Recent Achievements in Regulating Nuclear Power Activities in Taiwan

Ouyang M.[1]
[1] Atomic Energy Council, Taipei, Taiwan ROC

1. Introduction

Taiwan began the nuclear-free society initiative in 2000. A bill, drafted by the Executive Yuan in 2003, to enforce implementation of the nuclear-free society policy has been waiting to be reviewed at the Legislative Yuan. However, since the "Kyoto Protocol" to the UNFCCC (United Nations Framework Convention on Climate Change) took effect in February 2005, compounded with creeping prices of oil and the gas pipeline dispute between Russia and the Ukraine, more and more policy makers, energy experts and leading environmentalists around the world realized, by mere coincidence, that nuclear power is not only economic but cleaner and greener than other forms of power. Furthermore, for countries with scarce energy sources, such as Taiwan, nuclear power provides a secure option for diversity of energy mix. While the bill on realization of nuclear-free society remains to be reviewed by the legislators, high government officials and opinion leaders in Taiwan has begun to reassess the role of nuclear power in nation's energy policy. To the people in Taiwan, nuclear power is not a matter of choice; even under the current policy of phasing-out nuclear power in the long run, nuclear power is still a necessary path to nuclear-free society.

The question of whether we should use nuclear power or how much nuclear power we need is a socio-economic one and should be decided based on a consensus by the society. As the country's nuclear safety regulator, our responsibility at the Atomic Energy Council (AEC) is that, once the amount of nuclear power for generation and consumption has been decided, we must make sure that this power is being generated and consumed by the society in the safest way possible. And that has been one of AEC's major focuses and achievements in recent years: making nuclear power plants safer. The following sections summarize some of AEC's recent and ongoing efforts in regulating nuclear power activities in Taiwan.

2. Reactor Safety

In Taiwan, there are three operating nuclear power plants, Chinshan, Kuosheng and Maanshan, operated by the state-owned utility Taiwan Power Company (TPC). A fourth plant, Lungmen, is under construction and expected to begin operation in 2009. In 2005, over 98% of energy sources were imported. The three nuclear plants with two operating units at each site, contributed a share of 17.6% to the total electricity production – compared to 18.1% in 2004.

2.1 2005 Safety Performance of the Nuclear Power Plants

The overall safety performance of nuclear power plants in Taiwan is continuously maintained at a high level of standards. Figure 1 shows the average capacity factor for all six units over the past decade, increasing steadily from 76.2% in 1993 to 88.7% in 2005. Both Kuosheng unit 1 and Maanshan unit 1 are also on the list of top 50 units by capacity factor in the world. The annual average number of abnormal events per unit was 1.5 (or 9 events for all six units), and the average number of automatic scrams per unit was 0.5 (or 3 scrams for all six units) in 2005.

Among these remarkable achievements, Chinshan unit 1 (with an 18-month refueling cycle) has set a record of 538 days continuous operation. Both Kousheng unit 1 and unit 2 have not encountered any automatic scram for three consecutive years. Maanshan unit 2 has conducted a shortest refueling outage for 33.5 days in TPC overhaul maintenance experience. As a whole, it reflects the effectiveness of the efforts made, and also gives clear targets for both the regulator and operator to continue improvement in every aspect.

