November 2013

EUROSAFE TRIBUNE

Towards Convergence of Technical Nuclear Safety Practices in Europe

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WHAT IS AT STAKE?
The future of nuclear energy

The evolution of **public opinion** on nuclear risk

STRESS TESTS: PROSPECTS OF THE GARCHING WORKSHOP page 32

Stress tests for enhancing nuclear safety

Construction of the European Pressurised Water Reactor at EDF's nuclear power plant in Flamanville (France). This reactor was among the nuclear facilities which safety was assessed as part of the European stress tests.

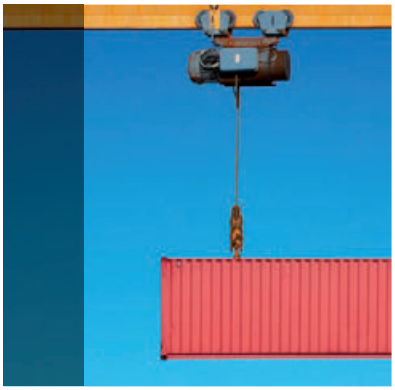
To our readers

To what extent will the stress tests performed on the nuclear facilities in Europe effectively contribute to raise their actual safety performance? The present issue of the EUROSAFE Tribune aims at bringing together facts and considerations to inform this debate. What we can assert so far is that the results from the stress tests confirmed the validity of the first findings from the Fukushima Daiichi accident: the underestimation of the potential of beyond design natural hazards to overcome the safety defence capability of nuclear reactors was a root cause of the disaster. This issue was the starting point for the regulatory authorities and technical safety organisations tasked with designing the stress tests investigation requirements both at European level and national level. That is the reason why this safety reassessment addressed first and foremost the nuclear power plants' behaviour under the stress of extreme natural hazards such as floods, earthquakes, and exceptional weather conditions to gauge their actual margins in the beyond design range. The feedback from the Fukushima Daiichi accident also urged safety experts to assess the plants' behaviour when confronted to extreme events such as a prolonged loss of the entire AC power supply, a loss of the ultimate heat sink, as well as possible combinations of such events. Last but not least, the accident questioned the effectiveness of emergency equipment and procedures aimed at cooling down the reactor core as well as the spent fuel pools, and maintaining the integrity of the containment over long periods of time following large degradation of the plants' capabilities in the aftermath of some natural disaster. In addition, some countries such as Belgium or Germany also included, in the scope of the stress tests, man-made hazards – e.g. airplane crash – and the loss of so-called precautionary measures such as double-walled pipes aimed to prevent internal flooding. France decided to apply the stress tests, beyond NPPs, to all its nuclear facilities.

Unprecedented by their extent, the European stress tests were a premiere by the innovative approach implemented to draft at EU level the specifications of the assessment to be performed within a very short period of time and without help of any template. They were also unprecedented in the way they were performed, i.e. through a cross-country review of obtained results, leading to a consolidated European report. In this regard, we would like to pay tribute to the ability of the experts involved to be up to the task, on top of their usual workload, as well as to the quality of the close interaction between regulators and TSOs, which allowed opening new avenues to enhance the safety of the European nuclear facilities, also through new research initiatives.

We submit these thoughts for consideration and wish you pleasant reading.

Frank-Peter Weiß and Jacques Repussard



● What if the load exceeds what was anticipated? How can the NPPs resist that? According to the solicitations, margins can be either important or conversely almost non-existent ●

Peter Hardegger, PSI page 28

The EUROSAFE Tribune 24

The EUROSAFE Tribune is a periodical from the EUROSAFE Forum published jointly by GRS and IRSN as a contribution to the EUROSAFE approach.

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Printing
Media Cologne, Hürth
ISSN: 1634-7676
Legal deposit:
November 2013

The EUROSAFE Tribune is available on the website: www.eurosafe-forum.org

Printed on Satimat Green, FSC® certified, produced from 60% FSC® certified recycled fibre and 40% FSC® certified virgin fibre, 100% biodegradable.

November 2013

EUROSAFE Tribune express their appreciation to Peter Hardegger from the Paul Scherrer Institute (Switzerland) for the valuable support provided throughout the design and production of the present issue.

Contents

Kaleidoscope

LESSONS LEARNED

At its 8th Plenary Meeting in Prague on 30-31 May 2013, the European Nuclear Energy Forum (ENEF) discussed the perspectives for nuclear energy in the EU in the medium to longer term; from long-term safe operation of existing plants to generation III reactors, demonstration of generation IV systems and development of waste management solutions. More on: http://ec.europa.eu

MEETINGS

6 and 7 February 2014
Final conference on the international project on the *Long-Term Performance of Engineered Barrier Systems: Backfill, Plugs & Seals (PEBS)* hosted in Hanover (Germany) by the German Federal Institute for Geosciences and Natural Resources (BGR). More on: www.pebs-eu.de > International Conference on the Performance of Engineered Barriers

1 and 2 April 2014
The new Senior Task Group on the Robustness of Electrical Systems of NPPs (ROBELSYS) set up by the OECD/NEA to improve the understanding of nuclear power plant electrical system robustness will organise a workshop in Paris under IRSN leadership. More on: www.oecd-nea.org/nsd/workshops/robelsys-2014/

ETSON News

During the network's annual meeting (Saint Petersburg, 2 to 4 July), the ETSON network members elected their representatives to the Board and welcomed two new member TSOs: The Jožef Stefan Institute (JSI) of Slovenia and the Institute for Nuclear Research and Nuclear Energy (INRNE) of Bulgaria.

Winter view of EDF's Cattenom NPP in north-eastern France, where transboundary emergency preparedness exercises were performed with the participation of Belgium, Germany and Luxembourg.

From 7 to 11 April 2014
3rd International Conference on Challenges Faced By Technical and Scientific Support Organisations (TSOs) in Enhancing Nuclear Safety and Security hosted in Beijing (China). More on: www-pub.iaea.org > meetings in 2014

ACHIEVEMENTS

GRS' new Emergency Centre for nuclear accidents was opened in Cologne in spring 2013. The newbuild was decided drawing on the experience gained from the Fukushima Daiichi accident. More on: www.grs.de > Communication & Media > Press

ON THE WEB

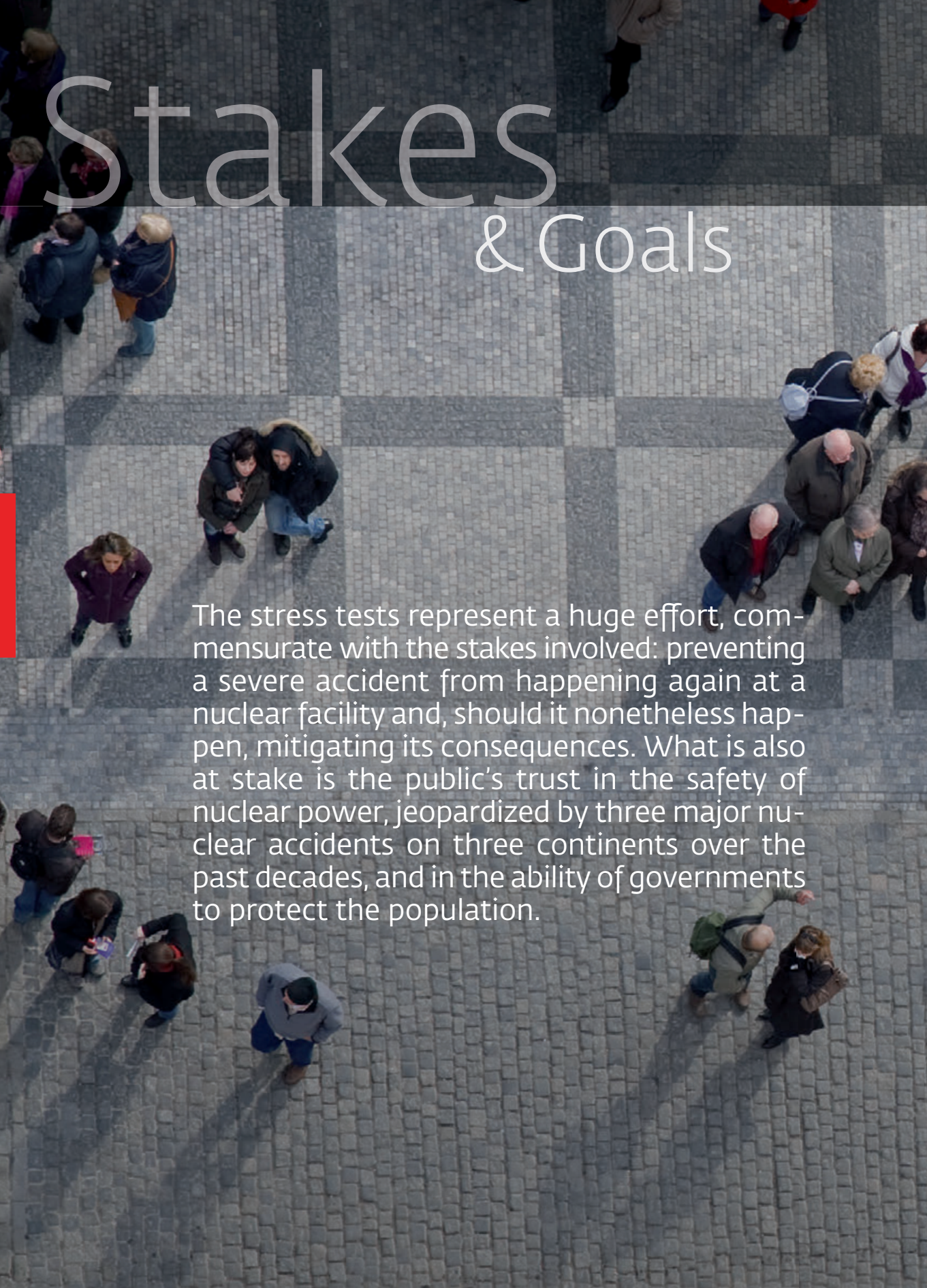
Identification of Research Areas in Response to the Fukushima Accident This report prepared by the Fukushima Task Group established within the Sustainable Nuclear Energy Technology Platform (SNETP) is downloadable at www.snetp.eu

Position paper on Periodic Safety Reviews taking into account the lessons learned from the TEPCO Fukushima Daiichi NPP accident Study published by WENRA's Reactor Harmonization Working Group. Downloadable at: www.wenra.org > Archives > WENRA > Position Paper on Periodic Safety Reviews

PROJECTS

In June 2013 the Directorate for Energy of the European Commission published new proposals for nuclear safety as an amendment of the 2009 nuclear safety directive. More on: http://ec.europa.eu/energy/nuclear/safety/safety_en.htm

Stakes & Goals



The stress tests represent a huge effort, commensurate with the stakes involved: preventing a severe accident from happening again at a nuclear facility and, should it nonetheless happen, mitigating its consequences. What is also at stake is the public's trust in the safety of nuclear power, jeopardized by three major nuclear accidents on three continents over the past decades, and in the ability of governments to protect the population.

