# The World Nuclear University Summer Institute

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## Abstract

The World Nuclear University (WNU) Summer Institute is a six weeks intensive training program aimed to develop a global leadership in the field of nuclear sciences and technologies. The topics covered include global setting, international regimes, technology innovation and nuclear industry operations. This event has been held annually since 2005.

Mark McIntyre and Dominic Rivard attended this activity as a personal initiative. In this paper they will present the WNU and its Summer Institute, share their participation experience and discuss as well of some technical content covered during the Institute, highlighting the benefits this brought to their careers.

## 1. Introduction

With the nuclear renaissance at our doorstep, the training of the future generation of scientists and engineers in nuclear-energy related fields is now of prime importance. With the combination of the large scale retirement of nuclear industry professionals and the decline in the enrolment in Nuclear Engineering university programs observed in the 1990's, there is an urgent need for new educational opportunities for the emerging generation of nuclear industry professionals. It was for this purpose that the World Nuclear University (WNU) was created.

The WNU was founded on September 4th, 2003, 50 years after the "Atoms-for-Peace" speech of President Eisenhower to the United Nations. The World Nuclear University (WNU) is a partnership focused towards international cooperation for the transfer of knowledge in nuclear engineering for peaceful use. The WNU has four founding partners: the International Atomic Energy Agency (IAEA), the World Association of Nuclear Operators (WANO), the World Nuclear Association (WNA) and the OECD Nuclear Energy Agency (NEA) and has members in more than 30 countries.
John Ritch, former US ambassador at United Nations and Dr. Hans Blix, director-general emeritus of the IAEA were the leading forces behind the formation of the WNU. In Canada, the membership in the WNU is assumed by the University Network of Excellence in Nuclear Engineering (UNENE).

The WNU is currently leading several projects and initiatives. Amongst them is a project to identify the global nuclear educational programs currently available all around the world. In supplement, the WNU supports several training activities. The WNU School of Uranium Production is a new project to offer short courses on various aspects of uranium production including the exploration, the mining and the processing of extracted minerals.

Another initiative of the WNU, and perhaps its most significant one, is the Summer Institute. Held once a year since 2005, the WNU Summer Institute is a unique educational opportunity aimed to develop a global leadership in the field of nuclear sciences and technologies. It consists of a 6 weeks training program with a curriculum focused on various topics related to energy policies,

environment, radiological protection, economical and safety considerations of nuclear energy, future developments of nuclear technologies and non-proliferation of nuclear weapons.

## 2. WNU Summer Institute Program Description

The official curriculum of the WNU Summer Institute covers a wide range of technical, political, environmental, and social issues surrounding the peaceful use of nuclear technology [1]:

• **Global Setting**, including energy supply and demand, global warming and climate change, nuclear technology in sustainable development, lessons in public acceptance, and key political issues and trends

• **International Regimes**, including safety, radiological protection, non-proliferation and security, waste management, transport, nuclear law, and global emissions control

• **Technology Innovation**, including next-generation reactors, advanced fuel cycle, hydrogen production, and desalination

• **Nuclear Industry Operations**, including industry economics, knowledge management, fuel market, comparative risk assessment, social ethics, and operational excellence

The main portion of the Institute' schedule is allocated to speakers. There are two types of lectures: those by the Faculty Speakers on specific topics outlined in the program' curriculum and those by Guest Speakers, mostly senior executives of corporations related to nuclear technologies, where the content of their presentations is left to their discretion. The invited speakers are worldwide recognized experts in their respective fields, including representatives of the International Atomic Energy Agency.

In order to support the participants (hereby called the fellows), there is a group of eight mentors. These mentors are senior professionals having an extensive experience in nuclear energy, which they share with the participants.

After each Faculty Lecture, there is a group review session where small groups of fellows review the presentation to identify the main points to remember (take away points). These points form the basis of group discussion. Due to the diversity in the backgrounds of attendees, various fellows will occasionally take turns complementing the discussion with personal experiences of the issues. A particularly important part of the lectures is the ability to question the speakers with a healthy unfiltered question.

