IAEA
International Atomic Energy Agency

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International Atomic Energy Agency
Agence internationale de l'énergie atomique
Международное агентство по атомной энергии
Organismo Internacional de Energía Atómica

# MEETING REPORT
Of the
IAEA Technical Meeting
on
**Promote the Awareness and the Use of Nuclear Facilities and Related Simulators as Effective Tools for Education and Research and for Capacity Building**
23-25 May 2011
Essen, Germany

Draft

# 1. Background

The important role which the International Atomic Energy Agency (IAEA) plays in assisting the Member States (MS) to preserve and enhance nuclear knowledge and facilitate international collaboration has been recognized by the General Conference of the IAEA in resolutions GC(46)/RES/11B, GC(47)/RES/10B, GC(48)/RES/13, GC(50)/RES/13 and GC(51)/12. Through these resolutions the MS requested IAEA support to provide assistance in their efforts to ensure preservation of knowledge in nuclear science and technology for peaceful purposes, which is a necessary prerequisite for succession planning, in particular through the networking and knowledge sharing among Member States and their institutions.

More than 50 Member States have recently approached the IAEA expressing interest in launching a nuclear power programme. In all cases the development of human resources capable of supporting the implementation of these programmes has been identified as one of the main challenges. Additionally, many of the 30 Member States that already have nuclear power programmes are either expanding or considering the expansion of their programmes. For many of them this comes at the same time as there is a need to replace the generation of workers that commissioned nuclear power plants (NPP) now in operation.

Given these needs, the education, recruitment, selection, training, qualification and retention of human resources to support the introduction and expansion of nuclear power programmes has been a matter of concern for many national governments and has attracted a great deal of attention and support from industry and international organizations. The decline in the number of younger people studying nuclear sciences and a growing number of universities giving up or strongly limiting their nuclear education programmes have given rise to new initiatives for networking educational institutions, universities and industry training centres. New national and international “platforms” for sharing knowledge and expertise in nuclear education and training (WNU, ANENT, ENEN, ANSN, UNENE and others) have been established and have become the drivers for renewed interest in nuclear education.

Knowledge preservation is a key element of capacity building in countries with NPPs as well as those that are on the verge of developing a nuclear programme. Some of the key tools for national capacity building through nuclear education are nuclear power simulators for education, which are considered as effective tools for nuclear education.

Over the past years, the IAEA has been working with universities to address future workforce demand developments and the quality and quantity of nuclear education. The coordinated efforts with Member State institutions led to the establishment of Networks for Education in Nuclear Technology (NENT) and a related web-based cyber learning platform.

The next step in the IAEA’s activity is to share experiences and good practices on the use of simulators for nuclear education and to integrate some of the key computer-based simulators in the NENT cyber learning platform to enable wider dissemination of these tools to our Member States through regional hubs.

## 2. Objectives

The objective of the TM is to provide participants with a forum to review and discuss currently available nuclear power simulators for education and their integration in the IAEA Cyber Learning Platform (CLP), in particular:

1. Share experiences and good practices on the use of simulators for nuclear education and capacity building with emphasis on computer-based simulators for various aspects of nuclear technology; and

2. Identify educational simulators to be integrated in IAEA CLP and discuss various practical arrangements for its accomplishment.

# 3. Agenda

## 23 – 25 May 2011
### Simulatorzentrum KSG/GfS Essen, Germany

### Meeting Rooms: Multi 1 and 2, Phone +43-1-2600-22896/25803

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OBJECTIVES OF THE MEETING:

**The objective of the Technical Meeting is to provide participants with a forum to review and discuss currently available nuclear power simulators for education and Research and their integration in the IAEA Cyber Learning Platform (CLP), in particular:**

- **share experiences and good practices on the use of simulators for nuclear education and Research and capacity building with emphasis on computer-based simulators for various aspects of nuclear technology; and**
- **identify educational simulators to be integrated in IAEA CLP and discuss various practical arrangements for its accomplishment.**

Meeting Chair**: Jochen Kruip, KSG|GfS**

Technical officers: **Lars Schnelzer and Andrey Pryakhin, IAEA**

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23 MAY 2011, MONDAY

| Time | Activity | |
|---|---|---|
| **09:00** | Bus transfer: Avantgarde Hotel Hattingen - Simulatorzentrum | |
| **09:30 – 10:00** | Opening. Welcome statement<br>Self-introduction of participants<br>Objectives; Agenda of the meeting; Expected deliverables | ***Dr. Hoffmann***<br>***Andrey Pryakhin***<br>***All Participants*** |
| **10:00 – 11:00** | IAEA Cyber Learning Platform for Nuclear Education Network | ***Andrey Pryakhin*** |
| **11:00 – 11:30** | Coffee break | ***Andrey Pryakhin*** |
| **11:30 – 12:30** | Country statements:<br>"Full Scope Simulator - effective tool for training, education and nuclear safety in Kozloduy NPP PLC" Kosta Dimitrov Stoychev, Kozloduy NPP<br>"Development of training simulators for small PWR reactors" Marino Reis Giada, Centro technologico da Marinha em Sao Paulo | ***Participants*** |
| **11:30 – 12:30** | Country statements cont´d.:<br>"Simulation: when practice makes perfect" Pierre-Jean Ajovalasit, CORYS TESS | |
| **12:30 – 14:00** | Lunch | |

