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EMOTIONAL ASPECTS OF NUCLEAR CONFRONTATIONS: CAN STUDENTS LEARN FROM PAST SITUATIONS ?

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ABSTRACT

No one in the nuclear sector can expect to avoid confrontation with people who do not appreciate the development of nuclear activities. Luckily young “nuclearists” are seldom confronted with demonstrators at the door of their plant or office, but quite often early in their carriers, they may be asked to participate in hearings, or encouraged to give talks to local schools or cultural associations. Confrontation can also happen within the family or during dinner parties with friends.

This means that nuclear students should learn about the emotional aspects of nuclear evaluation, about the fact that people’s “values” may be different and how this influences the interpretation of facts and figures. They should examine opponents’ arguments and the way they are presented in the media or during demonstrations. They should also be shown fiction in films and literature that, like the Simpson, are often accepted by the lay-man as an objective source of information.

The paper includes a selection of past events, documents, films and literature that could serve as case studies in a workshop/seminar within nuclear related studies.

1. Introduction

During the question time of a recent conference I gave in Namur (Belgium), I was asked why nuclear communicators or engineers willing to communicate with the public, are always taking a top-down attitude and not trying to listen to bottom-up information. This remark is probably not totally fair but it contains some truth. In most circumstances, we consider we should give information, make it understandable for the lay-people, answer his questions if any and if they make sense according to our criteria. Although we are aware our activities generate emotions, we consider our efforts should tend to alleviate them because for most of us, these scares are not justified.

“Communicating about the environment [and this is also true for nuclear] may have been seen in the not-so-distant past as mainly a matter of making the public understand the science and scientific evidence behind controversial environmental issues. Some of the most controversial environmental issues and debates of the recent period show a very different picture. Whether looking at the ozone layer, climate change, whaling, hunting, animal experimentation or the multiple issues relating to rapid advances in genetic modification and the bio-genetic sciences, it is clear that the battles over these issues are now much more to do with persuasive communication, with ‘winning hearts and minds’ than they are to do with understanding the ‘science’ behind these issues.”(1).

Presently, decision making by governments and parliaments is strongly influenced by what has been called by Louis Michel, a Belgian minister, “emocracy”. Politicians have been elected and they give some importance to their electors’ opinion. This is normal. But this opinion does not only rely on scientific or technological truth, it is influenced by the way the public perceives the situation and the emotions it creates. And emotions mark the human memories much more than technical facts.

Thus if we want to progress with our technical projects, we must listen to the emotions they create. We must listen to the opposition, be it rational or not. Opposition might accept a dialogue, as long as it feels it can influence decisions. But if it considers the circumstances are such – e.g. the pressure of powerful political or financial interests - that there is a low probably that the discussion will lead to some changes, “disruptive actions” as Yves Citton (2) calls them, will take place and are justified.

Thus I think there is a lot to learn from past confrontations, be it dialogues or demonstrations, contradictory reports or slogans and banners in the streets. Analyzing the documents we can access on such situations in the past, the students shall try to discriminate between arguments coming from trained opposition and locals NIMBY rejections. They shall evaluate what their own reactions would have been in these situations ...

2. Some typical examples that could be used

Historical examples of movements against civil nuclear plants or transport of wastes and used fuels are so numerous that the main problem will not be to find one but to select among the best documented. The arguments pro and con have not changed very much with time so old situations can still be useful to study the respective positions. I tried to summarize some in my book “Dompter le dragon nucléaire ?”(3). It seems that disruptive demonstrations started in the USA at the end of the seventies by local opponents but also by hard activists who knew how to organize such actions, following their participation in movements against the Vietnam war.

Actions took place through demonstrations but also by conferences and publications of scientific papers e.g. those of Gofman and Tamplin, who received a large audience in university campuses and media. Similar developments happened in Europe. In France, in April 1971,1500 persons, Frenchs but also Germans, marched against the construction of a PWR at Fessenheim on the Rhine. The same year they were 15.000 against the Bugey power plant on the Rhone.

In Germany at the site of the future Wyhl plant, locals organised themselves in so-called *Bürgerinitiativen,* reacting against the “intrusion” of federal initiatives with pamphlets and demonstrations. In many places, site occupation turned into violent confrontation. In France, the “battle” of Creys - Malville against the construction of Superphenix in July 1977 was a violent confrontation with the CRS[1]. Being fully involved in fast breeder designs, and my niece having been part in a prior more pacific demonstration on the same site in 1976, I collected heaps of press cuttings and pamphlets from both sides. The lack of dialogue between the two parties is flagrant. The objections of the locals grouped in diverse associations are well documented; the attempts to reach a consensus by the Conseil général and other authorities have been published e.g. in (4).

One of the situations in France that has lead to the most accessible documentation – very few cases have been studied in such details during so many years after the events – is the fight of the local population supported by numerous associations and scientists against the construction of a nuclear plant in Plogoff (Bretagne). It started in 1976 when the Conseil regional and the Conseil économique et social accepted the project. In 1978, the Conseil general du Finistère also approved the plant : 10.000 people and later 15.000 marched against this decision.

In 1980, the situation became a source of conflict; people opposed the installation of a “mairie annexe” to submit the public inquiry dossiers, protected by the CRS. Fights started early February and lasted five nights. Some were arrested and this lead to thousands of demonstrators in the streets of Quimper. Finally the objectors benefitted from the presidential election in May 1981 : the project was cancelled when Mitterand was elected.

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1 Compagnie Républicaine de Sécurité, heavily protected and armed police forces.

(5)

To analyse this case, there is first a book of photographs and comments published immediately after the events (5). At the same time, two persons who initially came just to support the locals, filmed the events. Nicole and Felix Le Garrec (6) received no financial support from film producers or other sources of finance but could present the resulting film in public places, totalling 250.000 visits in the cinemas. Twenty years later, Brigitte Chevet (7) decided to interview those who participated in 1980: she interviewed villagers, the mayor, EDF engineers, antinuclear activists, officials and politicians. She added images from archives and the result is an exceptional document. One of the participants in this fight wrote a book in 2004 (8) but the most extensive study was done by Gilles Simon and published in 2010 (9). This doctor in political science analyzes in the more than 400 pages of this study, the motivations of the participants and how they learned to be efficient through 7 years of social, political and physical fights. Finally very recently, two authors revived the memories with a spectacular "bande dessinée" (10).

Nuclear wastes treatments and transports of used fuels and wastes have always raised a lot of opposition in Europe. Efforts have been made by the organisations responsible for these tasks to obtain some acceptance. Nevertheless, these programs often lead to strong opposition, one of the most recent situation being the boycott of the public inquiry in Lorraine, on the Bure site for geological storage. These follow previous actions since years such as street sit-in .

Bar-le-duc 2005

The situation of waste management in Belgium remains quieter until now. Perhaps due to very progressive approach to formulate proposals to the government, and the concentration since the fifties of nuclear activities in a single area of nuclear research, fuel fabrication , wastes treatment and storage. The organisation responsible for the waste management, ONDRAF, obtained agreements for the storage of low level wastes in that part of country after a lengthy – many years - but successful consultation process between ONDRAF, local authorities, experts, environmental groups, locals, ...

In the same area, ONDRAF would like to store category B and C wastes. Since 1974, the experimental study of geological storage in clay below 200 meters is underway. Galleries with all types of experiments are operated. In 2006, the Belgian government asked ONDRAF to prepare a Strategic Environmental Assessment for the application of this solution. This evaluation has to include financial, economical, scientific and technical data but also societal and ethical aspects, probably essential to obtain public acceptance. In 2009, ONDRAF organised a number of consultations : the *Dialogues* to identify the various questions that worry the public, the *Conférence Interdisciplinaire* to collect advices from experts of different domains. But a most interesting approach was the *Conference citoyenne (11) :* organised by the Fondation Roi Baudouin, which has no connection with nuclear activities, but is expert in organising such meetings, They selected 32 citizens, representing different social and cultural positions. They declared : “none of us were experts on nuclear wastes but we took the challenge seriously and with enthusiasm, conscious of the societal importance of the subject”. They worked three week-ends, identifying the particular themes they would like to investigate, questioning the experts, defining their positions and summarizing them in a remarkable short report that was presented without delay after the last session. This process lead to an interesting conclusion : acceptance of the geological solution as long as it could be re-evaluated every ten years during the first 100 years.

