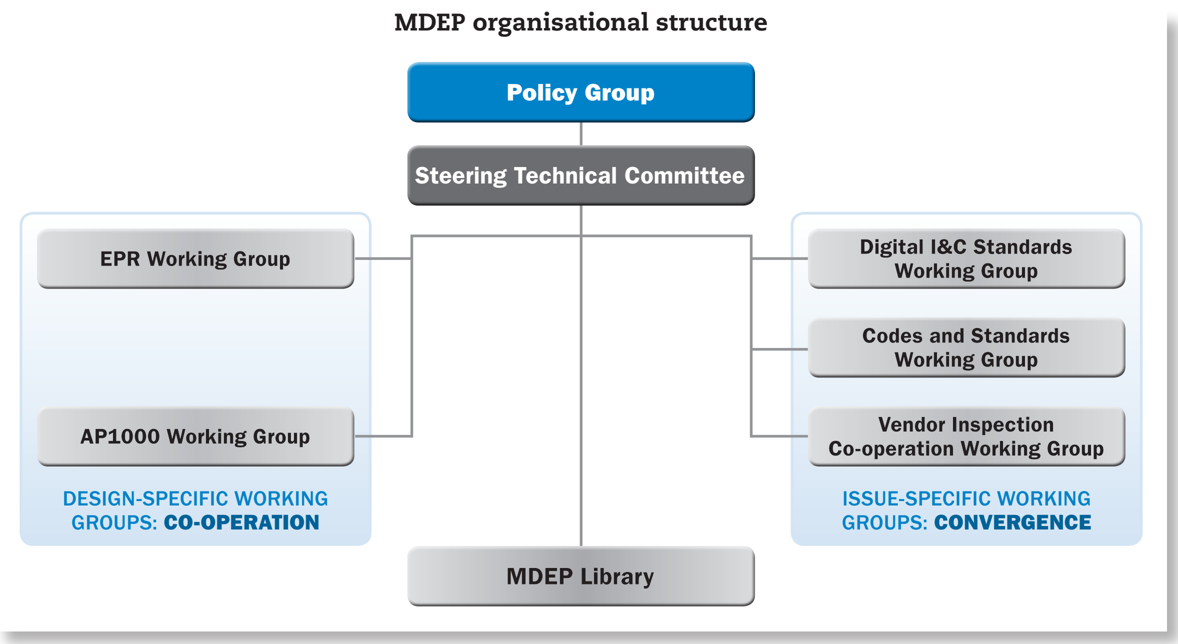


by the Steering Technical Committee prior to making them public. A common position captures the agreed upon technical and regulatory aspects of a particular safety issue; it is not mandatory but represents a recommended best practice in the area. Each MDEP regulator will incorporate the common position into the regulatory body's practices consistent with the national legal and regulatory framework as well as its need to support near-term safety reviews. Other stakeholders, such as non-MDEP regulators and industry organisations, are encouraged to review the common positions and to use them as appropriate as well as, when necessary, to provide feedback on the positions. The MDEP seeks to involve relevant stakeholders in working group discussions before common positions are established so that the final products are fully informed and widely accepted.

Other MDEP products are being made available publicly such as the Vendor Inspection Co-operation Working Group (VICWG) Witnessed and Joint Vendor Inspection Protocol that clearly explains the roles of the different regulators who may take part in witnessing and participating in VICWG-coordinated inspections. This document was generated based on experience gained from over 30 VICWG-coordinated inspections and activities which include observing fellow MDEP regulator's inspections. The vendor inspection protocol has been shared with vendors and other organisations which may be subject to such inspections. This protocol is being used by other design-specific working groups that are carrying out vendor inspections in particular areas of design and manufacture such as the manufacturing of Olkiluoto 3's main coolant lines and the design of the EPR digital instrumentation and control systems.

The STC's work on comparing the approaches of the MDEP regulators' definition and expression of safety goals is summarised in a document entitled "MDEP Steering Technical Committee Position Paper on Safety Goals". That paper and its more detailed companion "The Structure and Application of High-level Safety Goals" were used as input to the 11-15 April 2011 IAEA technical meeting to discuss safety goal approaches. Both of these documents are available online. The safety goal issue is a good example of one that was addressed by the MDEP STC, worked to a point of some maturity, and then transferred to a more appropriate organisation for follow-up and further elaboration (in this case the IAEA). Other issues, such as discussing different safety classification schemes of systems, structures and components, may also be handled in a similar fashion.

The Policy Group and the Steering Technical Committee are encouraging the working groups to continue producing relevant documents such as common positions, communicating with key stakeholders on important safety issues and addressing key areas of safety design reviews of new reactors and harmonisation. Products that should be made available by the MDEP in the near future include a mechanical codes comparison for Class 1 components (CSWG) and a comparison of quality assurance requirements among the ten MDEP countries, as augmented by comparison to IAEA standards and the US NRC's 10 CFR Appendix B requirements (VICWG). The DICWG is working on several potential common positions in areas including software common cause failures in safety systems, verification and validation, complex electronics, interactions between safety and security, configuration management of software, and factory and site acceptance testing, among others.