| Time | Activity | |
|---|---|---|
| **14:00 – 15:30** | Country statements cont´d.:<br>"The Role of Nuclear Power Simulators at a Nuclear Power Plant Supplier" Christian Schönfelder, AREVA NP<br>"e-Learning Status and Human System Lab. Simulator in Korea" Youngmi Nam, Nuclear Training & Education Center, Korea, Republic of Atomic Energy Research Institute (KAERI)<br>"Enhancement in Teaching and Learning of Introductory Nuclear Engineering Course through Incorporation of Simulator: University of Tenaga National Perspective" Nasri A. Hamid, Tenaga National University<br>"Simulator Training Related To The Power Up Rate Of Central Laguna Verde" Flavio Robles Márquez, National Commission on Nuclear Safety and Safeguards<br>"Simulator practices Nuclear power plant KCB" Jan Schillemans, Borssele NPP | ***Participants*** |
| **15:30 – 15:45** | Coffee break | |
| **15:45 – 17:00** | Country statements cont´d.:<br>"Design and Application of Soft Panel Simulator at PNRA" Iftikhar Ahmed, Pakistan Nuclear Regulatory Authority<br>"Human Resources Development In The Philippines For Nuclear Power" Christina Petrache, Philippine Nuclear Research Institute<br>"Application of WWER-1000 Reactor Simulator for Education and Research" Evgeniy Chernov, MEPhI<br>"Challenges in Developing HR for Nuclear Education programme in Vietnam" Manh Hung Nguyen, Vietnam Atomic Energy Institute<br>"Research Reactor (ETRR2) as a good NPP Simulator" Talal Abou Elmaaty, Egypt Atomic Energy Authority | ***Participants*** |
| **'17:00** | End of session for day 1 | |
| **17:00** | Bus transfer: Simulatorzentrum - Avantgarde Hotel Hattingen | |

*Please note: Coffee breaks will take place in room Multi 1*

*Social event:*

*18:30-: Dinner: Restaurant Kühler Grund Hattingen*

## 24 MAY 2011, TUESDAY

| Time | Activity | |
|---|---|---|
| **08:30** | Bus transfer: Avantgarde Hotel Hattingen - Simulatorzentrum | |
| **09:00 – 12:30** | Presentations and visits facilitated by KSG/GfS | |
| **09:00 – 10:00** | Presentation of the Simulatorzentrum KSG/GfS | ***Jochen Kruip*** |
| **10:00 – 10:30** | Simulation technology | ***Thomas Roth*** |
| **10:30 – 11:00** | Visits in two groups: | |
| | Simulator (room: D43) | ***Mr. Zimnol*** |
| | Glass model (room: GM) | ***Mr. Seewald/Mr. Thien*** |
| **11:00 – 11:30** | Coffee break | |
| **11:30 – 12:30** | Summary, questions/answers and discussions | |
| **12:30 – 14:00** | Lunch | |
| **14:00 – 15:30** | Breakout session:<br>Discussions and work in groups to prepare recommendations | ***Participants in groups*** |
| **15:30 – 15:45** | Coffee break | |
| **15:45 – 17:00** | Presentation of the conclusions and recommendations prepared in groups | ***All Participants together*** |
| **'17:00** | End of session for day 2 | |
| **17:00** | Bus transfer: Simulatorzentrum - Avantgarde Hotel Hattingen | |

*Social event:*

*18:00 Departure from Avantgarde Hotel to Villa Hügel (starting point of sightseeing tour)*

*18:30 - 20:30: sightseeing tour through Essen*

*20:30 Dinner Haus Schellenberg*

*22:00 Transfer: Haus Schellenberg to Avantgarde Hotel*

25 MAY 2011, WEDNESDAY

| Time | Activity | |
|---|---|---|
| **08:30** | Bus transfer: Avantgarde Hotel Hattingen - Simulatorzentrum | ***All participants*** |
| **09:00 – 12:30** | Discussing and generating recommendations for CLP | ***All participants*** |
| **12:30 – 14:00** | Lunch | |
| **14:00 – 15:30** | Finalizing meeting report | ***All participants*** |
| **15:30 – 15:45** | Coffee break | |
| **15:45 – 16:50** | Finalizing meeting report | ***All participants*** |
| **16:50 – 17:00** | Conclusions | ***Andrey Pryakhin*** |
| **'17:00** | End of meeting | |
| **~17:00** | Bus transfer to Essen HBF (central train station) | |

## 4. Brief Description of Presentations and statements by Participants

- ***Presentation by Andrey Pryakhin***

Andrey Pryakhin made an introduction to the TM Objectives, Agenda and organizational aspects. He introduced IAEA Cyber Learning Platform (CLP), concept of the regional hubs and described the Learning Management System (LMS) as a module/component of the CLP. He made an introduction to the IAEA Simulators for Education and their possible applications.

- ***Presentation and statement by Kosta Dimitrov Stoychev***

Mr Stoychev made a presentation on Full Scope Simulators – as an effective tool for training, education and nuclear safety in the Kozloduy NPP. Today, two 1000MW units (5 & 6) of Kozloduy NPP are operating, and its training centre prepares, organizes, conducts and registers the entire activity on the preparation of staff to operate the plant.

The educational process contains three main stages: first, the initial education including primary and periodical training, second, continuous training with periodical and extraordinary

training, and third, initial and periodic tests before a qualification examining committee. This practical and theoretical training in Kozloduy is complemented by the training on simulators.

Mr Stoychev stressed the importance of project IAEA/NSNI/ESS (Mr.Guerpinar, Mr.Godoy and Mr. Paolo Contri) and that the proposal for the CRP n.J72004 should be approved. (IAEA CRP on Probabilistic safety assessment of nuclear facilities, J72004).

- ***Presentation and statement by Marino Reis Giada***

The Navy Technology Center in Sao Paolo, Brazil is developing a new PWR with 48 MWth, the LABGENE reactor. For this reason operators training in CTMSP is underway for the future reactor LABGENE.

The simulator will serve as a testing workbench for development, validation and acceptance of the plant´s control and protection system.

The use of simulators has proved invaluable, allowing the personal training experience in simulated conditions of actual operation in normal, abnormal and emergency situations.

- ***Presentation and statement by Pierre-Jean Ajovalasit***

Pierre-Jean Ajovalasit is coming from CORYS T.E.S.S. in France. CORYS T.E.S.S. is a world leading simulator vendor for Power and Transportation Simulators (a subsidiary of AREVA).

