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Strategy for nuclear technology education at Uppsala university

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After the TMI accident 1979, and later the Tjernobyl accident, the future of nuclear power was vividly debated in Sweden. The negative public opinion governed a number of political decisions that marked an ambition to out-phase nuclear power prior to 2010. Due to this, the student's interest in nuclear technology ceased and together with the fact that public funding to nuclear technology was withdrawn, academic research and education within the field were effectively dismounted.
In the beginning of 1990 it became clear to the society that nuclear power could not easily be closed down and the issue of the future competence supply to the nuclear industry was initiated. In the mid-nineties the situation became acute due to the fact that personnel in the nuclear industry started to retire in an increasing pace necessitating measures to be taken in order to secure the future operation of the nuclear power plants.
In the year 2000, the Swedish nuclear power plants, Westinghouse Electric Sweden and the Swedish Radiation Safety Authority embarked a project together with the three major universities in the field, Uppsala University, The Royal Institute of Technology and Chalmers University of Technology. The aim of this project was to define a financial platform for reconstructing the Swedish research and education in nuclear technology. The project, named the Swedish Centre for Nuclear Technology (SKC), has during a decade been the major financier to nuclear technology research and education.
Using funding from SKC, Uppsala University formulated a strategy along two tracks: 1) Instead of creating ambitious master programs in nuclear technology, the already existing engineering programs in a wide range of fields were utilized to expose as many students as possible to nuclear technology. 2) A program was initiated together with the nuclear industry aiming at educating newly employed personnel.
The result is encouraging; starting from essentially zero, typically 100 undergraduate students follows at least one nuclear technology course each year and about 25 students conduct their Diploma work within nuclear technology annually. Meanwhile about 150 persons from the nuclear industry follow the "industrial" courses and an increasing amount of undergraduate students chose to follow also these courses. The volume goal has now been reached and the next step is to launch a Bachelor program in nuclear technology during second part of 2010.

1. Swedish nuclear power – a brief resumé

The nuclear age in Sweden commenced in 1947 when the Swedish parliament assigned the task of developing nuclear power to the company AB Atomenergi. The development program was a success; in 1954 the first research reactor went critical and a decade later a prototype nuclear power plant, Ågesta, located in the outskirt of Stockholm was commissioned. The Ågesta reactor was in operation during the period 1964 to 1974 and was used for district heating purposes. Following the global oil crisis in the early 1970ies Sweden embarked on a large scale expansion of nuclear power. During the period 1972 to 1985 twelve light water reactors at four sites, Barsebäck, Forsmark, Oskarshamn and Ringhals, were commissioned and connected to the electric grid. The reactors comprised 9 boiling water reactors constructed by the Swedish company Asea Atom AB and 3 pressurized water reactors constructed by Westinghouse Electric Company. Ever since, nuclear power accounts for approximately half of the electricity generated in Sweden.

Following the Three Mile Island accident in 1979 public support for nuclear power declined rapidly and the parliament parties agreed on a referendum about the future of Swedish nuclear power the following year. In the end, the outcome of the referendum was that the parliament would not permit new nuclear power reactors to be built, that the planning and/or design of new reactors were forbidden and that all existing reactors should be shut down no later than 2010. The consequences of these decisions were grave. With no

hope of new nuclear power plants being built in Sweden, Asea Atom AB ceased developing nuclear reactors and the remaining nuclear fuel fabrication facility was sold off. With no prospect of a long-time career within nuclear industry student's interest in nuclear technology ceased and together with the fact that public funding to nuclear technology was withdrawn, academic research and education within the field were effectively dismounted.

During the 1990ies it became clear to the society that nuclear power could not easily be replaced by other sources of energy and in 1997 an act was passed in the parliament that nuclear power should eventually be phased out, but without a fixed deadline. Instead, the parliament was given the right to decide about the closure of nuclear power plants at any time. This was commenced in 1999 and 2005 when the two reactors at the Barsebäck nuclear power plant were closed down ahead of time.