The NEA recently organised, under the direction of the MDEP Policy Group and with the assistance of the Steering Technical Committee, the 2nd MDEP Conference on New Reactor Design Activities. It was held at the OECD Conference Centre on 15-16 September 2011 and was a follow-up to the first conference held in September 2009. Mr. André-Claude Lacoste, ASN President and Chair of the MDEP PG, opened the meeting, and Mr. Luis Echávarri, NEA Director-General, provided welcoming and introductory remarks. Conference topics included the status of the five working groups, industry initiatives on new reactors and standardisation, and the Fukushima Daiichi accident, including the status of recovery efforts in Japan and MDEP efforts to incorporate lessons learnt into its activities. Over 120 people attended representing 24 national regulatory authorities and technical support organisations, major reactor vendors and licensees, as well as a dozen national, regional and international organisations such as the IAEA, various mechanical and electrical standards development organisations, the Western European Nuclear Regulators' Association (WENRA), the NEA Committee on Nuclear Regulatory Activities (CNRA), the European Commission (EC), the World Nuclear Association (WNA) and the World Association of Nuclear Operators (WANO). This conference was another step on the path of communicating MDEP activities to important stakeholders.

The Policy Group has also recently discussed the potential expansion of MDEP membership. Several national regulatory authorities have expressed interest in joining the MDEP including India, the Netherlands, Turkey, the United Arab Emirates and Vietnam, among others. The PG is currently considering India's nomination as a full member and should take a decision shortly. Other countries have expressed interest in becoming associate members because they are exploring particular designs and would like to co-operate on related safety reviews. The PG will consider those requests in a timely manner and ensure that a number of basic criteria are consistently met to ensure the most effective and efficient programme. In parallel, it will seek to meet the needs of those regulators that must perform safety reviews of new reactor designs in the near term.

In summary, over several years of activities, the MDEP has fostered close and important relations among the MDEP regulators participating in the working group activities, and the programme is meeting its expected outcome of enhancing co-operation among regulators involved in safety reviews of new reactor designs. The MDEP has reached some maturity and is making products available to key stakeholders, including non-MDEP regulators, so that these products, such as common positions, may be used to enhance safety reviews and to promote standardisation to benefit safety. Since the first MDEP conference in September 2009, there have been numerous interactions among MDEP representatives and other regulators and industry representatives which have helped the production of MDEP documents. The Fukushima Daiichi accident further highlights the need to increase the safety of new reactors, and the need for regulators to work closely with other stakeholders to ensure the safety of the new reactor fleet worldwide.

F. Vuillaume, OECD/NEA

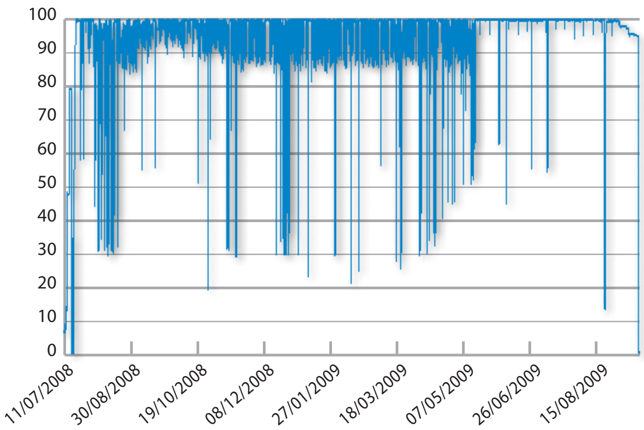
Speakers at the press conference organised during the 2nd MDEP Conference on New Reactor Design Activities in September 2011. From left to right: K. Nakamura (NISA, Japan), G.B. Jaczko (US NRC), A.C. Lacoste (ASN, France) and L. Echávarri (OECD/NEA).

Load-following with nuclear power plants

by A. Lokhov*

Traditionally, nuclear power plants (NPPs) have been considered as baseload sources of electricity as they rely on a technology with high fixed costs and low variable costs. In the beginning of the nuclear era, the share of nuclear power in the overall energy mix was usually small, and adjustments of electric load in response to variations in electricity demand could be left to technologies with different economic and technological characteristics, most notably low fixed cost and high variable cost gas plants. However, this simple state of affairs no longer applies in all countries. The share of nuclear power in the national electricity mix of some countries has become so large that the utilities have had to implement or to improve the manoeuvrability capabilities of their NPPs in order to be able to adapt electricity supply to daily, seasonal or other variations in power demand. This is the case in France where more than 75% of electricity is generated by NPPs, and where some nuclear reactors operate in load-following mode (see Figure 1).

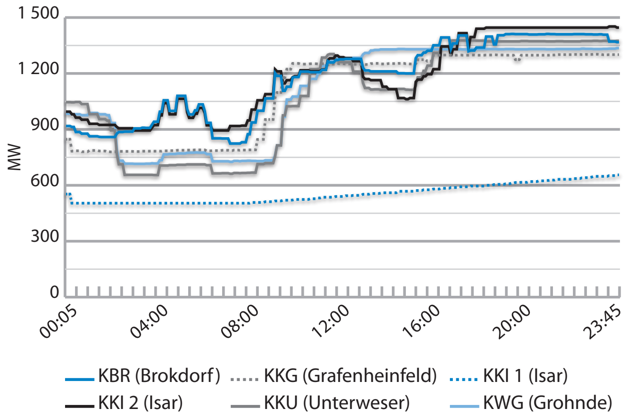
Figure 1: Typical power history during an EDF reactor cycle (in % of rated power)



Courtesy of Électricité de France (EDF).