What future for nuclear energy?

Within the past two years, the nuclear landscape underwent unprecedented change worldwide, with an extensive safety reassessment of the nuclear facilities, the reshaping of the safety organisation in some countries, and decisions to phase out nuclear energy in some others. In this context, ETSON member TSOs explain what is at stake, mainly in Europe.

What does the present of nuclear energy look like more than two years after the Fukushima Daiichi NPP accident? In Japan, the accident triggered major changes in the living conditions of a part of the population, placing the efforts aimed to keep the damaged reactors under control and to clean up the nuclear site under scrutiny. It also put the future of TEPCO[1] in jeopardy and was conducive to profound changes in Japan's nuclear safety organisation. In the rest of the world, some countries have decided to abandon or postpone their nuclear energy plans, leading at least initially to a larger use of fossil fuels – and correlatively to increased CO_2 emissions. Other countries, for which the economic incentive is stronger than the mistrust in nuclear technology, stick to their original program, since nuclear generates not only base load energy but also sustainable employment and revenues.

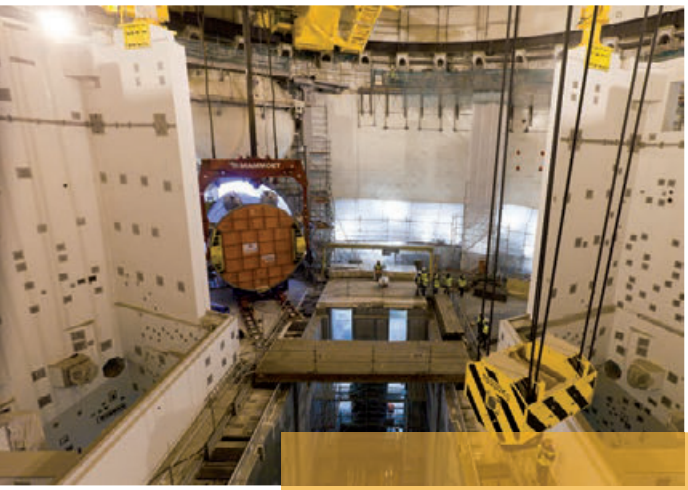
Nuclear stress tests: a unanimous decision

Realising that the future of their nuclear facilities – and thereby of their entire energy mix – was at stake, almost all nuclear countries decided to thoroughly reassess the safety of their NPPs and to implement measures aimed at decreasing the probability of occurrence and the consequences of a nuclear accident at home. These detailed reassessments are called *stress tests*, by analogy with the tests performed to measure the financial institutions' resilience to economic crises.

The nuclear stress tests were rapidly and simultaneously decided by all the EU's 'nuclear states', in spite of existing differences in terms of stakes and goals. International organisations such as the IAEA or the OECD/NEA were consulted to homogenise the content of the tests worldwide and to foster international consensus on improving the nuclear safety level across the globe.

Discordant views on the future among EU policy makers

Depending on the stress tests conclusions, quite different futures are conceivable for power production worldwide. In the EU for instance, Commissioner for Energy Günther Oettinger stated that weaknesses in the national safety control had been revealed through the results of the stress tests, calling for significant efforts aimed to raise and homogenise the nuclear safety levels in the EU Member States concerned, and for a revised directive on nuclear



From new build through to the dismantling of decommissioned facilities, the TSOs' priority remains the enhancement of safety.

safety reinforcing the European Commission's control.

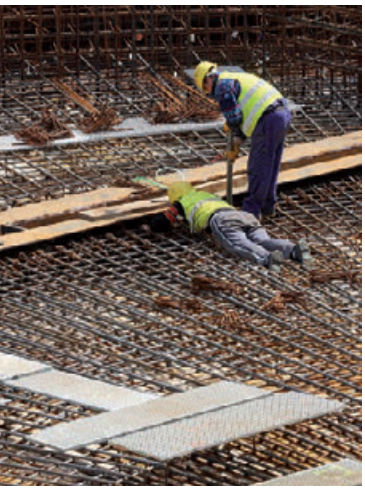
For the European Parliament and its Committee on Industry, Research and Energy (ITRE), nuclear energy is questionable. Therefore, the ITRE Committee is in favour of placing the national regulatory authorities (NRAs) under control by the EU, a position which conflicts with the present competence and independence of national bodies.

For the specialists of energy provision in the long run, represented in the Strategic Energy Technology Plan (>SET-Plan<), CO_2-free energy remains a necessity to achieve the environmental commitments, and nuclear energy should remain a significant part of any energy mix, notwithstanding the safety issues to be solved. The European Economic and Social Committee, for its part, considers that there is no sustainably operable energy source without a strong public consensus throughout Europe (see article on p. 10).

The TSOs' pragmatic approach to higher nuclear safety levels

Whichever scenario may be considered by each country's energy policy makers for the years to come, the TSOs' priority remains enhanced safety. In this spirit, they support EU-wide voluntary consensus rather than a revised safety directive which would not involve the input of the stakeholders. They also point out the important local component of human and technical efforts and the necessarily detailed knowledge

>SET-Plan<
Adopted by the European Union in 2008, the SET-Plan is a first step to establish an energy technology policy for Europe. Its aim is, among others, to maintain the EU's industrial leadership on low- carbon energy technologies. In this respect, the Sustainable Nuclear Energy Technology Platform – which promotes safety-related research and harmonisation at European level, for current and future generation of nuclear fission technologies – gave nuclear safety the highest priority in its Vision and Strategic Research Agenda (SRA). The European TSOs are involved in the platform, both at governance and working group levels.



As dismantling operations progress, protective measures ensure the containment of the radioactive waste.

of nuclear facilities to carry out science based activities such as safety assessment, without precluding transparency and stakeholder participation in the decisions. Placing increased emphasis on the practical means to fulfil the safety objectives proposed by WENRA, the European TSO Network (ETSON) is deeply involved in the nuclear R&D platforms and practical harmonisation initiatives. Therefore, ETSON members pay special attention to sharing the technical conclusions issued from the stress tests.

Nuclear safety enhancement: a long-distance race

By the time this issue of the EUROSAFE Tribune gets published, several national action plans aimed to improve nuclear safety will have been publicised by the NRAs. However, the effort is to be sustained over the long run, and all the TSOs feel the need to further analyse the technical aspects to be developed, both in safety research and in safety assessment. ✖

As an organisation with an increasingly global reach – notably with Russia becoming a member in January 2013 – the OECD/NEA aims at fostering consistent mid- and long-term regulatory practices in the nuclear safety area and industrial development. In this spirit, the NEA set up a task group to collect and analyse the data from the comprehensive safety reviews carried out in Europe, North America and Asia in the wake of the Fukushima Daiichi accident. After two years of work, the group reported to the Agency's Committee on Nuclear Regulatory Activities (CNRA) last June, stressing the consistency of the approach used in the countries concerned, in spite of some procedural differences that were explained. The NEA will issue a summary report on its member countries' response to the Fukushima Daiichi accident, highlighting what has been done already as a short-term response and in which areas the Agency is working to make sure that the end goal in the improvement of reactor design is consistent all over the NEA members, even if some technical options may be different. The NEA is also looking at additional safety research needs based on the lessons learnt from the accident.

Javier Reig
Head of the Nuclear Safety Division OECD/NEA

(1) Tokyo Electric Power Company (TEPCO) is the operator of the Fukushima Daiichi plant.

3 questions to...

Pierre-Franck Chevet

on the stress tests and their possible development

The French Nuclear Safety Authority (ASN) was deeply involved in the definition and planning of the stress tests, notably on behalf of the European Nuclear Safety Regulators Group (ENSREG). As the Chairman of ASN's commission, Pierre-Franck Chevet comments on the lessons learned in France and on the possible establishment of joint safety reviews.

To which extent were the European stress tests – in particular the peer reviews of the country reports – beneficial to the safety enhancement of the nuclear facilities in France?

From a regulator's perspective, I would say the peer review process enhanced the nuclear safety authorities' image as technically competent authorities. This was a reason for ASN to be very supportive at each step of the process, may it be within WENRA or ENSREG. Based on the conclusions of the stress tests, the European 'nuclear' countries established national action plans, which were also peer reviewed until mid-2013. In the context of the forthcoming EU directive on nuclear safety, ASN is discussing with its counterparts the feasibility of performing peer reviews not only as part of the actions taken in the wake of the Fukushima Daiichi accident, but more widely on major safety issues. This principle of 'topical peer reviews' could become reality in a near future. Another important lesson from the peer reviews pertains to the mainly deterministic approach of the French experts regarding safety assessment, our counterparts suggesting a wider use of probabilistic methods. Last but not least, the peer review of the French action plan corroborated that our provisional schedule for the implementation of the 'hardened safety core' on the power reactors and other nuclear facilities was a fairly ambitious one.

In this respect, what are ASN's objectives regarding the enhancement of the French nuclear facilities?

I would simply like to point out that we had decided in France to enlarge the perimeter of the stress tests to cover firstly the nuclear fuel cycle as well as the research facilities, and secondly organisational and human aspects. We initiated in-depth discussions in this field, bringing together subcontractors – who play a major part in guaranteeing the safety of nuclear facilities –, operators, technical safety experts, university experts, NGOs, etc. with a view to draw lessons for future progress. As regards the 'hardened safety core', after we had determined in 2012 the main features of the hardened safety core, we are currently in the process of defining the external load level – notably with respect to earthquakes – to be used as a basis for dimensioning the design of the corresponding SSCs, since this is a prerequisite for the operators to place orders and start upgrading work. Another matter of importance is the progressive deployment by EDF, until mid-2014, of a 'quick nuclear intervention force' aimed to be sent within hours to any nuclear facility countrywide, in the event of an accident.

What does ASN expect from the ETSON member TSOs for the future?

Generally speaking, the work performed as part of the stress tests was carried out in a national framework, with exception of the peer reviews. My feeling is that we should go one step further and, based on commonly defined goals, perform safety reviews at European level. This would give the initiatives taken by the nuclear safety authorities within WENRA and the TSOs within ETSON momentum for further harmonisation of practices on a continent where any severe accident would have inevitably transboundary impacts. 'Topical peer reviews' would provide regular opportunities to move in this direction. ✖

Nuclear risk: what do Europeans think?