If the ONDRAF actions lead to a report to the government in October 2011, decisions by the authorities are not yet taken. A similar process, with an even larger public consultation, was launched in November 2012 by the French government to define with the public, the future “energy transition”. The objective was to propose a plan to the parliament in autumn but the project was so ambitious with such a large number of meetings and consultations - 170.000 participants in about 1000 meetings - that the synthesis will be a hard job and the conclusions might frustrate a large part of the participants. The *Mouvement des Entreprises de France (MEDEF)* already considered that the debate was inconclusive . Nuclear was somehow pushed aside from the start due to the President‘s statements : early closing of Fessenheim plant and a reduction of nuclear electricity with a target of 50 %.

These are just a few examples. They show that depending on the time that can be devoted to the studies, the case must be carefully chosen, avoiding those that are insufficiently documented but also the situations that would be too wide to be interestingly analysed in the time allowed.

I took the examples above among the ones I knew best, mostly in France and Belgium, to show the sort of information that can be examined. But the interesting cases are many; In Great-Britain a well documented case is the controversy around THORP reprocessing plant with a basic book to start from : *The politics of anxiety* (13). The author was helped among others by two scientists deeply involved in the debate: F.G Berkhout and G.P. Walker from SPRU. The discussions around the PWR in Sizewell is also a well documented case starting with the Greenhalgh paper (14). Its summary gives a good overview already:

“The author sees the Inquiry as the latest in a line arising from government's wish to achieve greater public participation in controversial decisions. He believes that the Sizewell Inquiry is unlikely to shake the public out of its apathy, while a decision that goes against them will not satisfy the objectors. The concept of the Inquiry is based on the belief that the legal process will unearth objective truth, while most of the issues are matters of opinion and judgment. The wide-ranging terms of reference are leading to constitutional anomalies and attempts to

take on Herculean tasks in the search for objective truth. However, while concluding that an Inquiry Commission adopting a legal approach and following courtroom procedures is not a satisfactory way of dealing with large-scale technological projects, the author finds it hard to suggest alternatives short of more direct parliamentary control".

A quick look on the internet or any history of nuclear opposition, will also immediately give examples in Germany, Spain, Switzerland and many other countries like China where people demonstrations forced the government to cancel a uranium processing project *out of respect for public opinion* (15). A starting point can be the sites of the opponents organisations e.g. Greenpeace, Friends of the Earth, Sortir du Nucléaire (France, but also Switzerland).

3. What did we learn in a previous analysis of opponents actions ?

Years ago, we were confronted in Belgium with an organised opposition to the recycling of plutonium in Belgian reactors and the extension of the MOX fabrication plant. It lead to two years of demonstrations in front of the plants and in the streets and debates in the Parliament. *It was a sort of companion campaign to the well-known* - at the time*,- anti-THORP campaign conducted by the international anti-nuclear lobby* (12).

The main lesson we learned during this period, was that *creating confidence is the major factor of success. This can only be the outcome of a long term in-depth action.* Meanwhile, you cannot avoid a campaign against your nuclear projects. Thus when you plan a new activity, you must evaluate potential scenarios of the opposition and *define your position towards the various pressure groups that might interfere in a possible debate.* It must take into account that such a situation may last years on a single project and during this period *to win a battle does never mean the end of the war.* As the boy-scouts are supposed to be, *be prepared !*

You have to devote as much time to the local context as to scientific or technical facts. Approach of objections in the last ten years were very different near Mol, a nuclear area in Belgium, from what it was in Plogoff in the eighties. In some circumstances, Industries tend to offer information prepared in layman's terms, as most people have no time nor the adequate background to study technical or economical documents. But does the climate of confidence exist so that people do not simply reject this information, calling it *intox ?* Greenpeace among others is well known for its "never compromise" attitude so that it will reject the nuclear experts and bring forward its own that the public will believe more easily, suspecting the others of being "thick as thieves" with the nuclear business.

The role of the media is essential. Unluckily, in most cases in does not support nuclear activities. In Belgium, this is no surprise as a recent study by the *Association des journalistes professionnels* in April 2013 found that 45% of them, would vote green. Nevertheless, if well prepared in advance with interesting and attractive data, contact can be established, sometimes with the help of professional intermediates, obtaining more objective presentations in the media. A typical example during the MOX campaign was to provide a film of the complete process in the factory, without comments, only industrial noises, so that the televisions could illustrate their reports on plutonium activities with realistic images instead of atomic bombs explosions...

We concluded the PIME presentation saying that *it is time for industrial professional associations to ring the alarm bell and not simply wait until each of us is being challenged in his daily activities and has to fight for himself.* Since 1994, nuclear industry did react and the professional associations worked to find *democratic ways of developing nuclear activities with the population's consent.* Nevertheless, each of us is still subject to nuclear objections in our daily life, objections coming from nearby friends or local movements. Sometimes it is not easy to reply calmly. But we must learn, otherwise the result can be disastrous. During the

Fondation Roi Baudouin working week-ends I mentioned above, one of the experts lost his temper while defending the fact that his private company would manage the funds necessary to maintain the geological storage. The result was that the group recommended to transfer this task to a public institution...

4. Practically, how could we proceed ?

When selecting the case, consideration of the time allowed will be essential. I do not propose to analyze the consequence on the public opinion after Three Mile Island, Chernobyl or Fukushima, although it is documented in a large number of publications : books and films, internet sites, facts and fictions. For those interested, I give a first approach of these situations in my book (3) and I will not develop it here.

Rather, I would recommend to select a real situation that concerned the students as much as possible. If they are all from the same country, the last local opposition, which is sufficiently documented, would be the best. This condition could not apply to an international group of course but I would nevertheless chose a real case and not build an artificial situation.

If the teaching staff would not devote more than a day with no advance preparation by the students, they would have to collect the documents, possibly even summarize or translate some of them. To do the search, they might call for help from people who have been working on such subject like I did ! If I look at my own archives, I can find a number of cases where I have piles of press cuttings, books and films.

For courses that extend over longer periods like a year, with courses a few days every month or week, students may be asked to do their own research, to propose the event to be studied, select one and form small working groups. Another organisation would be required when students come from all places for residential courses lasting a few weeks, like the World Nuclear University in Oxford. Usually, they have to register a long time ahead and thus can be asked to propose cases. The teaching staff would select among them to form small groups; the students would be offered to chose among these, be confirmed in their choice by the staff so that they can collect information before they arrive. Thus the working groups during their residence could devote the time allowed for this subject, mostly to the analysis, the discussions between them and the presentations of their findings.

The objective is that students realize that opposition is a mix of rational argumentation and emotional objections, that bringing information is not sufficient. Opponents expect us to listen to their arguments, even if we consider them out of place. When people think that discussion will not drive changes, they will often consider that disruptive actions are justified. Then we are confronted with demonstrations and sometimes violent actions. It is better that students become conscious of this before they are involved personally.

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More references – also in English and German - on these subjects in my book (3). For those interested but who do not read French, I am willing to simply send copies by email of the reference list (167 references). Email your request to am462568@scarlet.be.

TRAIN AND BRING THE YOUNG GENERATION TO DISCOVER THE RADIOACTIVITY: AN ITALIAN PROJECT TO EDUCATE IN NUCLEAR SECTOR

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ABSTRACT

The project started from the consideration that the subjective perception (sensation) of the risk doesn't correspond very often to the objective and real risk of human activity. In particular, our perception of radioactivity is often misleading because of the lack of accurate information. A way to approach this theme, to make the public more trusting of nuclear issues related also to medical applications is to discuss radioactivity and ionizing radiation starting from young students. An experimental activity that involves secondary school students has been developed. It allows them to provide basic and correct information with the added benefit of being able to an experimental approach. On this basis was developed a project concerning the Italian secondary school, whose core idea is: (i) to provide the students a furnished laboratory at their school so that they can measure the radioactivity starting from the natural components that is a part of our environment. In this exercise, the measurement of the ^{222}Rn concentration is particularly well suited; (ii) to show the different types of radiations including ionizing radiations and how they are related each to the other; (iii) to demonstrate how ionizing radiations can be measured; (iv) to prove the fun a student can derive from discovery and detection of ionizing radiation.

1. Introduction

Usually the lack of information cause to be afraid about what we don't know, imputing to it a greater hazard. On the contrary we face up, without fear, activities that have a high level of riskiness, but for which we have direct experience. In other worlds the subjective perception of the risk very often doesn't correspond to the objective and real risk of an activity.

In particular the radioactivity theme is misled because it is almost unknown and a reason for general heightened sense of concern about radiation may be the lack of reliable and accessible information for not expert people [1].