In the years that followed, world-wide concerns about greenhouse gas emissions and the fact that viable alternatives to nuclear power failed to materialize, it became obvious that the remaining ten reactors would be needed in the foreseeable future. Consequently the nuclear power plant operators have been granted permits to perform lifetime extensions and power upgrades. In June 2010 a landmark legislation was passed that removes the dismantlement law of 1997. The new law allows permits to be granted for new nuclear reactors of any capacity to replace existing reactors on a one-to one basis, i.e., the number of reactors in operation will not be permitted to exceed 10.

2. Competence development

The indefinite postponement of nuclear power plant shutdowns in 1997 raised the issue of future competence supply to the nuclear industry. In the mid-nineties the situation became acute due to the fact that personnel in the nuclear industry started to retire at an increasing pace, necessitating measures to be taken in order to secure the future operation of the nuclear power plants. In the year 2000, the Swedish nuclear power plant operators, Westinghouse Electric Sweden AB and the Swedish Radiation Safety Authority (SSM) embarked on a project together with the three major universities in the field, i.e., Uppsala University (UU), The Royal Institute of Technology (KTH) and Chalmers University of Technology. The objective of this project was to define a financial platform for reconstructing Swedish research and education in nuclear technology in order to secure knowledge and competence development at an academic level in order to provide resources to the Swedish nuclear industry and its regulators. As a result the Swedish Centre for Nuclear Technology (SKC) was formed in 2002, Fig. 1. During the last decade SKC has been the major financier of nuclear technology research and education within Swedish universities. In its present form SKC is a centre at the School of Engineering Sciences at KTH. Two features of SKC stand out. First, it is notable that SSM, which is the regulatory, supervisory and licensing authority under the Ministry of the Environment, is a SKC partner. Second, the universities are partners on an equal footing with the other financing partners thus allowing the universities to influence the priorities and strategies of SKC.

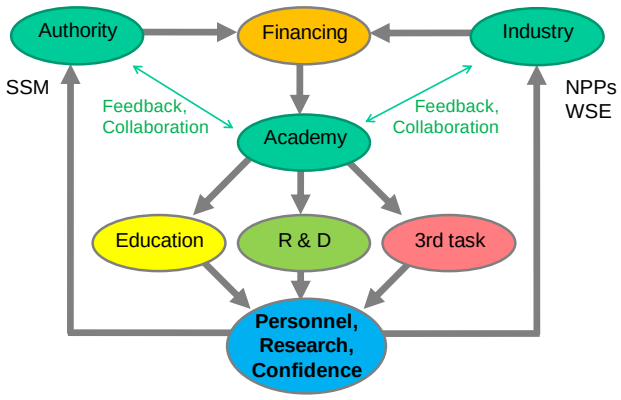

Fig. 1. In SKC industry, the governing authority and the universities are all partners on an equal footing. The ultimate objective of SKC is to enable the universities to provide education, research and development to meet the demands of the nuclear power sector including that of the governing authority, SSM.

3. Nuclear engineering education and training

In the aftermaths of the 1980 referendum, student interest in nuclear technology education ceased as did the

public funding of nuclear technology activities at the universities. As a result, until recently there have been no formal nuclear engineering bachelor's or master's degree programs in Sweden. Thanks to SKC funding, nuclear technology research at the universities has survived and low volume nuclear-technology related post-graduate programs have been maintained at Chalmers, KTH and UU. In the last couple of years KTH and Chalmers have established master's programs in nuclear engineering.

With no supply of nuclear engineers from the universities, the nuclear power plant operators have been forced to fulfil their demand for operation and maintenance staff by recruiting primarily technical college graduates, general production engineers and marine engineers with little or no prior knowledge of nuclear technology. Training and education of new staff has been provided by Kärnkraftsäkerhet och Utbildning AB (KSU) under the supervision of SSM. KSU, which was formed in 1972 is also operating all Swedish nuclear power plant simulators needed for the training of control-room staff. Similarly, administrative and R&D staff have been provided with on-the job education and training.