Another incentive for load-following with nuclear power plants has recently arisen from the large-scale deployment of intermittent electricity sources like wind power. The growing deployment of intermittent sources in several NEA member countries has introduced significant and irregular variations in the power supply and has made balancing electricity supply and demand increasingly difficult. The challenge is not only technical. Due to the sudden influx of large amounts of wind power, German power markets have experienced several hours of *negative* electricity prices in recent years and many more hours with prices that were lower than the variable costs of nuclear power plants, which have the lowest variable costs among the large-scale established power sources. For these reasons, some German utilities have started operating their NPPs in load-following mode (see Figure 2).

Figure 2: Example of load-following during 24 hours at some German nuclear power plants



Courtesy of E.ON Kernkraft.

Grid requirements and manoeuvring with existing nuclear power plants

It is often believed that nuclear power plants cannot operate in manoeuvring regimes. In fact, most of the currently operating NPPs were *designed* to have strong manoeuvring capabilities (NEA, 2011). However, operating an NPP at a constant power level is simpler and less demanding on the plant's equipment and fuel.

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From the technical viewpoint, one of the key design features for the load-following capabilities of the plant is the core monitoring system. Having rapid and precise power distribution measurements provide significant margin for manoeuvring, since the difference between the maximal local power density in the core and its safety limit can be accurately evaluated.

Usually three types of manoeuvring are defined: primary and secondary frequency regulation (which depend on current grid demand) and predefined variable load programmes (i.e. reductions or increases in power output agreed in advance with the grid operator).

Planned reductions or increases in power output allow initial balancing of electricity supply and demand. These variations can be significant. Some units in France have been designed to and indeed do modify on a daily basis their electric output by several tens of per cent of rated power (P_r). Another example is the German Konvoi reactors that were designed for 15 000 cycles with daily power variations from 100% P_r to 60% P_r, and 100 000 cycles with power variations from 100% P_r to 80% P_r (see Ludwig, H., *et al.,* 2010).

Demand for electricity can never be determined with exact precision in advance and thus there is a certain random variation in demand which results in frequency fluctuations of usually less than 20 mHz. The power plants have to monitor the frequency on the grid and immediately adapt their production in order to keep the frequency stable at the desired value. This is called *primary frequency control*. In French nuclear power plants, the corresponding power modulations are performed within ±2% P_r.

The primary frequency control allows short-term adjustments of electricity production according to demand every 2 to 30 seconds. Another type of frequency regulation – *secondary control* – acts over longer time frames (from several seconds to several minutes) and restores the exact frequency by calculating an average frequency deviation over a period of time. For this purpose, the grid operator sends a digital signal to the NPP to modify its power level by ±5% P_r.

Nuclear power plants in France and Germany operate in load-following mode, thus participating in the primary and secondary frequency control of the grid, and some units follow a variable load programme with one or two large power changes per day as shown in Figures 1 and 2.

Load-following with Generation III/III+ reactors

The minimum requirements for the manoeuvrability capabilities of modern Generation III/III+ reactors are defined by the utility requirements[1] which are based on the requirements of the grid operators. For example, according to the current version of the European Utility Requirements (EUR), the NPP must be capable of a minimum daily load cycling operation between 50% and 100% P_r, with a rate of change of electric output of 3-5% P_r/minute.

Most of the modern designs implement even higher manoeuvrability capabilities, with the possibility of planned and unplanned load-following in a wide power range and with ramps of 5% P_r/minute. Some designs are capable of extremely fast power modulations in primary or secondary frequency regulation modes with ramps of several percentage points of the rated power per second, but within a narrow band around the rated power level.

Regulatory aspects of load-following with nuclear power plants

During the licensing process, an NPP's mode of operation is defined, and all types of transients are analysed. In France and in Germany, load cycling is explicitly defined in the operating handbook of the NPPs.

For example, in France the possibility of load-following is taken into account in the operating manual through a certain number of specific margins associated with operating in manoeuvring regime. To calculate these margins, a load pattern (corresponding to the needs of the grid) is defined for some reactors: about 12-18 hours at full rated power (P_r), 5-11 hours at 30% P_r and two times 30 minutes for the ramping (i.e. about 2.3% P_r/minute), up to 85% of the fuel cycle length. This type of load-following pattern has been used to perform thorough multi-disciplinary safety studies that are used to define the safety margins by the regulator.