A way to make the public more trusting, to help to build up a personal understanding to have a more rationally reactions, is to open a discussion about these themes, starting from young generations [2].

On this basis in Italy, with the aim to disseminate the scientific culture, several University Physics Departments with Lauree Scientifiche Project, funded by Italian Minister of the University (MIUR), and sections of the National Institute of Nuclear Physics (INFN) with ENVIRAD-SPLASH Project start, few years ago, an activity especially devoted to students and teachers of the Italian secondary school system, that would give them the opportunity to

discuss and to experiment with nuclear related experiences [3]. The students were provided basic but correct information with the added benefit of being able to make experiments by themselves. Moreover, this program offers the students an opportunity to understand the meaning of a research activity [4].
The core idea is to assist the students to understand that radiation sources produced by man and in particular after the Chernobyl severe accident [5] contribute with negligible exposure if compared with the natural sources from cosmic and terrestrial radiation [6]. The best way is that they by themselves measure the natural component of radioactivity to realize that radiation is a natural component of the air we breathe, of the earth we walk on, of the homes we live in, of the food we eat and of human tissues and bones. In this exercise the measurement of the ^{222}Rn concentration that alone – according to ICRP – contributes with the 55 % of the total exposure which an individual receives annually is particularly well suited. This specific topic induces students to be confident with nuclear science, introduces in correct way the problem of the radioactivity, involves students in physics measurements, in handling equipment, in data analysis, in result report, stimulates students to know environment where they live or study linking also radioactivity knowledge with other disciplines as geophysics, biology, engineering.

2. Materials and Methods

The project has a national valence with the implication of many schools for each Italian region. At each school the students at their own set up a small-scale radiation laboratory, where are directly involved in indoor radon measurements. In order to can make an intercomparison between the different schools, to provide a scientific value to the activity and the results derived there from, so as to standardize the results and methodology, in all locations is adopted the same type of detectors. In particular at each school that participates to the project, nuclear training kits are distributed.
The kits, composed of low cost instrumentation, include passive dosimeters CR39; small plastic boxes to be used as expansion chambers; a fryer to be used as thermostatic bath to develop the dosimeters; a cheap optical microscope with webcam interfaced to a PC. The detectors are prepared by students themselves, by cleaning in distilled water and treating with antistatic solution and, after drying the detectors are placed and packed in diffusion chambers. Afterwards students started the survey procedure positioning the dosimeters and filling data sheets with information on the sampling sites (address, building characteristics, room characteristics) and radon devices (device code, period and place of exposure, device position within the room, etc.). After the CR-39 dosimeters exposure for an integrate period of 6 or 12 months, the students are involved in etching procedure too, with a 6.25 M NaOH solution at 80°C for 6 hours, in order to enlarge the alpha tracks, and on the CR-39 reading at the optical microscope equipped with a web camera connected to a personal computer, for the track counting to determine density and then radon concentration values. Outputs were extracted as radon concentration in Bq m^{-3}, which represents integration over the entire exposure period of the solid state nuclear track detector.
In Fig. 1 is shown the exposure, development and track reading procedure.
The instrumentation, even if not so sophisticated, is the same of the one required for the measurements of indoor radon concentration by the Italian Radioprotection Law (Dlgs 230/95, 241/2000 and 257/2001), that imposes in the underground working place concentrations that not exceed 500 Bq.m^{-3}. In Italy the guideline for radon concentration in homes recommended limits be lowered 400 Bq.m^{-3} for the existing buildings and 200 Bq·m^{-3}

for the new ones: for higher Rn concentrations, measures, through suitable mitigation techniques, should be undertaken [7].

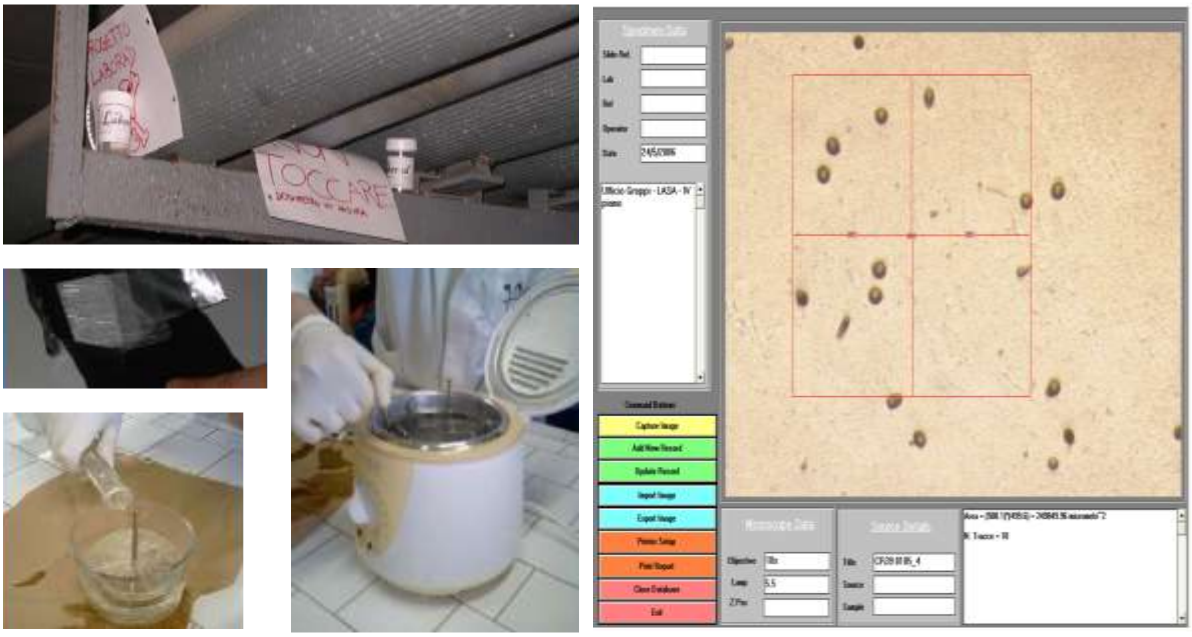

Fig. 1 – exposure, development and track reading of CR39 dosimeters

Each group of schools related to the different Italian Regions independently can complement with other methods of detection. In particular the students of Regione Lombardia compared the values measured with CR39 dosimeters with the results obtained with active portable radon monitor based on ZnS(Ag) solid scintillation chamber – or Lucas cell – (PRASSI, Silena, Italy) that can work in continuous and “grab sampling” way and by gamma spectrometry of ^{222}Rn chain daughters (^{214}Pb, ^{214}Bi), whose activity is accumulated in charcoal canisters (EG&G ORTEC, USA) exposed for some days. The scintillation chamber, the charcoal canisters and the gamma spectrometry system to analyze them are provided by our University research laboratory. Using different methods, students are challenged to reach a better understanding of the different measurements techniques and obtain more comprehensive data interpretation.
Finally with the help of their teachers, students prepare a report on the activity, like as a scientific publication and at the end of the year the students at the Physics Department of UNIMI and INFN during the “SPLASH Workshop” present, present, compare and discuss their results of the monitoring, the problems encountered, the future work in a really stimulating debate at the presence of other schools not jet involved, their teachers and University Professors.

3. Results and discussion

The measurements are done prevalently in the schools and in the houses of the students with the CR39 for periods of six months up to one year. The comparison with different measurement techniques prolonged up to some days, has given results in very good agreement, taking into account the errors present in these kinds of measures.

The students tried to find a correlation between the Rn concentration found in each measurement station with the year of building, the building materials, the floor and the soil composition. A group with the help of the Speleologist Group of the Club Alpino Italiano (CAI) of Saronno (VA), has exposed the dosimeters in some caves for three months. They could understand the problems related to make the measurements in this kind of environment, where the high humidity deforms the dosimeters and when radon concentration, ranging between 1 000 and 6 000 $Bq \cdot m^{-3}$ is so high to saturate them.
The project has achieved its goals. In particular it aims to promote a methodological approach in which the Physics (also the *most attractive*) is not only “introduced” to the students, but in which the Physics is “done” by the students; it is possible to underline to the students that the scientific method and the experimental approach is the same whether it is applied in the experiment smaller than in big experiments.
This activity would like to contribute to underline to the young people that the real risk in the field involving ionizing radiations is related to the loss of expertise, aspect that only with education and training it is possible to try to stem, but in meanwhile the activities using ionizing radiation become each day more and more employed in every field of our life.