The aim of the presentation was to show that with simulators, practices makes better by allowing the practice of nuclear plant management in normal conditions as well as abnormal conditions.

The focus of the presentation was basic principles simulators and micro-simulation modules rather than full-scope (like the Flamanville EPR simulator made by CORYS T.E.S.S.) or multifunction simulators as those latter would not be good candidates for insertion in the IAEA CLP platform. Furthermore, basic principles simulator and micro-simulation modules are good for increasing knowledge. Full scope simulators are focusing better on skills.

## Basic principle simulators

Basic principles simulators are simply deployable tools as they can run on a desktop/laptop. The Basic principle PWR simulator enables normal operations and transients. Many things are simplified but all systems are in place. The GDF SUEZ training process was presented with students who were very comfortable with the “what-if “approach and able to learn from their mistakes. Moreover, this approach is more appealing than lectures only and students can switch from theory to practice.

The CORYS PWR basic principles simulator is being used by many companies training center including:

- EDF (operating staff)
- AREVA (engineers)
- Rolls-Royce Civil Nuclear (France, USA)

- ATOS ORIGIN
- EXELON (USA)
- SCANA VC Summer (USA)
- KSG|GfS (Germany)

and universities like :

- INSTN
- INPG
- UTBM

## Micro-simulation modules

CORYS T.E.S.S. is the only company to be able to mix multimedia tools with modelling. This is made possible through the use of their own tool called SWING EDITOR. This kind of modules can be used all along the education and training phase including the lecture (a.k.a. chalk and talk phase). Micro-simulation can be used for two purposes:

- Classroom training: the lecturer/trainer can provide support to the student
- Stand-alone training tool: the student can use it alone and the trainer can get all data through the Learning Management System as SWING EDITOR is SCORM and AICC compliant.

Dedicated Micro-simulation modules have been developed for EDF-UFPI aiming at reaching particular pedagogical objectives. CORYS T.E.S.S. has worked with trainers in order to further understand their accurate needs for each module and what they want the student to understand. Then, this is translated into a real-time simulation model. As a result, the student is faced with some simplified schematics in order to clarify a theoretical view but with the power of a simulator behind. Hence he can:

- Accelerate the time to see the physical and/or electrical process occurring (regulation, shortcut, …)
- Interfere with it by closing valves, running/stopping pumps, manipulates switches…

Simulation is a kind of training tool that allows answering both general and detailed questions about the process/principle, in a very dynamic and interactive way.

Ambitious training objectives are reached in a shorter amount of time compared to tuitions only, and with better efficiency.

All of this shows that “Practice makes perfect”.

- ***Statement by Christian Schönfelder***

According to the TOR, the objectives of the IAEA Technical Meeting were:

The objective of the TM is to provide participants with a forum to review and discuss currently available nuclear power simulators for education and their integration in the IAEA Cyber Learning Platform (CLP), in particular:

1. Share experiences and good practices on the use of simulators for nuclear education and capacity building with emphasis on computer-based simulators for various aspects of nuclear technology; and

2. Identify educational simulators to be integrated in IAEA CLP and discuss various practical arrangements for its accomplishment.

In my opinion, objective no. 1 has only been partially achieved, and no. 2 not yet.

However, the presentations provided valuable information on various needs for and different approaches to education and training in the nuclear field as well as to the use of simulators. Nevertheless these presentations did not provide a full picture of the nuclear community's current status in these issues.

Two different topics seemed to prevail during the meeting that will need some further activities:

1. Building up a competent workforce for regulators, technical support organisations, operators, vendors to boost the application of nuclear power in a country with no or only limited nuclear experiences,

2. Use of simulators for nuclear education and training.

As for 1:

Here, often a broad approach is required, not only by sharing experiences but also by engagement in international organizations or specific partnerships (not only via IAEA, but also via ENEN, e.g.), with the focus on programs, curricula, practical know-how transfer. In my opinion the use of tools (like LMS or simulators) will have to be dealt with only in a later phase.

Consequently, I suggest no further activities of the TM group, as these already are being performed by other circles, groups or organizations.

As for 2:

In my opinion, only one presentation (that of Evgeniy Chernov) completely dealt with the use of simulators in nuclear education, and therefore the following needs to be further clarified:

- which type of simulator is required,
- for which target group or existing pre-competences or in which phase of education,
- and which learning objectives should be achieved by the use of simulators in education,

to finally enhance education effectiveness and additionally motivate the students to continue their nuclear education.

Consequently, I suggest developing some recommendations, clarifying the issues listed above, complemented by some good and fully documented examples, especially documenting the successful implementation (always with the focus on nuclear education).

However, in this case also educational institutions (universities etc.) should be involved to ensure an appropriate approach and their involvement in the final application of simulators in their respective field.

- ***Presentation and statement by Youngmi Nam***

Ms Nam delivered a presentation about the e-Learning experience in KAERI and the Human System Interface Lab. Simulator (HSILS) developed by KAERI in Korea.

The Nuclear Training & Education Center (NTC) of KAERI has education and training programs which consist of not only domestic courses for domestic people such as staff members, industry personnel and university students, but also international programs for foreign personnel.

Through the implementation experience of the education and training courses, NTC/KAERI has had needs for e-Learning. Because mandatory courses for KAERI staff members require a lot of resources to accommodate a large number of audiences and it is hard to gather all members at the same time and same place. Also, routine operation of courses for example HANARO research reactor operator's safety education program causes difficulties to meet irregular needs. And self-learning through e-Learning can promote knowledge management and significant savings in time and money. Also e-Learning is available to access anytime, anywhere, anyone who is registered. Thus, KAERI has developed on its own a cyber platform to carry out the e-Learning courses. Based on this KAERI's experience, ANENT cyber platform was developed by KAERI in 2006.

There were two e-training courses on Energy Planning using the ANENT cyber platform. The first one is e-training on evaluation external cost of health and environmental impacts of nuclear power and other energy options, which was held in KAERI, Korea November 2007. In this course, 33 learners from 9 countries attended. The other one is for e-training on MESSAGE Model for elaborating sustainable energy strategies, which was held in KAERI 2009. MESSAGE means Model of Energy Supply Systems and General Environmental Impact.

