LOW LEVEL WASTE REDUCTION IN TAIWAN, CHINA

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ABSTRACT

More than one hundred thousand drums (100,000) of Low Level Radioactive Waste (LLRW) have been produced in Taiwan since the first commercial operation of nuclear power plants (NPPs) in 1979. According to the Radwaste Management Policy (RWMP) proclaimed by the Atomic Energy Council (AEC) in 1988, radwaste producers shall strive to minimize the waste production rate and reduce the volume. In response to this demand and thanks to efforts implemented by the industry, the annual radwaste production for all three NPPs (six units) has been decreased from more than 12,000 drums before 1990 to less than 8,000 drums afterwards. In 1996, the number went down further to 5,200 drums. This paper addresses what will be done in our next step of LLRW volume reduction. The efforts involve such tasks as system improvement, change of solidification agents, and better management skills. Our goal is to reduce LLRW production rate to half of the current level by the end of this century.

INTRODUCTION

In Taiwan, there are three nuclear power plants with six operating units as shown in Table 1. Taiwan Power Company (Taipower), a nationally-owned company, is the operator of these NPPs that have a total designed power output of 5,144 MWe and account for 30% of the total electricity generation. These NPPs generate radioactive waste and more than one hundred thousand drums of LLRW have been produced since commercial operation began in 1979. This represents more than 90 percent of total volume of LLRW, with the remaining 10% coming from smaller producers such as hospitals and medical clinics, research institutes , and universities.

The Fuel Cycle and Materials Administration (FCMA) is the sole regulatory body of radwaste in Taiwan and the FCMA and Taipower work cooperatively to reduce waste volumes.

In this nation LLRW can be divided into two categories: wet waste and dry active waste (DAW). