Education & Training for the NPP Workforce

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Introduction

I am honored to have been invited to present this paper on education and training for the nuclear power plant workforce. Ten years ago I participated in a similar NPPP conference held in Warsaw, and it is that connection that lead to my invitation. I pointed out to the NPPP 2006 Program Committee that an important element was missing from their very preliminary draft program, that is, the challenge of preparing the workforce. Their response was, "Come tell us about it." While preparing the paper I learned that the IAEA has put much effort into identifying the needs for infrastructure to support member countries planning the introduction of nuclear power into their energy supply. I will make frequent references to IAEA documents. Note that all recent IAEA documents are available for download at www.iaea.org.

The development of a highly skilled workforce is an essential element in the infrastructure required by a country planning to introduce nuclear power. As IAEA (Reference 1) points out, the principle involved is to identify the human resource knowledge, skills and abilities needed to implement the nuclear project and to develop the educational and training institutions to prepare the workers for the discharge of their function. This paper describes some of the skills needed, gives some quantitative estimates of the numbers of workers needed, identifies some possible education and training resources and concludes with some suggestions for getting started on this important infrastructure element.

NPP Skills Needed

A wide range of engineering and technical skills are required to support the design, construction, operation and maintenance of nuclear power plants (NPPs). IAEA (Reference 2) lists the following:

- Computer Engineering (Plant process computers/simulators)
- Design/Modifications Engineering
  - Civil/Structural, including seismic
  - Mechanical

    - Electrical
    - Instrumentation and Controls
- Engineering Programs
    - In-Service Inspections and Testing
    - Corrosion Phenomena
    - Probabilistic Risk/Safety Analysis
    - Equipment Qualification
    - Motor/Air Operated Valves
    - Fire Protection
- Procurement Engineering
- Reactor Engineering/Nuclear Fuels Analysis
- Systems Engineering

Skilled craftsmen of many kinds are essential to the safe operation and maintenance of NPPs. These include:

- Reactor operators
- Plant equipment operators
- Radiation protection technicians
- Chemistry technicians
- Mechanics
- Electricians
- Instrument and control (I&C) technicians

The entire workforce of NPPs must be committed to a strong nuclear safety culture (Reference 3). Training in radiation awareness is an essential element of this culture. This training should cover a range of topics to include:

- Radioactivity and its sources,
- Radiation health (biological) effects,
- Radiation protection methods and regulations,
- Measuring of radiation,
- Exposure and contamination control,
- Handling of radioactive wastes,
- Establishment of radiation protection programs,
- Releases and emergency response

In past years it has been too common for organizations to assume that workers can transfer from non-nuclear work to nuclear plant work with little or no training in radiation safety. Workers must recognize that nuclear technology possesses unique risks, and every activity must be accomplished in a safe, responsible and environmentally sound manner. Workers demonstrate respect for nuclear technology when they: (1) accept responsibility for nuclear, radiological, environmental and industrial safety, and demonstrate safety in all their actions, (2)dedicate themselves to technical and operational excellence, (3) continually anticipate and prepare for handling the unexpected, (4) minimize their exposure to radiological and hazardous materials, (5) reduce production of nuclear and industrial waste to the lowest amounts possible, (6) comply with all requirements, but question requirements that do not seem to make sense, and (7) identify and report issues relevant to safety and quality, recommending solutions whenever possible, and encourage others to do the same. I have included these seven valued behaviors to emphasize the importance of recognizing the unique requirements for working with nuclear materials.

Number of Workers Required

There are many factors that influence the size of the workforce required to operate a nuclear power plant. Reference 2 gives a comprehensive list of these factors. Briefly they include such things as the number of units at a site, the plant location with respect to population centers and contractor support services, regulatory requirements for construction and operation, environmental laws and requirements for environmental monitoring, labor laws and whether or not the workforce is represented by unions, and the level of effort required for public awareness and education.

An Internet search turned up a number of references that gave staffing levels for various sized nuclear power plants. A survey of U.S. nuclear plants done in 2005 (Reference 4) determined that the average total staffing for single unit plants is about 800. From this survey and data found in IAEA reports, variances from the average are as great as + or – 300 personnel. Reference 5 breaks the staffing areas into the following groups: operations, maintenance, engineering, safety, support and site services. Personnel from these staffing areas support 46 processes that are divided among the four process groups shown in Table 1.

Table 1. Typical Nuclear Power Plant Staffing

Process Group	**Typical Staffing Number**
Operations	425
Licensing & Engineering	170
Corporate/ Finance & Administration	110
Common Processes	95
Total	**800**

Another way of looking at the staffing is to look at the various educational and training skills required. Table 2 provides some approximate numbers for some of these categories.

