June 2012

# EUROSAFE TRIBUNE

Towards Convergence of Technical Nuclear Safety Practices in Europe

21

**Operate SAFELY in the long term: HOW SAFE and how long?**

Networking of TSOs in crisis management

SPECIAL FOCUS: EXPERIENCE FEEDBACK FROM FUKUSHIMA DAIICHI page 25

# Nuclear safety: taking the bend

New challenges, gained experience and public expectations

The 2011 EUROSAFE Forum in Paris attracted a record audience of over 500 participants from nearly 50 countries, witnessing both the international reach of the Forum and the concern about the sustainability of nuclear power across the globe.

# To our readers

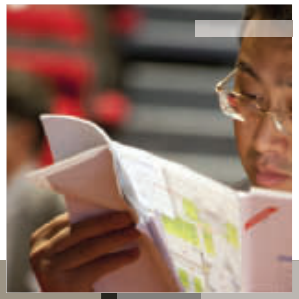
The 2011 EUROSAFE Forum held in Paris attracted nearly 500 nuclear experts from 43 countries, bearing witness to the nuclear safety community's thirst for an exchange of views on the future of nuclear power in the post-Fukushima era and on the lessons learned from the Fukushima Daiichi accident.

If one of the main roles of TSOs is to contribute to the prevention of accidents, they nonetheless have to be prepared at all levels in case an emergency occurs notwithstanding and develops into a severe accident. After TMI and Chernobyl, emphasis was placed on the comprehension of severe accidents with a view to preventing them, besides the research programmes focused on their consequences on man and the environment. Now, we need to strive for understanding the accidental sequences in order to mitigate better these consequences. Notably, this implies increased co-operation among technical emergency centres and exercised teams. In this context, there is still a long way to go for TSOs in Europe and worldwide to provide the authorities and the media with technical advice in a way that evidences that they are working together. TSOs must learn to harmonise their nuclear safety and radiation protection assessments in a co-ordinated and interactive manner.

Today, public expectations require that we quickly implement the lessons learned from the Fukushima Daiichi accident. In this regard, the aim of the European stress tests is to help us do more in the beyond-design range to better prevent and mitigate the consequences of severe accidents. This can be performed through enhanced convergence in the development of severe accident simulation codes, through better transmission of knowledge, as evidenced by the contract awarded at end of December 2011 by the EC to the European Nuclear Safety Training and Tutoring Institute (ENSTTI), as well as by improved networking of the emergency centers.
This EUROSAFE Forum shows the attractiveness of the European technical expertise in the international arena, as witnessed firstly by the decision made in 2010 by SSTC, the Ukrainian TSO and JNES, the Japanese TSO, and in 2011 by SEC-NRS from Russia to join the ETSON network of TSOs in the capacity of associate members, and secondly by the support provided by the IAEA to the creation of an international TSO Forum.

Moreover, the key role TSOs are playing in promoting nuclear safety worldwide is underlined by the TSO Forum founded under the umbrella of the IAEA Global Nuclear Safety and Security Network. We think this issue reflects this aim and we wish you pleasant reading.

Jacques Repussard and Frank-Peter Weiß



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Debate on the conditions for safe operation of nuclear facilities in the long-term: how safe and how long?

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Preparedness for the management of accidental and post-accidental situations: a central issue at the EUROSAFE Forum 2011.

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Emmanuelle Mur (IRSN)

Writer
Jean-Christophe Hédouin (HIME)

Design and production
Martin Brunner Associés, Vivian Scheithe (GRS)

Iconographer
Charlotte Heuzé

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Mounting of the new containment on a damaged reactor at the Fukushima Daiichi power plant.

- *It is sound to invest more in the mitigation of severe accidents with a view to preventing radioactive releases to the environment.*

Peter Líška, Vice-Chairman, VUJE page 13

**Experience feedback** **25**

How a tragedy contributes to improving knowledge, reorienting research priorities and intensifying international co-operation.


June 2012

Cover picture:
Embodying the globalisation of nuclear safety approaches, ETSON Junior Staff Project (JSP) members Tchen Minh Tang (Bel V) and Mathilde Prévost (IRSN) at a JSP working session organised as part of the 2011 EUROSAFE Forum in Paris.

**The next issue (#22)** of the EUROSAFE Tribune will deal with
Severe Accidents & Emergency Preparedness

# Contents

# Kaleidoscope

## MEETINGS

13-15 June 2012
**Phébus FP Seminar**
Dealing with the knowledge gained from 20 years of experimental research on fission products in the Phébus facility. In Aix-en-Provence (Southern France). More on: http://phebusfp2012-irsn.com/pro/Site/180200/28

5-6 November 2012
**EUROSAFE Forum 2012**
*Towards enhanced robustness in nuclear safety*, organised by Bel V with the support of GRS and IRSN. At Sheraton Brussels. More on: www.eurosafe-forum.org

## PROJECTS

**SARGEN IV**
Bringing together 22 organisations involved in severe accident research, the SARGEN IV European project coordinated by IRSN aims at fostering convergence between *methods developed for the safety assessment of the FBRs* being designed in Europe. ↗ First meeting in early 2012 in Paris.

## ENSTTI News

11 June-6 July 2012
**Training Programme**
The next European ENSTTI Induction to Nuclear Safety course will include specialised courses such as Safety Management for Nuclear Regulatory Authorities; Radiation Protection; Site Evaluation; Fire Protection; Nuclear Reactor Safety and Ageing; and Mechanical Analysis. More on: www.enstti.eu

**EC Contract**
On behalf of the EC, ENSTTI is preparing specialised training and tutoring for nuclear regulatory authorities and their technical safety organisations focussed on Nuclear Safety Assessment and Inspection. This includes the development of training modules for countries such as Armenia, Belarus, Brazil, Egypt, Malaysia, Mexico, Morocco, Philippines, Russia, Tunisia, Ukraine, and Vietnam.

## NUGENIA is born

Launched on 20 March in Brussels, the NUGENIA association is aimed at integrating research in the field of Generation II & III nuclear energy technologies. NUGENIA takes over the SNETP's Technology Working Group Gen II & III and encompasses important contributions from NULIFE and SARNET. ↗ Kick-off in Budapest: March 26-27. More on: www.nugenia.org

## ETSON NEWS

20-24 August 2012
**ETSON Summer Workshop**
The Junior Staff Programme Workshop will be held in Leuven (Belgium). This year's topic is Waste Management.