How did public opinion evolve over the past two years regarding nuclear power? How present is the Fukushima Daiichi accident still in people's minds? The EUROSAFE Tribune provides an overview of some meaningful results from opinion polls conducted in four countries: Switzerland, the UK, Sweden, France and Germany.

The Swiss consider 'domestic' nuclear energy as safe and inexpensive

One and a half years after the Fukushima Daiichi accident, Swiss people still trust in nuclear energy. This is one of the main findings of a survey carried out in September 2012 by the opinion research company Demoscope on behalf of swissnuclear: a growing majority of the participants comprising 74% is confident that the Swiss nuclear power plants are safe (they were 68% immediately following Fukushima). This provides clear evidence that the negative impact of the accident is receding and that the respondents return to 'historic' values, which have varied between 75% and 83% over the past ten years.

In addition, the growing awareness of the economic advantage of nuclear energy is noteworthy – despite the Fukushima Daiichi accident: 34.4% of the participants in the 2008 survey considered nuclear power to be rather inexpensive, compared to 63.6% in 2012.

Attitudes to nuclear energy in Britain: a hint of indecisiveness, but no increase in opposition

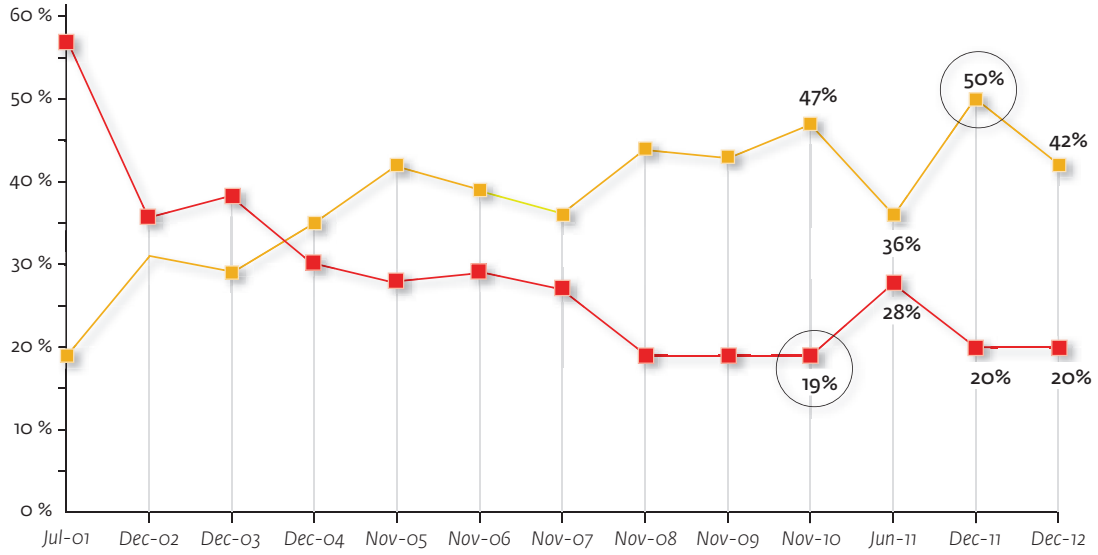
Support for nuclear new build in Britain has shown an upward trend in the decade to the end of 2011, notwithstanding the severe, but temporary, setback caused by the Fukushima Daiichi accident in early 2011. The June 2011 survey illustrated the impact of events in Japan, and the speed of recovery in the second half of the year. Support first overtook opposition as far back as 2004, and has outweighed it every year since then. The most recent survey, however, in December 2012, shows some loss of momentum and a hint of indecisiveness, although no increased opposition. With energy companies hesitating publicly, or pulling out completely from the development process, wrangles over guaranteed electricity prices and antipathy towards the proposed waste repository in Cumbria, the British public undoubtedly perceives that progress towards building new nuclear plants is anything but smooth or inevitable.

Swedish men are more in favour of nuclear power than women

The answers to the survey conducted over the Internet by the Swedish polling company Novus in May 2013 among a total of 1,013 randomly recruited Swedes provide the following main results: First of all, nearly four out of ten respondents agree with the idea that Sweden should keep using nuclear power and, if necessary, build new reactors. Secondly, men are more in favour of nuclear power than women, and elder people are slightly more positive than the younger generation. When they are asked where the safest nuclear power plants are

Support for nuclear new build in Great Britain

Q To what extent would you support or oppose the building of new nuclear power stations in Britain To replace those that are being phased out over the next few years? This would ensure the previous proportion of nuclear energy (i.e. 18%) is retained.



operated, their answer is clearly Sweden. Conversely, the greatest uncertainty exists with regard to the plants located in Russia and the Baltic States.

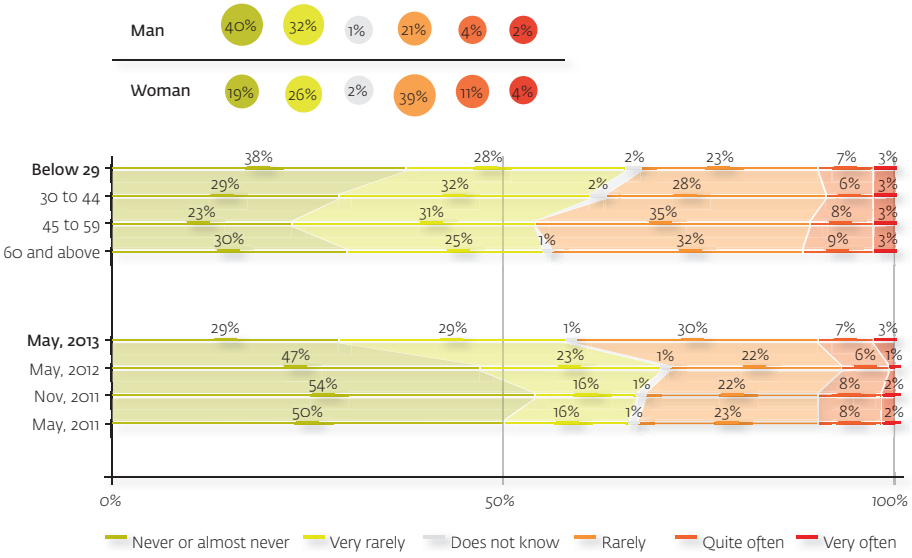
As regards the respondents' concern with respect to nuclear power, one in ten Swedes declared that he/she often becomes anxious when thinking of nuclear power. And when those who declared themselves anxious are asked how deep they feel this anxiety, nearly half of them answer that this feeling is "fairly deep" and that they are mainly worried about accidents. Last but not the least, to the question "Are you for or against old reactors to be dismantled and replaced with new ones to be built on the same site?" 49% of the respondents provide a positive answer, 21% do not know and 30% are against.

In France, economic and social issues overshadow the nuclear concerns

For nearly 30 years, IRSN has published an annual survey called the *IRSN Barometer on the perception of risk and security*. The scope of this survey is far broader than those performed in other countries, as it pertains to the perception by the French population of any kind of risk: economic, social, environmental, industrial, etc. Based on a face-to-face survey conducted by the polling institute BVA among 1,005 people in France in late 2012, the results published in the 2013 issue show that the primary concerns of the respondents are by far of an economic and social nature. Conversely, environmental concerns are down from 44% in 2007 to 21% in 2012. Similarly, far behind the economic and social concerns, nuclear risks are classified by 8% of

One in ten Swedes often becomes anxious when he/she thinks of nuclear power

Q Do you get anxious when you think of nuclear power?



the respondents only as their top concern, down from 18% in 2011 (by comparison, the average percentage was around 8% until 2010). The Fukushima Daiichi accident thus seems to fade in the minds, but 20% of the respondents still clearly see the risk of a catastrophic accident at an NPP. Finally, most respondents request pluralistic modes of nuclear risk management based on the sharing of safety assessment results.

The Germans support the phase-out of nuclear power and are in favour of research on radwaste disposal

In its 2nd quarter 2013 survey, the German opinion poll company Forsa asked a sample of 1,001 people about the nuclear phase-out. Firstly, to the question phrased "*Unlike many industrialised nations, Germany will abandon the use of nuclear power to generate electricity from 2023. Do you feel that this turnaround in Germany's energy policy encourages other countries that planned long-term use of nuclear power to phase out or that the German energy transition will not influence these countries?*" 31% of the respondent declared they think that the German decision will influence other countries, whereas 65% declared it will not. The second question pertained to whether or not the German Federal Government should push the countries that planned long-term use of nuclear power to phase out, too. 44% of the respondents declared Germany should push them to phase out, too, whereas 55% declared Germany should not interfere. Then Forsa asked a third question phrased: "*Intensive research is conducted on the safety of nuclear power plants and the disposal of nuclear waste as nuclear energy is still in use in Germany. Do you think such research should continue to maintain Germany's advance in these areas or should it be stopped?*" Regardless of the planned phase-out of nuclear power, 89% of the respondents believe that research on the safety of nuclear power plants and the disposal of nuclear waste should continue. Among them, 85% support the idea of continuing research pertaining to the geological disposal of radwaste and only 26% the development of new reactor concepts. ✖

Research: reconsider the assumptions used for calculations

Jean-Marc Cavedon is head of the Nuclear Energy & Safety Research Department and Member of the Board of the Swiss Paul Scherrer Institute as well as President a.i. of the Board of IRSN. He gives his views on the impact of the stress tests conclusions on future research priorities.

Stress tests conclusions and research priorities

The Fukushima Daiichi accident in 2011 revealed to the general public what nuclear scientists and engineers had known for decades: a nuclear reactor core meltdown can happen and trigger significant radioactive releases. Since the TMI accident in 1979, safety research endeavours to decrease the probability of occurrence of such an event. We consider that the core melt probability has been reduced by one order of magnitude every decade over the last three decades through research, backfitting and new design. The novelty is the rising awareness among nuclear safety experts that extreme loads can prove even more extreme than anticipated in the design, both in terms of intensity and frequency. This is where the real change occurred. Subsequently, the research 'portfolio' does not need to be fundamentally questioned, but the assumptions used for calculations should be carefully reconsidered. Moreover, the likelihood of combined events – whether external or internal – must be reassessed. We also learned that some old plants in Japan did not apply the backfitting measures recommended since long by nuclear scientists and engineers. But this is not an issue to be solved through research.