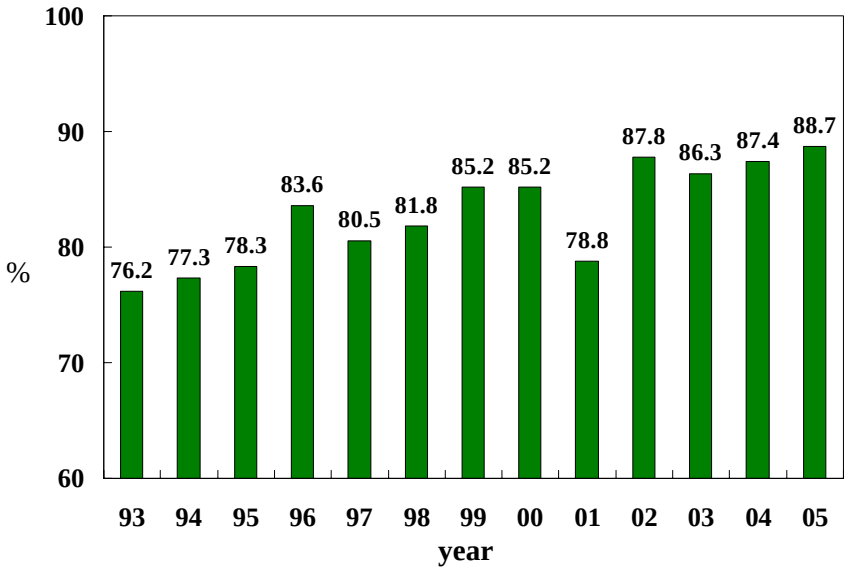

Figure 1 Average capacity factors of all six operating reactor units

As for the construction of Lungmen plant, despite numerous difficulties resulting in significant delays, the project is standing tough and moving firmly forwards. Construction continues for two ABWR units at Lungmen, with 63.75% completion by the end of 2005. Due to the suspension in 2000 and rising price of construction materials, the project anticipates a 5-year delay, and is scheduled for completion of unit 1 in 2009 and unit 2 in 2010.

2.2 Proactive measures to enhance nuclear safety

In answer to the government's transparency policy and risk disclosure concept, an objective and predictable approach has been developed. A so-called *"Color-designated Reactor Safety Indicator"* was devised based on the idea borrowed from the reactor oversight process (ROP) of the U.S. Nuclear Regulatory Commission (USNRC). Three reactor safety cornerstones (initiating event, mitigating system, and barrier integrity) have been counted and posted on AEC's website since 2005. Depending upon the performance indicators of various systems and equipment associated with each cornerstone, a safety assessment of nuclear power plants can be presented by color designation (from no safety concern to greater degree of safety significance): green, white, yellow, and red. The regulatory inspection findings are also classified into three cornerstones to reflect the safety significance by colors. So far, except for one "white" on "mitigating system" due to deficiency in maintenance of the reactor core isolation cooling (RCIC) system at Chinshan Unit 1, all of the postings in both performance indications and inspection findings are in "green".

To ensure safe operation and public health, AEC continuously takes regulatory measures to closely monitor nuclear plant performance. Last year, three unplanned reactor trips of Maanshan plant triggered AEC to enhance investigation and inspection on the area of electro-magnetic interference (EMI) of safety related systems, digital-control device installation, and the reliability of electric transmission buses. Recent regulatory activities are mainly focused on: urging TPC to recruit and train younger licensed operators for its nuclear plants, adopting risk-informed fire analysis (RIFA), enforcing underground cable monitoring program, requesting TPC to evaluate grid stability, inspecting BWR control rod crack, and setting a forum for discussing BWR fuel channel bow and fuel failure issues.

In addition to the ongoing regulatory activities, AEC anticipates review of foreseeing applications, including measurement uncertainty recapture (MUR) power uprate, final safety analysis report (FSAR) of Lungmen plant, license renewal (beyond 40 years) of Chinshan plant, and implementation of maintenance rules. The goal of the reactor regulation is not only to assure the safe operation and public health but also to maintain stable operation. Operational experiences and regulatory practices around the world are instrumental for AEC in regulating Taiwan's nuclear plant operations more effectively.

3. Radiation Protection

The Ionizing Radiation Protection Act (IRPA) of 2002 was the first of a series of laws passed in Taiwan as a result of a vigorous "rule-overhaul" process for regulating atomic energy related matters. As declared in Article 1 of IRPA, the law is enacted in accordance with the ALARA (As Low As Reasonably Achievable) principle. Article 5 of IRPA further stipulates that the latest standards of the International Commission on Radiological Protection (ICRP) be taken into consideration when AEC sets safety standards for protection against ionizing radiation. So far, as many as 20 daughter regulations were promulgated, many of which have even gone through further revisions to incorporate feedbacks from both the regulatory staff and the regulated, as well as to conform to new international standards or guidelines.

3.1 Dose optimization at nuclear power plants – an ALARA practice

In 2003, after extensive communication and consultation, a mutual understanding was reached between AEC and TPC with a common goal of achieving overall performance in radiation protection significantly higher than world average through TPC's voluntary program of improving performance, enhancing reactor safety and reducing workers' exposure, all at the same time. Detailed implementation plans with target values were developed for each plant with reference to the performance indicators of WANO (World Association of Nuclear Operators), and progress was monitored at AEC's periodic regulatory meetings. Starting in 2004, each plant adopted various administrative actions and technical measures to ensure radiation safety and to optimize dose by following the ALARA principle. Administrative actions include "adopt-a-task" initiative, radiation safety check-up before high radiation operations, and personal radiation dose tracking and control. Technical measures include removal of radiation sources, installation of radiation shielding, shifting and control of operational schedule, and consideration for environmental occupancy factors, etc. Among these, "removal

