Annals of the Academy of Romanian Scientists
Series on Engineering Sciences
ISSN 2066 – 8570 Volume **5**, Number **1/2013** 91

THE GREAT EAST JAPAN EARTHQUAKE AND THE NUCLEAR POWER IN A POST FUKUSHIMA WORLD

Serban Constantin VALECA[1], Ramona Maria MIHAIU[2]

Rezumat. *Evenimentele de la Fukushima Dai-ichi și-au pus amprenta asupra viitorului energeticii nucleare (concluziile publicate de echipa de experți IAEA aflați în misiune la unitățile afectate) și au pus în discuție mai multe aspecte: creșterea securității nucleare "paive" precum și creșterea elementelor de siguranță la bazinele de combustibil ars. Prezenta lucrare își propune realizarea unui rezumat al evenimentelor de la centrala nuclearo-electrică Fukushima, sublinierea impactului lor asupra energeticii nucleare precum și primele decizii luate, la nivel internațional, în ceea ce privește siguranța centralelor nucleare. Toate acestea pentru ca energia nucleară să rămână un vector important în mixul energetic.*

Abstract. *A team of international nuclear safety experts completed, a preliminary assessment of the safety issues linked with TEPCO's Fukushima Dai-ichi Nuclear Power Station accident following the Great East Japan Earthquake and Tsunami. Considering the gravity of the accident and the conclusions of the IAEA Fact-Finding Team, the European Council declared that "the safety of all EU nuclear plants should be reviewed, on the basis of a comprehensive and transparent risk assessment ("stress tests"). This paper presents a summary of the catastrophic events on Japan and their impact on world nuclear power.*

Keywords: energy, nuclear accident, stress tests

1. Introduction

The Great East Japan Earthquake on 11 March 2011, a magnitude 9 earthquake, generated a series of large tsunami waves that struck the east coast of Japan, the highest being 38.9 m at Aneyoshi, Miyako.

As well as other enterprises, several nuclear power facilities were affected by the severe ground motions and large multiple tsunami waves: Tokai Dai-ni, Higashi Dori, Onagawa, and TEPCO`s Fukushima Dai-ichi and Dai-ni.

The operational units at these facilities were successfully shutdown by the automatic systems installed as part of the design of the nuclear power plants to detect earthquakes.

However, the large tsunami waves affected all these facilities to varying degrees, with the most serious consequences occurring at Fukushima Dai-ichi. [1, 2]

[1]Prof., Ph.D., Eng., Senior Scientific Researcher, I grade, University of Pitesti, Pitesti, Romania, e-mail: serban.valeca@nuclear.ro.
[2]Eng., Institute for Nuclear Research (INR), Pitesti, Romania e-mail: ramonamaria.m@gmail.com.

The crisis at Japan's Fukushima power plant has sparked a national review of energy policy and turned public opinion largely against nuclear power, but Yukiya Amano, head of the International Atomic Energy Agency (IAEA), said many countries believed nuclear power was needed to combat global warming. The IAEA chief visited the Fukushima plant on Monday, 25 July for the first time since it was crippled by the earthquake and tsunami.

Mr Amano told reporters: *"It is certain that the number of nuclear reactors will increase, even if not as quickly as before; some countries, including Germany, have reviewed their nuclear energy policy, but many other countries believe they need nuclear reactors to tackle problems such as global warming. Therefore, securing safety is more important than anything"* [3]

Considering the accident at the Fukushima nuclear power plant in Japan, the European Council of March 24th and 25th declared that "the safety of all EU nuclear plants should be *reviewed, on the basis of a comprehensive and transparent risk assessment ("stress tests");* the European Nuclear Safety Regulatory Group (ENSREG) and the Commission are invited to develop as soon as possible *the scope and modalities of these tests in a coordinated framework in the light of the lessons learned from the accident in Japan and with the full involvement of Member States, making full use of available expertise* (notably from the Western European Nuclear Regulators Association); the assessments will be conducted by independent national authorities and through peer review; their outcome and any necessary subsequent measures that will be taken should be shared with the Commission and within ENSREG and should be made public; the European Council will assess initial findings by the end of 2011, on the basis of a report from the Commission". [4]

2. Fukushima Nuclear Accident

The nuclear crisis in Japan has revived fears over the safety of nuclear power and the potential danger posed to public health when things go wrong. There have been a number of serious nuclear incidents since the 1950's. In the figure below are shown, chronologically, the most serious.

Prior to the events in Japan, it appeared that the international nuclear industry had successfully overcome the "Chernobyl syndrome" but the accident came where few expected it to happen: 11 March 2011, a magnitude 9 earthquake, generated a series of large tsunami waves that struck the east coast of Japan, the highest being 38.9 m at Aneyoshi, Miyako.

As well as other enterprises, several nuclear power facilities were affected by the severe ground motions and large multiple tsunami waves: Tokai Dai-ni, Higashi Dori, Onagawa, and TEPCO`s Fukushima Dai-ichi and Dai-ni, as can be seen in figure 2.