Including research programmes in the strategic research agendas of the European platforms

The prerequisite is a strong will to coordinate research at European level. Undeniably, everyone agrees on the need for close coordination, be the research related to power reactors or nuclear fuel cycle facilities. This was given concrete expression among the safety research community with the set-up of ETSON. The position paper on Generation II and III reactors issued by the member TSOs is a noteworthy contribution to the SNETP platform. So, I think a lot has been done already and the work to be performed from now on is to incorporate the updates from the stress tests in these documents.

ETSON has a leading role to play in this process

The issuance of the position paper mentioned above gave ETSON unquestionable credibility and this was a strong motivation for the Paul Scherrer Institute, PSI, to join ETSON. PSI will contribute the network its knowledge in such fields as reactor systems, thermal hydraulics, severe accidents and their mitigation – e.g. via our recently patented iodine filter. Conversely, being an ETSON member will allow PSI benchmarking computer simulations as well as experimental results through the shared use of experimental platforms. More generally, I think ETSON can play a leading role in updating and consolidating research knowledge by sharing state-of-the-art methods and tools. In this respect, PSI is ready to share in-house capabilities with its partners. ✖

European stress tests: consistency at all levels

From the set-out of goals through to the identification of research needs for better prevention and mitigation of severe accidents, the stress tests performed on the European nuclear reactor fleet and the follow-up actions show a high degree of consistency between the countries involved, as Frank-Peter Weiß, GRS Scientific-Technical Director and Jacques Repussard, IRSN Director General, explain.

In terms of goals

The stress tests can be considered as the first truly European initiative in the domain of nuclear safety, even if different countries added items of their own, which were not subjected to the European peer review, and even if the decisions about the consequences from the tests results are taken at national level. France for instance decided to apply the so-called 'complementary safety assessments' to all the nuclear facilities and not only to power reactors. It was also decided to have an insight into organisational and human aspects of risk. Germany included man-made hazards such as plane crash into the scope of its tests and applied its so-called 'robustness approach' according to which German experts looked at the different impacts from earthquakes, floods, etc., considering the margin between the design basis and the point of intensity at which a cliff-edge effect occurs. "*But besides these country-specific additions, the 'core' goals of the stress tests remain the same for all countries,*" Jacques Repussard points out.

In terms of conclusions

The European stress tests came up with some essential findings that apply, to a greater or lesser extent, to all the nuclear facilities in all the countries involved in the stress tests. "*It should be recalled that the stress tests did not come up with the conclusion that any plant should be stopped in the short term,*" Frank-Peter Weiß emphasises, "*even in Germany, the shutdown of eight reactors was not a consequence of the stress tests.*"

In terms of action plans

Different measures are taken in different countries because of the specific features of the fleets, but the goals remain the same, i.e. enhancing accident prevention in the event of a prolonged loss of power supply or the heat sink, and enhancing accident mitigation resources to cope with a severely degraded situation. "*In France for instance, it was decided to add a 'hardened safety core' set of equipment, built to reinforced standards with respect to seismic aggressions, in order to reinforce the plants' capability to cope with such situations,*" highlights Jacques Repussard.

In terms of safety research

A major consequence of the stress tests is to re-launch research on aspects such as the re-flooding of a molten core, for example. NUGENIA, the European nuclear safety research platform, is addressing these issues in its strategic research agenda in order to enhance the safety of generation II and III reactors through research. "*As regards research, the* **>ETSON stress tests workshop<** *in Garching came up with the recommendation to have a workshop on post-Fukushima research early next year. This will be a valuable step to prepare the ETSON presentation at the TSO conference in Beijing in April 2014,*" Frank-Peter Weiß concludes.

>ETSON stress tests workshop<
A two-day seminar organised by the European TSO Network (ETSON) and hosted by GRS in Garching, near Munich, on March 25-26, 2013 with a view to gaining greater understanding of the initiatives that could be taken jointly to further harmonise the safety assessment methods and practices (See page 32).

From lessons to actions

From the definition of their goals to the implementation of the action plans derived from their conclusions, the European stress tests ushered in a new era of close collaboration among countries that operate nuclear power capacities, among NRAs and TSOs, among countries and international organisations... Could this be the basis of a New Deal in the nuclear sector?

Working jointly to ensure a consistent definition of the stress tests

> "The stress tests should not be considered as a one-off exercise, but rather as an on-going process to improve nuclear safety in the EU."

Massimo Garribba
DG Energy
European Commission

The European Commission and the Member States' national authorities worked closely together to define goals and methods for the stress tests to be performed on the European nuclear facilities. The defence-in-depth approach was the central issue in this work.

"*Stress tests or targeted risk and safety assessments of nuclear power plants in the EU were launched on a voluntary basis, as a response to the Fukushima Daiichi accident. In May 2011, the European Commission and the European Nuclear Safety Regulators Group, ENSREG, reached agreement on the methodology and the timetable of the stress tests,*" Massimo Garribba, Head of the Nuclear safety architecture and multilateral & international cooperation unit at the EC's Directorate-General for Energy, recalls. Both the EC and the Member States' national authorities agreed upon the aim of the tests: assessing whether safety margins used in the licensing of nuclear power plants are sufficient to cover extreme external events, such as earthquakes and floods, which could result in the shut-down of safety systems. "*A defence-in-depth logic was applied, starting with the assumption of initiating events to derive a consequential loss of safety functions and the appropriate management of severe accidents,*" Mr. Garribba explains. While the stress tests focused on extreme natural events such as earthquakes and flooding, other accident scenarios – e.g. extreme weather conditions or aircraft crashes – have also been taken into account to some extent. The work done on loss of safety systems and severe accident management was indeed relevant to all large accidents regardless of the initiating event.

A consistent approach at EU and national levels

In its capacity as scientific and technical support to the French Nuclear Safety Authority, IRSN contributed to the work performed to provide a first definition of the complementary safety assessments (CSA) in order to check the robustness of the plants against extreme events similar to those that occurred in Japan. IRSN's deputy director-general in charge of nuclear safety Thierry Charles stresses the two-fold approach of these CSA: "*On the one hand, a nuclear safety audit on the French civil nuclear facilities in the light of the Fukushima event, which was requested by the French government, and, on the other hand, the organisation of 'stress tests' requested by the European Council.*" The French TSO played an important part in the discussions which resulted in the evaluation of the NPP response when facing a set of extreme situations, assuming a progressive loss of the lines of defence-in-depth, irrespective of the probability of the situations considered: initiating events (earthquake, flooding, other extreme natural events), consequential loss of safety functions (electrical power, core and fuel pool cooling) and severe accident management. The aim was to evaluate the robustness of the defence-in-depth approach and to identify, for each of the considered extreme situations, any potential weak point and cliff-edge effect and the modifications to enhance safety.

The 960-MWe PWRs Shin Kori 1 and 2 operated by KHNP/KEPCO are located on South Korea's south-east coast near Busan, the country's second largest metropolis.

Performed by the EU's 'nuclear' member states plus Switzerland and Ukraine, the European stress tests were carried out with some differences, notably in the scope considered. The action plans derived from the conclusions of the national reports peer-reviewed by TSO experts also differ in terms of scope, priorities and scheduling. Similar safety reassessments were performed in other countries such as Japan or Russia. The country-specific focuses described below provide an overview of the similarities and dissimilarities between twelve countries which are represented at EUROSAFE. One common denominator among them might be the fact that the conclusions from the stress tests did not reveal any major deficiency calling for immediate steps to be taken.

Major outcomes of the stress tests: learning from each other

Belgium > In addition to the scope of the European stress tests, the Belgian nuclear safety authority (FANC), working in close relationship with the Belgian TSO (Bel V), included specific features in the specification file of the safety assessment to be performed on the Belgian NPPs. This comprised notably man-made hazards such as plane crashes, cyber-attacks or blasts in neighbouring industrial plants. The more than 300 actions proposed by Electrabel, operator of the Belgian NPPs, to upgrade the design and the operating organisation of the plants were assessed by FANC and Bel V to identify either potential safety gaps calling for more detailed studies, or difficulties in implementing the corresponding action plan; these actions are to be completed by the end of 2014. Together with FANC, Bel V supervises the implantation and the follow-up of the plan, and monitors changes as time progresses. Emphasis was placed on river flooding, as it appeared that the reference for historic floods at the Tihange site was actually close to several 100 years, while a 10,000-year return period should be considered. Non-conventional protection means were thus added with the highest priority, and a site perimetric protection will be constructed in 2014 to take into account the new flood reference in the site design.

Nuclear safety is a process of continuous improvement enshrined in Swiss law. In this respect, the national action plan provides clear and comprehensive information on how the safety of the country's NPPs will be improved following the recommendations and suggestions of the European stress tests. Several measures deal with accident mitigation and emergency situations preparedness, such as the set-up of a national storage of accident management equipment at Reitnau in June 2011. In addition, several commendable practices were identified, including multi-agency safety reviews (IDA NOMEX project), the fitting of all NPPs with seven layers of AC power generation, and complex seismic hazard reassessments (PEGASOS project).

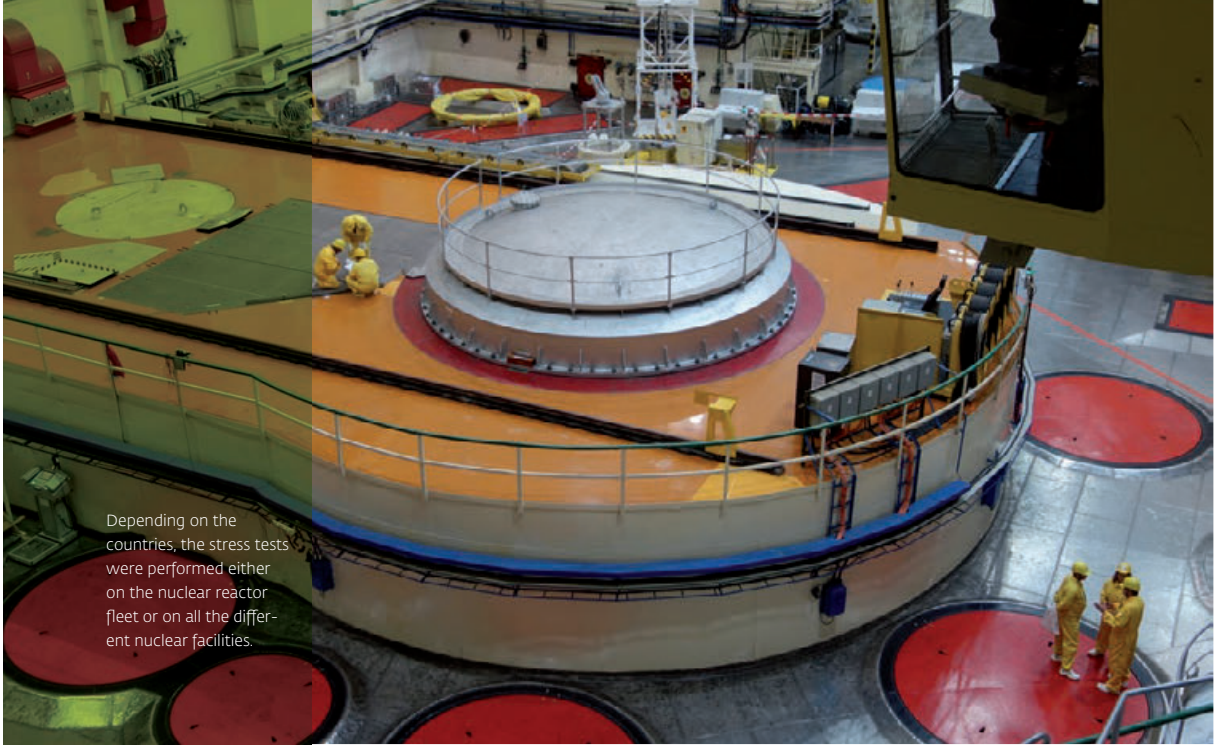
Swiss Federal Nuclear Safety Inspectorate ENSI

Could stress tests be the prelude to regular peer reviews ?