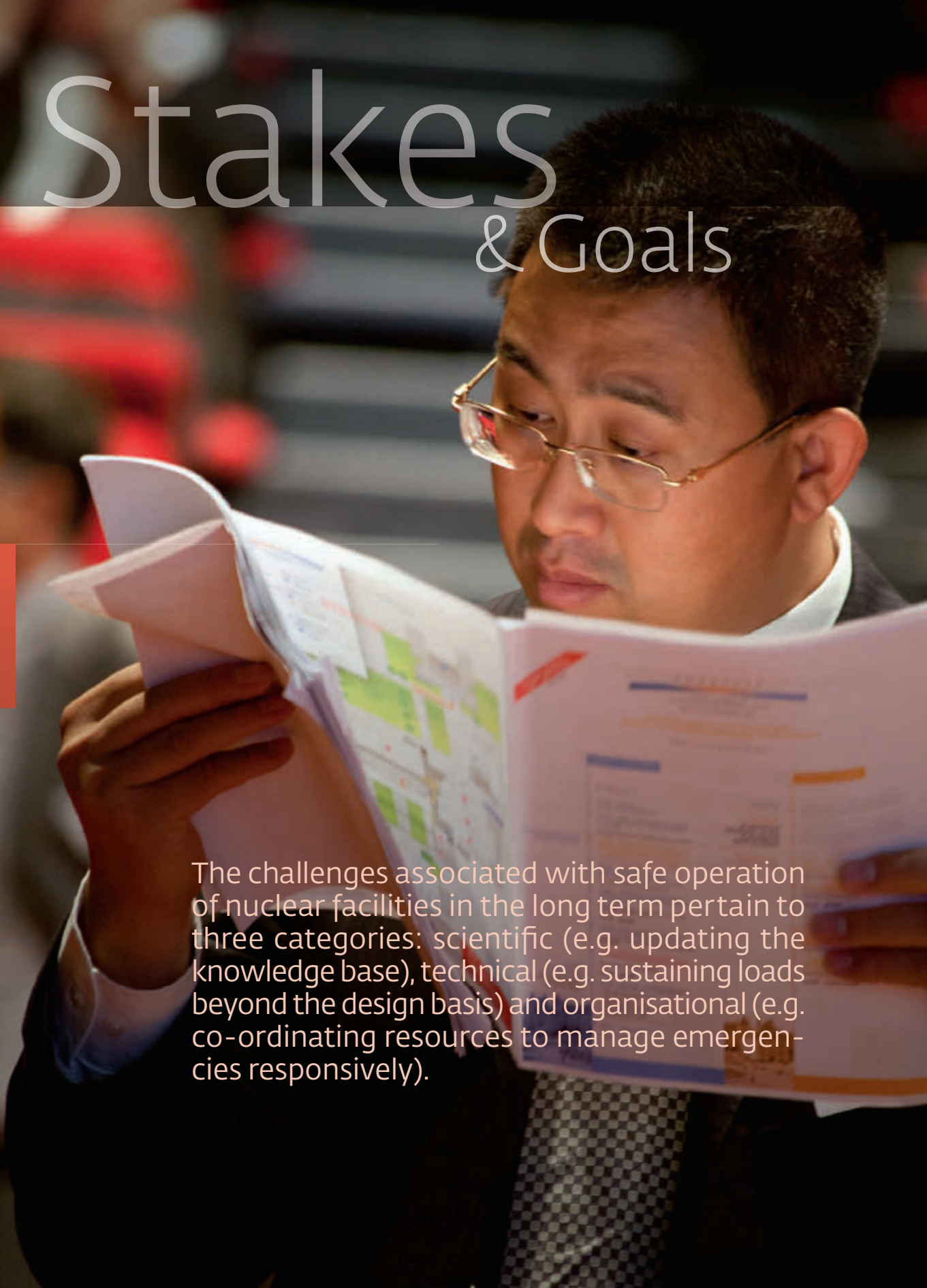
## COOPERATION

**The Franco-Japanese Committee on Nuclear Energy** initiated cooperation on safety studies in a number of areas such as severe accidents research, the monitoring of the environmental and health consequences of the Fukushima accident, post-accident management, and training in emergency response management.
↗ Kick-off in Tokyo: February 2012.
↗ Next meeting:end 2012 in Paris.

## BOOKS


**Nuclear Safety in Light Water Reactors – Severe Accident Phenomenology**
This 850-page book was written by 45 contributors from the SARNET Network of Excellence. Publisher: Elsevier

# Stakes & Goals



The challenges associated with safe operation of nuclear facilities in the long term pertain to three categories: scientific (e.g. updating the knowledge base), technical (e.g. sustaining loads beyond the design basis) and organisational (e.g. co-ordinating resources to manage emergencies responsively).

# A feeling of emergency

In his welcome address, IRSN's Director General Jacques Repussard firstly tackled several issues highlighted by the accident which occurred on 11 March 2011 in the Fukushima Daiichi NPP, starting with the need for reconsideration of *"the key paradigm of nuclear safety"*, ●defence in depth●, to identify possible weak points or loopholes in the concept. Mentioning crisis management as the second major point, he invited the audience to visit IRSN's technical crisis centre located in the Paris suburbs, pointing out that *"this centre was extremely active during the four weeks following 11 March, where several hundred experts kept analysing and exploiting the data as they flowed in from Japan."*

*How can a plant survive a load which is beyond the design basis?*

## Three major challenges in the post-Fukushima era

Recalling the role of the EUROSAFE Forum as a conference primarily aimed to exchange and update views on scientific and technical aspects of safety as well as on the practical methods to implement expert knowledge, Jacques Repussard explained that the challenges highlighted by the Fukushima Daiichi tragedy could be broken down into three categories: scientific, technical and organisational.

The first category pertains to the updating of the knowledge base, which draws upon the identification and analysis of the events that occur in operating plants and upon research. *"The European TSO Network (ETSON) has worked in close conjunction with the Sustainable Nuclear Energy Technology Platform (SNETP), the European platform set up on the initiative of the European Commission to address research issues in the nuclear sector with the co-operation of all partners in the industry and research organisations,"* Jacques Repussard explained, adding *"ETSON and SNETP have drawn up a research agenda for Europe. This also needs to be discussed internationally."*

Concerning the technical challenges, IRSN's Director General pointed out that the basic question behind the stress tests performed in many countries in Europe and abroad was: *"How can a plant survive a load which is beyond the design basis?"* and that the stress tests allow benchmarking and discussions between countries, and also allow the societal stakeholders to actually get involved, adding pressure on the nuclear system to improve things.

Regarding finally the issue of organisational questions, Jacques Repussard claimed that a nuclear accident is not an issue that can be treated separately in different countries: *"Had the accident happened in Europe, the need for co-ordination between the TSOs from the European countries would have been very demanding, and I am not sure it would have been possible to respond in time. So we need to work on this, we cannot wait until the next accident occurs!"* he concluded. ✖

### ●Defence in depth●

Application of this concept throughout design and operation provides a graded protection against a wide variety of transients, anticipated operational occurrences and accidents, including those resulting from equipment failure or human action within the plant, and events that originate outside the plant.
*(source : IAEA)*

PANEL DISCUSSION

Whereas several utilities worldwide had unveiled plans to obtain licences for extending the service lives of some of their plants, the severe accident that occurred at the Fukushima Daiichi NPP suddenly questioned in a challenging way the very idea of operating nuclear facilities safely over the long run. Should licence extensions of existing facilities be based on meeting current requirements? What are the implications of the accident in Japan and how should that be considered in licence extension initiatives? What is the need for additional research devoted to long-term operation? Seven panellists providing different views – regulator, TSO, NGO, operator, etc. – were invited to express their views on these issues.

# Long-term safe operation: what is achievable?

## The panellists

**George Apostolakis** Commissioner, US Nuclear Regulatory Commission (US NRC) / **Ute Blohm-Hieber** Head of the Unit for Nuclear Energy, Transport, Decommissioning & Waste Management, European Commission (EC) / **Benoît De Boeck** General Manager, Bel V / **Jean-Claude Delalonde** Chairman, French National Association of Local Information Commissions (ANCCLI) / **Juha Poikolainen** Head of Nuclear Safety, Teollisuuden Voima Oy (TVO) / **Lars Skånberg** Head of the Section for Reactor Technology & Structural Integrity, Swedish Radiation Safety Authority (SSM) / **Uichiro Yoshimura** Deputy Director, Safety & Regulation, Organisation for Economic Co-operation & Development – Nuclear Energy Agency (OECD-NEA)

## The moderator

**Ashok Thadani** Consultant. Former head of the Office of Nuclear Regulatory Research, US Nuclear Regulatory Commission (US NRC)

**The newer, the safer?**

*"We usually take it for granted that new plants are safer than old ones, but this is not necessarily the case,"* emphasises Bel V General Manager Benoît De Boeck in a thought-provoking manner. *"If you have two plants, an older one and a newer one, it is very hard to demonstrate which one is safer than the other. Of course newer plants have a broader scope of events that have been taken into account at the design stage, but older plants usually have more safety margins because of the lack of knowledge in the past. If the safety of an older plant has been improved after a periodic safety review, it is very hard to tell which plant is really safer than the other. We cannot just say*

*that we should shut down the old plant because we have a newer plant that is safer,"* he claimed.

**Implications of the accident in Japan**

Commenting on the situation in the United States, George Apostolakis declared: *"The US NRC approved a number of actions to be taken immediately, such as the re-evaluation of the design basis regarding seismic and flood hazards, preparation for plant work-downs, revisions to station blackout requirements and so on. But a major finding from the task force we had set up was that a sequence of events similar to what happened in Japan would be very unlikely to occur in the United States. Therefore, there was no need to take any action such as shutting down the plants, as there was no imminent risk from continued operation".*

**Validity of the defence-in-depth principles in the post-Fukushima era**

As a regulator, Commissioner Apostolakis emphasised the need to focus primarily on ensuring the correctness of the design basis and of the defence-in-depth principles: *"I think defence in depth is an excellent principle, but the Fukushima Daiichi accident shows that it should be accompanied by a probabilistic safety assessment (PSA) of the risk, given that you have lost some or all of the defence-in-depth barriers. I think defence in depth and PSA should be at the same level, because if you do a simple scenario analysis of what happened in Fukushima, you would see that the frequency was really unacceptable, given the very high conditional probability that you would have a tsunami following an earthquake."*

**Long-term safe operation of nuclear facilities and European policy-making**

In charge of this issue at EC level, Ute Blohm-Hieber stressed that long-term safe operation requires a continuous improvement of safety. Such on-going progress draws upon increased co-operation among TSOs, regulators, vendors and operators in different areas such as the operation experience feedback (OEF) from NPPs. Recalling the creation of a ●clearinghouse● to collect, evaluate and share this OEF, Mrs. Blohm-Hieber said: *"This clearinghouse establishes European best practices for the assessment of operating events."*

Advocating that technical improvement should go hand in hand with transparency, she claimed: *"There must be a dialogue with society so that they know the plants are still safe. Therefore, we created a platform called the* European Nuclear Energy *Forum to give nuclear energy a stage to debate the opportunities and the risks and to think about transparency."*

**● European Clearinghouse ●**

Mechanism aimed at jointly exploiting safety-related data on NPP operations among a dozen European countries. It allows notably sharing lessons learned and recommendations, giving countries with small reactor fleets access to the operating experience of countries with larger fleets.