4. Conclusions

We retain that starting from the measure of natural radioactivity is the best way for the students to approach the theme related to the nuclear on a more *rationale* basis and that the effective experimental activity is the best way to provide for an adequate scientific background.
Trough this project, also the teachers can carry out training or refreshers the course on these subjects.
Moreover, recognizing the importance of the communication, many seminars and workshops are periodically organized specifically for the students or devoted to the population. Also it is important to discuss different possible energy production sources, compare the risks and benefits in order to provide unambiguous and comprehensive answers to a wide range of questions related to these subjects.

5. Acknowledgements

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OVERVIEW OF THE SPANISH FUEL CYCLE: TECHNICAL TOURS ORGANIZED BY SPANISH YOUNG GENERATION IN NUCLEAR (JÓVENES NUCLEARES, JJNN)

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ABSTRACT

Spanish Young Generation in Nuclear (Jóvenes Nucleares, JJNN) is a non-profit organization that depends on the Spanish Nuclear Society (Sociedad Nuclear Española, SNE). Since one of its main goals is to spread the knowledge about nuclear power, several technical tours to facilities with an important role in the nuclear fuel cycle have been organized for the purpose of learning about the different stages of the Spanish fuel cycle.

Spanish Young Generation in Nuclear had the opportunity to visit ENUSA Fuel Assembly Factory in Juzbado (Salamanca, Spain), where it could be understood the front-end cycle which involves the uranium supply and storage, design and manufacturing of fuel bundles for European nuclear power plants. Afterwards, due to the tour of Almaraz NPP (PWR) and Santa María de Garoña NPP (BWR), it could be comprehended how to obtain energy from this fuel in two different types of reactors. Furthermore, in these two plants, the facilities related to the back-end cycle could be toured. It was possible to watch the Spent Fuel Pools, where the fuel bundles are stored under water until their activity is reduced enough to transport them to an Individual Temporary Storage Facility or to the Centralized Temporary Storage. Finally, a technical tour to ENSA Heavy Components Factory (ENSA) was accomplished, where it could be experienced at first hand how different Nuclear Steam Supply System (NSSS) components and other nuclear elements, such as racks or shipping and storage casks for spent nuclear fuel, are manufactured.

All these performed technical tours were a complete success thanks to a generous care and know-how of the workers in charge of leading the technical tours. The unanimous opinion of the participants was that taking part in this kind of activities is a worthwhile experience which has exceeded their expectations.

1. Introduction

Spanish Young Generation in Nuclear (Jóvenes Nucleares, JJNN) is a non-profit organization that depends on the Spanish Nuclear Society (Sociedad Nuclear Española, SNE). Since one of its main goals is to spread the knowledge about nuclear power, several technical tours to facilities with an important role in the nuclear fuel cycle have been organized for the purpose of learning about the different stages of the Spanish fuel cycle.

2. The Spanish Nuclear Fuel Cycle

The nuclear fuel cycle includes all processes and operations involved in manufacturing nuclear fuel, its irradiation in nuclear power reactors, as well as spent fuel reprocessing, recycling or disposing of the fission product waste produced during irradiation.

Depending on the management of the irradiated nuclear fuel, two cycle options may be considered:

- Open or once-through fuel cycle, without reuse of nuclear materials.
- Closed fuel cycle, with reuse of nuclear materials extracted from irradiated fuel.

In Spain, the closed fuel cycle was chosen for the reprocessing of irradiated nuclear fuel from the longest-serving nuclear power plants (Vandellós I NPP, José Cabrera NPP and Santa

María de Garoña NPP). This practice was interrupted in 1982, except for Vandellós I NPP. This plant was shut down in 1989, due to a turbine fire, and its fuel had to be reprocessed in its entirety. As a result of the commitments acquired from the different reprocessing contracts, several medium and high activity wastes should be returned to Spain from foreign fuel reprocessing facilities.

Nowadays the fuel cycle strategy adopted by Spain is the open or once-through cycle (see figure 1), mode of operation in which the nuclear material passes through the reactor just once. After irradiation, the fuel is stored in reactor spent fuel pools until it is sent to a storage facility, as it is done in Spanish nuclear power plants in operation (Almaraz NPP, Ascó I&II NPP, Vandellós II NPP, Cofrentes NPP and Trillo NPP).

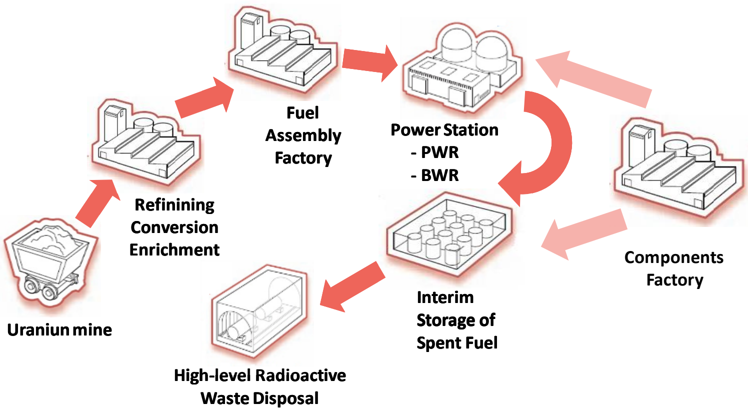

Figure 1.- Scheme of the Spanish open or once-through fuel cycle

All the activities involved in the fuel cycle may be divided into three categories:

- First category involves activities that take place prior to fuel irradiation, when fuel radioactivity levels are relatively low. These activities include milling, refining, conversion to uranium hexafluoride, enrichment in the fissile isotope ^{235}U and fuel assembly manufacturing.
- Second category of activities consists of fuel cycle design and irradiation of the fuel elements and assemblies in the reactor.
- Third category of fuel management activities includes operations on the highly radioactive spent fuel storage, shipping and disposal.

3. Spanish Fuel Cycle Facilities

Taking into account that the open or once-through cycle is the strategy adopted by Spain, it is important to make an overview about the current situation of the Spanish facilities belonging to each category of the cycle.

- First category:

All the facilities existing in Spain for the extraction of uranium ore have now ceased to operate. Certain of the mining sites have now been restored, while others are in the rehabilitation phase or are scheduled to be restored in the near future.

In addition to extraction and treatment of the ore, the first part of the cycle also involves the manufacturing of uranium concentrates. At present, the Quercus Plant, an uranium concentrates manufacturing facility, is shut down and no longer produces. Other disused concentrates manufacturing facilities, such as the Lobo G Plant, have been decommissioned or are in the final phases of dismantling and decommissioning, for example the Elefante Plant and the AUM (Andújar Uranium Mill).

The final stage of the first category of the cycle is the manufacturing of the fuel assemblies. In Spain, there is a fuel cycle facility in operation for the manufacturing of pellets, rods and fuel assemblies, located in Juzbado (Salamanca).

<u>- Second category:</u>

The second category of activities of the fuel cycle is the irradiation of the fuel in the reactor. Spain has eight nuclear power reactors in operation located at six sites, two power reactors closed down, in different steps of the decommissioning process, and a power reactor temporarily shut down.

<u>- Third category:</u>

After passing through the reactors, the irradiated fuel contains high levels of activity due to fission products and small amounts of plutonium. The last part of the cycle encompasses the management of the waste generated throughout the process. This waste may have low and intermediate or high levels of activity. The low and intermediate level waste is taken to the El Cabril disposal facility, called 'El Cabril' and located in the South of Spain. The irradiated fuel assemblies are stored in each nuclear power plant pool. However, due to the lack of capacity in reactor pools or to decommissioning, three temporary individual storage facilities have been built in three nuclear power plants sites, where the irradiated fuel assemblies are stored in dry casks. Nowadays, a centralized temporary storage facility is projected. The planned facility is designed to receive and store for decades all the spent fuel resulting from Spanish nuclear power reactors, the high-level vitrified waste and long-lived intermediate level waste generated abroad in the reprocessing of Spanish fuel and the intermediate level radioactive waste from nuclear power plants decommissioning, those with activity levels higher than 'El Cabril' low and intermediate level waste disposal facility acceptance criteria.

Besides, in figure 1, in light-red colour, it is represented an additional facility located in Spain, with an important role in the fuel cycle, which supports the second and final categories of the nuclear fuel cycle. It is the heavy components factory, which supplies Nuclear Steam Supply System (NSSS) components and other nuclear elements such as racks and shipping and storage cask for spent nuclear fuel.

4. Technical Tours

Several technical tours have been organized to comprehend the different stages of the Spanish open fuel cycle. These tours have provided an excellent opportunity for young professionals to increase their understanding of the technical process accomplished at the different Spanish fuel cycle facilities.