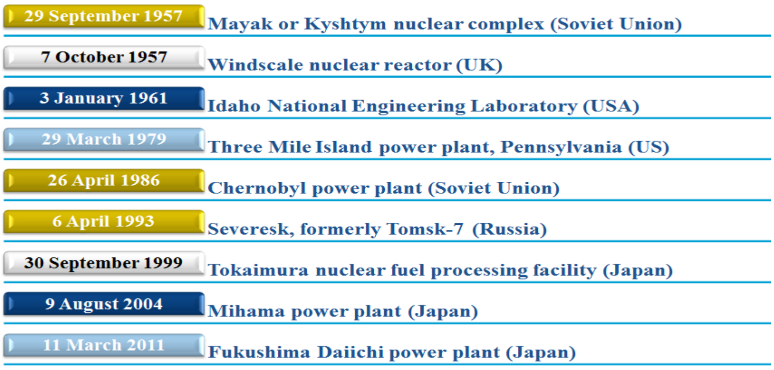

Fig. 1 Serious nuclear incidents/accidents over time.

The operational units at these facilities were successfully shutdown by the automatic systems installed as part of the design of the nuclear power plants to detect earthquakes. However, the large tsunami waves affected all these facilities to varying degrees, with the most serious consequences occurring at Fukushima Dai-ichi (see figure 3).

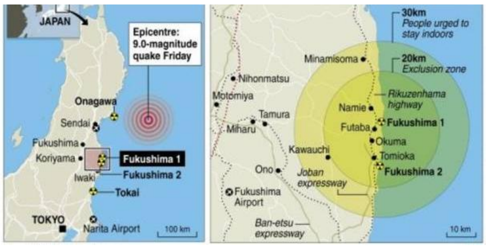

Fig. 2. Map showing the area surrounding Fukushima Dai-ichi Nuclear Power Plant no. 1 northeast of Tokyo (Source: USGS/World-nuclear.org).

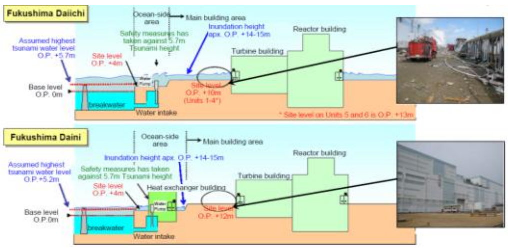

Fig. 3. The larger waves that impacted the Fukushima Dai-ichi and Dai-ini facilities on that day were estimated to be over 14 m high (Source: TEPCO).

Although all off-site power was lost when the earthquake occurred, the automatic systems at Fukushima Dai-ichi successfully inserted all the control rods into its three operational reactors upon detection of the earthquake, and all available emergency diesel generator power systems were in operation, as designed. The first of a series of large tsunami waves reached the Fukushima Dai-ichi site about 46 minutes after the earthquake. These tsunami waves overwhelmed the defences of the Fukushima Dai-ichi facility, which were only designed to withstand tsunami waves of a maximum of 5.7 m high. The tsunami waves reached areas deep within the units, causing the loss of all power sources except for one emergency diesel generator (6B), with no other significant power source available on or off the site, and little hope of outside assistance.

The station blackout at Fukushima Dai-ichi and the impact of the tsunami caused the loss of all instrumentation and control systems at reactors 1–4, with emergency diesel 6B providing emergency power to be shared between Units 5 and 6. The tsunami and associated large debris caused widespread destruction of many buildings, doors, roads, tanks and other site infrastructure at Fukushima Dai-ichi, including loss of heat sinks.

The operators were faced with a catastrophic, unprecedented emergency scenario with no power, reactor control or instrumentation, and in addition, severely affected communications systems both within and external to the site. They had to work in darkness with almost no instrumentation and control systems to secure the safety of six reactors, six nuclear fuel pools, a common fuel pool and dry cask storage facilities.

With no means to confirm the parameters of the plant or cool the reactor units, the three reactor units at Fukushima Dai-ichi that were operational up to the time of the earthquake quickly heated up due to the usual reactor decay heating. Despite the brave and sometimes novel attempts of the operational staff to restore control and cool the reactors and spent fuel, there was severe damage to the fuel and a series of explosions occurred. These explosions caused further destruction at the site, making the scene faced by the operators even more demanding and dangerous. Moreover, radiological contamination spread into the environment. [3]

These events are provisionally determined the Japanese authorities to raise the severity rating of the nuclear crisis at the damaged Fukushima Dai-ichi power plant to the highest level, seven. The decision reflects the on-going release of radiation, rather than a sudden deterioration. Level seven previously only applied to the 1986 Chernobyl disaster, where 10 times as much radiation was emitted. But most experts agree the two nuclear incidents are very different. Explore the table below to find out how they compare:

Table 1. Fukushima and Cernobyl compared (Nuclear Energy Institute, Fact Sheet, Comparing Chernobyl and Fukushima *April 2011* Key Facts)