Table 2. Categories of Personnel Required for NPP Staffing

Workforce Category	Approximate Number Required
Civil engineers	5
Computer, electrical & I&C engineers	20
Mechanical engineers	15
Nuclear engineers	25
Project/plant engineers	30
Control room & plant equipment operators	75
Chemistry technicians	20
Maintenance technicians*	135
Radiation protection & rad waste handling technicians	35
Security personnel	70
Trainers	35
All other personnel	335
Total	**800**

*Includes electricians, I& C technicians, mechanics

These numbers are intended to give some idea of the workforce required for operations and maintenance of a nuclear power plant. Many other workforce skills are required for the design and construction of an NPP. Again the reader is referred to the IAEA for details.

Education & Training Resources

The global nature of the nuclear power industry greatly expands the pool of resources available to a country embarking on a nuclear power development program. Internet communications present access to enormous amounts of information. Advancements in electronic, distance learning programs give access to education and training (E&T) opportunities from many diverse sources.

But, clearly one starts with an assessment of the national institutions. Dr. Tadeusz Wojcik and Professor Jerzy Niewodniczanski provided a summary of the state of nuclear science and engineering education in Poland. None of the universities in Poland provide nuclear engineering degree programs at either the undergraduate or graduate level. In part, this is because young people have not seen any prospects for jobs in this field. However, practically all the technical universities have electric power degree options in their electrical and mechanical engineering programs. Within their general energy or physic programs, some of the technical universities do offer elective introductory courses in nuclear engineering. The technical universities of Warsaw, Crakow, Gdansk and the Silesian Technical University are likely candidates for initiating nuclear engineering programs. Such programs existed in these university centers in the late 1980s. None of the research institutes, including the Institute of Nuclear Chemistry and Technology provides courses in nuclear power or radiation safety/health physics. Some of them provide PhD programs in selected nuclear related areas provided that there are professors on staff representing these areas. Some of the universities do provide courses in medical physics or radiation safety at the Bachelor or Master of Science level. Given that the situation described here has existed for about 15 years there will be a need to develop future teachers (faculty members) of nuclear engineering. This will be discussed further in the next section.

With the exception of radiation safety technicians, there are in Poland trade schools that provide training for chemistry, mechanical, electrical and I&C technicians. There are two levels of education of technicians: (1) vocational schools, with 2-3 year programs, and (2) technical colleges, with 4-5 year programs. At both levels candidates are accepted after 9 years of initial education. There are also apprenticeship programs educating craftsmen within unions (guilds). The scope of these programs seems to be decreasing. In all cases it is unlikely that student trainees receive training in radiation awareness as discussed above.

Given this brief assessment of nuclear education and training as it currently exists in Poland, it is clear that development of a nuclear power program in Poland will require that new education and training programs must be a strong element in the planning.

Getting Started

Since my knowledge of the real E&T capabilities in Poland is very limited, the following ideas are offered only to stimulate thinking about how to get started with the human resources planning. In the U.S.A. we would probably form a committee! This committee of educators and utility managers would assess current resources, determine future needs and perform a gap analysis, i.e., what needs are not able to be met without introducing new programs? Table 3, which is taken from Reference 1, shows the IAEA assessment of minimum infrastructures needed for educational programs and human resources.

Table 3. Minimum Infrastructures for Educational Program and Human Resources

Infrastructure Item	Description
1- Development of Educational Facilities for nuclear related subjects	Facilities to be considered: • Universities, community colleges and vocational schools in particular those in the region where potential site is located. Sources of educational staff • Departments of civil, mechanical, electrical, metallurgical, chemical, computer and environmental engineering and department of physics
2- Courses to be added to strengthen the human resources development for the first nuclear power reactor	• Nuclear physics and reactor design • Nuclear safety • Radiology, radiography and radiological protection • Thermal, hydraulics and thermo hydraulics analyses • Advanced structural analysis and structural mechanics • Advanced computer hardware and software design and maintenance (control computers hardware and real time control software) • Materials sciences for civil, mechanical and process related applications (steel, concrete, zirconium, ceramics, resins, cabling, etc.) • Application, calibration and maintenance of electrical, mechanical and digital instrumentation devices • Human factors engineering principles • QA/QM processes and methodology • Planning, scheduling, material management and cost control • Environmental analysis
3- IAEA supported training programs	Arrange through technical cooperation with IAEA for a combination of: • IAEA technical missions with workshops on implementation of nuclear power plant and its required infrastructure • IAEA short term (weeks) and long term (months) training programs in countries with nuclear power program
4- Training programs from countries with nuclear power program	• Training programs arranged directly with reactor vendors and constructors • Training programs arranged directly with nuclear regulatory bodies of countries with nuclear power technology • Education & training programs arranged directly with universities or colleges having nuclear engineering, nuclear engineering technology or

	health physics degree programs (This bullet added by paper author.)

The process used in the U.S.A. in the 1950s and 1960s for development of Infrastructure Item 1, "educational facilities for nuclear related subjects," may provide a useful model for Poland. The biggest difference today is that there are so many more resources available. Perhaps my personal story may serve as an illustration of the process. The U.S. Atomic Energy Commission (AEC), predecessor to the Department of Energy, sponsored summer workshops for college and university professors to prepare them to teach nuclear engineering courses. One of the Bucknell University chemical engineering professors attended a workshop and returned to the campus to teach the first "Introduction to Nuclear Engineering" course in which I was enrolled in the Fall of 1957. I became so interested in nuclear engineering that I applied for and received a government fellowship to study nuclear engineering in graduate school.