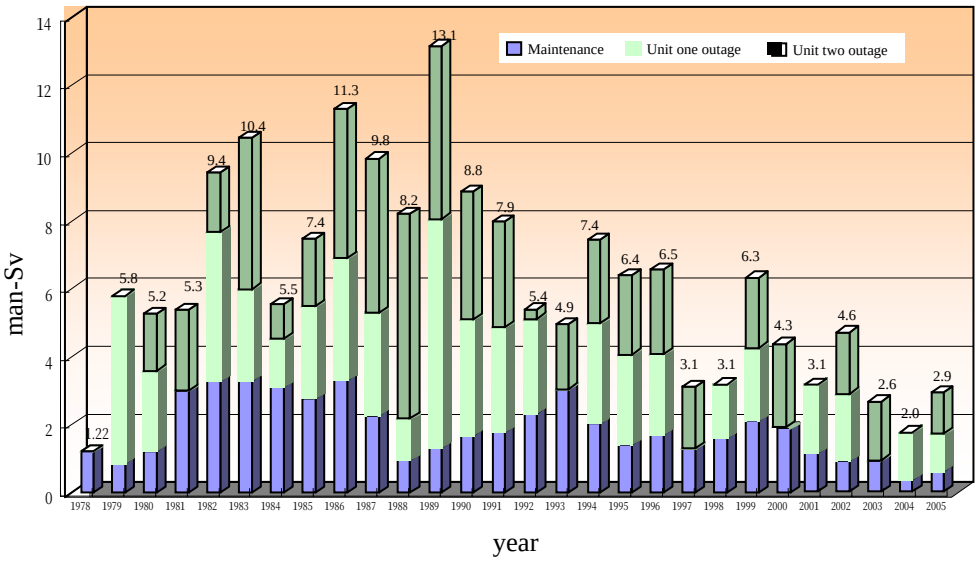

Figure 2 Outage collective dose at Chinshan plant, man-Sv

After three years of implementation, the efforts devoted by the plants began to pay off, especially at Chinshan plant. In 2004, the average worker's annual dose at Chinshan was 1.13 mSv (with one unit in outage), and no worker received a total dose exceeding 20 mSv. The collective dose was 1.03 man-Sv per unit, which was listed among the first quarter of WANO's single year collective dose index. In 2005, the average worker's annual dose was 1.30 mSv (with both units in outage), no worker received a total dose exceeding 20mSv, and the collective dose was 1.46 man-Sv per unit – the lowest ever achieved for a domestic plant with both BWR units in outage in a single year. Figure 2 is the histogram of outage collective doses at Chinshan plant. Note that in 2005, the outage collective dose hit a record low of 1.24 man-Sv and 1.03 man-Sv, for Units 1 and 2, respectively, a significant improvement compared to an average outage dose of 3 man-Sv per unit in its operating life of 28 years, or to an average of 2 man-Sv in the past 5 years. Chinshan plant's implementation of the "adopt-a-task" initiative was also awarded by TPC as best practice of radiation safety in 2005, and regarded as a role model among all nuclear plants.

To better integrate radiation protection with the risk-informed concept, it has become an international trend in radiation protection to regard "dose constraints" as the "most fundamental protection standards". Special attention has also been given to "stakeholder involvement". To face future challenges, radiation workers and radiation protection personnel, regulatory staff included, should work closely together in actively and persistently pursuing optimized actions for radiation dose management, enhancing safety culture, maintaining flexibility in radiation risk management, and taking ALARA measures that will help reduce workers' dose.

3.2 Enforcing control of Categories I&II radioactive sources

In Taiwan, IRPA and corresponding regulations had been in place for effective control of import and export of radioactive sources since 2003. To increase control of sealed radioactive sources, AEC established in March 2004 an online reporting system through the Internet, assisting source owners in reporting their sources every month. After having over 90 percents of owners reported through the system regularly, AEC revised relevant regulations to incorporate this initiative with existing practices.

To further conform to the Code of Conduct on the Safety and Security of Radioactive Sources, published in September 2003 by the International Atomic Energy Agency (IAEA), and its corresponding guidance document, which became effective December 25, 2005, AEC has taken the following actions:

1. Informed IAEA of our commitment to conforming to the Agency's Code and Guidance;
2. Established an inventory of Categories I&II radioactive sources, which is suitable for use in our country;
3. Revised relevant regulations on import and export of radioactive sources, which became effective on December 29, 2005; and
4. Conducting special inspection on Categories I&II radioactive sources and establishing a management plan to expedite handling (recycling, storage or disposal) of radioactive sources.