Some Faculty Lectures used case studies as a means to supplement classroom learning. These "hands-on" experiences were conducted in small groups followed by a presentation amongst all fellows. For the last Summer Institute, it was found that the two subjects deserving of case studies were Nuclear Law and Public Communications. The first one was to investigate the legal aspects of establishing a multinational uranium enrichment facility, it shown the complexity of regulations and agreements that has to be signed between countries in order to carry out this initiative. The other case on public communications shown the steps to follow in order to give various types of message related to nuclear issues while maintaining a high level of trust by the public. Each case study was facilitated by the expert speakers that gave the corresponding lectures.

Each group completed a final project related to a nuclear issue. Up to now the topics suggested include development of national energy policies for a number of different countries, new non-proliferation paradigms and programs for cancer therapy in developing countries, Generation IV nuclear reactors, making a decision whether to begin building nuclear power plants, spent fuel reprocessing, limiting fuel production and enrichment capability, regional or multinational repositories. It is a good opportunity to summarize the knowledge acquired during the others activities of the Summer Institute.

The WNU Summer Institute ends with a formal graduation ceremony where diplomas are presented by Mr. John Ritch, the WNU/WNA President and by Dr. Hanx Blix, Chancellor of the WNU.

## 3. The first two WNU Summer Institutes

The inaugural Summer Institute was held in 2005 at Idaho Falls, the nuclear centre of excellence in nuclear engineering the US, it was hosted by the Idaho State University in collaboration with the Idaho National Laboratory (INL). Major funding came from the US Department of Energy. The 2005 event brought together 77 students and young professionals (the fellows) associated with 63 different nuclear related organizations in 34 countries, with technical experts and global leaders representing all aspects related to the nuclear industry.

The second annual Summer Institute was held in Sweden and France in 2006, being hosted by the Swedish Centre for Nuclear Technology (SKC), Sweden's Royal Institute of Technology (KTH) and France's Commissariat à l'Energie Atomique (CEA). The participation increased to 89 fellows originating from 34 countries.

For the past two years, the fellows were on average in their early thirties and most of them had at least a Master's Degree. The majority is funded by their parent institution/organization, a funding from the IAEA supported those from developing countries.

Although the curriculum of the lectures is similar years after years, the field tours are obviously specific to the hosting area. These visits intend to complement the lectures and to cover as many aspects of the fuel cycle.

Field trips for the 2005 Summer Institute included tours of the Idaho National Laboratory, the Experimental Breeder Reactor, the (EBR1-site of the first nuclear reactor to produce electricity) and Yucca Mountain Geologic Repository and a behind the scenes tour of the Hoover Dam. The 2005 fellows were also able to hear opinions on the proposed repository from local Las Vegas journalists, academics and public spokespeople.

During the 2006 Summer Institute, a week-long trip in France allowed the visit of several nuclear-related facilities. This included the AREVA Chalon/St-Marcel Plant (PHTS component manufacturing), the MELOX Plant (MOX fuel manufacturing), the Centraco Plant (treatment and conditioning of low level radioactive waste), the EURODIF Plant (uranium enrichment by gaseous diffusion process), the AREVA La Hague Plant (spent fuel reprocessing) and Tore Supra at Cadarache (superconductor Tokamak). These tours covered several aspects of the nuclear fuel cycle, while giving an interesting perspective of the French nuclear industry. In addition, the group visited the Simpevarp nuclear waste management site in Sweden. This site includes the Äspö Hard Rock Laboratory where underground experiments are being conducted to test the principles and technologies involved in a final repository for spent nuclear fuel.

## 4. Highlights of the WNU Summer Institute program

In order to give a more in-depth view of the WNU Summer Institute content, the authors will present a few highlights of program that kept particularly their attention. Obviously, this information is reported here on the basis of the content of the lectures.