Before a generic licence can be issued, experiments are performed on a selected unit to analyse operating experience and to validate the safety margins. Once the safety margins are established and the operating licence is issued, the utility commits itself to operate within these margins. In addition to the general license, some supplementary conditions regarding the fuel and the state of equipment (e.g. steam generators) must be fulfilled by the plants to obtain authorisation for manoeuvring. In some situations, the regulator can ask to suspend manoeuvring, for example if the physico-chemical characteristics of the core indicate a leak in a fuel element or other malfunction. The operating license also determines the maximum total number of load cycles based on the original design and the type of transient (magnitude and rate of power variation, etc.).

In some countries, there are explicit regulatory limitations on manoeuvring in the automatic mode. For example, according to the US Code of Federal Regulations (10 CFR Part 50), *"the licensee may not permit the manipulation of the controls of any facility by anyone who is not a licensed operator..."* and *"Apparatus and mechanisms other than controls, the operation of which may affect the reactivity or power level of a reactor shall be manipulated only with the knowledge and consent of an operator or senior operator licensed pursuant to part 55 of this chapter present at the controls"*.

Although this does not prohibit power load variations controlled by the operator (if justified from the technical and economic viewpoints), manoeuvring in automatic mode is not authorised by current regulations in the United States.

Conclusions

Most of the currently operating Generation II nuclear reactors were designed to have strong manoeuvring capabilities. Nuclear power plants in France and Germany operate in load-following mode. They participate in the primary and secondary frequency control, and some units follow a variable load programme with one or two large power changes per day. In France, load-following is needed to balance daily and weekly power variations in electricity supply and demand since nuclear energy represents a large share of the national mix. In Germany, load-following became important in recent years when a large share of intermittent sources of electricity generation (e.g. wind) was introduced to the national mix.

The minimum requirements for the manoeuvrability capabilities of modern Generation III/III+ reactors are defined by the utility requirements which are based on the requirements of the grid operators. According to the current version of the European Utility Requirements (EUR) the NPP must be capable of a minimum daily load cycling operation between 50% and 100% P_r, with a rate of change of electric output of 3-5% P_r/minute.

The economic consequences of load-following are mainly related to the reduction of the load factor. In the case of nuclear energy, fuel costs represent a small fraction of the electricity generating cost, especially compared to fossile sources. Thus, operating at higher load factors is profitable for nuclear power plants as they cannot make savings on fuel costs while not producing electricity. In France, the impact of load-following on the average unit capacity factor is sometimes estimated at about 1.2%.

Since most of the currently used nuclear power plants have strong manoeuvrability capabilities in their designs (except for some very old NPPs), there is no or limited impact (within the design margins) of load-following on the acceleration of ageing of large equipment components. However, load-following does have some influence on the ageing of certain operational components (e.g. valves), and thus one can expect an increase in maintenance costs. Moreover, for older plants some additional investment could be needed, especially in instrumentation and control, in order to become eligible for operation in load-following mode.

Licensing of load-following is specific to each country. In France and in Germany, for instance, load-following is considered early in the licensing process, and no further authorisation needs to be obtained by the utility to operate in manoeuvring regime. In other countries, load-following restrictions apply: for example in the United States, automatic load-following is not authorised.

Acknowledgements

Philippe Lebreton, John Nakoski, Jan Keppler and Philippe Gress have provided valuable input and comments for this article.

Note

1. Utility requirements are defined in the Utility Requirements Document (URD) by the Electric Power Research Institute (EPRI) in the United States (EPRI, 2008), and in the European Utility Requirements (EUR) document in Europe (EUR, 2001).

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International survey of government decisions and recommendations following Fukushima

by H.B. Okyar*

A key issue in nuclear emergency management is the need to keep decision makers informed of the details of a situation which is evolving quickly. For example, decision makers need the latest information, and periodic updates, when making decisions regarding advice to citizens, policies on the import and export of food and goods, and industries that may be affected. During the 17 March 2011 meeting of the Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE), which was the first of a series of meetings following the Fukushima Daiichi nuclear accident, participants discussed the possibility of establishing a "database" of the decisions and recommendations made by various governments at an early stage of the Fukushima accident, as well as updating and modifying the database as long as it remained of use. The IACRNE agreed that this information would be very useful, and mandated the NEA to try to collect it.

A survey co-ordinated by the NEA (including GHSI member countries[1]) was conducted using the questions below.

1. What has your government recommended with regard to your citizens living in or visiting Japan?
2. What has your government recommended with respect to the monitoring of passengers returning by air from Japan?
3. What has your government recommended with respect to importing food or goods from Japan?
4. What are your policies or plans with respect to stable potassium-iodine (KI) distribution to nationals in Japan?
5. Have you established any recommendations regarding the screening of a) passengers and crew, b) baggage and cargo, c) cabins on airplanes or ships, and d) outer surfaces of airplanes or ships, arriving from Japan?

In addition, participants were asked to provide the technical basis for their answers as well as some information regarding the monitoring of radioactivity in the environment and the activation of a call centre for public information, if any.

In total, 34 countries (26 NEA members) participated in the survey. The survey results were consolidated into a single document indicating the country, the decision taken or recommendation made, the applicable date and the population concerned. Three updates were made (the last being on 21 April) and posted on the International Atomic Energy Agency (IAEA) Emergency Notification and Assistance Convention (ENAC) secure website[2] for official use only by participating regulatory authorities. During the survey period, a request to make the document public was forwarded to the participants, but this was not supported due to the importance of the information collected that needed to be analysed and evaluated in terms of emergency management by competent authorities.