- The e-training on Energy Planning was implemented as follows;
- The assessment codes on EP, SIMPACTS and e-learning courses and contents for using the codes were developed by PESS, IAEA.
- The course contents were uploaded on ANENT CP.
- The codes were provided on CD ROM by mail to learners.

The e-training consisted of video conference for opening, on-line self-learning on ANENT CP, off-line case study in group by country using assessment code and help of tutor, respectively.

Through these e-training experiences, the Learning Management System (LMS) of the cyber platform was improved for user friendliness. And the backup server was installed at IAEA in 2009 and another virtual ANENT server was installed at KUSTAR, UAE in 2010. These ANENT activities are supported by IAEA TC project RAS0047. The cyber platform has shown a good performance for ANENT e-Learning, however, there are needs for upgrading to new standards and advanced IT, diverse requirements along with ANENT progress and higher expectations on user-friendliness. For the enhancement of the cyber

platform, the NTC/KAERI is customizing Moodle 2.0 introducing functions such as course design, video conference, networking, mobile learning, etc. A prototype CP is being tested.

The other topic of the presentation was the Human System Interface Lab Simulator (HSILS) which has been developed by KAERI in 2003. HSILS has been designed and implemented for experimental control, acquisition and analysis of operator performance data. The HSILS provides environment for research on human factor experiments and human-system interface design. Also the HSILS meets ANSI/ANS-3.5 (1998), "Nuclear power plant simulator for use in operator training and examination" and Reg. Guide 1.149 (1996), "Nuclear power plant simulation facilities for use in operator examinations".

The process model characteristics of HSILS are referenced to 993MW W/H 3 loop PWR especially Kori Unit 3&4. Simplified simulation is used to show principles, not all detail actions as in control room, and understanding the process can be more efficient than full scope simulation. The HIS Builder was used as a graphic tool for designing HSI for control and monitoring in NPPs based ILOG.

The HSILS was installed at the Institute of Nuclear Energy (IEN) in Brazil in 2003, and another version of the HSILS based on PC was developed for education of university students and installed at the KAIST in Korea.

To conclude, the NTC of KAERI has a plan as follows:

- Upgrading of Cyber Platform with diverse functions using advanced IT, improvement of user friendliness and facilitation of networking.
- Development of courses and contents for specialized e-Learning with a customization to the characteristics of respective courses and improvement of attractiveness, availability and accessibility.
- Implementation of e-Training courses to promote of participation in international networks.
- Development of web-based training course on simulator

In these efforts the IAEA's leadership, initiative, support and cooperation are really important.

- ***Presentation and statement by Nasri A. Hamid***

## Introduction

University of Tenaga Nasional (UNITEN) was established in 1997 and it was benchmarked with the Indiana University – Purdue University, Indianapolis, USA (IUPUI). It is the subsidiary of Malaysia's premier utility company, Tenaga Nasional Berhad. Currently, the number of students' enrolment in UNITEN is about 8500 and the College of Engineering has the highest number of students with 3,996 students. Out of that, the Mechanical Engineering program has 1,157 students, the highest number in any program at UNITEN. On 26th June 2009, the Malaysian Cabinet has decided to include nuclear power as an energy option for post 2020. On 4th May 2010, the Malaysian Government approved the setting up of the first nuclear power plant to operate from 2021. And on 11th January 2011, the Malaysian

Government formed the Malaysia Nuclear Power Cooperation (MNPC – equivalent of NEPIO) to spearhead the country's push for nuclear energy. The Tenaga Nasional Berhad (TNB) is expected to be one of the key players in Malaysia's ambition towards building the first nuclear power plant (NPP) by 2021. As the education arm of TNB, UNITEN is given the responsibility to develop human resource capability of the nation in NPP engineering and technology.

## Activities

Training in using NPP simulator software

Two participants from Malaysia were invited to the "Joint ICTP/IAEA Workshop on Nuclear Power Plant Simulators for Education", between 12th – 23rd October, 2009 at ICTP in Miramare - Trieste, Italy:

Mr. Abi Mutaqqin Jalal Bayar (Malaysia Nuclear Agency) and

Dr. Nor Azlan Mostafa (University of Tenaga Nasional)

They were exposed to the following types of simulator software:

- PCTRAN simulator
- TRIGA simulator
- CANDU 9 simulator
- APWR simulator
- ABWR simulator
- WWER simulator

1. Applications of NPP simulation software

a) Malaysia Nuclear Agency:

- The researchers at the agency have identified the PCTRAN and TRIGA simulators as the suitable software simulators to be used by their researchers.
- PCTRAN software is used by several researchers to understand general concepts of "Reactor Physics" and "Thermal hydraulics" in nuclear power plant.
- Nevertheless, they found that the "Power ramp feature" in the TRIGA software is not compatible with the TRIGA Mark-II reactor at the institution.

b) University of Tenaga Nasional:

- In November 2009, the Department of Mechanical Engineering, College of Engineering has started the "Introduction to Nuclear Technology" as an elective

subject for the Mechanical Engineering Department final year students. The course is also opened to students of other departments and the response is overwhelming.

- The course constitutes a 17 weeks syllabus that includes the following modules:

  (1) Introduction to nuclear energy
  (2) Nuclear power plant system
  (3) Atomic & nuclear physics
  (4) Reactor theory
  (5) Nuclear safety
  (6) Nuclear fuel cycle
- Students have been introduced to the PCTRAN simulator which is a very powerful tool to understand the processes in the nuclear reactor power plant but it is more on static situation.