Czech Republic > The conclusions from the report on the stress tests of the Czech NPPs conducted under ENSREG's guidance were used as a basis by SÚJB, the Czech regulatory body, to prepare the National Action Plan, a legally binding document which will be monitored at least twice a year. During the assessment and the preparation of the report, SÚJB was technically supported by the TSO-Centrum of Research Řež. The National Action Plan includes a series of safety improvement measures to be implemented before December 2015, such as the installation of additional diesel generators, seismic strengthening of selected buildings, the installation of hydrogen recombiners, the strengthening of intervention groups, the construction of an alternative ultimate heat sink (at Dukovany), the review of the severe accident management guide, emergency training as well as the conduct of feasibility studies and experiments on in-vessel retention and vented containment (at Temelín).

Finland > Based on the results of the assessments conducted in Finland to date, the Finnish National Action Plan concludes that no hazard or deficiency has been found that would require immediate actions at the Finnish NPPs. The Action Plan addresses the measures initiated both at national and at NPP level as a result of the Fukushima Daiichi accident. At national level, it includes actions in various domains such as natural hazards, design issues, severe accident management and national organisations, emergency preparedness and response and post-accident management (off-site). In the field of international cooperation, the Action Plan involves Finland's participation notably in the IAEA's International Seismic Safety Centre (ISSC), in WENRA's Reactor Harmonisation Working Group (RHWG), in the NEA's Committee on Nuclear Regulatory Activities (CNRA) and in the Steering Technical Committee (STC) of the NEA's Multinational Design Evaluation Programme (MDEP) and EPR design specific working group.

France > Complementary safety assessments (CSAs) based on specifications consistent with those requested by the European Council for the



Depending on the countries, the stress tests were performed either on the nuclear reactor fleet or on all the different nuclear facilities.

The stress tests did not reveal any deficiency calling for immediate steps to be taken.

stress tests were performed by the licensees in 2011. The CSAs included the power reactors in operation or under construction (EPR), as well as all other nuclear facilities considered by ASN to be a priority. The outcome is that the nuclear power plants are robust to the hazards considered in the baseline safety requirements. However, ASN considered that the safety of nuclear facilities should be made more robust to unlikely risks, significantly larger than those currently included in the initial design of the facilities or following their periodic safety review. In this spirit, significant provisions to improve the safety of French nuclear facilities were proposed, such as the implementation of a 'hardened safety core' aimed at preventing a severe accident or limiting its progression; preventing large-scale releases in the event of an uncontrolled accident; and enabling the licensee to perform its emergency management duties as well as the creation of a 'Nuclear Rapid Response Force'.

Germany > Immediately after the accidents at the Fukushima Daiichi NPP, the German Federal Government decided to perform stress tests on the robustness of the 17 NPPs with regard to beyond-design external impacts, including man-made hazards. Specific robustness scales were developed to represent the design margin to yield point for the various impacts under consideration. Depending on the plant being analysed, the results show some margins regarding the beyond-design hazards. No major weaknesses that would necessitate immediate actions at the German NPPs were found, neither in these national stress tests, nor in the EU stress tests. Nevertheless, the German Reactor Safety Commission RSK decided to reassess some issues related to external hazards in more detail such as the potential loss of the ultimate heat sink, earthquakes occurring during low-power and shutdown operation as well as the implementation of severe accident management guidelines and other measures.

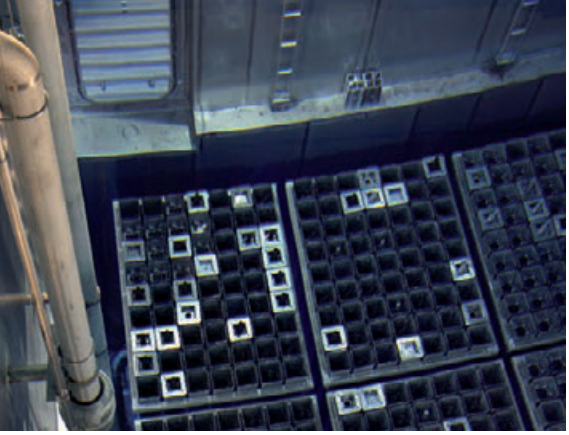
Japan > Reformed in 2012, the new Japanese nuclear safety regulation system stipulates that the safety of the nuclear facilities should be assessed in accordance with the revised standards. The comprehensive safety assessment of NPPs was ordered before the entry into force of this new regulation. This two-stage process consisted in a primary assessment aimed to determine whether or not to resume operation of the NPPs under annual outage, and a secondary assessment planned to judge whether or not to shut down operating NPPs. The operators undertook the primary assessment at their 30 NPPs. Two of them obtained the endorsement from the Nuclear Safety Commission to resume operation as of July 2013.

Taking into account the lessons learned from the Fukushima Daiichi NPP accident, the new regulatory requirements are focused on strengthening of the design basis, severe accident measures (prevention of core damage and containment failure), and enhanced measures against earthquakes/tsunamis. The safety of nuclear facilities is being assessed in light of the new regulatory requirements enacted on July 8, 2013.

Lithuania > The stress tests performed in Lithuania on units 1 and 2 of the Ignalina NPP (currently under decommissioning) and the spent fuel interim storage facilities led to a series of measures to enhance safety of the nuclear facilities. Several provisions pertain to the seismic hazard, such as the prevention of spent fuel cask tip-over, seismic alarm and monitoring system, and emergency preparedness for the existing and new spent fuel interim storage facilities. Others address the power supply to the instrumentation and control system in the spent fuel storage pools, the fuel supply for assuring long-term operation of diesel generators and the upgrading of the information system to improve the information transfer on the spent fuel storage pools of both units to the main control room, the accident management centre and Lithuania's State Nuclear Power Safety Inspectorate (VATESI).

Russia > The major outcomes from the supplementary safety assessment of the Russian nuclear plants in 2011 highlight the compliance of the NPPs operated in the Russian Federation with the current nuclear regulation, the appropriateness of the short-, medium- and long-term actions developed by Rosenergoatom, the utility to improve the safety of its NPPs, and the suitable update of the Russian regulatory framework in the field of nuclear energy use. In 2012, Rosenergoatom performed a supplementary assessment of the new Russian NPPs, currently under construction or siting with regard to extreme and combined external loads. The review performed in April 2013 by Rostechnadzor, the Federal Environmental, Industrial and Nuclear Supervision Service, on eleven units under construction as a complement to the previous stress tests show that the utility has analysed the lessons from the Fukushima Daiichi accident, modifying accordingly, among other actions, the design of the units concerned with the introduction of additional technical features. For instance, additional mobile diesel devices are planned as part of the Novovoronezh-2 project. Moreover, quick-connection pipelines and mobile cooling units will guarantee heat removal to the ultimate heat sink in case of long-term blackout or long-term loss of heat removal systems.

Slovakia > The results of the stress tests performed on the Slovak NPPs were submitted to ÚJD, the national nuclear regulatory authority. ÚJD assessed the National Action Plan prepared by Slovenské elektrárne, a.s., the Slovak utility. The Plan, a legally binding document for all NPPs, will be implemented and regularly inspected as part of ÚJD's annual inspection plan. The 57 measures recommended are divided into two groups: short-term measures to be finished by 31/12/2013, and medium-term measures to be finished by 31/12/2015. Examples of some important measures involve the provision of new 0.4 kV diesel generators and alternative means for feeding the steam generators, the functional duplication of power supply and of the borated-water reservoir system, the remote control of severe accident equipment from emergency response centres, the construction of independent lines for refilling the spent fuel pools using a mobile source, the installation of permanent means against the penetration of water into safety-important buildings in the case of flooding... not forgetting, of course, the personnel training for intervention and mitigation in case of extreme external events.



(From left to right)
Maintenance work performed on a Diesel engine at an EDF plant / Ten-year inspection of the spent fuel cooling pool at Cattenom unit-3 NPP.

Spain > In May 2011, the Consejo de Seguridad Nuclear (CSN) sent a series of legally binding orders called 'Complementary Technical Instructions' to all nuclear power plants to perform the stress tests agreed by WENRA/ENSREG. The reports conclude that the design bases and the licensing bases set for each facility are currently fulfilled and no safety-relevant weakness has been identified which could require the urgent adoption of measures. The verifications and studies that have been conducted reveal the existence of margins that ensure that the safety conditions of the plants are maintained beyond the cases contemplated in their design. However, a series of preventive and mitigative measures are proposed to increase the plants' capabilities to respond to extreme situations: provisions to withstand an extended power outage, cooling water injection, passive catalytic recombiners, filtered venting systems, enhancement of communications systems, an alternative emergency management centre, a centralised emergency support centre able to respond in 24 h, etc. In addition, CSN issued specific orders aimed to mitigate the extreme situations resulting from events induced by malicious acts.

Switzerland > The EU stress tests provide renewed confirmation that Swiss nuclear power plants maintain a high standard of safety, and that the measures implemented on the basis of the knowledge gained from the Fukushima Daiichi accident are correct. The plants feature notably a high level of protection against impacts from earthquakes, flooding and other natural hazards, and also against power supply and reactor cooling failures. The Swiss Federal Nuclear Safety Inspectorate (ENSI) has identified a further eight 'open points' out of the stress tests which supplement the 37 checkpoints derived from the safety analysis in Switzerland initiated just after the accident at Fukushima Daiichi. Three of these eight measures relate to protection against earthquakes, two concern emergency management and the three remaining ones deal respectively with protection in case of flooding, extreme weather events and loss of power supplies. Processing of the identified points is due to be completed by 2015. To achieve this goal, ENSI will present an annual action plan and will report on the status of work. The list of the points mentioned above will be reviewed and updated continuously drawing upon the latest knowledge.