In summary, 28 countries recommended to their citizens in Japan to follow Japanese government recommendations; however, 12 countries recommended that their citizens evacuate an 80-km zone surrounding the Fukushima Daiichi nuclear power plant. No restrictions on flights to Japan were recommended, although 25 countries issued travel warnings and 13 advised to eliminate non-essential travel to Japan, as well as to consider leaving Tokyo in the early days of the accident. Several countries (7) made airplanes available for flights from Japan to their home countries for their citizens wishing to leave Japan.

On a voluntary basis, medical and radiological controls were performed for thyroid uptake and total body counting (7 countries). Special instructions on screening were given to customs officials by 6 countries for the monitoring of passengers, baggage, cargo and airplanes coming from Japan. People arriving from the affected areas were recommended for screening at special facilities by 2 countries. Of the 34 countries surveyed, 19 initiated monitoring of foodstuffs from Japan based on EC recommendations (pre-defined EU levels were introduced for food imports to Europe, and later adjusted to match those in Japan). In addition, 2 countries required all goods from Japan to pass through assigned customs points equipped with radiation control devices (especially for toys, clothes and shoes).

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Residents of Kawauchi village, located in the 20-km evacuation zone, were allowed to return to their homes briefly to pick up their personal belongings on 10 May 2011.

Stable iodine tablets were sent by 13 countries to their embassies in Japan and distributed. The actual intake of the stable iodine tablets was recommended by 16 countries only should the request be made by the Japanese or local authorities.

Continuous routine monitoring programmes were initiated by 4 countries, including gamma dose rate monitoring and air sampling. Several countries (8) introduced reinforced monitoring programmes (for air and rainwater) by increasing the frequency of monitoring; special monitoring of the radioactivity in the air (7), rainwater (2), soils (2) and plants (3) were also introduced. Call centres for the public were activated (18) mostly by using electronic platforms; governments extended their working hours (6); and relevant information was made available on websites (including FAQs with Q&As) (15), and in some instances through social platforms such as Twitter and Facebook (2).

In conclusion, it is important to note that countries submitted differing amounts of information at different points in time during the accident's progression. The survey results indicate that an international overview is required to better understand how national governmental decision-making could be further co-ordinated. The NEA has undertaken some initiatives to analyse the types of decisions made, including the information available and necessary to support such decisions, and the implications for co-ordination needs and mechanisms.

Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE)

Pursuant to the obligations placed on it by the emergency conventions, the IAEA regularly convenes the IACRNE, whose purpose is to co-ordinate the arrangements of the relevant intergovernmental organisations for preparing for and responding to nuclear and radiological emergencies. Currently its members include representatives from the 14 organisations listed below:

- European Commission (EC),
- European Police Office (EUROPOL),
- Food and Agriculture Organisation (FAO),
- International Civil Aviation Organisation (ICAO),
- International Criminal Police Organisation (INTERPOL),
- International Maritime Organisation (IMO),
- OECD Nuclear Energy Agency (OECD/NEA),
- Pan-American Health Organisation (PAHO),
- United Nations Environment Programme (UNEP),
- United Nations Office for the Co-ordination of Humanitarian Affairs (OCHA),
- United Nations Office for Outer Space Affairs (OOSA),
- United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR),
- World Health Organisation (WHO),
- World Meteorological Organisation (WMO).

Notes

1. The Global Health Security Initiative (GHSI) is an informal network including Canada, France, Germany, Italy, Japan, Mexico, the United Kingdom, the United States and the European Commission to ensure the exchange and co-ordination of practices within the health sector in confronting new threats and risks to global health posed by terrorism.
2. The ENAC website and the Nuclear Event Web-based System (NEWS) were replaced in September 2011 by the Unified System for Information Exchange on Incidents and Emergencies (USIE), hosted by the IAEA, to unify and to simplify information exchange during nuclear or radiological emergencies.

NEA nuclear law education programmes

by B. Okra*

International School of Nuclear Law

The 11th session of the International School of Nuclear Law (ISNL), a unique academic programme organised by the NEA and the University of Montpellier 1, took place on 22 August-2 September 2011.

Over the past 11 sessions, the ISNL has trained more than 600 participants from around the world. This last session brought together 57 participants from 33 countries who benefited from lectures delivered by 25 highly renowned experts such as Mr. Stephen Burns, General Counsel of the US Nuclear Regulatory Commission, Dr. Norbert Pelzer, Honorary President of the International Nuclear Law Association, and Mrs. Laura Rockwood, Section Head for Non-proliferation and Policy-making Organs in the IAEA office of Legal Affairs. Mr. Paul Bowden from Freshfields Bruckhaus Deringer LLP, London, United Kingdom, served as programme leader and engaged participants in various Q&A sessions and case studies.

A special panel was organised to address the Fukushima Daiichi accident and its impact on nuclear safety, radiological protection and emergency management instruments. Participants showed considerable interest with their follow-up questions and comments.