### 4.1 A memorable lecture of 2005 WNU Summer Institute – Dr. Zack Pate

Of the 30+ lectures at the 2005 Summer Institute, the most memorable was delivered by Dr. Zack Pate. His lecture dealt specifically with the "Leadership". It is highlighted in this paper because of its importance and relevance to the authors' work in the area of nuclear power plant operational excellence. Zack Pate's lecture helped in understanding of the inter-connections within our industry. In the 1990's he was the leading the paradigm shift on the attitudes towards the links between the safest and the most economic nuclear plants [4].

He possesses a Ph.D. in Nuclear Engineering from MIT and spent the years 1958-1980 in the US Navy where he describes his most rewarding experience as serving as Special Assistant to Admiral Hyman Rickover. He was the First President of the Institute of Nuclear Power Operations (INPO) between 1983-1997. He was also the 2nd Chairman of the World Association of Nuclear Operators (WANO) between 1997-2002. Zack Pate is retired however still acts as the Chairman Emeritus of the World Association of Nuclear Operators.

Zack began by summarizing the key conclusion of the Three Mile Island report, indicating that simply meeting the Nuclear Regulatory Commission (NRC) regulations was not enough. The nuclear industry concluded it needed its own standard setting body: INPO was formed because NRC was the enforcer of minimum standards. At the time of INPO's formation there were 54 utility operators in US fleet. Today there are twenty-something due to consolidation.

While in the US Navy, Zack spent a lot of time at sea. He did not get much interaction with colleagues from around the World. Zack sees the WNU as providing this international experience to the WNU fellows early in our careers as extremely beneficial. Zack's first exposure to international diplomacy for INPO was about 1983. He travelled to Japan to visit the ever growing nuclear community there. He had no prepared speech so when he was asked to give some remarks he said: "It is a pleasure to be here in Japan and INPO appreciates the hospitality". The interpreter went on to speak for 5 minutes. Zack asked: "Did I really say all that?" The interpreter responded: "No. But you should have." Zack said this experience taught him to be prepared before any briefing, meeting, or presentation. He encourages WNU fellows to do the same. Always be prepared.

In 1986 after the Chernobyl accident, Pate was asked to poll international utilities to see if there was support for an international version of INPO. Pate could not imagine an organization that would be worldwide because of the difficulty in the formation of INPO where all 57 utilities were from the same country and spoke the same language. Pate was convinced by Lord Marshall of the UK. There was general consensus the nuclear community needed an organization with international governance. Andrew Clarke (prominent in the UK nuclear industry) took the first official WANO leadership role. Pate continued supporting WANO through INPO. The decision was made to set up regional WANO offices that would align with regional cultures. Pate bought into the idea and offices in Tokyo, Atlanta, Paris and Moscow with a coordinating centre in London England were set up. The inaugural meeting of WANO was in 1989.

Pate advised that everyone in our industry should internalize with a definition of Safety Culture, which for him meant adopting a "Protect the Core" attitude into every person…every day. If one can do this it would then be possible to become a true nuclear professional. Other steps that can improve professionalism are reading the IAEA documents: "Basic Safety Principles" (INSAG 3, updated by INSAG-12), and "Safety Culture" (INSAG 4).

The US nuclear performance has improved according to an evolution. This evolution he believes can and needs to be transferred to other national nuclear programmes. The US experience showed that by first enhancing professionalism, then developing leadership, then enforcing human performance, then instituting self assessments and enforcing operational decision making and then continually revisiting this attitude, a plant can achieve what is called a "positive safety culture". Pate has become the world leader in aligning the new attitude where the safest plants are also the most economic. This attitude can only be achieved by taking a long term view of the investment in a nuclear plant. Maximizing the short term output to the detriment of safety margins is not supportable in Pate's view of the nuclear industry [4].

On the topic of the specifics behaviours of personal leadership, Pate observed that there are over 30,000 books on leadership. Obviously a large number of people have a lot to say on the topic. Pate shared that he had worked for 2 types of leaders: Admiral Rickover and Admiral Wilkinson. Both were extraordinary leaders. Rickover was sometimes tyrannical, Wilkinson was often compassionate. Each behaved at different ends of the spectrum but both effective in their own way. Pate has observed that a leader must find their own niche within this spectrum and must also trust people around you and treat them with respect. An important corollary to trust is that every time you see something wrong, you should make a note of it and every time you see something seriously wrong- a true leader will stop-work, let everyone know, and make an issue of the event- so that everyone can learn not to repeat mistakes.