The above exercise is one example demonstrating AEC's commitment to, and action towards, strengthening control of high-activity radioactive sources. Meanwhile, AEC continues to engage actively in adopting measures to enhance the safety of the use of radioactive sources, ensuring that Taiwan's regulatory system in radiation protection conforms to international standards.

4. Radioactive waste management

4.1 Dry storage of spent fuel

Spent fuels are temporarily stored in the spent fuel pools at each nuclear plant in Taiwan. Although re-racking projects have been undertaken at each plant to extend the storage capacity for the spent fuel pools, Chinshan and Kuosheng plants will still lose their full core reserves by 2010 and 2015, respectively. To provide assurance for continued operation, TPC decided to go for an interim dry storage project at Chinshan plant, and later at Kuosheng. In the case of Chinshan plant, TPC has chosen a concrete cask system design by means of technology transfer from a qualified vendor, and is expected to submit an application for a construction license in 2006; in the hope to have pre-operational test performed in 2008 and the storage be put into operation by the end of 2009.

According to the "Nuclear Materials and Radioactive Waste Management Act" and "Regulations for the Review and Approval of Applications for Construction License of Radioactive Wastes Treatment, Storage and Final Disposal Facilities", licensing for spent fuel dry storage is a two-step process: a construction license is issued based on the approval of the Preliminary Safety Analysis Report (PSAR), and an operation license based mainly on the Final Safety Analysis Report. In the licensing review program, experts and scholars of different disciplines will be called upon to provide technical opinions. Confirmatory evaluations regarding structural seismic analysis and radiation shielding will also be carried out. International consultation through technical cooperation will be arranged, especially in the case when unresolved issues on safety are in question. A public hearing is also required before issuance of a construction license.

4.2 Low-level radioactive waste

4.2.1 Waste volume reduction

More than 90 percent (by volume) of low-level radioactive waste (LLRW) generated in Taiwan has been produced by the three nuclear power plants, while hospitals, research institutes and industry alike accounted for the remaining amount. Since the Fuel Cycle and Materials Administration (FCMA) of AEC launched a volume reduction strategy program in 1990, TPC has drastically reduced its annual output of solidified LLRW from nearly 12,000 200-liter drums in 1983 to only 601 drums in 2005, as shown in Figure 3. The accomplishment could not have been realized without successful implementation of the High Efficiency Solidification Technology (HEST) developed by AEC's research arm, the Institute of Nuclear Energy Research (INER). TPC's Volume Reduction Center, built on the premises of Kuosheng, has also been playing an important role in reducing volume of LLRW. The Center is equipped with a supercompactor to compress the compressible waste and an incinerator to incinerate the combustible waste from Chinshan and Kuosheng plants. Maanshan plant has its own incinerator on site.