Ukraine > The stress tests and peer review exercise performed by Ukraine under ENSREG's aegis covered the 15 reactors in operation, the 3 permanently shut down units at Chernobyl as well as the 2 spent fuel storage facilities operated at Zaporizhzhya and Chernobyl. The resulting National Report has been made available to the public and subjected to an international peer review. It has not revealed any significant external hazards or combinations that had not been considered in the design and/or in previous safety reports. It confirmed the reliability of operating plants in ensuring safety functions and the importance of on-going safety upgrades. In addition, areas for tangible improvements have been identified and dedicated measures such as, for instance, providing mobile equipment to secure the main safety functions under station blackout or introducing filtered containment venting at all VVER-1000 plants have been included accordingly in the National Action Plan, currently under implementation. ✖

The contribution of the peer reviews of the European stress tests

Two years after the Fukushima Daiichi accident, the complete understanding of the event remains to achieve. However, the stress tests performed at nuclear power plants, which followed a decision of the European Council of March 2011, and their subsequent peer review already resulted in the launch of a first-of-kind improvement process of nuclear safety across Europe. As the Chairman of the European peer review of the nuclear reactor stress tests, French Nuclear Safety Authority Commissioner Philippe Jamet provides an ENSREG perspective on this process.

What is new about the stress tests compared with previous safety assessments?

Although significant safety improvement programmes had been completed or were on-going in many countries prior to the accident, the post-Fukushima stress tests provided a unique opportunity to submit, at the same time, 140 nuclear reactors to an assessment based on common terms of reference and to compare the results between the 17 participating countries: all the EU's nuclear power countries as well as Switzerland and Ukraine.

What are the follow-up actions to the stress tests conclusions?

Pursuant to these stress tests, European countries identified further analysis needs, hardware improvements as well as organisational and regulatory actions and defined the corresponding implementation schedule in national action plans. Many activities, notably technical studies, have now been completed or are on-going and all modifications are scheduled for implementation by the end of the decade. The main enhancements which will result from these on-going actions are: improvements related to containment integrity in order to prevent off-site contamination, the strengthening of the robustness of installations beyond existing safety margins and a range of measures to better cope with severe accident management. In this respect, ensuring all aspects of installation safety while performing ambitious programmes within a tight schedule will certainly prove challenging.

Should such coordinated safety assessments be performed again in the future?

Undeniably, the stress tests process demonstrates the great value of a coordinated approach to nuclear safety among European countries, in particular through peer reviews, which led to effective decisions at national level. As a result of the Fukushima Daiichi disaster, which recalled that a nuclear accident is always possible despite all the precautions taken, EU Member States will definitely have taken a large step towards the continuous improvement of nuclear safety. In the future, this continuous process should imply other coordinated safety assessments, focused on specific issues.

Methods & Organisations

The post-Fukushima era is marked, in several countries as well as international organisations, starting with the IAEA, by a reorganisation of nuclear safety from different perspectives. To a greater or lesser extent, organisations in charge of implementing the updated regulatory framework undergo changes aimed at greater effectiveness, notably as a result of efforts in training and skill-building.
The goal: improve the management of crises and nuclear emergency situations with the ultimate aim of better protecting man and the environment against radiological hazards.

The Fukushima Daiichi NPP accident deeply questioned the bases of nuclear safety and nuclear safety regulation in Japan. It also resulted in a considerable loss of public confidence in the safety of nuclear power across the world. Although the accident was caused by natural phenomena, institutional and human factors also largely contributed to its devastating consequences, as shown by the Japanese Diet's and Government's investigation reports. "*Both regulators and licensees were held responsible and decided to fully reconsider the existing approaches to nuclear safety. Consequently, the regulatory system underwent extensive reform based on the lessons learned from the accident,*" Yoshihiro Nakagome, the President of Japan Nuclear Energy Safety Organisation, an ETSON member TSO, explains.

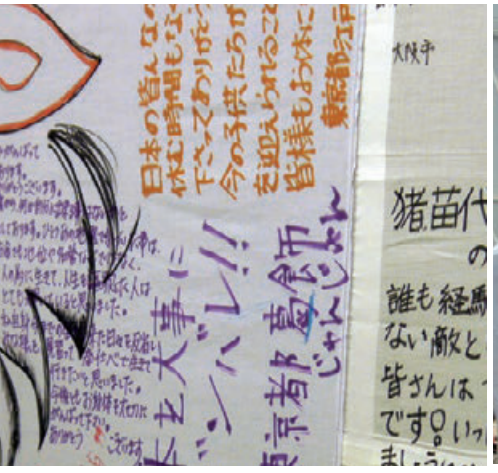
Japan reforms its nuclear safety

Re-building the safety regulatory organisation

The latest insights and best practices worldwide were taken into account to re-build the safety regulatory framework, especially as regards the restructuring of regulatory bodies, the revision of laws and regulations, and the incorporation of the latest technical knowledge as well as the Integrated Regulatory Review Service (IRRS) findings. The reform basically focused on securing the regulator's independence, consolidating its functions and developing new requirements in this field. "*To secure regulatory independence, the Nuclear Regulation Authority (NRA) was established in September 2012 as an external organisation of the Ministry of Environment. It replaces the former Nuclear and Industrial Safety Agency (NISA) placed under the Ministry of Economy, Trade and Industry, in charge of promoting the development of nuclear power. The NRA carries out its mission to protect people and the environment through rigorous and reliable regulation, in accordance with the principles of independent decision-making, effective actions, open and transparent organisation, improvement and commitment, and quick and effective emergency response,*" emphasises the President of JNES. The Japan Nuclear Energy Safety Organisation (JNES), which used to be NISA's TSO, now supports the NRA, and future integration of JNES' functions into the NRA is being considered.

A far more robust legal and regulatory framework

The revised law entered into force on July 8, 2013. It mandates severe accident measures as well as safety back-fitting based on the latest technical knowledge, and imposes a 40-year operation limit as a general rule for ageing management. "*Based on the lessons learned from the accident, the regulatory requirements were considerably revised by incorporating the IAEA's safety standards and by strengthening defence-in-depth: elimination of common cause failures, enhanced protection against extreme natural hazards, and incorporation of measures against intentional aircraft crash*", Mr. Nakagome comments. Moreover, the requirements for severe accident measures were enhanced in terms of prevention of core damage, ensuring of containment integrity, suppression of radioactive release, deployment of portable



regulatory framework

equipment, protection of spent fuel pools and emergency response facilities and systems.

The new design bases incorporate improved earthquake/tsunami measures, considerations for other natural hazards, improved fire protection measures, enhanced off-site power sources and protection of ultimate heat sinks. The requirements for diversity, independency and redundancy were enhanced to reduce common cause events and common use of equipment was further restricted, including passive components. A safety review of the existing plants is in progress, in accordance with the new requirements.

Going forward with effective implementation

To keep the safety regulation up-to-date, the requirements should be reviewed and updated, as appropriate, in light of the latest technical knowledge and experience. For that purpose, the NRA established new departments responsible for the development and implementation of the regulatory requirements, acquisition of necessary technical insights and coordination of safety studies for strengthening the technical bases. "*JNES has contributed to this by actively undertaking high priority safety studies on the basis of the lessons learned from the accident*", Mr. Nakagome points out.

The NRA was established to learn the lessons from Fukushima Daiichi.

International cooperation is indispensable also in this area, including collection of new insights and experience from other countries as well as feedback from communities worldwide. International cooperation via the IAEA, the OECD/NEA and bilateral/multilateral channels should be stimulated more than ever. JNES, in collaboration with the NRA, is promoting such international activities, including cooperation through TSO networks such as ETSON.

Providing for highly competent human resources

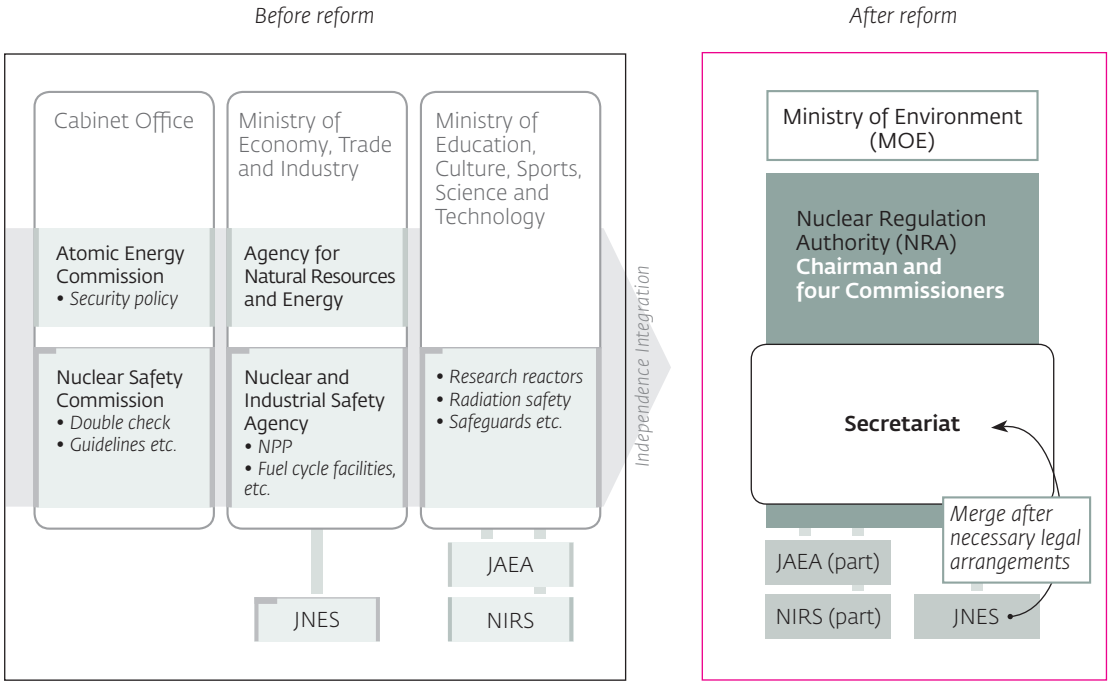
"*Technical competency is a prerequisite for effective regulation based on scientific and engineering judgment*", the JNES President reminds. The new regulatory requirements are performance-based and provide the licensees with flexibility in selecting approaches to meet specific safety requirements. A safety review based on such requirements demands a high level of technical competency of the staff involved in the review process, including at TSOs.