Category	Fukushima Dai-ichi	Chernobyl
Date of accident	11 March 2011	26 April 1986
Accident details	A magnitude-9.0 earthquake and resulting tsunami damaged the plant's power systems, causing cooling systems to fail. A series of gas explosions followed	A sudden power output surge during a systems test caused a reactor vessel to rupture, leading to a series of blasts. An intense fire burned for 10 days
Severity rating	Level 7 - major accident	Level 7 - major accident
Number of reactors	Six; but only three of concern, plus pools storing spent fuel	Four; but only one reactor involved

Type of reactors	Boiling-water reactors. Japanese authorities stress that unlike at Chernobyl, the containment vessels at Fukushima remain intact. Also, unlike Chernobyl, the reactors at Fukushima do not have a combustible graphite core	Graphite-moderated boiling water reactor. The graphite made it highly combustible. The reactor also had no containment structure and nothing stopped the trajectory of radioactive materials into the air
Radiation released	370,000 terabecquerels* (as of 12 April)	5.2 million terabecquerels*
Area affected	Officials say areas extending more than 60 km (36 miles) to the north-west of the plant and about 40 km to the south-southwest have seen radiation levels exceed annual limits	Contamination of an area as far as 500 km (300 miles) from the plant, according to the UN. But animals and plants were also affected much further away
Evacuation zone	20 km; 20-30 km voluntary zone. Five communities beyond the existing evacuation zone have also been evacuated	30 km
People evacuated	Tens of thousands	The authorities evacuated, in 1986, about 115,000 people from areas surrounding the reactor and subsequently relocated, after 1986, about 220,000 people from Belarus, the Russian Federation and Ukraine
Related deaths	No deaths so far due to radiation	A UN report places the total confirmed deaths from radiation at 64 as of 2008. Disputes continue about how many will eventually die
Long-term health damage	Not yet known, but risks to human health are thought to be low	Among the residents of Belarus, the Russian Federation and Ukraine, there had been up to the year 2005 more than 6,000 cases of thyroid cancer reported in children and adolescents who were exposed at the time of the accident, and more cases can be expected during the next decades
Current status	Concern remains over the potential effect on human health from radiation leaks at the stricken Fukushima Dai-ichi nuclear plant.	The damaged reactor is now encased in a concrete shell. A new containment structure is due to be completed by 2014

3. EU's Energy after Fukushima

By agreement with the Government of Japan, the International Atomic Energy Agency conducted a preliminary mission to find facts and identify initial lessons to be learned, by the entire world nuclear community, from the accident at Fukushima Dai-ichi.

The Mission visited three affected nuclear power plants (NPP) – Tokai Dai-ni, Fukushima Dai-ni and Dai-ichi – to gain an appreciation of the status of the plants and the scale of the damage. (Mission Report)

In the table below are summarized the conclusions (15) and the lessons (16) of the IAEA Mission (in the Preliminary Summary).

The international nuclear community must take advantage of the unique opportunity created by the Fukushima accident to seek to learn and improve worldwide nuclear safety.

Table 2. 15 conclusions and 16 lessons established by the IAEA Mission for the International Nuclear Community

Nr.crt.	Conclusions	Lessons
1.	The IAEA Fundamental Safety Principles provide a robust basis in relation to the circumstances of the Fukushima accident and cover all the areas of lessons learned from the accident.	There is a need to ensure that in considering external natural hazards: the siting and design of nuclear plants should include sufficient protection against infrequent and complex combinations of external events; plant layout should be based on maintaining a ”dry site concept; common cause failure should be particularly considered for multiple unit sites; an active tsunami warning system should be established.
2.	Given the extreme circumstances of this accident the local management of the accident has been conducted in the best way possible	For severe situations, such as total loss of off-site power or loss of all heat sinks or the engineering safety systems, simple alternative sources for these functions including any necessary equipment should be provided for severe accident management.
3.	There were insufficient defence-in-depth provisions for tsunami hazards.	Such provisions as are identified in Lesson 2 should be located at a safe place and the plant operators should be trained to use them.
4.	For the Tokai Dai-ni and Fukushima Dai-ni NPPs, in the short term, the safety of the plant should be evaluated and secured for the present state of the plant and site (caused by the earthquake and tsunami) and the changed hazard environment.	Nuclear sites should have adequate on-site seismically robust, suitably shielded, ventilated and well equipped buildings to house the Emergency Response Centres, with similar capabilities to those provided at Fukushima Dai-ni and Dai-ichi.
5.	An updating of regulatory requirements and guidelines should be performed reflecting the experience and data obtained during the Great East Japan Earthquake and Tsunami, fulfilling the requirements and using also the criteria and methods recommended by the relevant IAEA Safety Standards.	Emergency Response Centres should have available as far as practicable essential safety related parameters based on hardened instrumentation and lines such as coolant levels, containment status, pressure, etc., and have sufficient secure communication lines to control rooms and other places on-site and off-site.
6.	Japan has a well-organized emergency preparedness and response system as demonstrated by the handling of the Fukushima accident.	Severe Accident Management Guidelines and associated procedures should take account of the potential unavailability of instruments, lighting, power and abnormal conditions including plant state and high radiation fields.