- Incorporation of PCTRAN software contents into the "Introduction to Nuclear Technology" should include the following modules:

  PWR Plant Systems
  PWR Benchmark Analysis
  Theory and Mathematical Models
  Radiation Monitoring System and Source Term Model
- Establishing Memorandum of Understanding (MOU) with the Malaysia Nuclear Agency (Nuklear Malaysia) with the formation of four Technical Working Groups to execute the MOU:

  i) Education & Training – to include joint training in using PCTRAN & TRIGA NPP simulation software

  ii) Research & Development

  iii) PI / PA

  iv) Industrial Development & Support

c) The College of Engineering is planning to introduce a Degree in Mechanical Engineering with minor in Nuclear Engineering program by next year and is considering to offer the Degree in Nuclear Engineering program through a twinning program with a foreign institution.

## Recommendations

1. The developer of NPP simulation software should provide a more user friendly manual to accompany the software.

2. At the University of Tenaga Nasional, the PCTRAN and TRIGA NPP simulation software are found to be very useful to enhance the teaching and learning of nuclear engineering courses. As such, proper training to the trainers / teachers is needed and IAEA is suggested to organize such training in the future.

3. To recommend to the government through the university to provide fund for conducting training for trainers in NPP simulation software in one of the institutions in Malaysia.

4. Under IAEA and ANENT initiatives, it is suggested to establish a regional training centre in the area of NPP simulation software for the benefits of trainers / teachers in emerging NPP nations and developing / third world countries such as Malaysia, Vietnam, the Philippines, Indonesia and Thailand.

5. Using the platform of e-learning developed by IAEA to promote the learning of NPP simulation software to trainers, teachers and students.

- ***Presentation and statement by Flavio Robles Marquez***

All licensed staff of Units 1 & 2 were trained, retrained and evaluated on the systems, equipment and components new or modified as a consequence of EPU implementation during the 14 th refueling U-1 in the full scope simulator, which was previously updated to reflect the new EPU condition.

The use of full-scope simulator was very useful to train operating staff before operating the plant at the new power level.

Performance of the simulator was very similar to what was demonstrated during the Power Up rate tests from 2027 MWth to 2317 MWth.

- ***Presentation and statement by Jan Schillemans***

Mr. Schillemans stated that training on technical ground is not the only matter. The interaction of motivated staff with the opportunity to train them well is very important. For good practice there is a need of human performance and safety culture lessons.

He also stressed that training for reactor operators requires the usage of a full scope simulator.

- ***Presentation and statement by Iftikhar Achmed***

1. Training of Regulators

It is a strict requirement from regulators for NPP's operator to conduct the training of reactor operators at Full Scope Simulator after TMI Island. Regulators conduct the exams for licensing of operator. Therefore, it is necessary for the regulator in order to be able to carry out the assessment he must be trained on such type of Full Scope Simulator. But there is no need to develop the same type of Full Scope Simulator at their facility. So this problem can be minimized with developing a Soft Panel Training Simulator with capability of simulating full scope control.

2. It is recommended that IAEA creates a TECDOC on PC-based simulators systems.

3. To develop a Working Group between Member States.

4. Conduct this meeting at each calendar year.

5. It is required to identify the areas of Research on PC-based simulators systems.

6. In simulator meeting the starting presentation must be included with description of following information about simulator;

a) Basics of Simulator

b) Types of Simulator

c) Function and Application of each type of simulator

- ***Presentation and statement by Jochen Kruip***

Mr Kruip made a presentation on the German Simulator Training Centre and its two companies KSG and GfS.

He summarized the impressive operational history of the German nuclear power plants: i.e. more than 35 years of operation without any severe accidents while generating approximately 1/4 of the German electricity with the major benefits of nuclear such as almost zero emission, avoiding ~ 160 mio t of CO2 each year, without consumption of valuable resources. Nuclear is an electricity production of good value, long term stable with domestic control and independence.

The Centre provides certified training to the personnel of 16 German nuclear power plants and the Dutch Borssele NPP according to common rules:
technical competence and human behaviour.

The Simulator Centre is owned by five utilities operating nuclear power plants and trains with its 160 employees (incl. 55 licensed instructors), 14 simulators and the reactor glass model around 2500 trainees per year, which is achieved by more than 650 training courses a year.

Intensive communication with owners and power plants is assured by the centre's structure which guarantees great transparency for the joint venture's partners and tight co-operation with every power plant. Additionally, it essentially reflects the great interest in the safe operation of nuclear power plants shared by their owners in the optimal training given to the operators.

The simulator centre is a service company and a centre of competence at the same time with the goals: high training quality by concentration on training, competence and experience in simulation techniques, common training standards and methods, and good economy by synergies.

A typical NPP shift crew member requires in addition to the vocational training or university study a specialized initial training of 3-5 years including up to 15 weeks training on a full scope simulator. Subsequently, recurrent simulator trainings with sessions of 2 weeks per year follow.

Mr Kruip stressed that training on full scope simulators is needed and required when knowledge and competence is not used on a day by day basis and if there is a lack of building up experience. And in contrary to the use of simulators practising in reality is much more expensive. Therefore, simulators continuously find their way into other industries.

Several scenarios have to be trained e.g. normal operations, abnormal operations, accidents, and beyond design accidents in order to understand process engineering, instrumentation and control, and dynamics of NPP. That can only be achieved through professionalism caused by the interaction of technical competencies, a decent behaviour with personal attitudes. To combine this there are common behaviour rules for all German NPPs which are summarized as MARKERs for save and successful operations and compose an integrated part of each simulator course.

- ***Presentation and statement by Thomas Roth***

Mr Roth provided a detailed and technical presentation on model building and real-time simulation of a Konvoi PWR full scope simulator.

How simulators are developed was explained: by starting with a model reality can be broken down into a describable and simplified form through reduction of complexity what can be achieved by a computer model.

Mr Roth explained the three modelling methods simulation, emulation, and stimulation and possible ways of their implementation. Additionally, the structure of a simulator was described. A typical Konvoi simulator is a sophisticated system comprised of a modelling software with around 15000 programmes and more than one million data points, and the non-modelling software part like data flow control, human-computer-interface, instructor station, databases, and the process computer which.