Participants enrolled in the ISNL programme have the possibility of applying for a University Diploma in International Nuclear Law recognised by the University of Montpellier 1. This diploma is also recognised within the ECTS (European Credit Transfer & Accumulation System) and represents 12 credits. Components of the final grade for the award of the diploma include satisfactory class participation, a multiple-choice questionnaire to be taken roughly a month after the course and a dissertation on nuclear law to be completed before mid-December the same year. This year, 42 participants applied for the diploma out of the 57 who attended the session.

International Nuclear Law Essentials

Building on the success of the International School of Nuclear Law, the NEA launched a new one-week course called International Nuclear Law Essentials (INLE). The first session took place on 3-7 October 2011 at the NEA in the Paris area and attracted 35 participants from 19 countries.

The INLE covers all aspects of international nuclear law. It is primarily designed for lawyers from both the public and private sectors, but is also of interest to others who are active in the nuclear field (scientists, policy makers...).

The programme consists of individual presentations followed by discussion periods during which relevant scenarios are analysed. During this year's programme, lectures were delivered by well-known specialists in nuclear law from international organisations, governments, the nuclear industry and other experts in the nuclear field, many of whom teach or have taught at the ISNL. The keynote speech was delivered by Lord Hutton of Furness, a former Secretary of State and Member of Parliament, and currently the Chairman of the Royal United Services Institute and of the Nuclear Industry Association. As for the ISNL, the programme was conducted under the leadership of Paul Bowden.

The following 13 topics were addressed over a five-day period:

- Introduction to nuclear law;
- International radiological protection standards;
- Nuclear accident notification and assistance;
- Nuclear safety;
- Nuclear regulatory activities;
- Management of spent fuel and radioactive waste;
- Nuclear activities and environmental law;
- Liability, compensation and insurance for nuclear damage;
- Non-proliferation of nuclear weapons and international safeguards for nuclear materials;
- Nuclear security: physical protection, illicit trafficking and terrorism;
- International trade in nuclear material and equipment;
- Transport of nuclear materials and fuel;
- Nuclear law in context.

The next INLE session will be held on 4-8 June 2012. More information regarding both programmes, including applications, is available on the NEA website at www.oecd-nea.org/law/.

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NEA joint projects: nuclear safety, 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, Spain, Sweden, United Kingdom, United States.	€ 0.9 million
Cable Ageing Data and Knowledge (CADAK) Project Contact: axel.breest@oecd.org Current mandate: December 2011-December 2014	Canada, France, Japan, United States.	€ 40 K /year
Cabri Water Loop Project Contact: radomir.rehacek@oecd.org Current mandate: 2000-2015	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: alejandro.huerta@oecd.org Current mandate: June 2011-December 2014	Canada, Chinese Taipei, Czech Republic, Finland, France, Germany, Japan, Republic of Korea, Spain, Sweden, Switzerland, United States.	€ 120 K /year
Computer-based Systems Important to Safety (COMPSIS) Project Contact: jean.gauvain@oecd.org Current mandate: January 2008-December 2011	Chinese Taipei, Finland, Germany, Hungary, Republic of Korea, Sweden, Switzerland, United States.	€ 80 K /year
Co-operative Programme on Decommissioning (CPD) Contact: wei-whua.loa@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.	≈€ 69 K /year
Fire Incidents Records Exchange (FIRE) Project Contact: alejandro.huerta@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. All NEA joint projects currently under way are listed below.

At present, 17 joint projects are being conducted in relation to nuclear safety, two in support of radioactive waste management, one in the area of nuclear science (advanced fuels) 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
• To 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). • To 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). • To develop a common understanding on how to extrapolate confidently from small-scale studies to reactor-scale conditions.
• 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 under 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.
• To 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. • To 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. • To develop topical reports on degradation mechanisms in close co-ordination with the NEA/CSNI Working Group on Integrity of Components and Structures (WGIAGE).
• Define a format and collect software and hardware fault experience in computer-based, safety-critical NPP systems in a structured, quality-assured and consistent database. • Collect and analyse COMPSIS events over a long period so as to better understand such events, their causes and their prevention. • Generate insights into the root causes of and contributors to COMPSIS events, which can then be used to derive approaches or mechanisms for their prevention or for mitigating their consequences. • Establish a mechanism for efficient feedback of experience gained in connection with COMPSIS events, including the development of defences against their occurrence, such as diagnostics, tests and inspections. • Record event attributes and dominant contributors so that a basis for national risk analysis for computerised systems is established.
• Exchange scientific and technical information amongst decommissioning projects for nuclear facilities.
• 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 to better understand 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: greg.lamarre@oecd.org Current mandate: July 2011-June 2016	Belgium, Canada, Finland, France, Germany, Japan, Spain, Sweden.	€ 7 million
Halden Reactor Project Contact: radomir.rehacek@oecd.org Halden contact: Fridtjov.owre@hrp.no Current mandate: 2009-2011	Belgium, Czech Republic, Denmark, Finland, France, Germany, Hungary, Japan, Kazakhstan, Norway, Republic of Korea, Russian Federation, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom, United States.	≈€ 43 million
Information System on Occupational Exposure (ISOE) Contact: halilburcin.okyar@oecd.org IAEA contact: j.ma@iaea.org Current mandate: 2008-2011	Armenia, Belgium, Brazil, Bulgaria, Canada, China, Czech Republic, Finland, France, Germany, Hungary, Japan, Lithuania, Mexico, Netherlands, Pakistan, Republic of Korea, Romania, Russian Federation, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Ukraine, United Kingdom, United States.	≈€ 450 K /year
International Common-cause Failure Data Exchange (ICDE) Project Contact: axel.breest@oecd.org Current mandate: April 2011-March 2014	Canada, Finland, France, Germany, Japan, Republic of Korea, Spain, Sweden, Switzerland, United Kingdom, United States.	≈€ 120 K /year
Loss of Forced Coolant (LOFC) Project Contact: jean.gauvain@oecd.org Current mandate: March 2011-March 2013	Czech Republic, France, Germany, Hungary, Japan, Republic of Korea, United States.	€ 3 million
Primary Coolant Loop Test Facility (PKL-2) Project Contact: jean.gauvain@oecd.org Current mandate: April 2008-December 2011	Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, Japan, Republic of Korea, Spain, Sweden, Switzerland, United Kingdom, United States.	€ 3.9 million
Rig of Safety Assessment (ROSA-2) Project Contact: abdallah.amri@oecd.org Current mandate: April 2009-September 2012	Belgium, 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-June 2012	Czech Republic, France, Germany, Hungary, Italy, Japan, Norway, Republic of Korea, Spain, Sweden, Switzerland, United Kingdom, United States.	€ 4 million