As required by law, the Government should secure and foster the human resources, in order to allow efficient and effective regulatory work backed by technical competency. "*The NRA and JNES will continue to actively recruit staff with adequate expertise and experience. Cooperation with universities, international organisations and overseas nuclear regulatory agencies will be further promoted also for human resource development*", Yoshihiro Nakagome asserts.

Restoring public confidence through continuous improvement

The NRA was established to learn the lessons from the Fukushima Daiichi accident, to prevent such an accident from happening again, to restore worldwide public confidence in nuclear safety regulation, and to rebuild nuclear safety management including an improvement of safety culture. "*To restore the lost confidence, it is essential to continuously improve the regulation and successively achieve satisfactory performance in line with the approaches mentioned above. In cooperation with the NRA, JNES will devote maximum efforts to achieve this goal,*" its President concludes.

The reshaping of the nuclear safety regulatory organisation in Japan



JNES: Japan Nuclear Energy Safety Organisation (Inspection, safety analysis and evaluation, etc.)
JAEA: Japan Atomic Energy Agency (Nuclear safety research, etc.)
NIRS: National Institute of Radiological Sciences (Radiation research, etc.)

Planning mitigation as carefully as prevention

Taking stock of the Fukushima Daiichi accident and of the outcomes of the European stress tests implies a new appreciation of safety margins and, subsequently, of the adequacy of organisations aimed at providing such margins, especially in the mitigation area. Three senior experts from ETSON member TSOs, Peter Hardegger (PSI), Miroslav Hrehor (ÚJV Řež) and Marc Vincke (Bel V) - from left to right below - exchange views on this subject.

Miroslav Hrehor

Scientific Secretary
Nuclear Research Institute
Řež (ÚJV Řež)

The Fukushima Daiichi accident and the stress tests highlighted fundamental issues that should have long been paid utmost attention and were overlooked – or perhaps misunderstood. One of them is the importance of external events that nuclear power plants are more or less well protected from, depending on the country and operators.

Marc Vincke

Global Projects Manager
Nuclear Safety and Radiation Protection Projects
Bel V

Right, Miroslav, in Belgium, for instance, the most recent units include a second level of protection against external events to be considered at the design stage. We thus set a threshold for earthquakes, floods, storms, etc. and prescribe design provisions to make sure nuclear facilities can at least withstand this level of load and more, taking some safety margins. In this regard, let me recall that all units are not on an equal footing with respect to this type of stress, depending notably on their age.

Peter Hardegger
Technology Transfer & Controlling
Paul Scherrer Institute

You are addressing a very important point, I mean the potentially 'beyond design' nature of such events. What if the load exceeds what was anticipated? How can the units resist that? According to the solicitations, margins can be either important or conversely almost non-existent. If you take earthquakes for instance, the dimensioning of a given facility may have left some 'room'. But if you take floods, things are more binary: you are above or below the level. Stress tests have put the spotlight on such aspects.

Marc Vincke

Another point I would like to underline pertains to mitigation. In the past, many operators used to think in terms of decoupled mitigative means: water, power, etc. They thought they had water reserves for so many days, power reserves for so many days and so on, before concern arises. And it was quite commonly assumed in the safety analyses that these reserves would give the operator sufficient time to solve the water issue, or the electric power issue, etc. The Fukushima Daiichi accident and the stress tests provided clear evidence of the erroneous nature of such reasoning. You might indeed have water reserves for ages, but what does it help if you cannot pump that water because electric power is suddenly unavailable? The lessons made regulators and operators aware of the impossibility to leave the organisation of mitigation to chance.

Peter Hardegger

Absolutely! And this represents a major organisational change within European nuclear safety. Among other things such as periodic safety reviews with a focus on external events, we are now placing emphasis on the necessity of planning accident mitigation as carefully as prevention. We all know that, if we want mitigative capacities to be available at the right time, we must anticipate their availability both from a technical and from an organisational perspective. This is the notion of emergency plan. (Continued on p. 30)

3 questions to...

Denis Flory

on crisis management and emergency preparedness

In his capacity of Deputy Director General of the IAEA and Head of the Agency's Department of Nuclear Safety and Security, Denis Flory was actively involved in the steps taken by the IAEA to update its crisis organisation and enhance its capabilities as regards actions related to assessment and prognosis.

What conclusions did the IAEA reach from the Fukushima Daiichi accident with respect to managing crises and nuclear emergency situations?

Two main conclusions were reached, the first one being that the IAEA's role in response to a radiation emergency should be extended to analysing available information and predicting possible scenarios for emergency development, consequences, associated radiological impact and response actions. This is to be carried out based on the capabilities of the Agency's 159 Member States, but many of them do not have such capabilities, and rely on information and assessment provided by the Agency to assist them on response measures in case of a nuclear emergency. The second conclusion – and recommendation – was that Member States should make more systematic use of the IAEA Emergency Preparedness Review missions (EPREV) to appraise national emergency preparedness and response arrangements. These two points are part of the IAEA Action Plan on Nuclear Safety, which includes 12 key areas.

How does the Agency intend to align its crisis organisation to this new context?

Our mantra has been to build on our Member States' capabilities, and also to better coordinate and federate international initiatives. In this view, we took different steps, starting with the establishment of an Emergency Preparedness and Response Expert Group to advise us on strengthening and sustaining international preparedness. We also launched a revision of the Joint Radiation Emergency Management Plan of the International Organisations within the Inter-Agency Committee on Radiological and Nuclear Emergencies. Thirdly, we developed operational tools and procedures for use in the event of an emergency, based on the most effective assessment and prognosis systems provided by our Member States through RANET, the Response and Assistance Network. Then, we updated our regular exercise regime to include issues related to assessment and prognosis as part of full response exercises, the November 2013 ConvEx3 exercise providing an opportunity to organise assessment and prognosis related actions, including communication of results with Member States and the general public. Finally, we have recently developed a mapping capability to incorporate monitoring data provided by our Member States with a view to sharing these data with our Member States and the public at large.

What support does the IAEA expect from its Member States and partners in this process?

At a global level, the acknowledgement of the beneficial role of the IAEA's peer review services leads to an increased need for expertise to be contributed by key experts from our Member States. RANET has been expanded to allow an as effective as possible use of the Member States' capabilities for assessment and prognosis related actions, and we 'actively' expect that more Member States will register their national assistance capabilities under RANET, including with regard to on-site mitigation needs during a nuclear emergency. ✖

A comprehensive re-assessment of the NPPs – in operation and also in permanent shutdown – has been performed in Germany on a national level as part of the EU stress tests. Several strong points have been identified which are mainly based on the continuous upgrading of the NPPs and, in particular, on the accident management measures performed to comply with recommendations by the Reactor Safety Commission (RSK). However, areas of improvement have also been identified, such as the further development of Severe Accident Management Guidelines (SAMGs) and the extension of battery capacity. The insights resulted in a considerable upgrading programme which is mainly focused on measures aimed at increasing the robustness of the NPPs against beyond-design-basis loads. These measures include e.g. the provision of additional mobile equipment and its storage in secured buildings. A further driver for upgrading measures is the 'GRS Information Notice' which includes eleven recommendations derived from lessons learned from the Fukushima Daiichi accident like SBO coverage for at least 10 hours, a diverse ultimate heat sink and two separated feeding points for the connection of mobile equipment. Information Notices are prepared by GRS on behalf of the Federal Environment Ministry (BMU) containing recommendations for a further improvement of the safety of German nuclear power plants.

Dieter Müller-Ecker
Expert,
Reactor Safety Analysis
GRS

Miroslav Hrehor Definitely, the Fukushima Daiichi accident and the stress tests gave impetus to this fundamental change. The catastrophe pointed out particularly the necessity to improve preparedness for accidents that impact multiple units and leave on-site infrastructure devastated. Some provisions existed of course in this field, but they needed to be improved, systematised in a concrete and pragmatic manner. Anticipation, organisation and quality still needed to be developed to a level up to the potential accident scenarios, to make sure that what we engineer to manage the situation will be definitely available when it is needed, thanks to the specifications imposed on equipment and also to the monitoring of mitigation equipment failure. This supplementary level of protection supports other levels in case an issue arises.

Peter Hardegger This evolution is equivalent to extending the 'conventional' design provisions to what is still regarded as 'unconventional' means! However, such an evolution is not only a technical and methodological one, but also a cultural one. The organisational change must be accompanied by appropriate communications, monitoring, support, etc. both at the nuclear facility and at corporate levels. And this is the third fundamental point: successful mitigation requires a boost of emergency response plan set-up amongst operators at unit and corporate levels. This represents a major cultural evolution for a community that had a traditional aversion reflex to the simple mention of mitigation measures, as this implies the underlying recognition that accidents can actually happen.

Special Focus

ENHANCING SAFETY ON LAND AND AT SEA

Stress tests results of safety assessment: current position and

With a view to gain greater understanding of the initiatives that could be taken jointly to further harmonise the safety assessment methods and practices, the members of the European TSO Network (ETSON) held a two-day seminar hosted by GRS in Garching, near Munich, on March 25-26, 2013. Bringing together eight of the eleven ETSON member TSOs, this workshop provided insights into different topics to the participants, such as the results from the national and European stress tests, the national actions resulting from the stress tests conclusions, and future ETSON activities. The EUROSAFE Tribune reports on the highlights of this meeting.

Results of national and European stress tests

The first session of the Garching workshop was devoted to the presentation of the stress tests results in eight ETSON member countries, starting with **Germany**, where the stress tests performed on the robustness of the 17 NPPs with regard to beyond design external impacts, including man-made hazards, showed no weaknesses within the frame of the national and EU stress tests. The German Reactor Safety Commission, however, decided to re-assess the potential loss of the ultimate heat sink as well as the impact of earthquakes occurring during low-power and shutdown states.

In **Belgium**, the safety assessments performed encompassed criteria – such as aircraft crash, explosions, toxic gases and cyber attacks – beyond the EU stress tests definition. The results showed that further consideration is needed with respect to fires, cliff-edge effects, and a re-evaluation of criticality.

In **Lithuania**, all existing nuclear installations were considered, including stopped NPPs under de-fuelling. Criticality and cooling capacities were assessed for external hazards such as defined in the EU stress tests for non-power reactors, some additional measures were proposed to the regulatory authority.