The complex and sophisticated simulator system requires a clear structure that enables the developers and the users to keep abreast of the system, e.g. through combination of similar components and by separation of differing items, as well as through standardization which can e.g. be achieved by using code generators.

The full scope simulators utilize a variety of means in order to resemble as much as possible a Nuclear Power Plant. These means are e.g. usage of original-NPP-documents, standardization, intensively and extensively testing, having separate specification, coding and tests, permanent adjusting to the state of scientific and technical standards, using a good documentation, receiving training and skill enhancement, keeping contact to science, industry, simulator vendors, simulator users, and being a certified contractor.

- ***Presentation and statement by Christina Petrache***

## HRD in the Philippines for Nuclear Power

## Summary:

In 2007, the President of the Philippines at that time sent “feelers” to the Department of Energy (DOE) Secretary for his staff to study the feasibility of including nuclear power in the Philippine Energy Plan. The DOE then requested recommendations from the Philippine Nuclear Research Institute (PNRI), the agency with both promotional and regulatory mandates on nuclear matters. The Institute recommended to DOE to request for a team of experts from the International Atomic Energy Agency (IAEA). In January 2008, a team of experts came to the Philippines for a week and their recommendations were (a) to develop a national infrastructure program for nuclear energy and (b) to conduct a comprehensive feasibility study on the mothballed Bataan Nuclear Power Plant (BNPP). Consistent with the

recommendation of the IAEA Expert Mission, the Inter-Agency Core Group was formed. It was established in January 2009 by virtue of Joint Department Order No. JDO2009-01-001 signed by the Secretaries of Energy and Science and Technology. The Group was chaired by the DOE Undersecretary for Planning; co-chaired by the Department of Science and Technology (DOST) Undersecretary for R&D and National Power Commission Senior Vice President. The members were (a) DOE Task Force on Nuclear Power Program, (b) Philippine Council on Industry and Energy Research and Development (PCIERD-DOST), (c) PNRI and (d) NPC (the utility maintaining the mothballed BNPP). The Core Group was tasked to study the 19 infrastructures necessary to launch a nuclear power program. Later, The NPC had a Memorandum of Understanding (MOU) with the Korean Electric Power Company (KEPCO) to conduct a safety study on BNPP. There were also initiatives in the Philippine Congress. Two House Bills were filed: (a) House Bill No. 3254 or the "Comprehensive Nuclear Law" which proposes to create a separate and independent nuclear regulatory authority and address gaps in the present laws and (b) House Bill No. 4631 which proposes for the rehabilitation, commissioning and operation of the BNPP, and appropriates funding for a feasibility study. The Group assigned to human resource development realizes the need of trained personnel for the NPP construction, commissioning, operation, and maintenance. One way of achieving this is to send people abroad to undertake MS/PhD academic programs. First priority are 12 PhDs and 32 MSc in nuclear engineering, nuclear/radiation physics, nuclear/radio analytical chemistry, radiation biology, health physics by 2013. On the side, PNRI had prepared three modules to start off training of human resources for nuclear power. Module 1 is Introduction to Nuclear Power, a 3-day training course for participants from DOE, NPC & PNRI. Module 2 is Introduction to Nuclear Engineering, a 2-week training course and Module 3 is PWR & the Overall Description of BNPP-1, a 1-week training course. The participants from NPC are required to have a passing grade for each module before they can proceed to the next one. For Module 1, a total of 176 participants took the course, of which 146 were engineers, 6 were chemists and 24 of other professions. Module 2 had 98 participants, of which 89 were engineers, 3 chemists, 2 physicist and 4 from other professions. Module 3 which was held at the BNPP plant site had 85 participants, of which 77 were engineers, 5 chemists and 3 from other professions. Up to this point in time, the PNRI continues to offer these training modules to whoever is interested. The Institute has also talked with the Deans of the College of Engineering and the College of Science of the University of the Philippines of the possibility of offering Bachelor of Science degree in nuclear engineering. To entice students to enrol in nuclear engineering requires a promise of job opportunities after graduation. Unfortunately at this point in time, this is non-existent. The recommendation then was to include nuclear engineering as an elective for engineering students and a requirement for those who enrol in M.S. Energy Engineering. The PNRI has also facilitated the participation of personnel from DOE, PCIERD-DOST, NPC and from the Institute itself to attend meetings, workshops, seminars and training courses conducted by IAEA. The Institute looks forward to acquiring a basic educational simulator to allow the participants with theoretical knowledge in nuclear reactor physics to apply this in a simulated working reactor.

## Recommendation:

From this technical meeting, I learned about the availability of basic simulator software on different types of reactors. I hope that if I send my request for a copy of the software specifically on PWR the IAEA will grant the request. This software will help to improve our training program that the Institute has conducted and will be conducting for future nuclear operators. The basic software particularly on PWR will be very useful in giving participants a "feeling" and knowledge on what goes on inside the nuclear steam supply system.

The trainers for these courses will also require updates or additional education on basic knowledge simulators, it is recommended to conduct "train the trainers" activities on this topic for Member States on a regional basis.

- ***Presentation and statement by Evgeniy Chernov***

Mr. Chernov presented application of the WWER-1000 Reactor Department Multi-Functional Analyzer (MFA-RD) for education and research.

MFA-RD can be used for WWER-1000 reactor steady-state and transients analysis. Analyzer was benchmarked against a wide range of WWER-1000 experimental and calculated data and certified for WWER-1000 type reactors computations by the State Atomic Inspection of Russia. MFA-RD is specifically adapted to solution of numerous educational problems in the field of neutron physics, thermal-hydraulics and control of nuclear power plants.

Scope of MFA-RD modelling includes reactor, control rod and boron regulation systems, in-core and ex-core instrumentation systems. MFA-RD is only a small part of Full Scale Simulator of WWER-1000 reactor, so that scope of modelling can be easily extended from the reactor to the reactor department and more.