In view of the on-going life time extensions, power upgrades and the possibility of new nuclear reactors being built it in Sweden it has become obvious that the existing system of training and education does not have the capacity to fulfil the future demand for nuclear power plant staff.

4. Contract education at Uppsala University

At the Division of applied nuclear physics (TK) at UU, it was realized some ten years ago that nuclear technology education could provide a platform for expanding its activities in a new direction and to establish itself as a player in the field of nuclear technology education and research. With that in mind TK approached KSU suggesting collaboration where TK would provide nuclear technology contract education to the industry. A long-term agreement was reached where TK took on the obligation to provide courses in, e.g., reactor physics, thermal hydraulics, nuclear chemistry, ionizing radiation and protection at the request of KSU. One element of this agreement that has proved crucial for its success was that KSU recognized that in order for TK to provide high-quality education one had to fund not only the teaching activities, but also to provide funding for the competence development of the university staff involved in the teaching. Commencing in 2003, the commissioned education activities at TK has increased from 9 course weeks per year to 29 weeks in 2009.

The contract education, which is planned to continue in the foreseeable future, has been of great benefit to TK and UU in two ways. First, the funding has allowed TK to recruit senior staff members that in addition to teching has been involved in SKC research projects as part of their competence development. Second, some of the contract courses have been made available for UU engineering students. Earlier, students have only been exposed to nuclear technology as part of the course curriculum in, e.g., energy physics. Now they have the opportunity to take electable reactor technology courses within the framework of existing engineering programs at UU. The student participation in the contract courses has proved a big success. Students, often for the first time in their education, get the opportunity to establish contacts with professionals within the nuclear industry. Also, the nuclear industry recognizes that participating students constitute a previously unavailable recruitment basis. It is very common that students that have participated in reactor technology contract courses elect to conduct their diploma work within the field of nuclear technology. After receiving their degree these students are almost always offered employment within the nuclear industry. Approximately 100-150 persons from the nuclear industry and 20-25 undergraduate students follow at least one contract course each. Interestingly, almost 50% of the undergraduate students participating in the contract courses are female, a situation that is not reflected in the undergraduate engineering programs, where female students are a minority.

4. Strategy for nuclear engineering education at Uppsala University

Following the success of the contract education and recognizing that there is a huge demand for engineering staff at various levels within the nuclear industry TK formulated a strategy along two tracks:

- Instead of creating ambitious master programs in nuclear technology, the already existing engineering programs in a wide range of fields should be utilized to expose as many students as possible to nuclear technology.
- The largest demand for new engineering staff at Swedish nuclear power plants is on the bachelor level. Thus a bachelor's program in nuclear engineering program should be established at Uppsala

university in collaboration with the nuclear industry.

The reasoning behind the first objective is that the Swedish nuclear industry in the short- to midterm perspective faces a huge demand for engineers and technicians within different fields of engineering not directly related to reactor technology, e.g., mechanical and electrical engineering. However, in order to minimize on-the-job training and education it is desirable that these engineers have a general knowledge about reactor technology and its related subjects. The first objective has been met by making available undergraduate courses in nuclear technology to students in the existing programs, i.e., energy system engineering, engineering physics and the program for systems in technology and society. The result is encouraging; starting from essentially zero, typically 100 engineering students follow at least one nuclear technology course each year and about 25 students conduct their diploma work within nuclear technology annually. With the volume goals being met, efforts are now being made to introduce in-depth courses and a "nuclear track" comprising a series of electable courses in nuclear technology is being established within the energy systems engineering program.

Another considerations when formulating the strategy to not pursue a master's program at UU is that at present, the experience from other master's programs is that they attract very few Swedish students (<20%). Most master's students are from abroad with an obligation to return to their home countries after receiving their degree, thus not helping to resolve the recruitment needs of the Swedish nuclear industry.