Spanish Young Generation in Nuclear had visited three fuel cycle facilities and the heavy components factory, which supports the second and final categories of the cycle. All of them are listed below and are located in the map of Spain shown in figure 2:

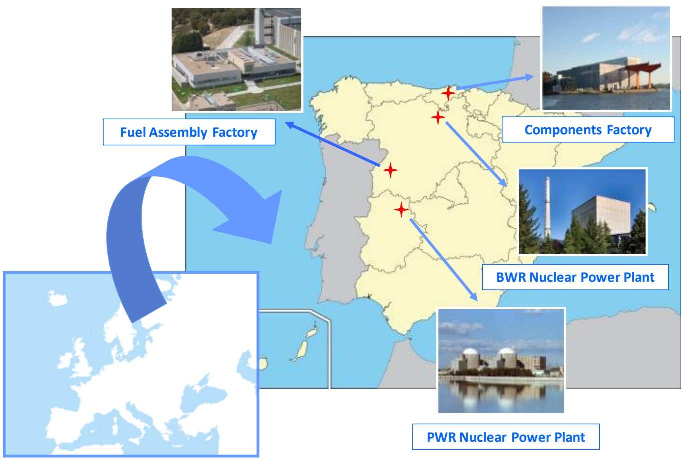

Figure 2.- Location of the nuclear facilities toured

- ENUSA Fuel Assembly Factory in Juzbado (Salamanca).
- Almaraz Nuclear Power Plant (PWR) in Almaraz (Cáceres).
- Santa María de Garoña Nuclear Power Plant (BWR) in Santa María de Garoña (Burgos).
- ENSA Heavy Components Factory in Maliaño (Santander).

The tours have allowed the participants to experience at first hand how the different activities of the fuel cycle are performed and to broad their knowledge about the front-end cycle. As it is shown in figure 3, a wide part of the different categories of the cycle have been covered: fuel assembly factory, power stations (BWR&PWR), spent nuclear fuel pools and heavy components factory.

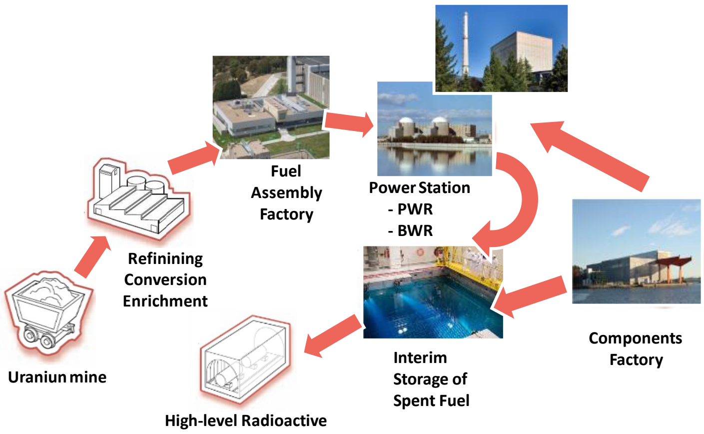

Figure 3.- Nuclear fuel cycle facilities toured

4.1. ENUSA Fuel Assembly Factory

Enusa Industrias Avanzadas, S.A. is focused on the design, manufacture and supply of fuel assemblies to Spanish and international power plants. Enusa core business is the front end of the nuclear cycle, which includes everything from the management and supply of enriched uranium to fuel manufacturing, as well as provision of engineering and fuel services to the nuclear power plants.

Present in the town of Juzbado, in the province of Salamanca, since 1985, the Enusa fuel assembly factory is one of the most innovative in Europe, as it incorporates latest generation technology that optimizes resources and protects the environment. This centre has a specialized, highly qualified team that covers the entire fuel production cycle: uranium supply and storage, and logistics of the components required for manufacturing, fuel production, product quality control, development of equipment for PWR, BWR and VVER product manufacturing and management of logistics and distribution to the plants throughout Europe.

The group of young participants could visit the main areas of Enusa fuel assembly factory:

- Ceramic area where it could be observed how the powder of uranium oxide and/or uranium oxide plus gadolinium is turned into high density sintered pellets.
- Mechanical area where ranges from the loading of the pellets in the rods to the manufacturing of the fuel assembly, including all the required inspections to ensure the final product quality.

Figure 4.- Technical Tour to ENUSA Fuel Assemblies Factory

4.2. Almaraz Nuclear Power Plant

Almaraz Nuclear Power Plant is located in the province of Cáceres, in the area known as Campo Arañuelo, cooled by water from the Arrocampo reservoir on the Tajo River.

There are two Westinghouse three-loop pressurized water reactors (PWR) operating on the site with an electric power of around 1000 MWe each one. Unit I was connected to the national grid in 1981 and the Unit II was connected two years later, in 1983.

As introduction, the visitors entered to the Information Centre, where there is a mockup of the plant and, basing on it, the improvements required from post-Fukushima nuclear stress tests were commented.

Inside the plant the group of young people could visit the turbine building, the electrical building, the control room, the technical support centre and one of the five emergency diesel generators. Subsequently, the visitors gained access to the controlled area, in particular, to the safeguard building, the auxiliary building and the fuel building where the Cherenkov effect could be seen glowing in the spent nuclear fuel pool.

Figure 5.- Technical Tour to Almaraz Nuclear Power Plant

4.3. Santa María de Garoña Nuclear Power Plant

The Santa María de Garoña Nuclear Power Plant is located in the meander formed by the Ebro River in the surroundings of the town that gave its name to the site, in the Tobalina valley in the province of Burgos.

In 1971, Santa María de Garoña was connected to the national electricity grid, achieving full power 27 days later, with 460 gross electric megawatts, which correspond to 1,381 thermal megawatts, the greatest amount installed in Europe at that date.

Figure 6.- Technical Tour to in Santa María de Garoña Nuclear Power Plant

The nuclear power plant has a Series 3 Boiling Water Reactor and Mark I type containment, which produces 466 MW of electric power and was supplied by General Electric Company.

Upon arrival the group was conducted to the Information Centre, receiving an explanation about the main characteristics of Series 3 BWR and an outline of how Fukushima accident happened, due to both plants are twin plants. Once it was understood how a BWR reactor works, the young people had the opportunity to visit the secondary containment, the pressure suppression pool torus and the spent fuel pool, as well as the emergency diesel generator building, the control room and the simulator.

4.4. ENSA Heavy Components Factory

ENSA is a worldwide leader in the supply of manufactured equipment and services for the civil nuclear industry.

ENSA factory is located in the north of Spain, in Maliaño (Cantabria), 9 km from Santander city. ENSA manufactures components in compliance with the most exigent standards, regulations and customer requirements. They are world leaders in supplying steam generators for nuclear power plants. They also supply reactor vessels, reactor vessel cover heads, reactor vessel internals, reactor vessel supports, casks for fuel storage and/or transportation, racks for fuel, nozzles for fuel and heat exchangers.

Figure 7.- Technical Tour to ENSA Heavy Components Factory

Tour participants visited the Advanced Technology Centre (CTA), where the materials and process performed during the manufacturing and test of the heavy components are developed, proved and qualified. The centre comprises four working units: metrology and materials testing laboratories, welding development, robotic applications and defectology. Finally they traversed the heavy nuclear components factory, being able to see casks for fuel storage and shipping up close, reactor vessel cover heads and to compare the steam generator from conventional PWR reactors with ones from AP1000 reactors.

5. Conclusions

The unanimous opinion of the participants was that taking part in technical tours is a worthwhile experience which has exceeded their expectations. Taking into account the interest wakened in the young participants, it can be concluded that visiting technical facilities is an overwhelming teaching practice which provides an excellent opportunity to experience at first hand the whole process of electricity production in nuclear power reactors.

All the performed technical tours were a complete success thanks to a generous care and know-how of the workers in charge of leading the technical tours.

Spanish Young Generation in Nuclear is extremely grateful to the Spanish Nuclear Society for the support for all the activities accomplished.

6. References

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- ENSA http://www.ensa.es/

HOW TO BUILD A NUCLEAR POWER PLANT?
A KNOWLEDGE TRANSFER INITIATIVE

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ABSTRACT

Jóvenes Nucleares, the Spanish Young Generation Network, has organized five of lectures explaining the evolution of Spanish nuclear power program, milestones and achievements for today involving nuclear energy 20% of the energy consumed in Spain.