**Stakeholder contribution to long-term nuclear safety**

As the chairman of a national association of stakeholders, Jean - Claude Delalonde firstly invited the panel and the audience at this EUROSAFE Forum to recognise that nuclear accidents still happen and that the Fukushima Daiichi accident taught us many lessons, starting with the fact that nuclear facilities remain vulnerable and that all stakeholders must remain vigilant in the follow-up of their operations: *"Whatever political decision is made to continue with nuclear power or to phase it out, the process takes decades anyway, so the point is to know how our society should be organised to live with nuclear energy in the long run. This is particularly the case in a country like France, where 58 reactors are in operation."* Even if it is too early to have a clear idea on how the available information was used in Japan to minimise the risk before and after the accident, one thing is clear to Mr. Delalonde: *"Safety matters are not only the oper-*

*ators', TSOs' and authorities' business. Society at large is concerned, as an accident creates a real disruption in the lives of a considerable number of people."* Stakeholders can provide a valuable contribution to long-term nuclear safety, he advocates, provided they can access scientific and technical knowledge *"I would like to make you – people in the know – aware of your responsibility regarding laymen. Your duty – our common duty – is to improve information and communication with the public, to educate and enhance everyone's ability to supervise nuclear safety and security. If we are successful, I am sure many problems from the past would be avoided in the future."*

**Limits to the improvement of existing plants**

*"Where is the limit? How much do we need to invest in existing power plants if we can prove that they are operating safely? What is reasonable? What kind of expectations do we have from the regulator's point of view or from the legislation in the long term? I would love to get some answer to these questions!"* declared Juha Poikolainen, reflecting the typical concern of operators whose primary aim is to guarantee production. *"It would be very beneficial for the operator to know what kind of investments are needed to guarantee long-term operation. Of course, research can help us on this point and on the kind of structures to investigate as well as on the type of techniques to use,"* he commented.

**Ageing management**

For Lars Skånberg, the question of long-term operation refers to two kinds of expectations. The first one is maintaining and demonstrating compliance with current regulations, including aspects such as plant operating procedures or ageing management. The second one is the continuous enhancement of the plant's safety level, compared to new safety standards. *"In my regulator's view,"* he says, *"the industry has been rather successful so far in ageing management, even though we have seen several rather serious degradation incidents over the years. However, our experience shows that research on ageing mechanisms has to continue as a support*

*"The real lessons learned from the Fukushima Daiichi accident – which translated into the action plan approved by the IAEA's General Conference in September 2011 – pertain to the need to prepare for very-low-probability events that have very high consequences. Firstly, each IAEA member state needs to check whether its own plants are designed to the right external events. The Agency's International Seismic Safety Centre has programmes to reconsider seismic and tsunami events, and a new IAEA safety guide on tsunamis is just about to come out. Now, we need to work more on flooding events other than tsunamis and other extreme natural hazards. We encourage our member states to participate in the development of updated safety standards and to use our peer-review services, as these help each country improve its own work, whereas the peer review team benefits in turn from each country's experience. In addition to other initiatives such as the Agency's Regulatory Co-operation Forum, this can also help embarking countries build their own capacity."*

**James E. Lyons**
*Director, Division of Nuclear Installation Safety/Department of Nuclear Safety and Security, IAEA*

*to maintenance and inspection programmes. We were talking about long-term operation. I feel there is a need for further research, particularly in cable ageing and concrete ageing, where little has been done so far."* Recalling that the goal of ageing management was to demonstrate that ageing had not reduced the safety level below the design basis requirements, the NEA's Deputy Director for Safety & Regulation Uichiro Yoshimura declared: *"At the NEA, we have two database projects that collect passive metallic component degradation and failure information. The first one, CODAP, brings together 12 participating countries. The second one, CADAK, focuses on cable ageing issues. But besides physical ageing, we also monitor technological ageing, i.e. obsolescence. Ensuring long-term availability of spare parts and the replacement of obsolete equipment is the other issue to be considered."*

**Assessment criteria for licence renewal**

*"How long could operation continue for? In the case of licence renewals, the maximum permissible period is generally specified by the degradation,"* indicated Uichiro Yoshimura. *"Alternatively, the long-term operation period could be based on an estimation of the remaining lifetime of the plant. However, assessing the remaining lifetime independently from the operator's interest may prove very difficult,"* he stressed.

**A conclusive comment from the floor**

In the form of a comment, IAEA Deputy Director General Denis Flory reflected the Agency's view on long-term operation by declaring: *"I think it is imperative that when older generation plants are relicensed, there is an effort to minimise the safety gap between these plants and the new ones. Safety objectives are studied as part of the Multinational Design Evaluation Program and I have asked the International Nuclear Safety Group to think about safety objectives for the 21st century and beyond. I cannot believe that keeping existing nuclear power plants for 30 years more at the level of safety they are at today will be accepted if there is no effort to minimise the safety gap between new and older generations."*

# From needs to results

The Fukushima Daiichi event highlighted the need for enhanced robustness of nuclear facilities regarding external loads and, to the same extent, for enhanced responsiveness in the event of an emergency. The stress tests performed worldwide and the strengthening of ETSON are essential steps in this direction.

# Learning from failures

It is a long way to go from the observance of an issue to the implementation of new procedures and organisations capable of preventing the same issue to occur twice... As witnessed by the successive speakers at the 2011 EUROSAFE Forum, this profound change requires strong-willed stakeholders – supervisory bodies, regulators, TSOs, operators, etc. – to strive for years in a convergent direction.

*"Let me briefly outline the current status of the Fukushima Daiichi plant restoration and the response activities,"* suggested Kazuo Shimomura, the Special Adviser of Japan Nuclear Energy Safety (JNES) President Yoshihiro Nakagome, in his presentation of the report on the lessons drawn by the Japanese safety organisations from the Fukushima Daiichi NPP accident. *" Now the reactors are being cooled by circulating water, in stable conditions. The temperature on the reactor vessel is below 80 °C. Site restoration work is in progress including the reduction of water intake, the treatment of contaminated cooling water, the disposal of wreckage and the covering of the damaged reactor buildings. The contamination in the vicinity of the Fukushima Daiichi site is an issue we have to work on as soon as possible,"* he stated. After the initial phase of the accident, JNES initiated the work to derive lessons and to identify recommendations for the future.

## Fukushima Daiichi NPP: an inescapable accident?

*"If we had been prepared enough to natural phenomena such as those we experienced at Fukushima and their consequences, we might have been able to mitigate the effects of the accident, at least to some extent,"* Mr. Shimomura claimed, recognising insufficient awareness of the possible occurrence of such kind of accident. *"We had not experienced this scale of natural phenomena and did not anticipate their possible consequences upon designing, constructing and operating the plant. Moreover, we did not sufficiently consider in our safety regulation the specific issues related to such kind of accident in a multi-unit site. We think these are possible root causes of the accident,"* he explained.

## A failure in mitigating the accident propagation

A similar lack of preparedness can be observed in the response and the mitigation measures.

Environmental radiation monitoring equipment on top floor of the Eiffel Tower in Paris.

*"These measures were not sufficient,"* Mr. Shimomura stressed, *"for instance we did not have adequate reactor cooling alternatives. Moreover, had the unit been equipped with so-called 'hardened vents', more adequate venting operations might have been possible in the reactor buildings."* It seems the regulatory safety prescriptions, as well as the regulatory requirements for severe accident response, were inadequate, causing unnecessary confusion.

### What should JNES do as a technical support organisation?

As the technical support organisation to the Japanese regulatory body, JNES has a lot of things to do in response to the Fukushima Daiichi accident, as stated by Mr. Shimomura: *"Firstly we have to perform further fact-finding activities with Tepco, the operator, to accurately understand the accident's phenomenology and sequence. We have to further analyse and evaluate the identified deficiencies in safety-ensuring measures to provide further improvements. We have to check the safety of other nuclear facilities, especially for spent-fuel reprocessing in the light of the Fukushima Daiichi accident. In a word, we have to carry out a lot of actions for solving safety issues!"*

### A substantive research programme

JNES completed a short-term research programme by the end of March 2012, just one year after the accident, and performs further investigation on this basis prior to embarking on medium-term research. The short-term programme addressed the investigation, analysis and evaluation of the accident and its impact; the evaluation of a seismic source model, ground motion and the tsunami behaviour of the earthquake; the evaluation of effectiveness of existing earthquake and tsunami countermeasures; the evaluation of the ruggedness of equipment exposed to sea water; investigations on the disposal of wreckage waste; and the safety enhancement of reprocessing facilities.