The second objective; that of establishing a bachelor's program in nuclear engineering is motivated by the fact that in the past, Swedish nuclear power plant operators have often recruited technical college graduates in order to fulfil the demand for operation and maintenance staff. With changes in the Swedish secondary school system, technical college educations are vanishing and the nuclear industry has to look to elsewhere for new staff. Increasingly, industry's interest has been directed towards recruiting B.Eng. graduates even though there are no bachelor´s programs in nuclear engineering at Swedish universities. Some problems have been identified with this approach:

- Because Swedish nuclear power plants are located far from large population areas where most of the universities are located, industry has experienced difficulties in recruiting new staff.
- Even with B.Eng. graduates there is a significant need for on-the job education.
- Because of the recruitment demands in other fields of engineering, retention is a future concern.

TK approached industry suggesting that a bachelor's program in nuclear engineering should be established that would provide industry with a long-term solution to its recruitment needs while addressing the problems above. In 2009 an agreement was reached between Swedish nuclear power plant operators, KSU and UU that such a bachelor's program should be established, starting in the autumn 2010. The program has been started and presently it is the only one of its kind in Sweden. There are several aspects of the bachelor's program that are unique. First, the nuclear power plant operators jointly support the education with the largest industry sponsorship program in Sweden. Part of the sponsorship goes to KSU, to conduct simulator teaching, training exercises in the Barsebäck training facility, etcetera. Thus, industry and academy join forces in a much closer collaboration than hitherto attempted in Sweden. In contrast to industry funded contract education, the university retains the right to decide on, e.g., admission requirements, program and course syllabuses and examination requirements. The funding is needed for several reasons, most notably that the education is rather more expensive than other engineering programs, e.g., reactor laboratory work and simulator training are much more expensive than traditional laboratory teaching. Similar to the contract education agreement industry also acknowledges that funding is needed for competence development of the teaching/research staff, especially so since for historical reasons there is a lack of senior nuclear technology research and teaching staff at Swedish universities.
Second, the bachelor's program is a one year program. For students to be admitted to the program they must have completed at least two years of studies in primarily mechanical or electrical engineering at a Swedish university. The motivation for this is twofold. Students can be recruited to the programs from universities close to the nuclear power plant operators, which increase the chance of them taking up employments at the local nuclear power plants. Also as previously noted, the demand from industry is not for engineers specialized in nuclear engineering, but rather mechanical and electrical engineers with a solid knowledge in nuclear technology.

Third, extensive use is made of specialists from industry and authorities for teaching different subjects

unique to the nuclear industry, e.g. nuclear power operations and project management.
Fourth, industry puts several of their specialized facilities at the disposal of the program that would otherwise be inaccessible for undergraduate education. A notable example is the Barsebäck nuclear power plant that has been shut down, and at present is operated by KSU as a training facility for nuclear power plant staff and contractors.

Fifth, an extensive mentoring program has been established in collaboration with the Swedish chapter of Women in Nuclear™ (WiN). The objective of the mentoring program is to give students the opportunity to get to know industry professionals and get a valuable insight into the industry, learn about career opportunities and obtain advice on career planning. Each student is assigned a personal mentor and during the course of the education several mentoring seminars are arranged.
The program, which started in September 2010 attracted approximately 80 applicants, 25 of those being admitted to the program.

5. Conclusion

During the last two decades when public funding was not available for nuclear engineering research and education, SKC very successfully provided the financial means to keep these activities alive at Swedish universities. Nuclear power is again part of Swedish energy policy and even though public funding has started to emerge, SKC will continue to play an important role in the future. Master's programs have been established at Chalmers and KTH, while at UU nuclear engineering contract education has flourished. Presently, UU is by far the largest provider of contract education to professionals within the Swedish nuclear industry. In fact, the contract education directed towards the nuclear industry constitutes almost 10% of the total value of contract education at UU. In order to resolve present and future recruitment needs of industry, UU has successfully launched a bachelor's program in nuclear engineering in close collaboration with the nuclear industry. For the first year 25 students have been admitted to the program.

The bachelor program as developed in Uppsala may serve as a template for deeper integration of authority and industry into the academic teaching, and for a larger involvement of academic staff into industry and authority competence development

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