Objectives

- Answer questions concerning smoke and heat propagation inside a plant, by means of experiments tailored for code validation purposes.
- Perform tests on smoke and hot gas propagation through a horizontal opening between two superposed compartments.
- Provide information on fire spreading to cables and electrical cabinets and on cable damage.
- Generate useful data and information on fire extinction phenomena using various 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.

- 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.

- 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 for mitigating 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 for validation for one of the most important safety aspects about reactor kinetics, core physics and thermal-hydraulics;
- provide experimental data to verify the capabilities of these codes regarding the simulation of phenomena coupled between reactor core physics and thermal-hydraulics.

- 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.

- Address 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, also considering that BWR data will be made available to project participants.

NEA joint projects

Project	Participants	Budget
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
Steam Explosion Resolution for Nuclear Applications (SERENA) Project Contact: jean.gauvain@oecd.org Current mandate: October 2007-March 2012	Canada, Finland, France, Germany, Japan, Republic of Korea, Slovenia, Sweden, Switzerland, United States.	€ 2.6 million
Studsvik Cladding Integrity Project (SCIP-2) Contact: axel.breest@oecd.org Current mandate: July 2009-June 2014	Czech Republic, Finland, France, Germany, Japan, Republic of Korea, Spain, Sweden, Switzerland, United Kingdom, United States.	≈ € 1.5 million /year
Thermal-hydraulics, Hydrogen, Aerosols, Iodine (ThAI-2) Project Contact: jean.gauvain@oecd.org Current mandate: 2011-2014	Canada, Czech Republic, Finland, France, Germany, Hungary, Japan, Netherlands, Republic of Korea, United Kingdom.	€ 3.6 million
Thermochemical Database (TDB) Project Contact: nea.tdb@oecd.org Current mandate: 2008-2012	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: jim.gulliford@oecd.org Current mandate: January 2012-December 2014	Canada, European Commission, France, Japan, Netherlands, Republic of Korea, Sweden, Switzerland, United States.	≈€ 100 K /year

Objectives

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.

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

- 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.

To address remaining questions and to provide experimental data relevant to nuclear reactor containments under severe accident conditions:

- atmospheric flow and graphite dust transport in high-temperature gas reactors;
- 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.

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.

New publications

General interest

Nuclear Energy Data 2011

978-92-64-12187-4. 140 pages. Price: € 40, US$ 56, £ 36, ¥ 5 200.

Nuclear Energy Data, the OECD Nuclear Energy Agency's annual compilation of statistics and country reports on nuclear energy, contains official information provided by OECD member country governments on plans for new nuclear plant construction, nuclear fuel cycle developments as well as current and projected nuclear generating capacity to 2035. For the first time, it includes data for Chile, Estonia, Israel and Slovenia, which recently became OECD members. Key elements of this edition show a 2% increase in nuclear and total electricity production and a 0.5% increase in nuclear generating capacity. They also show excess conversion and enrichment capacities in OECD Europe, and insufficient capacity to meet requirements in the North American and Pacific regions. Further details are provided in the publication's numerous tables, graphs and reports.

ウラニウム2009: 資源、生産、需給

(Japanese version of Uranium 2009: Resources, Production and Demand)

482 pages. Free: web.

技术路线图: 核能

(Chinese version of Nuclear Energy Technology Roadmap)

48 pages. Free: paper or web.

Economic and technical aspects of the nuclear fuel cycle

Carbon Pricing, Power Markets and the Competitiveness of Nuclear Power

978-92-64-11887-4. 108 pages. Price: € 33, US$ 46, £ 29, ¥ 4 200.