### Comprehensive probabilistic risk assessments

Ulla Vuorio, senior advisor at the Finnish Radiation and Nuclear Safety Authority (STUK), provided insights into the regulatory basis on external events, explaining notably that the Government Decree on the Safety of Nuclear Power Plants requires that all systems, structures and components must be designed in a way that they will function reliably under design-basis environmental conditions and that combined effects of accident conditions because of internal reasons and simultaneous natural phenomena shall be considered. *"In Finland, a full-scope, plant-specific probabilistic risk assessment (PRA) for level 1 and 2 is required,"* she pointed out, adding: *"This means that external hazards are comprehensively and systematically analysed, including extreme weather conditions, external flooding, seismic events and also a human-induced external hazard. Moreover, all major modification must be analysed with PRA."* The external phenomena to be considered

*"I think a major asset of ETSON is its widely recognised independence, which makes the Network a respected player in the nuclear safety arena and allows it having a positive influence on the management of utilities. In this respect, the Fukushima Daiichi accident showed that the management of these reactors – and of the post-accident crisis – was not flawless, as stated by the Japanese themselves. Perhaps is this linked to the fact that the culture of utilities' top management often is a profit-orientated more than a safety-orientated one? I this respect, I think it should be recalled that a nuclear accident has huge economic and financial consequences, and that it is sound to invest more in the mitigation of severe accidents with a view to preventing radioactive releases to the environment. The unprecedented number of participants in the 2011 EUROSAFE Forum evidences the awareness of the nuclear community regarding these issues in a context where many countries committed themselves to fighting against climate change and renewable energies are not yet ready to massively replacing fossil fuels."*

**Peter Líška**
*Vice-Chairman, VUJE (VUJE is a member of ETSON)*

regarding meteorological and hydrological issues are: air temperature, extreme wind conditions, precipitations, lightning strikes, extreme seawater level, seawater temperature, ice conditions, snow load, and the combination of correlated phenomena.

### A flat and stable bedrock, but...

Finland is located in the intraplate region and seismic activity is low. There is historical evidence of earthquake magnitudes of approximately 5.5 on the Richter scale. However, micro-seismic events are fairly common. The design earthquake corresponds to a return period of 100,000 years with a 50% confidence level. *"When the operating reactors were built there were no seismic requirements at all, but the probabilistic risk assessment has revealed that there are some potential problems with the resistance against tremors and weaknesses could be pointed to the anchorage of electric cabinets and batteries and some larger tanks,"* Ulla Vuorio observes. Besides naturals hazards such as wind, snow, ice, high seawater levels or algae and mussels, industrial and transport activities are also considered, the main concern being the increasing traffic of oil tankers from Russia on the Gulf of Finland. *"Some studies are ongoing, in relation to oil spillage and the behaviour of oil in the seawater,"* she stressed, adding: *"We have a national nuclear safety research programme called SAFIR. It has two sub-programmes respectively related to extreme weather and to seismic safety. Also, the effect of climate change and the impact on extreme weather and seawater are dealt with."*

> "If we had been prepared enough to natural phenomena such as those we experienced at Fukushima and their consequences, we might have been able to mitigate the effects of the accident."
>
> **Kazuo Shimomura**
> Special Adviser of Japan Nuclear Energy Safety Organization (JNES)

### In connection with the results of the European stress tests

In light of the Fukushima accident, no hazards or weaknesses were identified in Finland which would require immediate actions. *"However, there are reasons to go further and study the protection against some exceptional external events which potentially might require safety improvements,"* Mrs Vuorio concluded, *"Of special interest are events that could simultaneously endanger the function of redundant or diverse systems or several levels of defence in depth, such as the prevention and the management of core-melt accidents. Possible safety improvements will be studied and planned in connection with the results of the European stress tests".*

### Guidance and assistance

Dealing with the definition and realisation of the stress tests worldwide in 2011 and beyond, Jim Lyons, the Director of the IAEA's Division of Nuclear Installation Safety, reminded the audience that the Agency's action reached far beyond a set of some 100 safety standards, established and adopted in close co-operation with 151 member states. The Agency thus provides assistance to member states to develop, in a sustainable and efficient manner, their national infrastructure and human resources necessary to assume their responsibility for ensuring the application of the highest standards of safety and to respond in an appropriate and transparent manner. *"In addition, we provide regulators and operators with peer-review missions,"* Jim Lyons recalled.

### The role of the Incident Emergency Centre

In the area of emergency preparedness and response, the IAEA works primarily with two conventions, adopted in the aftermath of the Chernobyl accident; the Convention on early notification of a nuclear accident and the Convention on assistance in the case of a nuclear accident or radiological emergency. *"To fulfil its responsibilities under these conventions, the IAEA created an Incident Emergency Centre (or IEC),"* Mr Lyons explained, adding *"The IEC serves as a focal point for receiving information from the states where an emergency occurred and sharing the information with other member states."* Alerted within one hour after the 11 March earthquake by the on-call IAEA expert seismologist and forewarned of the risk of damage to four nuclear power plant sites on the north-east coast of Japan, the IEC established communications with the Japanese Nuclear and Industrial Safety Agency, NISA, the contact point designated by the Japanese government for emergencies. *"This contact was established within one and a half hours after the earthquake. The IEC was staffed up and remained in full res-*

# 3 questions to...

## Jean-Claude Delalonde

### on the public's involvement in nuclear safety issues

Chairman of the French National Association of Local Information Commissions (ANCCLI) set up around nuclear sites, Jean-Claude Delalonde is also an experienced locally elected official who served as President of the Nord department's General Council from 1998 to 2011.

**What are the major milestones of the stakeholders' involvement in the nuclear debate?**

*In France, the relationship between the public and nuclear power can be split into three main periods of time: before Chernobyl, after promulgation in 2006 of the laws concerning nuclear transparency and safety (called TSN law) and radioactive waste management (called radwaste law), and since Fukushima. Before Chernobyl, the governance of nuclear activities was resting on three pillars: the state, the operator and the public expert. Civil society was not invited to the table. Then, the TSN law gave a 4th pillar official existence: civil society, in the form of Local Information Commissions (LICs). The work carried out by independent experts on the impact of nuclear activities on man and the environment provided a new perspective, different from those of the operator and the public expert. The nuclear tragedy in Fukushima Daiichi highlighted again the threat of a large-scale nuclear accident, nearly 25 years after Chernobyl. As everyone was in search of information to assess the current situation and possible developments, as well as the danger for man and the environment, the part played by civil society in providing independent information became obvious.*

**What do local information commissions contribute to nuclear safety?**

*After Fukushima, the representatives from civil society claimed firstly that the conventional affirmation that no such accident could ever happen in France was no longer acceptable, and secondly that the public at large should demand more transparency and more involvement in nuclear topics. When it was created in 2000, ANCCLI started thinking about the prerequisites for a full-fledged participation of stakeholders in the debate on nuclear safety, irrespective of the government's nuclear policy. Even if a decision were taken not to build any new plants, those presently in operation as well as those under dismantling must be taken care of and monitored for decades, or even centuries. This requires the legislator to pass bills and decrees – such as the TSN law and radwaste law – accordingly.*

**What are the conditions for more effective stakeholder participation?**

*One of our concerns at ANCCLI is to take appropriate steps, with the support of ASN (the regulatory body), IRSN (the TSO), and HCTISN (the information and consultation body), depending on the questions and concerns voiced by LICs. To date, 3 000 volunteers are working within LICs in France, and they keep a watchful eye on their independence! Half of them are locally elected officials and half are representatives from trade unions, nature conservation associations, universities, economic circles, etc. 70% of them are utter laymen regarding nuclear technology and their priority is to gain knowledge in this area through the training provided by ANCCLI and its Scientific Committee, and through the information and awareness-raising events organised with ASN or IRSN. But beyond this co-operation with the national TSO, we need to establish links with third-party experts capable of providing highly skilled assessments. This is how we, civil society representatives, will contribute efficiently to the enhancement of nuclear safety.*


IRSN scientists collect seawater to study the behaviour of radio-nuclides notably in the aquatic environment. As part of their radio-ecology activities, IRSN perform environmental monitoring among others off the coast of Toulon (French Riviera) and the Rhône River mouth, as several nuclear facilities are located along the river.

*"In Almaraz, we have 8 reactors which produce approximately 20% of the power available on the Spanish market. To renew their licence every 10 years, the licence holders must submit a Periodic Safety Review (PSR) to the regulatory authority, CSN. This PSR provides a thorough analysis of the past 10 years of operation to demonstrate that the safety of the plant is better now than in the previous licence renewal. The safety improvements required by CSN to renew the licenses are part of an attachment called Complementary Technical Instruction (ITC), which includes a scheduling of implementation of the future design modifications, evaluations and analyses, etc. Since the commissioning of Almaraz, we have performed more than 6,000 design modifications on the plant, some of them being quite substantial. We replaced reactor vessel heads, all the internals of the secondary heaters, turbines, etc. Every year, we perform approximately 100 design modifications. Moreover, the replacement and the modernisation of some equipment increase output and therefore profit for us: for instance, we increased the power in each transformer unit by 10 MW. In parallel to the plant equipment, we place emphasis on human resources. Since 2001, Almaraz has renewed approximately 25% of its original personnel, with retention periods of five years, to ensure proper knowledge transfer and a consistent overlap.*

*The preliminary results of the stress tests performed after the Fukushima-Daiichi accident have confirmed the robustness of the Spanish nuclear power plants and notably Almaraz. The preliminary results are good but we have to implement a lot of improvements in the Spanish NPPs as a result of the accident in Japan. With these improvements, the Spanish plants will be even more resistant to the impact of external loads. As improbable as such hazards were considered before the Fukushima-Daiichi event, it is necessary to keep them in mind!"*

**Jose Maria Bernaldo de Quiròs**
*Manager, Almaraz NPP*

*ponse mode around the clock until 3 May. Such an operational record for the IEC was made possible thanks to the efforts of all the staff trained in crisis management. Over 200 of the agency staff brought their competencies to the IEC during this period,"* Jim Lyons highlighted.