In a first conference in the series titled "The Rise of Spanish nuclear program", Mr. Agustín Alonso, spoke of the actions carried out by the Spanish Government and the Utilities, in the development stage euphoria of Spanish nuclear. The second lecture of the series, "José Cabrera Nuclear Power Plant", by Mr. Jesus Fornieles, talked about the characteristics of the plant, the most important milestones in its construction and investments implemented.

In the third lecture, "Almaraz Nuclear Power Plant", Mr José María Zamarrón, spoke most representative landmarks of plant construction and improvements implemented. The fourth conference, "Santa María de Garoña Nuclear Power Plant", by Mr. Elias Fernandez Centellas, talked about of the milestones most representative of the construction of the plant, difficulties and lessons learned.

In the fifth lecture, "Trillo Nuclear Power Plant", by Victor Sola, was talk of energy, political and economic environment in which the project was initiated and developed, representing milestones in the construction and the contribution of nuclear generation to development of Spain.

1. Introduction

Spanish Young Generation in Nuclear (Jóvenes Nucleares) is a commission of the Spanish Nuclear Society (SNE), whose main goals are to promote the transfer of knowledge and experience between mature and young generations of nuclear professionals and encourage communication and discussion among these professionals.

The objective of the cycle of conferences is to present to young nuclear professionals the experiences and knowledge of professionals who have worked in the industry since its inception and have made it an industry leading.

In the first lecture "The Rise of Spanish nuclear program" was shown to the audience the Spanish nuclear program origins, the development, resources, training people, site selection.

The following conferences related with the construction of nuclear power plants in Spain, served to show to the attendees the design phase, construction phase, commissioning phase and operation phase; particularized to each of the plants.

2. Lectures Development

The introductory lecture "The Rise of Spanish nuclear program" was conducted by Dr. Agustín Alonso, Professor Emeritus at the UPM who has worked in the nuclear industry development. The young and experienced attendees learned about positive and negative milestones that changed the history of the world nuclear development, the milestones of the nuclear development in Spain, the origins of the Regulatory Body, the different national energy plans, the motivation of the antinuclear movement and the origins of the Spanish nuclear moratorium in the 80´s.

Figure 1. Lecture "The Rise of Spanish nuclear program"

The second conference called "José Cabrera Nuclear Power Plant", was given by Mr. Jesús Fornieles, who has worked at this plant from the 70´s, having different responsibility positions. The lecture showed the different stages through which it has passed the plant: preliminary design phase, design phase (site selection, business owners, economic data), construction (Spanish and local participation, programming and planning, purchasing, quality, engineering), operation, post-operation and decommissioning.

The conference "Almaraz Nuclear Power Plant", was given by Mr José María Zamarrón who worked for 30 years in all phases of project Almaraz Nuclear Power Plant: site selection, construction, testing, commissioning and operation, occupying multiple positions technical and management. Attendees learned the facts most representative of the construction of the plant, from the "Prior authorization" to "First criticality", through the "Building permit" and "Cold hydrostatic test" and the recents improvements.

Figure 2. Lecture "Almaraz Nuclear Power Plant"

The conference "Santa Maria de Garona Nuclear Power Plant" was given by Mr. Elias Fernandez Centellas that is working for this plant since its construction phase. In this conference was presented the most important milestones from the construction to commissioning and various curiosities such as difficulties in transporting large equipment on the roads of that time. The presentation was accompanied by a video made by the Spanish Public Television during the first years of plant operation to publicize the work done there.

Figure 3. "Santa Maria de Garona Nuclear Power Plant"

The conference "Trillo Nuclear Power Plant", was done by Mr. Victor Sola, responsible for the commissioning of this plant. The young participants learned more about energy, political and economic environment in which the project was initiated and developed, as well as details specific to implementation: project phase, authorization, construction and operation. The conference also discussed nuclear generation contribution to the development of Spain and future prospects of the nuclear sector.

Figure 2. "Trillo Nuclear Power Plant"

3. Conclusions

All conferences were a large number of attendees, young professionals and mature professionals, some of whom lived the reality exposed at conferences.

Young professionals attended these conferences motivated to know more about the origins of the sector for which they work and the mature generation of professionals attending in order to transfer their experience and knowledge to younger generations.

These experience is quite valuable for those young workers that may participate in a NPP construction in the next years, being in Europe, Asia or America.

RECENT DEVELOPMENTS IN NUCLEAR TRAINING AND EDUCATION – IN A NON NUCLEAR POWER COUNTRY

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ABSTRACT

Due to Austrian legislation it was never easy to train and educate people in Austria about nuclear issues. The Institute of Atomic and Subatomic Physics (ATI) in Vienna together with the Austrian Nuclear Society (ÖKTG) has taken, several steps to bring the subject of nuclear topics closer to the public. This was especially important as the TRIGA reactor at the institute was in the phase of negotiations for a new core, just during the crisis caused by the Fukushima accident. Without the good education program of the institute, that enabled an information centre of students and professionals for the public and media during the Fukushima crisis, the reactor would now be shut down. This paper will show the latest education efforts at the institute, together with the ÖKTG: It will be shown how information and training at the secondary education level is essential for the civil society. School classes have different possibilities of requiring nuclear training at the ATI Vienna: They can either choose a simple visit to the institute and reactor, a presentation in class by a member of the Young Generation, or full-day training at the reactor (which includes a start of the reactor for each student). Further, a project was started in 2011 to train high school teachers at the institute for a longer period so that their knowledge stays up to the current research level and they can give their students up to date and interesting lectures. The last point will be a showcase of public information. A book aimed for a general audience was written just after the Fukushima accident, with the goal to inform the public about all relevant nuclear topics. This book was recently translated into English and shall be available for all training and education purposes at undergraduate levels. Additionally, in mid-2012 a project was started together with a private company and EHRO-N investigating how the Fukushima nuclear accident affected enrollment numbers at a University level. A paper with the first results of this study is currently on its way to publication and a second one focusing on the European status in education after Fukushima is under work, and should provide results in July 2013.

1. Introduction

Due to the Austrian legislation it was never easy to train and educate people in Austria about nuclear issues. The Atominstitute in Vienna has taken, together with the Austrian Nuclear Society (ÖKTG) several steps to bring the subject of nuclear topics closer to the public. This was especially important as the TRIGA reactor at the institute was under negotiations for a new core. These negotiations took place in 2011, when the Tsunami hit Japan and caused severe crises in the nuclear industry. Without the good education program of the institute, that enabled an information centre of students and professionals for the public and media during the Fukushima crisis, the reactor would now be shut down. This paper will state the current status of courses at the Institute of Atomic and Subatomic Physics, discuss the initiatives driven together with the Austrian Nuclear society (ÖKTG) for schools and teachers. It will furthermore describe a showcase of how a simple book can be used for educational purposes. The last part of this paper is dedicated to a study carried out of a private company together with EHRO-N determining the changes of university education programs after the Fukushima crises.

2. University Level Courses at the Institute of Atomic and Subatomic Physics (ATI)

The ATI offers courses for national students and for students of foreign universities. The most important international courses are listed and described below. This is an important part of knowledge management and is very well perceived from European Countries.

2.1 Eugene Wigner Course

The Eugene Wigner Course was established in 2005 in cooperation between TU Bratislava, TU Budapest, TU Prague and the Vienna University of Technology (VUT). A group of about 15 students was subdivided into four groups, started together in Bratislava, and then rotated among the involved Technical Universities. At this course they carried out practical work at three different research reactors including theoretical lectures, and a final examination which was accredited by their home university with 6 ECTS. During the last two years, financing of this course became very difficult and the course was terminated in 2009 due to lack of financial support from external sources although the feedback from all participants was very positive.

2.2 Training Course for the MTR+3I EU project

The ATI took part in the above mentioned EU project together with about 25 other European research centers. The contribution of the ATI was to prepare a practical demonstration training course for future reactor operators. This course took place in March 2009 with five international participants and was successfully accepted as a demo course by the EU.

2.3 Nuclear Technology Education Consortium NTEC, UK

In 2007, the NTEC, coordinated by the University of Manchester, contacted the ATI if it could offer a one week academic reactor course for NTEC students. The contract was signed and since this time a total of twelve courses (two per year) were carried out, each course with six NTEC students. The course is credited by NTEC with six ECTS.

2.4 NPP Staff from Slovakia

For several years, the Technical University of Bratislava is involved in the re-training of the NPP staff of the NPP Bohunice and NPP Mochovce. Since Slovakia does not operate a research reactor and Bratislava is very close to Vienna, the ATI was asked to take over the practical part of the training course which has been performed 11 times since 2002.