Most of the half dozen or so schools offering the courses required by the government for their fellowship recipients had programs operated by an interdisciplinary group of faculty. At Purdue University, where I attended, this group included faculty from mechanical, electrical and chemical engineering, engineering science, and physics. Most of the graduate students came with undergraduate degrees in these same disciplines. The AEC and national laboratories assisted the colleges in obtaining laboratory teaching and research equipment. Students were offered summer internships and research appointments at the national laboratories. And over time, formal nuclear engineering departments were established at many universities, e.g., at Purdue in 1960.

Now in the 21st century, Poland appears to have many of the elements needed to establish a similar process. Summer workshops could be established with assistance from many of the IAEA member countries. As noted above there at least four universities in Poland that are well positioned to begin nuclear engineering programs.

Next, consider Infrastructure Item 2, "courses to be added to strengthen the human resources development for the first nuclear power reactor." There are a number of opportunities for English speaking students to take nuclear engineering courses and even complete masters degree programs through distance learning , web-based programs. These include programs at the University of Tennessee, http://anywhere.tennessee.edu/ne/ms/program.htm, Oregon State

University, http://ecampus.oregonstate.edu/soc/ecatolog, and Pennsylvania State University, http://www.engr.psu.edu/cde/nuclear_engineering.htm. On-line courses in nuclear engineering technology are offered by Excelsior College, based in Albany, NY, www.excelsior.edu. And the Southeast Innovation in Nuclear Infrastructure and Education (INIE) Consortium has been supporting the development of an Internet-based nuclear reactor laboratory at North Carolina State University. Universities in Poland could work with these and possibly other universities in Europe to provide courses where qualified instructors are not yet available.

The World Nuclear University (WNU), www.world-nuclear-university.org, held its first Summer Institute, July 9 to August 20, 2005 in Idaho Falls, ID with 77 participants from 34 countries. The average age of participants was 30 years. I have urged that Poland have participants enrolled in the 2006 WNU Summer Institute (SI) that will be held 8 July – 18 August 2006. It will be 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). For 5 weeks, formal lectures and group-work activities will take place at the Royal Park Hotel in Stockholm. This will also be where Fellows stay. The French component of the SI will be a one-week technical tour covering several of France's nuclear fuel cycle and research facilities. This, or subsequent years' WNU Summer Institutes, will provide great opportunities for development of leaders for nuclear power in Poland.

Table 3 Infrastructure Item 3, "IAEA supported training programs" and Item 4, "training programs from countries with nuclear power program," are self explanatory. There are many resources available today that did not exist during the early development of nuclear power programs. For example, the U.S. Institute of Nuclear Power Operations publishes detailed guidelines for training of nuclear power plant workers.

It is important to recognize that years of lead time are required to prepare the nuclear plant workforce, e.g., 4-6 years for graduate nuclear engineers, 2-4 years for senior reactor operators and longer still for plant shift supervisors.

There is an aspect of infrastructure that is not covered in Table 3, that is, the need for public education/outreach programs. Almost anywhere we go, there is still widespread uncertainty and fear, often irrational about all things nuclear. In a subsequent paper, Dr. Ann Bisconti discusses some of these issues.

Outreach programs focus on recognizing the benefits of nuclear science and technology in every day life. The message is that nuclear science and technology improves the quality of life -- by producing electricity for refrigerators and computers, providing medical diagnostics and treatments for illnesses, helping produce abundant food supplies and keeping them safe, enabling the operation of life-saving smoke detectors, etc. An example of an outreach program is the American Nuclear Society (ANS) Public Education Program (PEP) that educates and informs the public, teachers, students, and policymakers by:

- Presenting information on the ANS website
- Creating informational brochures and pamphlets
- Sponsoring educator workshops on nuclear topics
- Producing a free newsletter for 21,000 educators
- Providing factual information to the media
- Supporting ANS Section/Branch outreach events
- Supporting a website for the general public at www.aboutnuclear.org

The ANS Outreach program is supported by voluntary donations from members, organizations, nonmembers, and Federal/private grants. There are other World Wide Web sites that provide much information that can be used in public education and outreach programs. These include the Nuclear Energy Institute, www.nei.org , Environmentalists for Nuclear, www.ecolo.org, and IAEA, www.iaea.org.

Conclusion

Nuclear utility executives with the best performing plants unanimously state that the most important contributor to their success is a highly educated, trained, and dedicated workforce. The IAEA has many documents attesting to the critical importance of human resource planning for any country developing a nuclear power program. This paper is intended to stimulate and encourage the participants in NPPP 2006 to begin the processes for developing a workforce that will meet the challenge of providing safe, environmentally clean and economical nuclear power for Poland in the 21st century.

References

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