### Safety assessments: a priority task for IAEA member states

In September 2011, the IAEA General Conference endorsed the action plan on nuclear safety aimed to make nuclear safety post-Fukushima more robust and effective than before. The first action member states should undertake are safety assessments, or ●stress tests●, of their nuclear power plants in light of the accident. "*The IAEA has developed a methodology for carrying out these national assessments against site-specific extreme natural hazards and provides assistance and support in the implementation of a national assessment as well as peer reviews of the national assessments, if requested,*" explained the Director of the IAEA's Division of Nuclear Installation Safety.

### A thorough review of the member states' response capabilities

The second action in the action plan is that the existing IAEA peer reviews, design missions and emergency preparedness review services are to be strengthened by incorporating lessons learned from the accident. "*Member states have committed to provide experts for these peer-review missions and member states are being strongly encouraged to voluntarily host IAEA peer-reviews,*" Mr. Lyons advocated. The third action is for member states to conduct a prompt national review of their emergency preparedness and response arrangements and capabilities. "*Again we will provide assistance and support in these reviews if requested,*" he explained. Member states are also called on to conduct the prompt review of their regulatory bodies, including an assessment of their effective independence, the adequacy of human and financial resources, and the need for appropriate technical and scientific support. They are also called on to ensure that there are adequate management systems, a safety

### ● Stress tests ●

The European Council of 24/25 March 2011 requested that the safety of all EU nuclear plants should be submitted to "stress tests" defined as targeted reassessments of their safety margins, on the basis of guidelines developed by the European Nuclear Security Regulators Group (ENSREG).

culture, human resources management and scientific and technical capacities in their operating organisations.

### Communication and transparency

The September 2011 action plan makes several recommendations for improving the communication process and for strengthening the IAEA's role in providing information and analysis to member states and the public. "*This is a role that we have not had in the past and was the subject of a lot of frustration in the wake of the Fukushima Daiichi accident,*" admits Jim Lyons. "*We are also being asked to organise international experts meeting to analyse all relevant technical aspects and to learn the lessons from the Fukushima accident. To facilitate the sharing of a fully transparent assessment of the accident and co-operation in Japan, we are working on the scheduling of such a technical meeting,*" he concluded.

*IAEA Member states are encouraged to voluntarily host peer reviews*

### Room for more international collaboration and support in crisis situations

From 11 March onwards, the ETSON member TSOs supported their respective national nuclear emergency services by providing them with technical and radiological information such as preliminary safety assessments of the current situation and the prediction of the accident progression in the reactors, radiation dispersion calculations, etc. "*They gained thereby deep insight into the cause of the accident, into the emergency management aspects, and into the potential environmental and health effects,*" underlined GRS scientific-technical director and ETSON board member Frank-Peter Weiß. The ETSON members held a workshop at GRS in Cologne in July 2011 to exchange knowledge and experience gained in the context of the accident and to draw conclusions for the improvement of emergency preparedness and crisis management. "*The main conclusions from this workshop are that accurate information was predominantly missing, in the first hours after the accident, on the plant's siting and its design against natural hazards, on the actual status of the reactors during the accident, on the radiological situation and on the accident management measures that were taken, and above all whether they were effective or not. And some information was available in Japanese only,*" Frank-Peter Weiß explained. Altogether the ETSON members came to the conclusion that the Fukushima Daiichi accident has shown room for more international collaboration and support in crisis situations.

### TSO networking: beyond limitations

In case of a severe accident, every crisis organisation of the impacted country needs full access to its technical and human resources to clear up the situation and to mitigate the potential consequences. The information exchange among the technical emergency centres could also be restricted by national security requirements to maintain the protection against malicious acts, as well as to avoid communication risks. The discrepancy in the missions and capacities of each centre also makes it difficult to develop effective international networking among the technical crisis centres to properly prepare for the event of an emergency. "*Such limiting issues can be solved, or at least relieved, by making the international collaboration of the technical crisis centres an official and integral part of their work. Therefore a new framework has to be settled to establish a really functioning worldwide network of emergency centres,*" Mr. Weiß advocated, adding: "*Some practical steps could be simple to implement in the next two to five years, such as the nomination of persons to be contacted and the implementation of transmission lines for data exchange, commonly accessible data libraries, a common standard for the data and the exchange, etc. In the long run, the use of safety assessment methods and analysis tools including the plant and the radiological simulation tools could be shared.*" With this purpose, a dedicated task force will be founded to draft a detailed proposal for the creation of a network of the technical emergency centres operated by the ETSON partners.

# Methods & Technology

Protecting the people living around nuclear facilities involves reducing the technological gap between Gen II and Gen III reactors as regards the mitigation of severe accidents. It also involves emergency teams to be trained to addressing swiftly very complex questions to provide safety authorities with proper advice.

# Getting prepared for complex emergency management

Irrespective of the topic dealt with – reactor safety, radiation protection and environment or nuclear security – the word repeated most frequently at the technical seminars of the EUROSAFE Forum 2011 was undoubtedly "*preparedness*". As evidenced by the Fukushima Daiichi experience, a severe accident with a very low probability of occurrence can happen, suddenly questioning established design assumptions and emergency management organisations. Below, some of the views of the GRS and IRSN co-chairmen of these seminars on the major lessons learned from Fukushima Daiichi and the TSOs' project priorities for the future are given.

## A clear focus on emergency management

Giovanni Bruna
Scientific Director
IRSN

Reinhard Stück
Head of Reactor Safety Analyses Division
GRS

Preparedness for the management of accidental and post-accidental situations, site recovery: these aspects were put at the forefront of the stage at the technical seminar of the EUROSAFE Forum 2011 devoted to safety research and expertise. The aim is to elaborate advanced methods for the assessment of the environmental consequences of an accident, as regards for example the contaminants spread around the power plant. *"Today, it is very difficult to have an accurate view on the amount of contaminants spread on the ground, though this is key information to recover quickly!"* Giovanni Bruna stressed. Another focus is decision-making in a confused situation. The Fukushima Daiichi experience shows how complex decision-making can be in an emergency situation, due to the amount of information one gets, the amount of people involved, etc., and how a country's political and social culture influences that mechanism. *"Therefore, this point is to be addressed as a top priority to enhance preparedness for emergency management,"* claimed Reinhard Stück.

## Reconsidering external loads

Giovanni Bruna

The seminar's co-chairmen shared the idea that the design of reactors is consistent with the assumptions made at the time they are designed, and that external events of different kinds were addressed in a holistic manner, up to a recent period of time, as one overall load plants were designed to withstand.

*"Today,* Giovanni Bruna pointed out, *we see this approach is not satisfactory, as several effects can combine, just as the earthquake and the tsunami in Fukushima."* The TSOs' concern is to make the best possible use of the feedback from the Fukushima Daiichi accident to improve their safety approach to existing and future reactors and gain knowledge of the possible impact of each external load separately and in interaction with other loads.

### Multiple-unit sites: a benefit or a disadvantage?

Jean-Claude Micaelli
Director of Safety Research
IRSN

Andreas Pautz
Head of Reactor Safety
Research Division
GRS

*"There are six reactors on the Fukushima Daiichi site, most of them sharing connections,"* Jean-Claude Micaelli recalled. *"It is now more and more widely admitted that the cause of the explosion in unit no. 4 could be found in unit no. 3."* Multiple-unit site effects are not sufficiently understood, the co-chairmen agreed, and what was previously regarded as a benefit could also, in some circumstances, be a disadvantage. Moreover, the destruction of part of the infrastructure – though it cannot be considered as an external load in itself, but as the consequence of external loads – hindered rescue and mitigation operations such as diesel power supply or freshwater supply for reactor cooling, because the rubble had made the site hardly accessible. *"All this Fukushima Daiichi experience feedback must be factored into future research and analyses, as it is part of any robust design,"* Andreas Pautz advocated.