The safety assessment performed in **France** on the 59 NPPs and the main fuel cycle plants revealed that protection against external hazards and fires had to be further analysed. In the meantime, a set of provisions against beyond design basis accidents, such as additional diesel generators and a 'Nuclear Rapid Response Force' (FARN), is implemented in the short-term, additional margins in robustness being obtainable by the operator in the longer run through a 'hardened safety core' programme.

and alignment

prospects by ETSON TSOs

In-situ inspection carried out at the Institut Laue-Langevin's nuclear research facility in Grenoble (France) as part of the European stress tests.

In the **Czech Republic**, the stress tests exercise showed that the diversification of power supply sources should decrease the station blackout probability for the Dukovany and Temelín plants to a very low value, but also that the loss of the ultimate heat sink is still possible, calling for additional severe accident management measures to be taken. It was also shown that, among further features to enhance safety, the capacity to retain the corium in the vessel needs more detailed investigations.

In the **Slovak Republic**, the assessment carried out with respect to earthquake, flooding and extreme weather conditions prompted the implementation of preventive measures on the Bohunice site, which was found to be insufficiently robust against flooding. Moreover, further severe accident management measures need to be taken in Bohunice and Mochovce.

Concerning the 15 **Ukrainian** NPPs with particular respect to seismic resistance, flooding risk and effects of tornados, the tests performed showed that the combination of station blackout and loss of the ultimate heat sink would lead to core damage within 3 to 18 hours depending on the plants, calling for measures to improve the water inventory. In addition, such a combination is supposed to be mitigated through fire brigades mainly, and different severe accident management strategies, such as filtered containment venting.

Last of the eight ETSON countries to be reported on, **Switzerland** has received very good evaluations and belongs, despite the age of some of its reactors, to the best in class category. The permanent proactive investment in the improvement of the safety of the reactors by the operators has proved to be a very successful approach. However, needs for some improvements were identified as regards decay heat removal from the stored fuel and further protection of the primary containment integrity through venting and hydrogen build-up prevention. The other safety improvements decided pertain to additional measures in terms of feedwater supply (from nearby hydroelectric plants), cooling of the spent fuel pools, temperature and seismic instrumentation, as well as containment venting and integrity restoration.

Generally speaking, the participants in the workshop pointed out that no evaluation of margins to cliff-edge effects were performed as part of the EU stress tests, most probably because the corresponding input data are not clearly defined and best-estimate calculations are not available for all the yielding, destruction, ruin or collapsing mechanisms.

National actions resulting from stress tests

The second part of the Garching workshop was devoted to a presentation of the steps taken by various ETSON countries to enhance the robustness of their nuclear facilities regarding extreme natural loads. Among them, the presentation of the improvements considered for German

NPPs with respect to natural hazards was the opportunity to discuss ambiguous notions such as the 'return period': should it be understood as an average value, or as a median value? What probability distribution is assumed? Does the notion make sense at all? The debate showed how important the disambiguation of such concepts is, since they are used to characterise the event level and to dimension the corresponding preventive and mitigative measures. Another highlight of this session was the presentation of the general design approach proposed in Belgium for coping with beyond design basis external events with consideration of two bounding situations: flooding and station blackout following an earthquake. The approaches for ensuring the robustness of additional ultimate means – e.g. quality assurance, qualification and periodic tests, procedures for use and maintenance, integration into plant technical specifications, etc. – were introduced, drawing upon the example of the Tihange site, where the protection against beyond design basis floods is now mostly in place.

Discussion on future actions

Based on the different presentations and discussions held during the workshop, the experts gathered in Garching finally debated on the needs for future cooperation and on the recommendations to be proposed to the ETSON board and general assembly in July 2013. Six major initiatives emerged from the exchanges:

1. To hold a workshop on post-Fukushima research in January 2014 conducted by the ETSON members, as a preparation of the ETSON contribution to the 2014 TSO Conference in Beijing.

2. To organise an exchange of information and data among the ETSON partners on the implementation of passive features, active measures and procedures to enhance the robustness of NPPs. The discussion should focus on the so-called "hardened safety core" in France and the comparison with the approaches in other ETSON member countries.

3. To exchange information on the assessment of natural hazards. As a first step, PSI will present the results of the Swiss PEGASOS study on seismic hazards. Moreover, the debate would be broadened to include other natural hazards such as flooding and extreme weather conditions.

4. To evaluate the results of the OECD/NEA SERENA project on steam explosion issues with regard to the options and limitations of in-vessel melt retention.

5. To arrange a workshop on containment venting, as different technical solutions are implemented in the reactors of the ETSON member countries, with a view to discussing the pros and cons of the different solutions.

6. The development of a common and consistent approach for future NPP stress tests, making use of the lessons learned from the ENSREG and the national stress tests, is an open issue and depends on the EC's or ENSREG's decision to repeat that exercise.

Maritime transport safety enhancement

About the author

Professor at the National Technical University of Athens, Manolis Samuelides is the Director of the Division for Marine Structures of the University's School of Naval Architecture and Marine Engineering located in Zografos (Greece).

As the density of sea traffic keeps growing, designing ship structures capable of withstanding accidental loads such as collisions or grounding without detrimental consequences proves an ever-greater challenge. Double hull designs play a major role in this respect, as explains Manolis Samuelides, Professor at the National Technical University of Athens.

The role of ship classification

Of vital importance for all structures, structural integrity and strength capacity have become a challenge in the case of large ships travelling in a harsh environment and transporting hazardous cargos. >Classification societies< have assumed the mission to provide ships that may safely transport goods across the globe and to this aim they establish technical standards for their construction and operation. To be registered in a given class, a ship design must satisfy the corresponding requirements and be inspected by the competent surveyors during construction. During lifetime, the ship is regularly surveyed in order to guarantee that the structure maintains the ability to carry the anticipated loads. In addition, port authorities or other duly authorised agencies may survey the structure of a ship that is in their jurisdiction.

The regulatory framework of ship design and construction

In 2006, the International Association of Classification Societies (IACS) issued common rules applicable to double hull tankers and bulk carriers over 150 m long, which are known as Common Structural Rules (CSRs). The CSRs clearly distinguish three phases in the design process: firstly, the determination of the design loads, then the calculation of the scantlings, and finally, the verification of the design based on the assessment of the ship's structural response under the anticipated loads. The CSRs consider operational and extreme load conditions, but have limited provisions related to the accidental loads. In particular, in the case of double hull tankers and bulk carriers, they consider only the loading in case of flooding of a compartment without anticipating any damage to the structure. However, the so-called Goal Based Standards (GBS), which have been recently adopted by the International Maritime Organisation (IMO), are 'higher level rules' that define requirements. Classification Rules include minimum strength requirements for a ship in the event of damage resulting from collision or grounding.

Double hulls: a design against pollution

The 'double hull' concept was introduced and has been enforced in tankers after the adoption of the Oil Pollution Act by the US Senate in 1990 and the subsequent revision of the International Convention for the Prevention of Pollution from Ships (MARPOL) by the IMO. In a number of cases in which a tanker's outer hull has been breached, pollution has been avoided by the containment afforded by the intact inner hull. In a further study, it has been

>Classification societies<
are non-governmental organisations such as testing, inspection and certification companies that establish and maintain technical standards for the construction and operation of ships and offshore structures. Classification societies also validate that construction is according to these standards and carry out regular surveys in service to ensure compliance with the standards.

>nuclear powered merchant ships<
Two units built in the late 1950s, the *Savanah* and the *Otto Hahn*, and they both had collision barriers consisting of extra decks located to the sides of the reactor space. The collision barrier of *Savannah* would protect the nuclear reactor in case of a collision with a T2 tanker travelling at 15 knots, which correspond to a kinetic energy of the striking ship of approximately 671 MJ.

Securing the sea transport of nuclear materials

"Three levels of agreements are requested to authorise the execution of each shipment of nuclear materials by sea. Firstly, the carrier must submit a file to be assessed by the security authority in view of issuing a license for the transport of nuclear materials. This file describes the nature and volumes of materials to be transported as well as the measures envisaged to meet the corresponding security requirements, with a view to bringing the carrier's security culture up to the highest standards. Secondly, the vessel must obtain the agreement of the French and flag state's security authorities to operate. For the transport of sensitive materials such as MOX fuel or vitrified high-level waste, dedicated vessels are fitted with special bilges with controlled access and specific security devices such as continuous monitoring of the vessel's position by AIS, on-board CCTV, double hulls, etc. For less sensitive materials such as yellow cake or uranium hexafluoride, regular cargo ships are commissioned. In addition, crews are provided with handling instructions for hazardous material. Thirdly, each individual shipment must be authorised, based on the submission by the carrier of a logistical file well ahead of the shipment." **Frédéric Mermaz,** IRSN expert

Designing ship structures able to withstand accidental loads without detrimental consequences is a great challenge for naval architects.

shown that in case of collision or grounding, the mean oil outflow per ship year is substantially lower for double hull tankers.

Limit the consequences of ship-ship collisions: the case of ships carrying nuclear materials

The motivation to design ships with a structure capable of withstanding accidental loads, in particular loads induced during collision and grounding, emerged in the late 1950s, when the first >nuclear powered merchant ships< were designed. For this type of ships, it was obviously necessary to design the hull so that they would have the capacity to absorb the energy released during a ship-ship collision, without damaging the space where the nuclear reactor was located. In the late 1970s, the use of nuclear power in merchant vessels was abolished. However, there is still a need to provide ship structures that are able to protect nuclear cargo, as some ships transport nuclear materials such as irradiated nuclear fuel (INF) or vitrified high-level waste. For the protection of the cargo holds of INF vessels, it is required to have a barrier that should withstand a collision with a T2 tanker travelling at a speed of 15 knots, a requirement that remains practically the same to that applied to nuclear powered merchant ships such as *Savannah*. These barriers consist of four, 30-mm thick decks of high tensile steel, fitted between the outer and an inner skin of the hull.

The way ahead

Today, considering the size and speed of the ships and consequently the energies that are available to cause structural damage as well as the density of sea traffic, there is a great challenge for ship designers to suggest ship structures that are able to withstand accidental loads without detrimental consequences. The application of GBS in combination with prescriptive requirements may be an opportunity to design innovative ship structures that are safe and efficient in accomplishing their mission. ✖

A diesel generator is airlifted from the emergency equipment storage centre located in Reitnau (Switzerland) as part of a mitigation exercise conducted at the Leibstadt NPP.

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Safe Disposal of Nuclear Waste

In connection with the November 2013 EUROSAFE Forum hosted by GRS in Cologne, the EUROSAFE Tribune 25 will deal with the safety of nuclear waste disposal. Senior experts will review the different aspects of this multifaceted topic, covering scientific, technical, political and societal issues.

More on: www.eurosafe-forum.org

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Towards Convergence of Technical Nuclear Safety Practices in Europe