7.	Dedicated and devoted officials and workers, and a well-organized and flexible system made it possible to reach an effective response even in unexpected situations and prevented a larger impact of the accident on the health of the general public and facility workers.	External events have a potential of affecting several plants and several units at the plants at the same time. This requires a sufficiently large resource in terms of trained experienced people, equipment, supplies and external support.
8.	A suitable follow up programme on public exposures and health monitoring would be beneficial.	The risk and implications of hydrogen explosions should be revisited and necessary mitigating systems should be implemented.
9.	There appears to have been effective control of radiation exposures on the affected sites despite the severe disruption by the events.	Particularly in relation to preventing loss of safety functionality, the robustness of defence-in-depth against common cause failure should be based on providing adequate diversity (as well as redundancy and physical separation) for essential safety functions.
10.	The IAEA Safety Requirements and Guides should be reviewed to ensure that the particular requirements in design and severe accident management for multi-plant sites are adequately covered.	Greater consideration should be given to providing hardened systems, communications and sources of monitoring equipment for providing essential information for on-site and off-site responses, especially for severe accidents.
11.	There is a need to consider the periodic alignment of national regulations and guidance to internationally established standards and guidance for inclusion in particular of new lessons learned from global experiences of the impact of external hazards.	The use of IAEA Safety Requirements (such as GS-R-2) and related guides on threat categorization, event classification and countermeasures, as well as Operational Intervention Levels, could make the off-site emergency preparedness and response even more effective in particular circumstances.
12.	The Safety Review Services available with the IAEA's International Seismic Safety Centre (ISSC) would be useful in assisting Japan's development in the following areas: external event hazard assessment, walkdowns for plants that will start up following a shutdown and pre-earthquake preparedness.	The use of long term sheltering is not an effective approach and has been abandoned and concepts of "deliberate evacuation" and "evacuation-prepared area" were introduced for effective long term countermeasures using guidelines of the ICRP and IAEA.
13.	A follow-up mission including Emergency Preparedness Review (EPREV) should look in detail at lessons to be learned from the emergency response on and off the site.	The international nuclear community should take advantage of the data and information generated from the Fukushima accident to improve and refine the existing methods and models to determine the source term involved in a nuclear accident and refine emergency planning arrangements.
14.	A follow-up mission should be conducted to seek lessons from the effective approach used to provide large scale radiation protection in response to the Fukushima accident.	Large scale radiation protection for workers on sites under severe accident conditions can be effective if appropriately organized and with well led and suitable trained staff.
15.	A follow-up mission to the 2007 Integrated Regulatory Review Service (IRRS) should be conducted in light of the lessons to be learned from the Fukushima accident and the above conclusions to assist in any further development of the Japanese nuclear regulatory system.	Exercises and drills for on-site workers and external responders in order to establish effective on-site radiological protection in severe accident conditions would benefit from taking account of the experiences at Fukushima.
16.		Nuclear regulatory systems should ensure that regulatory independence and clarity of roles are preserved in all circumstances in line with IAEA Safety Standards.

The IAEA Mission Report supports the decision of the European Council and is a useful tool for EU's countries that must revise the nuclear safety and certainly they must improve it.

Considering the accident at the Fukushima nuclear power plant in Japan, the European Council of March 24th and 25th declared that "the safety of all EU nuclear plants should be *reviewed, on the basis of a comprehensive and transparent risk assessment ("stress tests"); the European Nuclear Safety Regulatory Group (ENSREG) and the Commission are invited to develop as soon as possible the scope and modalities of these tests in a coordinated framework in the light of the lessons learned from the accident in Japan and with the full involvement of Member States, making full use of available expertise. (notably from the Western European Nuclear Regulators Association).*[5]

On the basis of the proposals made by WENRA at their plenary meeting on the 12-13 of May, the European Commission and ENSREG members decided to agree upon "an initial independent regulatory technical definition of a "stress test" and how it should be applied to nuclear facilities across Europe".

Definition of the "stress tests"

*A **"stress test"** is a targeted reassessment of the safety margins of nuclear power plants in the light of the events which occurred at Fukushima: extreme natural events challenging the plant safety functions and leading to a severe accident.* This reassessment must consist in an evaluation of the response of a nuclear power plant when facing a set of extreme situations and in a verification of the preventive and mitigative measures chosen following a defence-in-depth logic: initiating events, consequential loss of safety functions, severe accident management.