2.5 MOL Courses

The Belgian research centre MOL is requested by the regulatory body to offer a re-training programme for their operators. In view of this task, the ATI was asked to host a total of 36 operators divided into six groups of six participants each to perform a course using experiments both from the standard reactor physics and kinetics course as well as from the reactor instrumentation and control course.

2.6 IAEA Junior Safeguards Traineeship Program

To fulfill the IAEA requirements for an application as Safeguard Inspector, the ATI offers, together with the IAEA a specific training for applicants from emerging countries. Since 1984 every two years a 9 month training course is held for up to 6 technicians from emerging countries. The first part of the course takes place at the ATI and covers practical training at the TRIGA reactor Vienna as well as basic nuclear- and reactor physics, reactor safety and fuel cycle. Since 1984 totally 114 trainees passed the course at the ATI.

2.7 Eastern European Research Reactor Coalition (EERRI)

In 2008, the IAEA initiated several research reactor coalition programs to increase cooperation and utilization of research reactors in various regions. One region is Central and Eastern Europe and therefore the Eastern European Research Reactor Initiative (EERRI) was created. The ATI is part of this coalition and one target of this initiative is to offer practical training to young professionals. Since the formation of EERRI two different types of courses were carried out, the first course coordinated by the ATI in cooperation with the Institute Josef Stefan in Ljubljana/Slovenia, the KFKI and Technical University in Budapest/Hungary, and the second course was coordinated by TU Prague in cooperation with the ATI and the Institute Josef Stefan in Ljubljana/Slovenia. A total of 8 courses have been carried out since September 2013 with more than 50 trainees from 30 nuclear emerging countries. Two more courses are already planned for 2014. Participants are accepted either through IAEA Technical Cooperation projects from all over the world or by direct contract between the ATI and the requesting countries.

2.8 Selected Courses for IAEA Technical Cooperation projects

The ATI hosts IAEA fellows for periods of one month to one year through IAEA Technical Cooperation projects. Since 1983, more than 130 fellows participated at highly specialized training project from all over the world, and fellows are attached according to their interest in one of the working groups. Experience shows that after their return to their home institute long term relation and cooperation between the two institutes result as a positive outcome from these fellowships.

2.9 Master of Nuclear Security Course

The Master in Nuclear Security Programme is based on the IAEA publication NSS 12 and was established as a cooperation of the Delft University of Technology, VUT, Brandenburg University, University of Manchester, University of Oslo and the National centre for Scientific Research DEMOKRITOS (Greece). The programme is financed by the Lifelong Learning Programme of the EU. The ATI with its close relation to the IAEA plays an important part in this course, providing lecturers on nuclear physics, physical protection as well as detection of criminal or unauthorized acts involving nuclear and other radioactive material out of regulatory control. The pilot course started in March 2013, and 4 lectures were given at the ATI. The course is planned to continue as a regular course in the next years.

2.10 Conclusion

It has been shown that even a small university research reactor can be efficiently used, not only for standard training course within the academic field, but can also be used commercially by offering education and training experiences to other groups as mentioned above.

3. Initiatives for High Schools and Teachers

Driven by the initiative of a high school physics teacher the ÖKTG – YGN started an educational program in 2010. Several ideas were put together, which are described in the next points.

3.1 High School Initiatives

To introduce the topic of radioactivity and nuclear technologies to interested high school students the ÖKTG – YGN proposed two different options: They could either “book” a day at the ATI or could be visited by a member of the YGN. The first option included a three point program with the first part being an introduction to radioactivity, the second part a guided tour through the ATI and the last part a start up by every pupil of the reactor.

The introduction to radioactivity was carried out by members of the YGN, who also talked about their personal experience of working in NPPs or their interest in the studies of technical subjects. The pupils were given radiation pagers, and searched for hidden radioactive objects (NORM material).
The tour through the ATI showed them the different options the subject “Physics” provides, the highlight was the train driven by superconductivity in the basement of the ATI.
As the TRIGA reactor is very easy to handle, and especially made for training, the ATI was also able to let all visiting pupils start the reactor up. A certification was given to the pupils, after successfully carrying out this task.
The second option was a visit of an YGN member to the school class. This included a presentation about the basics of radiation, the basic working principles of a reactor and applied radiation in different fields. In the end was time for a discussion.

3.2 Teachers Initiatives

To achieve a longer lasting effect, the Austrian Nuclear Society started together with the club A.L.F (Up-to-date Teacher’s education) an initiative to show physics high school teachers the up-to-date research in several institutes of the VUT. Teachers visited the institute for a day, got insight knowledge of the current research at the institute and had to choose a topic for an essay. In the beginning teachers were interested, as it was also part of their on-going and mandatory training, but the initiative came to a halt. It was planned to have a training of teachers every 18 month.

4. Educational Showcase

During the Fukushima Crises, the ÖKTG-YGN was managing an information centre [1]. This lead to the idea of writing a book [2] which can be used as background and basic knowledge information. This book was published in October 2011, translated into English in 2012 and is now available for everyone. It is a useful tool to inform and educate the broad public. Without the help of this book the TRIGA reactor would now be shut down [3].

5. Nuclear knowledge Management after the Fukushima Accident

Nuclear education has seen many ups and down since the birth of nuclear technology. Due to the highest prior support from all stakeholders during 1960s, nuclear education, along with its technology, has witnessed its peak time. In the 1970s, the development of nuclear power technology was severely damaged by some local and global nuclear accidents. The Chernobyl nuclear disaster in 1986 further deteriorated nuclear education, especially in industrialized countries. Many local, regional, and international efforts were put together to restore a system of nuclear education. These painstaking efforts started the nuclear education system growing again, but the Fukushima nuclear disaster in 2011 seems to be creating serious obstacles in the restoration of nuclear education in many counties. This study shows light on the influence of the Fukushima nuclear accident on nuclear education. For this purpose, a worldwide survey has been conducted through a well-designed questionnaire, seeking the most information possible about the trends of nuclear education. This questionnaire collects student enrollment data from 2007 to 2012. It was distributed to about 210 different institutions in 57 countries with nuclear power programs, or intentions to develop a nuclear program. Out of these 210 institutions, a total of 69 institutions responded the questionnaire. This survey covered the continents of Europe, Asia, and The Americas. Based on these international survey results, this research highlights the impacts of the Fukushima nuclear accident on nuclear education programs in European, Asian, and American countries individually. Due to great interest this study lead to a second study together with EHRO-N taking a closer and more detailed look at European student enrollment numbers.

5.1. The questionnaire

The questionnaire was designed to be answerable in 5-10 minutes and still collect as much information as possible. It included answers about:

- Name and country of the institution
- Nature and length of nuclear education program
- Special academic/training program (if any)
- Total number of applications per year
- Student enrollment data of the current year (2012)
- Enrollment data of last six years (from 2007 to 2012)
- Main employer of the graduates
- Inclusion of Fukushima accident in the course
- Student interests in response to Fukushima accident
- Impact of Fukushima accident in the funding
- Institution is interested in the final report
- Rating the questionnaire
- Confidentiality of data

After collecting the data from 29 different countries in Europe, Asia, and The Americas, the trends in nuclear education have been seen in different regions, reflecting the nature and size of their respective nuclear programs. It has only been one and half years since the Fukushima accident, which is not enough to predict the visible influence of the accident. The visibility of trends in nuclear education may take some more time. The Fukushima accident affected the nuclear environment in some developed countries like Germany, Italy, Austria, Switzerland, and Japan, while in India, Pakistan, and China, the public perception is still pro-nuclear and there have been increasing trends in nuclear education. This section is divided into three subsections: Europe, The Americas, and Asia. Out of the 69 received responses, 48 have shown complete enrollment records, 12 presented incomplete records, and 9 were unable to provide any enrollment data. It is safe to say that many universities did not respond to the questionnaire because of their own reasons, and possibly due to lack of data. 85% of Universities did not record a change in their budgets, 5% reported an increase and 10% reported a decrease directly linked to Fukushima which is problematic since nuclear education would need more money to train better professionals.
Figure 1 depicts the overall state of nuclear education around the globe. After the Fukushima nuclear accident, Germany shut down half of their nuclear power plants, Italy held a referendum which cancelled their plans for new build, Switzerland put their nuclear plans on hold, and other European countries also didn't show much enthusiasm for nuclear development. It is not surprising that European universities show the biggest decline in student numbers. American universities show almost no impact from Fukushima.