### 4.2 Highlights of WNU Summer Institute lectures on fuel cycle and nuclear technologies

Many lectures the WNU Summer Institute were focused to give an overview of the whole nuclear fuel cycle from the mining up to the used fuel treatment and disposal, as well as others applications of nuclear technologies. A few key points that were elaborated during these lectures will be given here.

Uranium constitutes an average of 2,8 ppm of the Earth' continental crust. We can talk of high grade ore when uranium is present at more than 2% (20000 ppm). Interestingly, sea water contains 0,003 ppm uranium.

Australia has the largest known recoverable reserves of uranium, totalling 24% of all world reserves. Although Canada is currently the largest producer of uranium in the world, it has the third largest known recoverable reserves, with 9%. Of all currently used uranium in the world, 60% of it is freshly mined and 40% comes from stocks and old weapons.

Natural uranium takes the form of various minerals. After mining and milling, uranium is transformed as $U_3O_8$. If used in a light water reactor, it is transformed later to $UF_6$ for enrichment. The uranium is transformed as $UO_2$ for use in the fuel assemblies of both light and heavy water reactors.

Typically, the spent fuel of a fission reactor consists of: 95,5% uranium, 0,9% plutonium, 3,6% fission products and 0,1% minor actinides. Several countries are considering the deep geological disposal of used fuel. Others countries, including France and Great Britain, opted to a closed fuel cycle and reprocess the used fuel, thus minimising the final volume of high level waste to be disposed while taking profit of the reusable uranium and plutonium.

A significant portion of the long-term radiotoxicity of the spent fuel comes from the minor actinides (Np, Am, Cm). The long-lived nuclides can be chemically separated from the used fuel by partitioning process. After irradiation in a fast neutron reactor, these long-lived nuclides can be transmuted into stable or short-lived nuclides. The partition/transmutation significantly decreases the radiotoxicity of the used fuel constituents to be disposed. As opposed to direct disposal, used fuel vitrification prior to disposal reduces its radiotoxicity while increasing the proliferation resistance.

Considering the global warming, the need of safety of supply and given the increase of the fossil fuels costs and the fact that they come mostly from unstable regions of the world, nuclear power is considered as a technically sound and financially competitive way of producing electricity. Mostly everywhere around the world, there were a good improvement of the public opinion towards nuclear energy over the past years.

Outside of electricity generation, nuclear technologies are used in a large variety of applications [5]. In industry, radiation beams are used to measure the thickness of materials as well as to change the composition of materials. On the medical side, we find nuclear medicine and diagnostic imaging, radiation oncology, cancer treatment and equipment sterilization. In food processing, food irradiation reduces or eliminates unwanted organisms and pathogens, increasing the shelf life of many foods and reduces significantly food-borne disease organisms. For the environment, insects can be sterilized by radiation and released to the environment in order to control insect pest. Isotope hydrology can contribute to study water dynamic. Isotope technique can help to detect leakage in dams and reservoirs. On the humanitarian aspect, neutron probes can facilitate de-mining by discriminating between explosive material and other materials.

## 5. Conclusion and perspectives

All WNU Summer Institute fellows agreed that this was an extraordinary experience to get a broad overview of the nuclear industry and of the whole nuclear fuel cycle, by adding an international perspective to it. As the first of its kind, this event was a unique opportunity for establishing bonds with peers from the international community and inspiring participants to advance the global contribution of nuclear science and technology. This chance for exposure to, and exchange with, peers from around the world developed perspective on some of the world challenges and provided a better understanding of different approaches based on differing cultures, politics and economics.

Overall, the WNU-SI is an exceptional educational and professional opportunity that has the potential to better the fellows' careers, their institutions and the entire nuclear industry. In 2007, the WNU Summer Institute will be held at Daejeon, Korea and in 2008, this event will be in Canada [1].

## 6. References

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