The core simulation includes: transients on prompt and delayed neutrons, xenon radial and axial power distribution oscillations, samarium poisoning, fuel burn-up and residual heat.

The simulator offers a user-friendly interface with: display screens that show reactor state, important plant parameters, trends, axial and radial distribution; and controls for control rod operation.

MFA-RD reactor core has following configuration features: more than 50 fuel assembly types in neutron XS-library; arbitrary (first) core loading configuration; arbitrary and real plant refuelling chains simulation manually or from the input file; arbitrary control rods location into reactor core and CD banks configuration; multi-cycles fuel burn-up calculation using arbitrary or real plant refuelling chains.

MFA-RD reactor core has following computational features: statics and dynamics reactor core computational modes; boron regulator to find a critical boron concentration for an arbitrary core state; reactor core model easy connection or disconnection from the primary circuit model (boundary conditions for core thermal-hydraulics model); ex-core instrumentation model allows to reproduce directly real plant measurements.

MFA-RD can be used for following list of training tasks: CR banks worth calculation and analysis; reactor scram simulation, comparison of “measured” data with computational one; reactivity effects and coefficients computation and analysis; fuel management: core loadings and fuel cycles analysis; xenon transients computation and analysis; xenon transients control; automatic Power Regulator parameters setup.

Mr. Chernov presented to participants example of laboratory work - “CR banks worth calculation and analysis”. Learning objectives; list of tasks to be performed in this laboratory work; user interface; step-by-step student's instruction for every task; student's report format and recommendations; student’s report sample have been demonstrated.

MEPhI effectively uses MFA-RD in two lectures courses and related laboratory works:

- Lecture course - “Automatic control in Nuclear Power Plants” and Labs “Control and Protection Systems”
- Lecture course - “Numerical modelling of physical processes in equipment of NPP” and Labs “Control and Safety of operation of NPP”

MEPhI successfully shares its positive experience of MFA-RD application for education and research with Belorussian State University. It's planned to share this experience with Ukraine and Armenia with support of IAEA.

## Conclusions and Recommendations

WWER-1000 Reactor Department Multi-Functional Analyzer (MFA-RD), from Moscow Engineering and Physics Institute (MEPhI) is considered as a good example of computer tools for student's educational and research purposes.

Member countries should be encouraged to use this type of simulator and further cooperation among member countries in this direction should be accelerated.

Member countries may be urged to upgrade educational programmes with practical training using engineering simulators.

- ***Presentation and statement by Manh Hunh Nguyen***

The presentation covered the following:

## A. Introduction

1. Current Status.

2. Overview of Energy situation in Vietnam.

   - Preparatory work for nuclear power development

   - Proposed schedule for nuclear power program in VN

3. Information about the nuclear power project

   - This project consists of a nuclear power plant Ninh Thuan 1 (Phuoc Dinh) and a nuclear power plant Ninh Thuan 1 (Vinh Hai). Total capacity is 4.000 MW, 2.000 MW for each plant. Technology: light water reactor system. Russia and Japan will be the suppliers.

   - It has been submitted by the government to the National Assembly and approved on 25 November 2009.

   - After the policy approval by the National Assembly, the investment project (feasibility study) will be carried out in 2-3 years.

   - The investor will submit an application for authorization in 2012.

   - Tender & signing EPC (Engineering, Procurement and Construction) in about 2013.

   - Commencement of construction in about 2015.

4. Implementation the Strategy of nuclear energy application

General plan on nuclear energy development and application until 2020, approved by the Prime Minister on 2010 with Decision No. 957/QD-TTg.

- Plan on radiation development and application in agriculture, heath care (medical physics)

- Plan on radiation development and application in industry and economic – technical sectors

- Program of human resources development in the nuclear energy domain

- Orientation Plan on nuclear power development

## B. Nuclear Training Centre

The Nuclear Training Center Established in December, 2010, cooperates with 5 Universities to prepare human resources for nuclear electricity and other applications by the Decision 1558/QD-Ttg dated 18/08/2010.

Main tasks:

- Organizing activities of post doc training for VAEI

- Opening speciality classes to prepare human resources for VAEI and other organizations

- Cooporating with domestic and international institutions for training workers

- Training for objects study.
- To supply HR to have professionals for the institute of VINATOM, VARANS and VAEA. (Environmental monitoring, radioactive waste management, legal systems, improving management capacity ..).
- Training and Certification Circular of the Ministry of Science and Technology.
- Prepare Project Application Simulator method for training operator reactor help by IAEA
- Organization of the International training course.
- Teaching foreign language: English, and Russian

Six months Training Courses on:

- Basis Nuclear Orientation for the newly appointed Scientists/Engineers/Physicians

Short term courses on:

- Radiation Protection for the Radiation Control Officers of various Gov/Non Gov Organizations
- Control quality X ray machine use in Medical
- NDE

Irregular Courses for the Scientists/Engineers working in the different fields of Nuclear Science and Application:

- Nuclear Training Center has started M.Sc. on Nuclear Engineering. Curriculum is being developed.

Master Plan 2011-2015

Setting up the programmes of training and education:

***Target****:* a standardized programme of training and education at the postgraduate level to create a team of young and capable cadres to join in various projects of VAEI and other units when needed.

***Started: 2011, March.***

***Have prepared*****:** contacted with some laboratories and constructed the education frames of accelerator, nuclear fuel.

***Partner*****:** cooperate with VAEI's laboratories to implement training and education orders.

***Support needed*****:** technical documents that are related to 19 groups of science and nuclear techniques choosen by VAEI from IAEA. The National Committee and the Ministry of Science and Tech, the Ministry of Training and Education also get involved in the programme of human resources.

***Priority works:***

Training and education programme of nuclear electricity for the government staffs at the management level.

Training and education programme of nuclear reactor technology, safety analysis and other issues of operating nuclear reactor.

Setting up a group consisting of key staffs to work and train in the above fields.