### Mitigation of severe accidents: reducing the gap between Gen II and Gen III reactors

Giovanni Bruna

The Fukushima Daiichi accident evidenced the need for TSOs to acquire sufficient knowledge to push the industry into developing and deploying improved mitigation systems such as core catchers or fission product filtering systems to address potential containment failure. The aim is to give emergency teams

**The text of the contributions presented at the technical seminars of the EUROSAFE Forum 2011 is available on-line at: www.eurosafe-forum.org/eurosafe-forum-2011**

enough time to manage critical situations. According to Giovanni Bruna, *"A major challenge in this domain is to reduce the current gap between Gen II and Gen III designs as regards in particular the potential for radioactive releases to the environment in case of a severe accident."*

### What can be expected from the stress tests of nuclear facilities?

Andreas Pautz

*"The main focus in performing stress tests on European NPPs is to verify the correctness of the design basis and, drawing upon the knowledge gained from R&D and operating experience feedback, to identify the points that were not covered by the design,"* explained Andreas Pautz. But what about significant gaps? Implementing important alterations in existing plants – such as the reinforcement of the base mat – is highly challenging and costly. Therefore, the industry has to evaluate the interest of such alterations with regard to the risk and to the current status and expected service life of the plant.

> "The Fukushima Daiichi experience feedback must be factored into future research and analyses, as it is part of any robust design."
>
> **Andreas Pautz**
> Head of Reactor Safety Research Division, GRS

### Radiation protection and environment: the experience feedback from Chernobyl

Jean-François Lecomte
Senior Expert
IRSN

Gunter Pretzsch
Head of Radiation and Environmental Protection Division
GRS

*"Though Chernobyl was the first severe accident with massive releases to the environment, insufficient consideration was paid to understanding how the contaminated territories managed to recover over the long run,"* claimed Jean-François Lecomte. In fact, some organisations conducted studies in situ, but the nuclear community as a whole did not realise how valuable the experience feedback from the Chernobyl post-accident management could be, perhaps partly because of the belief that what had happened in Chernobyl could not happen in 'Western' countries. *"There is a lot to learn from Chernobyl about how living on a contaminated territory disturbs daily life from economic, social, familial points of view, just to mention those,"* Gunter Pretzsch emphasised, *"and what it takes to adapt to this situation and reinstate into the national and international community."*

### Managing highly complex accidental situations

Jean-François Lecomte

Severe accidents are very challenging for organisations such as TSOs, faced with suddenly addressing very intricate situations to bring proper advice to authorities, governments, international counterparts, etc. In an emergency situation, the teams involved have to work swiftly, under bad conditions and are expected to provide answers to a lot of complex questions, as pointed out by Jean-François Lecomte: *"In the field of radiation protection, one of the difficulties comes from the fact that, even in the case of a severe reactor accident, doses are not as high as those resulting from accidental exposures in the medical sector for instance. Except for some emergency workers, we are still here in the range of so-called "low doses", and it is really difficult to explain in a believable way that the health effects induced by the accident overtake those coming from the radiation exposures."* TSOs must be capable of

# 3 questions to...

## George Apostolakis

## on the management of the Fukushima Daiichi crisis

Commissioner of the United States Nuclear Regulatory Commission (US NRC), George Apostolakis is an internationally recognised expert in risk assessment. He exchanged views with other experts at the EUROSAFE Forum's panel discussion on the long-term operation of nuclear plants.

### What is your assessment of the Fukushima Daiichi crisis management?

*I think Fukushima Daiichi emphasises the need to have one single decision-maker empowered to make decisions in real time, without requiring the approval of any other body or being second-guessed by any other authority: this would be my major conclusion from a crisis management perspective. As long as the accident evolves within the plant, the operators need to have the authority to act according to what they think is appropriate. But once there are releases outside the plant, other emergency organisations are obviously involved in the mitigation of the accident's consequences. There too, one single authority should make the decisions, since you cannot afford to have debates among different parties while managing the accident. Even in running simulations and exercises in the event of an accident, it is essential to have good co-ordination, good communication with the public... and with nuclear safety expert bodies around the world! This is another lesson learned from the accident.*

### What can be inferred from such an accident for other countries operating nuclear plants?

*We have to understand in depth what has happened in Fukushima Daiichi, to compare with what we are doing in our respective countries – the United States as far as I'm concerned – and to draw the right conclusions. The local situations, the regulatory systems, the safety culture, the political systems... all this differs from one country to another. Therefore, this comparison requires some effort! Our task force for instance was specifically directed to tell the NRC what, among the things we learnt from the accident, could be applicable to the reactors in the US. We have to be aware of what happens in other countries to improve our own facilities. Another message from Fukushima Daiichi is the issue of multi-unit sites: most of the safety studies, at least in the US, deal with a single reactor accident. But some sites have two or three units, and the possible impact from an accident occurring in one unit on the other units is something we have to consider carefully.*

### How do you regard nuclear safety after Fukushima Daiichi?

*I think the principal lesson from a reactor safety perspective is we should check whether the design basis of the existing plants is sound. I think we should reinforce defence in depth by performing probabilistic safety assessments (PSAs) of scenarios where one or all barriers fail. I don't subscribe to the view that claims defence in depth is the ultimate safety philosophy and everything else is just supporting it. I think defence in depth combined with insights from PSAs should be the number one safety philosophy. In the US, we have already approved a number of recommendations from our task force concerning, for example, the re-evaluation of the design basis for earthquakes and floods, the installation of new instrumentation for spent-fuel pools, and protection of accident mitigation equipment from external hazards. Concerning earthquakes, we are going on with an initiative started before the Fukushima Daiichi accident to update the seismic basis for nuclear plants, as the understanding of seismic hazards in the Central and Eastern United States and earthquake assessment methods have progressed significantly since those plants were built.*

sharing with the public their reference levels, their rationale, their uncertainties, and what they think is appropriate to protect people... There is still room for improvement in this area!

### The delicate balance between security and safety imperatives

Jean Jalouneix
Deputy Director of Nuclear Defence Expertise
IRSN

The types of aggressions in the field of nuclear security differ from those in nuclear safety. However, there can be some interfaces and common views in terms of emergency management. A sophisticated attack on a nuclear facility for instance may challenge both safety and security, demanding close co-ordination of rescue operations. *"In this regard, the compatibility of safety and security procedures must be considered carefully,"* Jürgen Sternkopf stressed. *"Security for instance requires access to sensitive areas to be as restricted as possible, whereas safety requires, e.g. in case of a fire, the concerned area to be as quickly accessible to firemen as possible. Striking the right balance in this domain is a challenging task!"* added Jean Jalouneix.

Jürgen Sternkopf
Technical Expert
GRS

### Exercises to enhance preparedness

Jean Jalouneix

Among other initiatives, the European Commission funded the so-called STAR project, which consists in performing security tabletop exercises and simulating the management of potential emergencies resulting from malicious acts. This approach allows identifying the major challenges of such an emergency and understanding notably that common-mode failures could result from malevolent actions, prompting emergency management teams to deal simultaneously with several facilities on the same site. *"In this respect, the Fukushima Daiichi accident evidenced the existence of such common-mode failures, and also the possible loss of many safety-related equipment on one site, calling among other things for a more precise segregation and physical separation of equipment and units to better protect them against site effects and ease access to the different premises,"* Jean Jalouneix concluded.

*"The lessons learned from the Fukushima Daiichi accident as well as the subsequent stress tests conducted in several countries relying upon nuclear power will induce significant changes in the ETSON member TSOs' work programme, in terms of R&D as well as safety assessment. It appears for instance that the reactor buildings at Fukushima Daiichi were not designed to withstand powerful tremors and tsunamis with a typical occurrence frequency of about a century... Had a greater awareness of those risks existed when those reactors were engineered, they would probably have been designed and built in a more robust manner. No doubt ETSON members will address such topics as nuclear fuel behaviour under seawater sprinkling, severe accident scenarios in storage pools, hydrogen build-up and behaviour, site effects in case of an accident, the improvement of probabilistic approaches concerning human factor or external loads, just to mention these. The additional knowledge gained will be used as a basis to update the safety of present and future nuclear facilities."*

**Marc Vincke**
*Global Project Manager*
*Bel V*

Special Focus

# Fukushima Daiichi: Experience feedback


Why did the Fukushima Daiichi NPP accident occur? How did the accidental sequence develop? What were the priorities in the management and mitigation of the accident? The first part of the special workshop titled *Experience feedback on the Fukushima NPP accident*, chaired by Kazuo Shimomura, Senior Adviser to the President of JNES, recalled essential facts to answer these questions.

# Flashback to the accident

11 March 2011 14:46 — 11 March 2011 15:45 — 11 March 2011 19:30

## The initiating events: the combination of two exceptional external loads

• **11 March 2011 14:46** The 2011 earthquake off the Pacific coast of Tohoku strikes the coast of the Tohoku region. With a magnitude of 9.0 (Mw), it is one of the five most powerful earthquakes in the world since 1900 and the most powerful event in Japan since the start of record-keeping in the 18th century. The distance between the epicentre and the Fukushima Daiichi NPP is approximately 170 kilometres. The Fukushima Daiichi NPP's units 1, 2, and 3 are automatically shut down by the tremor, whereas units 4, 5, and 6 were undergoing routine maintenance. The tremor causes the plant to be cut off from the electricity grid. However, 11 backup diesel generators are turned on to continue cooling.