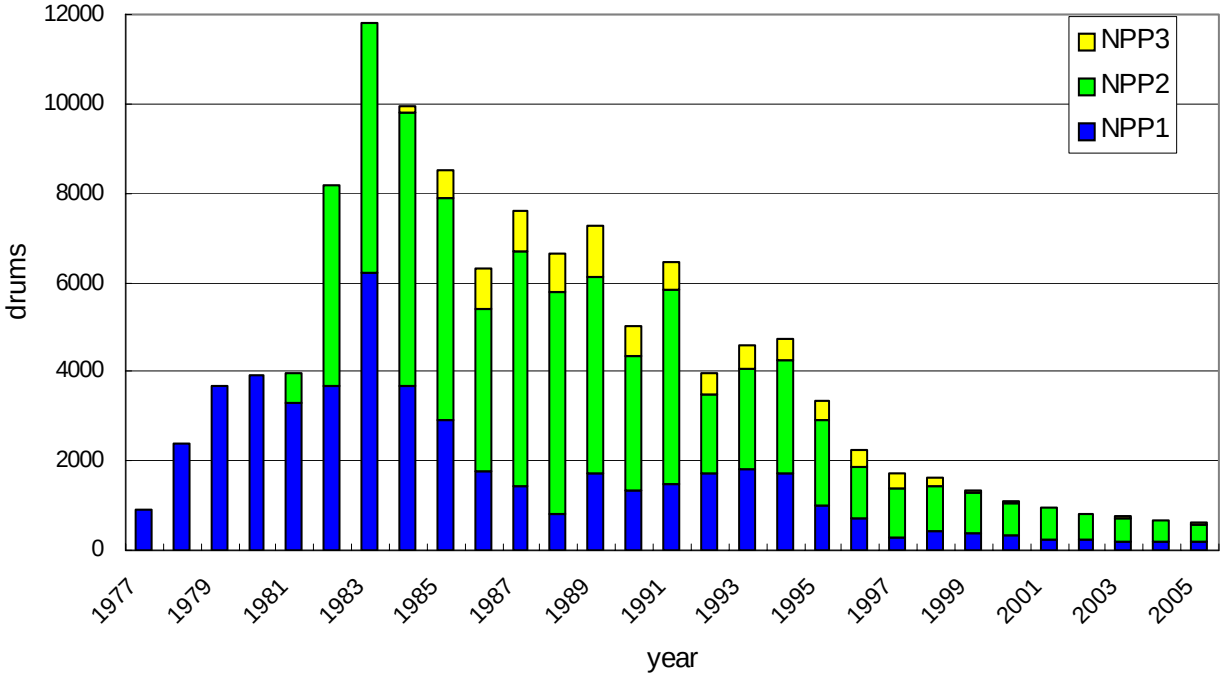

Figure 3 Solidified Waste Generation from nuclear power plants in Taiwan

INER has also been active in developing thermal plasma technology in recent years with the goal of treating LLWR to reduce volume and for safe storage. INER has successfully created an indigenous thermal plasma capacity, with a five- to 1,200-kilowatt plasma torch system to vitrify different types of waste, including low-level nuclear waste as well as ashes from traditional incinerators, a major source of dioxin. The treatment capacity is being raised to over 70 tons a day to meet industrial needs.

4.2.2 Site selection for final disposal facility

In order to lay a legal foundation for selection of a site for final disposal of low level radioactive waste and for effective oversight of disposal operations, AEC drafted a bill on "Site Selection for Low-level Radioactive Waste Final Disposal Facility", and submitted it through the Executive Yuan to the Legislative Yuan for examination in December 2002. After years of debate, the law passed the Legislature on April 28, 2006 and took effective by presidential decree on May 24, 2006. The passage of the bill marked a milestone in Taiwan's nuclear development history, as the utility can now build a final repository for low-level nuclear waste. The issue had been unresolved for years and had spawned protests and demonstrations by anti-nuclear activists.

Under the terms of the new law, the radioactive waste disposal site should not be built in a place with a dense population, active geological faults, or other geological or hydrology conditions that would affect the safety of the facility. While the site selection committee, organized by the Ministry of Economic Affairs, is to recommend at least two candidate sites, local governments may voluntarily propose such sites for consideration, and their residents will decide by referendum whether they want such a facility in their hometown before the central government can officially decide on a candidate site. Upon approval of the environmental impact assessment by the regulatory authority, i.e. the Environmental Protection Administration, the site becomes final. TPC will build a repository following strict requirements comparable to high international standards, and a contribution fee of up to NT$5 billion will be drawn from the Nuclear Backend Fund to the local government as a way to give back to the people.

Meanwhile, TPC continues examining the 97,672 drums of LLRW stored at the interim storage facility on an offshore islet Lanyu. To improve waste storage conditions and prepare for shipment of the waste drums to a final disposal facility in the future, TPC has carried out a pilot project to gain experience by re-packing 600 waste drums and re-painting 2600 waste drums. A full-scale project will be launched in June 2006, and planned for completion in five to seven years, prior to eventual commencement of final disposal operation.

5. Conclusion

As widely recognized by the international community, nuclear safety has no national borders, and there has been growing international cooperation in nuclear infrastructure, safety regulation and R&D to enhance the safety of nuclear activities. Although not a contracting party to United Nations conventions on nuclear activities, Taiwan has always committed itself to bindings of high international standards in nuclear safety. Communication tests are conducted regularly between AEC and IAEA in lieu of “the Early Notification Convention” and “the Assistance Convention” on nuclear emergency. National reports, prepared in accordance with the Nuclear Safety Convention were peer-reviewed between AEC and USNRC. For the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, a similar review is anticipated with AEC’s bilateral cooperative states. In the area of nuclear safeguards, IAEA conducts safeguards inspections in Taiwan following the spirit of the UN Nuclear Non-Proliferation Treaty and an Additional Protocol established between Taiwan and the Agency in 1998.

Keeping people safe from nuclear harm is meant to be a guarantee -- a guarantee that our sustained growth and development can be achieved. We at the Atomic Energy Council take pride in being the agency that ensures people's safety, and we will continue to do a good job at it.