In the stress tests will be assessed whether the nuclear power plant can withstand the effects of the following events:

- ***Natural disasters:*** earthquakes, flooding, extreme cold, extreme heat, snow, ice, storms, tornados, heavy rain and other extreme natural conditions;
- ***All man-made failures and actions:*** air plane crashes and explosions close to nuclear power plants, whether caused by a gas container or an oil tanker approaching the plant, fire. Comparable damaging effects from terrorist attacks (air plane crash, explosives) are also covered;
- ***Preventive and other terrorist and malevolent acts:*** preventive measures for terrorist attacks – meaning all measures which should stop an attack from happening in the first place - will be dealt with separately, involving experts such as anti-terrorism experts, officials of ministries for national security. The reason is that these concerns are issues of *national security.*

By their nature, the stress tests will tend to focus on ***measures that could be taken after a postulated loss of the safety systems*** that are installed to provide protection against accidents considered in the design. Adequate performance of those systems has been assessed in connection with plant licensing. Assumptions concerning their performance are re-assessed in the stress tests and they should be shown as provisions in place. It is recognised that all measures taken to protect reactor core or spent fuel integrity or to protect the reactor containment integrity constitute an essential part of the defence-in-depth, as it is always better to prevent accidents from happening than to deal with the consequences of an occurred accident. The licensees have the prime responsibility for safety therefore it is up to the licensees to perform the reassessments, and to the regulatory bodies to independently review them. The timeframe is as follows: The national regulator will initiate the process at the latest on ***June 1*** by sending requirements to the licensees.

Table 3. Final dates of the reports

	Progress report	Final report
Licensee report	*August 15*	*October 31*
National report	***September 15***	***December 31***

Another important aspect is that the tests will be carried out at ***three levels:***

- ***Pre-Assessment:*** The plant operators have to answer all the questions in the stress tests questionnaire and describe how the plant would react in different situations. To support what they say, they have to submit engineering studies.
- ***National Report:*** In the second step, the **national regulator** will look at the preassessments and check whether the assumptions are credible. As they know the particular design of the plants and have made controls on the spot, they are best placed to do that.
- ***Peer Reviews:*** In a third step, the national report of the regulator will be reviewed by other regulators within European Nuclear Safety Regulators' Group (ENSREG), which represents the 27 independent national authorities responsible for nuclear safety in their country. This will be done by **peer teams consisting of seven people including:**
  - ➢ one European Commission representative
  - ➢ two permanent ENSREG members. They will be part of all the peer review teams cross-checking the 14 national reports of all the Member states having nuclear power). This is to guarantee the consistency of the tests
  - ➢ four non-permanent ENSREG members (the composition of each of the teams will be decided together by the EU Commission and ENSREG).

According to ***IP/11/640 Brussels, 25 May 2011,*** from 1 June 2011 onwards, all 143 nuclear power plants in the EU will be reassessed using EU wide criteria. These are comprehensive tests as the Commission has called for which embrace both natural and man-made hazards. The European Commission and the European Nuclear Safety Regulator's Group (ENSREG) agreed today on the criteria covered and the way controls will be done. [6]

4. Cernavoda Nuclear Power Plant stress tests

4.1. Comparing BWR with CANDU

Given the general emergency situation at Fukushima Dai-ichi Nuclear Power Plant in Japan it's understandable to raise a series of questions and opinions about the security of other nuclear facilities.

Cernavoda NPP, which provides 18% of electricity in Romania, is a robust CANDU 6 nuclear power plant, burning natural uranium, where cooling is done with heavy water in a closed circuit, featuring major technological differences from the Fukushima Daiichi power plant that uses enriched uranium fuel and light water cooling, producing radioactive steam into the reactor directly.

CANDU technology is a great advantage over other technologies because the amount of potential energy stored in the reactor is much smaller than in other types of light water cooled reactors because fuel is loaded weekly as compared to other types of reactors charged annually and has great cooling water tank reactor vessel (450 tons heavy water) and the reactor caisson where the reactor vessel is located contains approx. 500 tons light water, which can provide comfort cooling to restore normal cooling in case it is lost.

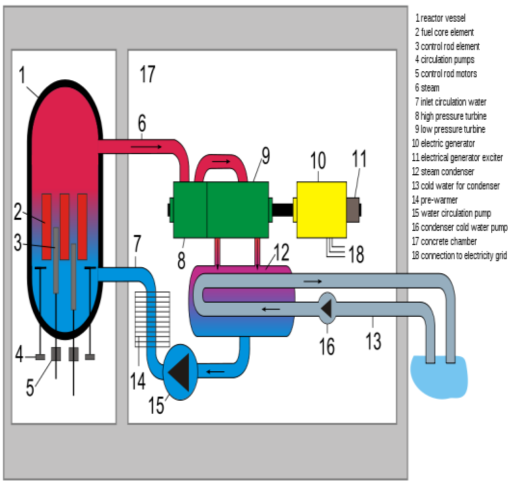

Fig. 5. Boiling Water Reactor
(source: USNRC Technical Training Center)

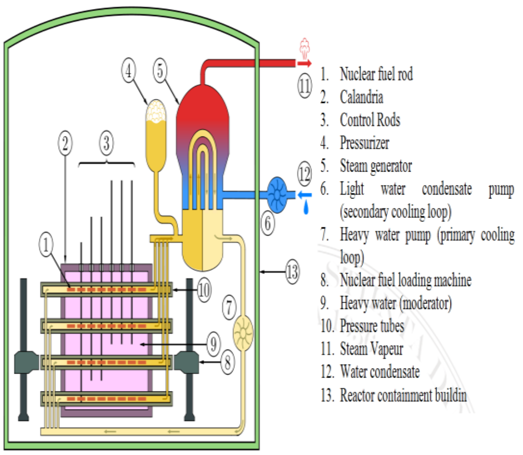

Fig. 6. CANadian Deuterium Uranium Reactor
(source:http://en.wikipedia.org/wiki/CANDU_reactor)

Also, if after the radiolysis process there is an accumulation of hydrogen in the reactor dome inside the building there is a special system of hydrogen burning, in the case of a controlled discharge into the atmosphere, the hydrogen does not cause violent ignition in contact with air. NPP Cernavoda is designed to counteract the effects of an earthquake, based on authorized studies prepared by the Center for Earth Physics taking into account a conservative history of the entire region, including the closest seismic areas: Vrancea area and the Sabla area (Balkan Mountains).