• **11 March 2011 15:45** A >15-metre high tsunami overtops the seawall designed to protect the plant from a tsunami of 5.7 metres, flooding the Fukushima Daiichi NPP, which was built only 10 to 13 metres high, as well as the sea water pumps facility for component cooling, located at a height of 5.6 – 6 metres. All of the 11 diesel generators stop, except one used for air cooling at unit 6, disabling decay heat removal to the ultimate heat sink.

## The accidental sequence

The timing of the main sequences in unit one to four is as follows:

• Set-up of alternative cooling water injection from an auxiliary fire-fighting line not using AC power after the stop of the core cooling system.
Time interval without water injection:
- Unit 1: 14 hours and 9 minutes;
- Unit 2: 6 hours and 29 minutes;
- Unit 3: 6 hours and 43 minutes.

• During this time, the uncooled fuel is exposed, and the cladding temperatures start escalating to reach 1100°C, initiating hydrogen generation through Zircaloy oxidation by steam, an exothermic reaction that increases the clad and fuel temperature exponentially.

• **11 March 2011 around 19:30** The fuel in unit 1 becomes fully exposed above the water surface, and the core meltdown begins, releasing fission products, and the mixture of hydrogen and steam and fission products moves to the suppression pool of the containment.


| Fukushima I – 4 | Fukushima I – 3 | Fukushima I – 2 | Fukushima I – 1 |
|---|---|---|---|
| BWR | BWR | BWR | BWR |
| 1978 | 1976 | 1974 | 1971 |
| 784 MWe | 784 MWe | 784 MWe | 460 MWe |
| Hitachi | Toshiba | General Electric | General Electric |

12 March 2011 15:36 — 14 March 2011 11:01 — 15 March 2011 — 12 to 31 March 2011

• In unit 3, the containment pressure increases up to eight bars, almost twice the design pressure. The operators open the valves in the primary containment vessel vent line manually. Hydrogen and fission products leak into the reactor building.

• **12 March 2011 15:36** A hydrogen explosion in the outer structure of unit 1 causes the concrete building surrounding the steel reactor vessel to collapse, injuring four workers and releasing a large quantity of hydrogen outside the reactor building.

• **14 March 2011 11:01** The unit 3 building explodes, injuring six workers and destroying the operation floor. Additional radioactive materials are released to the atmosphere and the radiation dose in the vicinity of the site increases.

• **15 March 2011** An explosion occurs in the reactor building of unit 4. An inflow of hydrogen from unit 3 might be possible as an exhaust pipe for the primary containment vessel venting joined the exhaust pipe from unit 4 before the outlet.

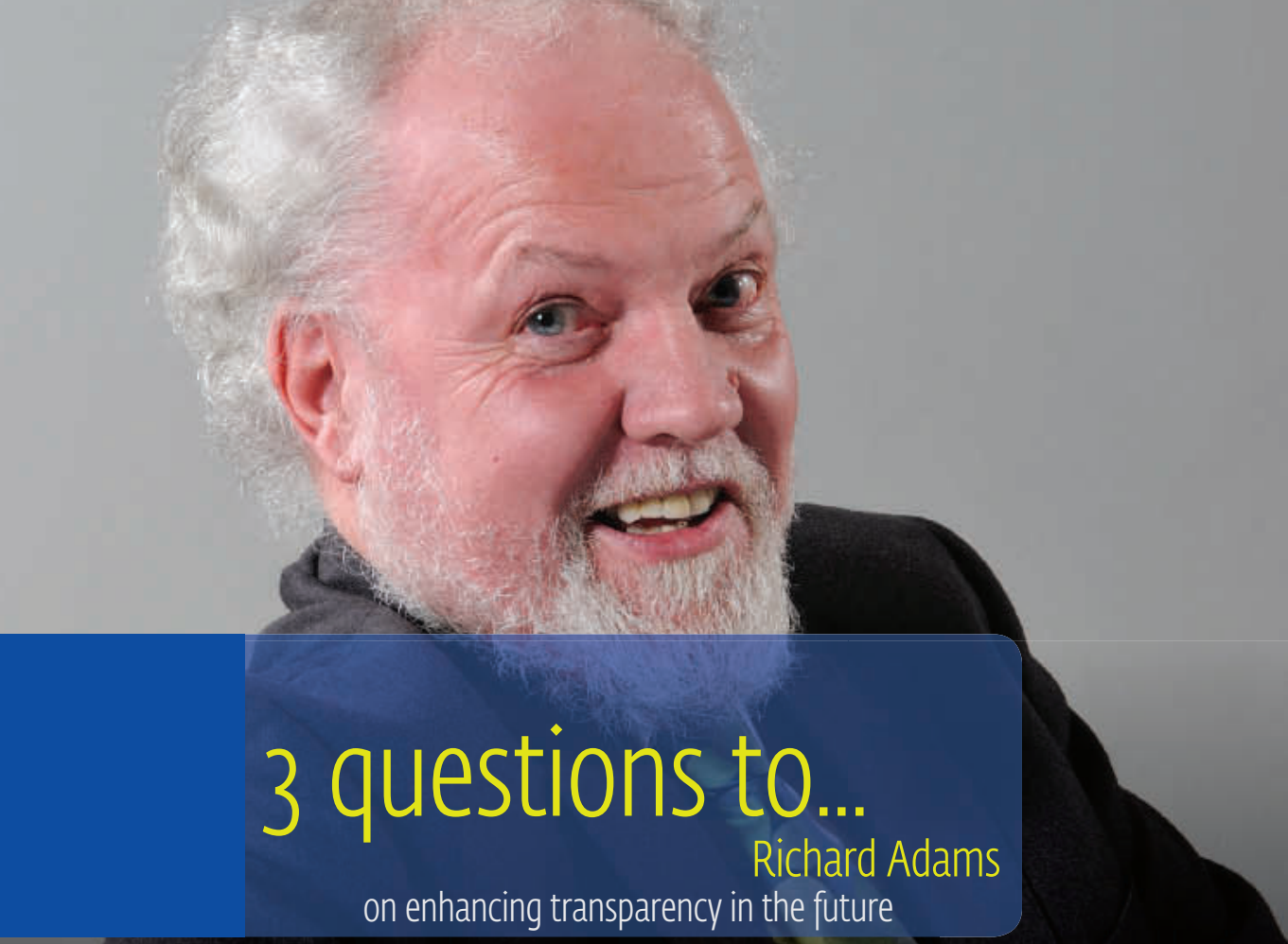
### The accident management and mitigation

• **12 to 31 March 2011** Restoration of reactor cooling and power supply:

- Alternative coolant injection relying upon the condenser water make-up system;
- Venting of the primary containment vessel installed to bypass the gas treatment system;
- Installing of power interchange facility between units 1 and 2, 3 and 4, 5 and 6.

• **April 2011** Getting on-site and off-site releases under control:
- Discovery of contaminated water flowing into the seawater from the pit in unit 2;
- Total amount of discharged radioactivity between 2 and 6 April assumed to be approximately 4.7 x $10^{15}$ Bq;
- To minimise this release: drilling of a hole and injection of water into the pit; insertion of fabrics and concrete inside the pit; reconfirmation of other leakage possibilities, and strengthening of the monitoring.

The cool-down of the damaged units, firstly with seawater and then with freshwater injected into the reactors' feedwater system, supplemented from 1 September onwards by the injection of water through the core spray system, brought the pressure vessels in units 1 to 3 to a cold shutdown below 100 °C and, ultimately, to a stabilisation below 19 °C.



# 3 questions to...

## Richard Adams

### on enhancing transparency in the future

Among his responsibilities as a member of the EU's Economic & Social Committee, Richard Adams chairs the Transparency Working Group within ENEF. The future of nuclear, he stresses, does not depend only on scientific progress.

**How did the Fukushima Daiichi accident impact transparency issues in the EU?**

In Europe, we shifted within months from the so-called 'nuclear renaissance' to a 'nuclear retrenchment'. From a transparency point of view, this is not perhaps too bad a thing, because the nuclear sector still has to be much more open about the risks and opportunities involved in the generation of electricity through nuclear power. The accident revealed not only failures in the plant's design specifications, but also growing suspicion regarding regulatory aspects. For us as Europeans, the question arises whether or not we have got effective regulatory mechanisms. The implementation responsibility for regulatory issues remains in the hands of member states. This means we have to be much more open to the degree member states vary in their capacity to set up, finance, resource and stand by independent regulatory bodies.