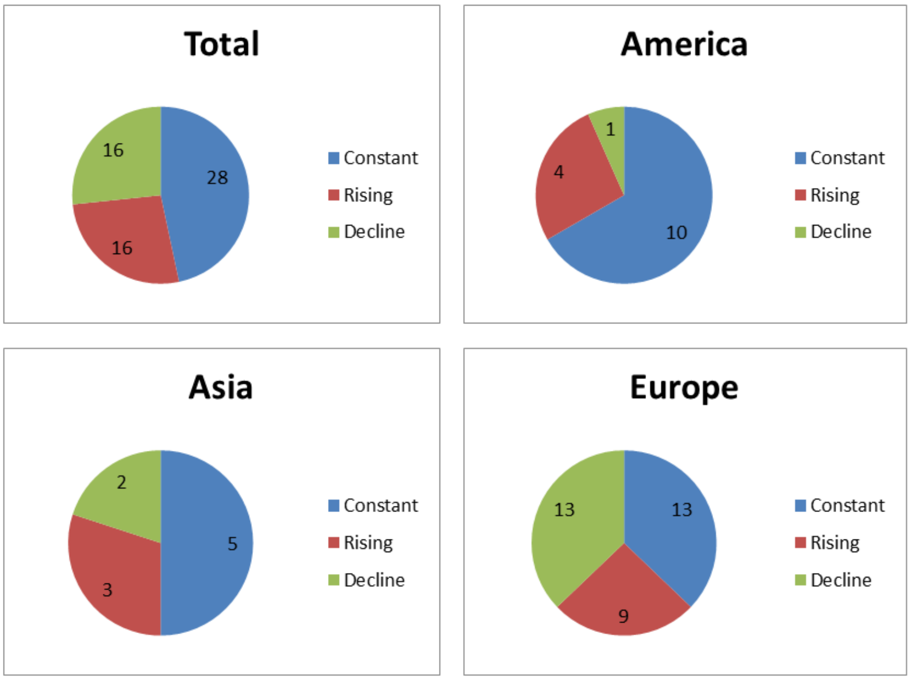

Fig. 1. Nuclear Education Trends in Different Regions of the World

Before the Fukushima nuclear accident, the nuclear knowledge management landscape in Europe (EU-27) has been observed as growing in variety, as well as in number of instruments and initiatives [4]. The effects of the Fukushima Daiichi accident on the workforce situation are significant in some countries. For example, the main changes that affect the supply of/demand for nuclear experts, at least at a national level, occurred in Germany (where 8 nuclear power reactors were taken off the grid, and the rest will be closed by 2022.

The overall picture is changeable, and a clear judgment of the consequences is considerably challenging at this moment. It is, however, clear that there is still the need for highly competent experts on nuclear safety in the EU-27, which should provide a drive for good job opportunities in the region for decades to come [4].

To show the real influence of the Fukushima accident, the responses on the above-described questionnaire were received from 24 different institutions of nuclear education, located in 18 European countries.

Europe is quite important for the nuclear future, since many countries have their own programs, but do not coordinate much with one another. EHRO-N has already started to find out how flexible nuclear experts in Europe are, and how much they are willing to travel or resettle in a new location.

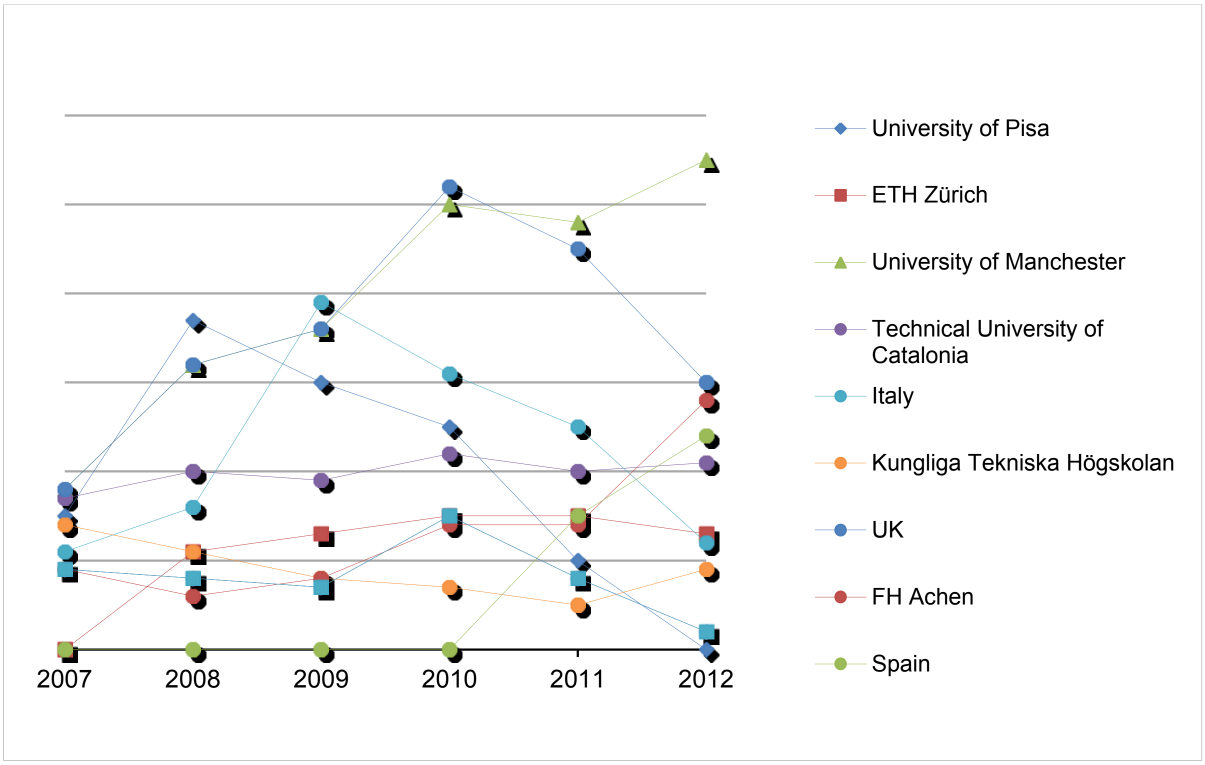

Fig. 2. Pre and post Fukushima Trends in Nuclear Education in Some European Countries without labeling due to privacy reasons

The results of the new survey carried out together with EHRO-N are still incomplete and not enough data was received to make a reliable conclusion but preliminary results show mostly increased or steady student numbers.

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RISKY KNOWLEDGE : E-LEARNING METHOD AND TOOL FOR SECURITY AND SAFETY DOMAINS

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Risky Knowledge is a European Transfer of Innovation project. The aim is to develop an innovative e-learning tool and a specific training approach for professionals, focusing on **Security and Safety topics**. Funded by the Leonardo da Vinci Programme, the RISKY project sets a collaborative network to promote experience exchange between trainers, learners, industrial experts and professional associations. The RISKY project will result in an online, competence- and Work-Based-Learning vocational training approach for Security and Safety professionals.

Nowadays, there is a lack of Security and Safety skills in SMEs and large companies. Enterprises do not have enough experienced people able to provide efficient judgement and workforce.

Thanks to this collaborative project we are implementing an e-learning platform to address Security and Safety specific training needs by providing pragmatic content created by professionals and experts, available in different languages. **The first outcome of this innovation project is a training catalogue of innovative e-learning courses on security and safety**, created by professionals of the sector.

Moreover, our tool is designed according to job requirements and trainee profile, thus giving the opportunity to have a **very personalized training course**. The second outcome of this project is a specific pattern of Security and Safety knowledge in order to follow-up the progress and paths to develop the appropriate competencies. Our ambition is to give trainees the opportunity to adjust their skills and competencies to cover professional profile requirements **by following a specific learning path for attendee or managing profiles for Human resources or head of security and safety.**

The long-term ambition is to offer to future client companies the opportunity to use this platform to **capitalize on their own proper knowledge**: our platform will be used as a staff management tool regarding competence and training needs.

Feedback continuously provided to RISKY partners by European industrials (like Euro Nuclear Society, French Space Agency or IK4-IKERLAN) and professional associations (like ISACA) helps to tune the training approach, adapting it to the appropriate competences.

To put it in a nutshell, the e-learning tool we are developing is much more than mere online learning. It is job-oriented (i.e. dedicated to Security and Safety professionals), with a focus on competences (i.e. what are you able to do with your knowledge) and uses an innovative methodology called work-based learning, thus enabling the learner to quickly apply his knowledge to practical working situations.

Lifelong Learning Programme

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