This study assesses the competitiveness of nuclear power against coal- and gas-fired power generation in liberalised electricity markets with either CO_2 trading or carbon taxes. It uses daily price data for electricity, gas, coal and carbon from 2005 to 2010, which encompasses the first years of the European Emissions Trading System (EU ETS), the world's foremost carbon trading framework. The study shows that even with modest carbon pricing, competition for new investment in electricity markets will take place between nuclear energy and gas-fired power generation, with coal-fired power struggling to be profitable. The outcome of the competition between nuclear and gas-fired generation hinges, in addition to carbon pricing, on the capital costs for new nuclear power plant construction, gas prices and the profit margins applied. Strong competition in electricity markets reinforces the attractiveness of nuclear energy, as does carbon pricing, in particular when the latter ranges between USD 40 and USD 70 per tonne of CO_2. The data and analyses contained in this study provide a robust framework for assessing cost and investment issues in liberalised electricity markets with carbon pricing.

Nuclear safety and regulation

CSNI Technical Opinion Papers – No. 13

LOCA Criteria Basis and Test Methodology

978-92-64-99154-5. 40 pages. Free: paper or web.

Acceptance criteria for emergency core cooling systems (ECCS) define the maximum temperature and degree of oxidation in order to avoid excessive embrittlement and hence failure of the fuel cladding, which would affect core cooling in the case of a loss-of-coolant accident (LOCA). The criteria are mainly based on experimental data obtained in the 1970s-80s. Several types of tests have been performed to evaluate structural integrity and embrittlement of the cladding under LOCA conditions, and consequently different test methodologies have been used for determining the cladding embrittlement criteria. The current trend towards high burn-up and the use of new cladding alloys has increased the need for international discussions on these test methodologies and acceptance criteria. In response, the NEA Committee on the Safety of Nuclear Installations (CSNI) and its Working Group on Fuel Safety produced this technical opinion paper, which should be of particular interest to nuclear safety regulators, nuclear power plant operators and fuel researchers.

Radiological protection

Practices and Experience in Stakeholder Involvement for Post-nuclear Emergency Management

978-92-64-99166-8. 25 pages. Free: paper or web.

One of the most important aspects of post-accident consequence management is the involvement of stakeholders: in the planning, preparation and execution as well as in sustaining efforts over the long term. Having recognised the significance of stakeholder participation in several International Nuclear Emergency Exercises (INEX), the NEA Committee on Radiation Protection and Public Health (CRPPH) decided to organise the Practices and Experience in Stakeholder Involvement for Post-nuclear Emergency Management Workshop to explore these issues. This summary highlights the key issues discussed during the workshop, which brought together 75 emergency management and communication specialists from 16 countries. In light of the accident at the Fukushima Daiichi nuclear power plant, the experience shared during this workshop will be central to further improving national emergency management arrangements.

Nuclear law

Nuclear Law Bulletin No. 87 (June 2011)

Volume 2011/1

0304-341X. 110 pages. Annual subscription (two issues per year): € 116, US$ 150, £ 92, ¥ 16 500.

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 this issue address the 25th anniversary of the Chernobyl accident, Japanese legislation in light of the Fukushima Daiichi accident and the long-term operation of nuclear power plants.

Nuclear science and the Data Bank

Potential Benefits and Impacts of Advanced Nuclear Fuel Cycles with Actinide Partitioning and Transmutation

978-92-64-99165-1. 74 pages. Free: paper or web.

This report provides a comparative analysis of different studies performed to assess the potential impact of partitioning and transmutation (P&T) on different types of geological repositories for radioactive waste in various licensing and regulatory environments. Criteria, metrics and impact measures have been analysed and compared with the goal of providing an objective comparison of the state of the art to help shape decisions on options for future advanced fuel cycles. P&T allows a reduction of the inventory of the emplaced materials which can have a significant impact on the repository. Such a reduction can also make the uncertainty about repository performance less important both during normal evolution and in the case of disruptive scenarios. While P&T will never replace the need for waste repositories, it has the potential to significantly improve public perception regarding the ability to effectively manage radioactive waste by largely reducing the transuranic (TRU) waste masses to be stored and, consequently, to improve public acceptance of the geological repositories. Both issues are important for the future sustainability of nuclear power.

Technology and Components of Accelerator-driven Systems

Workshop Proceedings, Karlsruhe, Germany, 15-17 March 2010

978-92-64-11727-3. 442 pages. Price: € 90, US$ 126, £ 81, ¥ 11 700.

The accelerator-driven system (ADS) is a potential transmutation system option as part of partitioning and transmutation strategies for radioactive waste in advanced nuclear fuel cycles. These proceedings contain all the technical papers presented at the workshop on Technology and Components of Accelerator-driven Systems held on 15-17 March 2010 in Karlsruhe, Germany. The workshop provided experts with a forum to present and discuss state-of-the-art developments in the field of ADS and neutron sources. It included a special session on the EUROTRANS as well as four technical sessions covering current ADS experiments and test facilities, accelerators, neutron sources and subcritical systems.

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