The above-mentioned studies have shown that historically, in the two seismic sites located at over 100 km has never been an earthquake greater than 7.5 degrees and in this context the NPP project took into account a maximum possible earthquake of 8 degrees at Cernavoda and it's called The Earthquake Basis Project (EBP). Last but not least, the side effect that was a major contributor for Fukushima, the tsunami, can be completely eliminated at Cernavoda NPP as the project took into account a credible risk of external flooding at the NPP site. These studies have shown that inside the NPP is performed at a high rate of 15.8 compared to the Black Sea and 2m from the theoretical maximum level of the Danube.

In these cases, the Cernavoda NPP is prepared in case of an earthquake by:

1. ***Design solutions which ensure that:***
   - All structures and security systems are designed to maintain the integrity and ensure safety functions (reactor shutdown and cooling, containerization radioactivity) in the case of an EBP;
   - Cooling the reactor at Cernavoda NPP, in the first phase after the loss of normal cooling sources, can be achieved without requiring any source of electricity, by natural circulation of water (thermosyphonation) in the primary circuit (reactor) and the spray tank in the secondary circuit steam generators;
   - There is a source of emergency power supplies (EPS) consisting of two diesel generators 2×100%, specially designed for the case of an earthquake EBP.
2. ***Existing response procedures in abnormal situations (APOP)*** that operators are trained to apply in the event of an earthquake. To note that operating the plant in an earthquake is the secondary control room (SCR), a structure designed and built especially for this situation, resistant to EBP.
3. ***Ensuring continuous availability of the systems*** mentioned above by executing the periodic checking and testing programs approved by the regulatory authority CNCAN and in the event of malfunction, immediate remedial measures are taken.
4. ***Training of personnel operating at all levels and all specialties*** and responsibilities within the organization, testing and periodic re-authorization by regulatory authorities.

Even if the power plant is designed to provide safe stopping and resuming operation after several basic design events, measures are still taken to protect the public in extreme situations, measures covered by our legislation in force. These measures are aimed at sheltering the population from the consequences of potential radioactive releases.

Consequently, we can say that, until now, the events in Fukushima - Japan cannot make the object of immediate action to implement at the Cernavoda NPP. However, preventive additional verification activities were initiated of the existing provisions. [7-9]

4.2. Decisions for stress testing the Cernavoda NPP

The National Commission for Nuclear Activities Control (CNCAN) as competent national authority of Romania, in the field of nuclear safety and physical protection of nuclear facilities, has already started to reevaluate the measures implemented at Cernavoda Nuclear Power Plant for severe accident prevention and response to emergency situations.

To ensure decisions transparency and to provide the informations to the institutions with responsibilities in security and national nuclear safety and other interested organizations, CNCAN held, on Wednesday, May 18, 2011, a meeting for presentation and analysis of documents adopted by ENSREG group, respectively the technical specifications for stress tests as well as the discussion of the general strategy for the implementation of tests in response to European Commission recommendations. At the meeting were invited representatives from the Ministry of Economy, Trade and Business, Senate (The Economic Commission, Industry and Services), Chamber of Deputies (Committee for Industries and Services), Ministry of National Defense, Ministry of Administration and Interior, Ministry of Foreign Affairs, Ministry of Transport and Infrastructure, the Romanian Informations Service, Foreign Informations Service, The Nuclear Agency and for Radioactive Waste, National Company Nuclearelectrica SA, EnergoNuclear and Constanta County Council.

During the meeting, the CNCAN President, Mrs. Borbala Vajda presented the range and the methodology of the stress tests, as results from the latest proposals discussed by ENSREG and the European Commission at the last plenary meeting held in Brussels on 12 and 13 May. She pointed the voluntary nature of these tests and also indicate to CNCAN commitment to use the technical specifications for stress testing in nuclear safety reevaluation of the Cernavoda nuclear plant. CNCAN President said that the revaluation involved by stress tests and any actions resulting from it shall be entered in the field of competence and responsibility of national regulators and holders of permits for nuclear power plants in each EU member state.

The implementation of stress tests will officially begin on 1 June 2011, according to European Commission recommendations. To inform the European Commission and European Council, authoritarian regulators will develop reports on the results of stress tests by the end of 2011. [10]

4.3. Past, present and the future of nuclear energy

As of 2010, a total of 30 countries were operating nuclear fission reactors for energy purposes – one fewer than in previous years. Lithuania became the third country ever to revert to "non-nuclear energy" status, following Italy, which abandoned nuclear power after Chernobyl, and Kazakhstan, which shut down its only reactor in 1999.