**How can civil society be involved in the future of nuclear?**

*At the European Economic & Social Committee we try to marshal and consolidate the perspective of civil society around Europe and maintain a balanced view on the issue of nuclear safety. Something I picked up talking to people is why the perception of risk varies so much between ordinary members of the public in the different EU member states. In some countries, there is a majority of pros, in others, a majority of cons. We need to understand the reasons for that. If we take the interim progress reports on the stress tests issued by national regulators, those reports seem to be quite varied in length and, to some degree, in content. We need to understand the reasons for that too! Public acceptance and implementation of nuclear programmes within the EU is another area where the difference between member states is substantial. And, again, we intend to explore why there is such a difference.*

**What are the ENEF Transparency Working Group's priorities in this context?**

*We are going to emphasise the importance of transparency, communication and the public seminars to discuss the results of the stress tests. I hope the EESC can also play a part in encouraging this civil society dialogue. I have talked to a lot of people in the industry over the past six months, and what strikes me is the absolute engagement in safety issues that the industry has. They don't necessarily have the answers yet, but they are really aware that gaps still have to be filled. This brings me to the conclusion that if insufficiently clear answers are given to the safety questions that remain to be addressed, coupled with the problem of people not actually trusting governments, nuclear may be in a position where it sells itself short in some sense. There is the possibility that the capacity of nuclear to make an appropriate contribution into the energy mix of Europe over the next 30 or 40 years may be affected by a set of non-scientific issues such as moral, ethical, political aspects. These are, of course, a legitimate part of the debate. However, we have a steadily increasing demand for energy, which we try to curtail, and a steadily increasing problem with $CO_2$, which we have to curtail. Therefore, we have to work on making nuclear power deliver what it was intended to, i.e. a safe contribution to sustainable low-carbon energy and technologies.*

# Never say never again

After a recollection of the major steps of the Fukushima Daiichi NPP accident sequence, the speakers at the special workshop focused on how the experience feedback from the tragedy could help deepen the understanding of severe accidents triggered by extreme external loads, reorient the working programme of the TSOs and, ultimately, intensify international cooperation in emergency management.

"*It is essential to keep in mind that the emergency management of a severe accident such as Fukushima Daiichi includes the radionuclide release phase, as it is a period of time when the capability to recover or mitigate the consequences of the release is deciding*," claims IRSN's Head of International Relations Department, Edouard Scott de Martinville. This implies emergency exercises to encompass this early stage. It is essential, during emergency exercises, to check quickly, within one hour, the status of safety functions such as power control, cooling, fission products containment, etc. This immediate diagnosis needs to be repeated several times to take into account changes in the scenarios. "*For TSOs, emergency preparedness is mainly the ability to succeed with this exercise and to stop the accidental sequence or mitigate the consequences. For example, in designing exercises, we include loss of external power supply, loss of coolant and so on*," Edouard Scott de Martinville goes on.

## Beyond responsiveness, coherence and harmonisation

Each country has its proper preparedness and response organisational pattern. Some are decentralised, like in Germany, or centralised, like in Belgium or France. However, there is in any case a national organisation that requires nearly all the available staff during an emergency, making it difficult for the teams involved to co-operate with their counterparts abroad, unless they are prepared well in advance. In other words, regular exercises are irreplaceable for safety authorities, TSOs, operators and designers to perform coherent work together inside and outside countries. They are also matchless to help speak the same language and to use technical information clearly defined in advance in terms of quantity and contents.

Therefore, TSOs are largely in line with the IAEA's proposals that call for improving the national emergency preparedness and response framework, as emphasised by Edouard Scott de Martinville: "*If we want to co-operate on improving the response to any event, then we should have co-operation at state level, we should have political discussions, not only discussions among technical experts.*"

*"I am presently head of BARPI, an entity within the French Ministry of Ecology & Sustainable Development, tasked notably with collecting and analysing the experience feedback (EF) from industrial accidents and pollution covering all industrial sectors with the exception of nuclear. As a previous member of the French Nuclear Safety Authority, my belief is that analyses of the links between EF from industrial accidents and nuclear events can help enhance safety in both sectors. The mechanisms of EF collection and analysis are very well developed and structured in the nuclear sector, both at national and international levels, and there are lessons to be learned by the industry in this regard. Conversely, the very large number of facilities operated by the industry provides a diversity of accident situations that may be usefully factored in the safety analyses performed in the nuclear sector. Therefore, I strongly support the idea of more synergies, even if each sector has its own specificity, and I consider the invitation to address the audience of the present EUROSAFE Workshop as a meaningful step in the right direction"*

**Simon-Pierre Eury**
*Director*
*French Bureau for Analysis of Industrial Risks and Pollution (BARPI)*

SPECIAL WORKSHOP

# The TSOs' working priorities

"To provide the correct response during an emergency, you need the people in charge of assessing the behaviour of the reactor and those evaluating the environmental impact to interact at the same place."

**Edouard Scott de Martinville**
Head of International Relations Department
IRSN

In the light of the Fukushima Daiichi NPP event, TSOs are adapting their working programmes with a triple objective: getting a better understanding of the accident, improving their safety assessment capabilities, and enhancing the safety of the existing and future installations. Pieter De Gelder, Head of the Nuclear Safety and Radiation Protection Assessment Department at Bel V, gives an insight.

## What insights can be expected from further investigations at the Fukushima Daiichi site?

As the event is still going on, further investigations may provide new material for developing the TSOs' understanding of the phenomenology of the accidental sequence. Now the main point is to know whether or not additional research is needed to understand some phenomena, to better predict the behaviour of a NPP in accidental situations. The possible areas for future work regard first the behaviour of the fuel, then the civil accident and finally our safety assessment approaches.

## Which items play a central part in the evolution of knowledge?

Regarding fuel behaviour, at least three items deserve attention drawing upon the Fukushima Daiichi lessons: fuel damage progression in spent-fuel pools, unusual emergency measures such as seawater injection and its impact on fuel cladding, and hydrogen production, transport and explosion. Regarding the progression of the accident, it would help to make an inventory in order to assess where knowledge improvement is possible.

## What about your safety assessment approaches?

One country alone cannot face a wide-scale disaster; therefore the TSOs' idea is to define a European platform for decision support and emergency management, which would gather all the parties involved. Regarding now the TSOs' involvement in the revision of national or international regulations and standards, after the Fukushima event, we expect to place the focus on natural hazards, complete loss of safety functions, and accident management.

# The OEF from facilities other than reactors

Co-chaired by Jean-Bernard Chérié, IRSN Deputy Director General, and Bernhard Gmal, Head of the Nuclear Fuel Department at GRS' Radiation and Environmental Protection Division, a special workshop held as part of the EUROSAFE Forum was devoted to the operating experience feedback (OEF) from facilities other than reactors, primarily nuclear fuel cycle facilities.

"*When I heard about the power supply blackout on the Fukushima Daiichi site, I thought to myself hopefully the spent-fuel storage facilities have been paid as much attention as the reactors themselves, since fuel cycle facilities pose safety problems too, for different reasons however*," Bernhard Gmal explains. These facilities are designed to return to a safe state in case of power supply blackout, but events such as the leakage of high activity material in a reprocessing plant as a consequence of an accident remain a real issue, because of the risk of contamination, as shown by the 1957 accident in the Mayak reprocessing plant in the former Soviet Union. Another difference to a reactor is that hazardous material – such as the contents of hydrogen tanks or chemical substances – can be spread over a very large area in a fuel-cycle plant. But taken as a whole, the risk is not as high as in a nuclear reactor. "*In most nuclear countries, the stress tests of spent-fuel facilities are well advanced and will provide highly interesting information*," Jean-Bernard Chérié concludes.

## Enhancing emergency preparedness: an ETSON view

- Co-operation is key: obtain sufficiently detailed technical data on the nuclear installations from the industry, and define common formats for exchanging data, notably among TSOs.
- Benchmarking is key: peer-review our response methodologies and our tools so that we can improve them and maybe share the common tools.
- Testing is key: perform regularly emergency management exercises together with several organisations, as it is the best way to progressively harmonise the emergency preparedness and response tools and organisations.
- Performance assessment is key: to improve organisations and training, systematic evaluation of the methodologies and human behaviour during those exercises is needed at international level through the setting-up of a committee.
- Networking is – more than ever – key: develop networking among several organisations in charge of similar installations, just as ETSON does, as this allows, in the long run, joint work during the response phase.


Credits

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Make sure to attend the next EUROSAFE Forum held at the Sheraton Brussels on 5 & 6 November 2012

The topic of the next Forum will be

# Towards enhanced robustness in nuclear safety

After a half-day plenary session dealing with the stakes and goals of the TSOs' contribution to long-term safety in the post-Fukushima era, the Forum's technical seminars will focus respectively on safety assessment and research; radiation protection; environment and emergency preparedness; waste; decommissioning and dismantling; and security.

The corresponding debates will be reported in the EUROSAFE Tribune #23

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*Towards Convergence of Technical Nuclear Safety Practices in Europe*