Russian courses (conversational and specific). Issues such as nuclear reactor technology, accelerator technology; nuclear fuel will be focused on in 2011.

Build up and organize training programme to meet urgent requirements of the society such as nuclear medicine, safety analysis of nuclear reactor technology.

Support VAEI in standardizing, strengthening training programmes for postgraduates to build up groups of key staffs.

## C. Recommendation

The objective of this Technical Meeting was to provide participants with a forum to review and discuss the currently available nuclear power simulators for education and their

integration in the Agency Network for Education in Nuclear Technology (A-NENT) Cyber Platform, in particular:

1. To share experiences and good practices on the use of simulators for nuclear education and knowledge preservation with emphasis on desktop simulators for various aspects of nuclear technology.
2. To identify educational simulators for the purpose of their integration in the Agency Network for Education in Nuclear Technology (A-NENT) Cyber Platform and make them available to A-NENT participants and to discuss and plan further practical arrangements needed to accomplish this task.
3. To explore the use of Internet Reactor Laboratory for supporting nuclear science and engineering education in developing countries.
4. Implementation.

- How to implement the plan of development human resource for the first NPP and nuclear non power applications.
- Experience sharing of human resources training for nuclear power sector by method Simulator
- Management of human resources in nuclear power sector
- Tools and material for training support from IAEA
- Application method e-learning, simulators for education and training**.**

- ***Presentation and statement by Talal AbouElmaaty***

The research reactor can introduce simplified general useful principles about the different systems, steady state operations, some transients, instrumentation and control of the nuclear reactors. So using it for training purposes is quite helpful because the operator touches the reality of many signals and parameters. Also the operator can execute many procedures for start-up check lists, plant start-up, power rising and plant shutdown, the matter which increases his awareness and experience. Different cooling regimes are adopted in research reactor, cooling during the normal operation or in an anticipated operational occurrence. Also the principles of redundancy and diversity for safety and safety related systems are now applied to the research reactor like, first shutdown system, second shutdown system, chimney water injection system, evacuation system and confinement ventilation system at ETRR2 reactor.

Finally I see that the research reactor represents an essential training and education device for the nuclear field.

## 5. Conclusions and Recommendations

The Technical Meeting provided a forum for exchanging information and experience in the usage of nuclear simulators in education and training, and research and for capacity building.

The meeting participants have recognized the importance and usefulness of simulators for nuclear education and training and encouraged to further develop simulators for that purpose.

The participants stressed that simulators reflect a cost effective way to provide and facilitate training which partly cannot even be realized otherwise. Furthermore, they enable to complement theoretical lessons with practical education on a “practice makes perfect” basis.

It was noted, that depending on their application and stage of education, different simulators have to be considered. Nevertheless, simulators will play an emphasised role in nuclear education and training in the future with an increasing number of institutions planning their inclusion in educational programmes.

One meeting participants stated, that it should be clarified which type of simulator is required, for which target group or existing pre-competences or in which phase of education, and which learning objectives should be achieved by the use of simulators in education. Furthermore, it is recommended to involve educational institutions (universities etc.) to ensure an appropriate approach and their involvement in the final application of simulators in their respective field.

Taking into account that the importance of e-learning is continuously increasing, a practical way to include simulators in education and training is e.g. the implementation into the IAEA Cyber Learning Platform in the form of a web based simulator. This combines the user-friendliness of a web based IT tool with a forum to exchange information between users. The meeting participants expressed the intention to strengthen their focus on e-learning applications and to continue to work on web based simulators.

The participants underlined the important role of instructors/teachers in nuclear education and that only the combination of tools, human resources and trainers achieves valuable results. For teachers, train-the-trainer courses should be provided to establish an adequate teaching staff. A further recommendation was to develop theoretical training courses in parallel to simulators in order to provide a comprehensive training tool. Additionally, the meeting participants highlighted, that documentation for the simulators should be made available. Well trained teachers, in combination with courses, IT tools and detailed documentation would provide a complete training platform.

The visits offered by the host institution were very much appreciated by the participants. In particular the glass model was perceived as really impressive and it was contemplated to include some of its exercises into the e-learning portal.

## Annex 1: List of Participants

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## Annex 2: List of Presentations

"Full Scope Simulator - effective tool for training, education and nuclear safety in Kozloduy NPP PLC" Kosta Dimitrov Stoychev, Kozloduy NPP

"Development of training simulators for small PWR reactors" Marino Reis Giada, Centro technologico da Marinhaem Sao Paulo

"Research Reactor (ETRR2) as a good NPP Simulator" TalalAbouElmaaty, Egypt Atomic Energy Authority

"Simulation: when practice makes perfect" Pierre-Jean Ajovalasit, CORYS TESS

"The Role of Nuclear Power Simulators at a Nuclear Power Plant Supplier" Christian Schönfelder, AREVA NP

"e-Learning Status and Human System Lab. Simulator in Korea" Youngmi Nam, Nuclear Training & Education Center, Korea, Republic of Atomic Energy Research Institute (KAERI)

"Enhancement in Teaching and Learning of Introductory Nuclear Engineering Course through Incorporation of Simulator: University of Tenaga National Perspective" Nasri A. Hamid, Tenaga National University

"Simulator Training Related To The Power Up Rate Of Central Laguna Verde" Flavio Robles Márquez, National Commission on Nuclear Safety and Safeguards

"Simulator practices nuclear power plant KCB" Jan Schillemans, Borssele NPP

"Design and Application of Soft Panel Simulator at PNRA" Iftikhar Ahmed, Pakistan Nuclear Regulatory Authority

"Simulator Training for the Operational Personnel
"Human Resources Development in The Philippines For Nuclear Power" Christina Petrache, Philippine Nuclear Research Institute

"Application of WWER-1000 Reactor Simulator for Education and Research" Evgeniy Chernov, MEPhI

"Challenges in Developing HR for Nuclear Education programme in Vietnam" Manh Hung Nguyen, Vietnam Atomic Energy Institute