Nuclear power plants generated 2,558 Terawatt-hours (TWh or billion kilowatt-hours) of electricity in 2009. World nuclear production fell for the third year in a row, generating 103 TWh (nearly 4 percent) less power than in 2006. This decline corresponds to more than the domestic annual nuclear generation in four-fifths of the nuclear power countries.

The gap between the public's perception of an increasing role for nuclear power and reality seems to be widening. Many countries are now past their nuclear peak. The three phase-out countries (Italy, Kazakhstan, and Lithuania) and Armenia generated their historical maximum of nuclear electricity in the 1980's. Several other countries had their nuclear power generation peak in the 1990's, among them Belgium, Canada, Japan, and the UK. And seven additional countries peaked between 2001 and 2005: Bulgaria, France, Germany, India, South Africa, Spain, and Sweden.

Among the countries with a remarkably steady increase in nuclear generation are China, the Czech Republic, Romania, Russia and the United States (except for 2009 when production dropped by almost 10 TWh). [11]

According to the statistics of IAEA, currently there are 440 units in operation worldwide, 5 units in shutdown process and 65 units in construction. Among the reactors that were recently connected to the grid, we account one unit of 202 MWe in India, another unit of 300 MWe in Pakistan and Lingao unit of 1000 MWe in China.

The only nuclear units that were shutdown up to present are Fukushima units 1-4 which have been officially declared in permanent outage on May 20th. At the same time, in Pakistan, works have officially started at Chasnupp 3 – a 315 MWe PWR reactor, on May 28th.

As one may notice, the global tendency is to continue the nuclear programs, as well as implementing the new safety measures that will result from the stress tests carried out at all the nuclear power plants in the world.

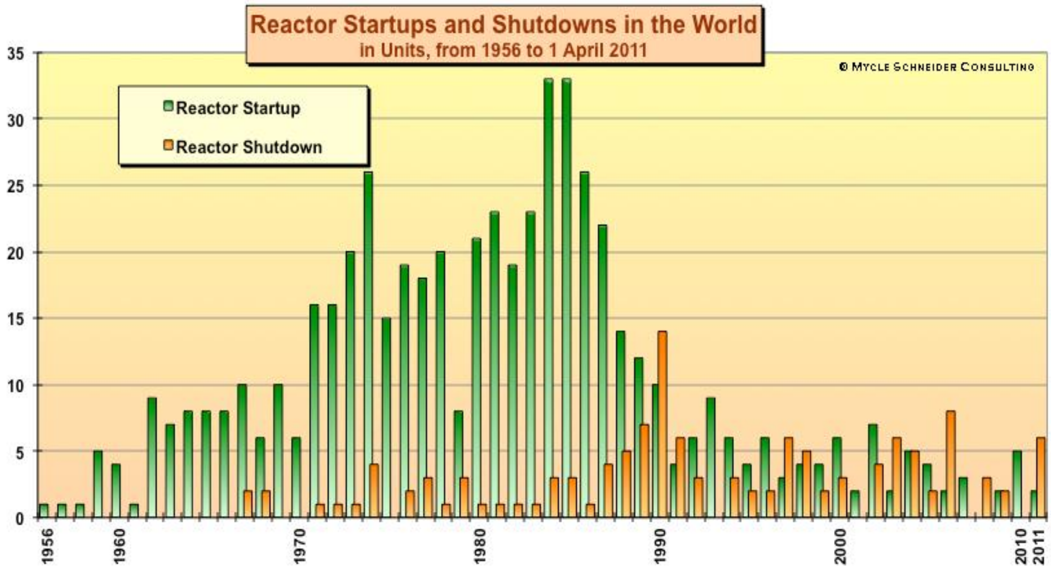

Fig. 5 Age Distribution of Operating Nuclear Reactors, 2011.

(Source: *World Nuclear Industry Status Report 2010-2011*)

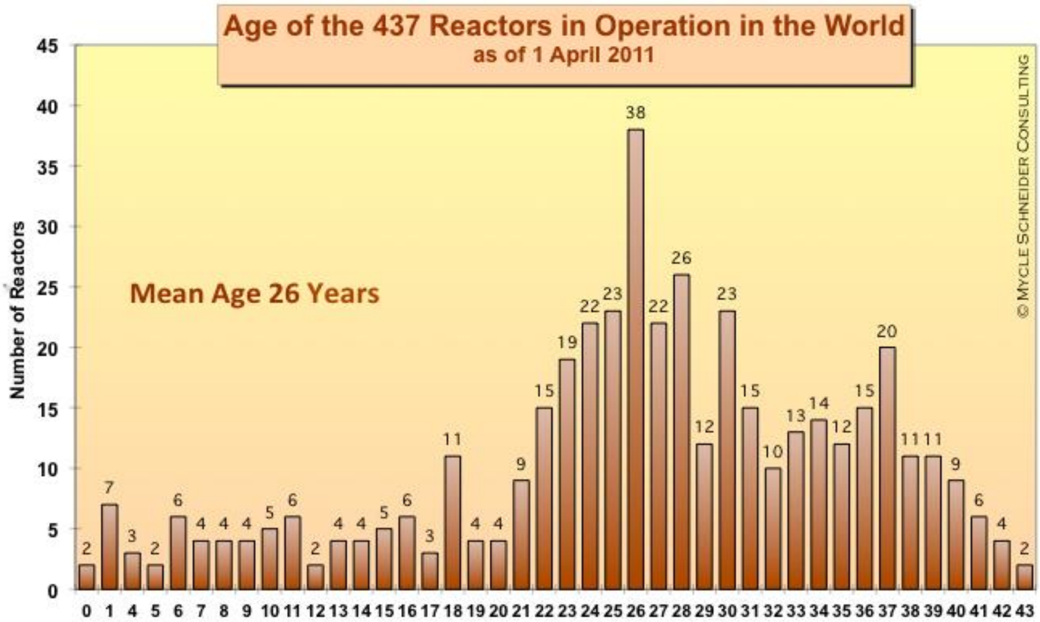

Fig. 6 Nuclear Power Reactor Grid Connections and Shutdowns, 1956–2011.

(Source: *World Nuclear Industry Status Report 2010-2011*)

At the European level, before Fukushima accident, a number of 4 nuclear reactors were under construction (in Finland, France and Slovenia) and other 13 countries among which Romania as well, planned to develop additional units.

After Fukushima, 13 European member states have stated the continuation of their nuclear programs and their firm engagement to perform the stress tests. On the other hand, 4 countries have declared their intention to gradually replace nuclear energy and to change their energy policy (Belgium, Germany, Italy and Switzerland).

Taking into account the fact that phasing out nuclear energy is a long and expensive process, there is still the possibility to review the phase-out policy in these 4 states. Romania also continues the development of the two additional units planned at Cernavoda – Units 3 and 4 – which benefit from the support of the central administration and the interest of international important companies, which wish to become partners in the project.

Units 1 and 2 of Cernavoda NPP take pride in the outstanding results of the year 2010 and continue the tradition started in 2009, when Cernavoda NPP Unit 1 occupied the first position in the top of CANDU nuclear power plants worldwide, with an average capacity factor of 100,1%. [12]

5. Conclusions

Three Mile Island in 1979, Chernobyl in 1986 and Fukushima today: to the third time a nuclear plant suffered a serious accident, requiring a global review regulations governing nuclear safety.

Concerning the two disasters, the international community must learn from the Fukushima accident to improve their international cooperation, both in terms of crisis management, as and risk prevention because prosperity without security is unsustainable.

How much more sustainable other resources prove to become will also strongly influence the long-term prospects of nuclear energy. For fossil-fuel based energy services, while relying on an exhaustible resource and thereby intrinsically non-renewable, their potential transitional role during the 21st century will be determined by how clean they can be rendered and how much they can be decarbonised, in addition to conventional arguments regarding availability and costs.

Globally, renewables have so far not been used on a large scale, so their external impacts and environmental drawbacks, related to e.g. their land requirements, cannot yet be fully apparent: their true sustainability is yet to be proved in practice, while many of them need to achieve further cost reductions to become fully competitive.

The extent to which fossil fuels continue to dominate our energy system, the scale at which renewables can be sustainably expanded, and conjointly energy savings measures may be realised, will affect the future of nuclear energy.

Whether or not nuclear energy will play a role of significance in the long run remains a difficult question, but the continued analysis of its prospects should be conducted, in a similar way for all energy technologies, in terms of its potential to contribute to goals of sustainable development, i.e. including the full set of environmental, economic, and social risks involved.

R E F E R E N C E S

[1] IAEA International Fact Finding Expert Mission, Japan 24 May – 1 June **2011** Preliminary Summary.

[2] FINAL REPORT - International Fact Finding Expert Mission, Japan 24 may – 2 June **2011**.

[3] (BBC, http://www.bbc.co.uk/news/world-asia-pacific-14292167).

[4] Declaration of ENSREG, 13 May **2011**.

[5] (Stress tests specifications, proposal by the WENRA task force, 21 April **2011**).

[6] MEMO/11/286 Brussels, 11 May **2011** Nuclear Stress Tests.

[7] BWR, USNRC Technical Training Center.

[8] Conceptul CANDU 600, PHWR,

[9] http://www.nuclearelectrica.ro/user/content/423301_conceptul_candu.pdf

[10] Semnal n, no.3, **2011**, pages 14, 15.

[11] http://www.cncan.ro/stiri/comunicat-de-presa-3/

[12] THE WORLD NUCLEAR INDUSTRY STATUS REPORT 2010–**2011** Nuclear Power in a Post-Fukushima World, 25 Years After the Chernobyl Accident By Mycle Schneider Independent Consultant, Mycle Schneider Consulting, Paris (France) Project Coordinator and Lead Author.

[13] Semnal n, no 3, **2011**, pages 1,3.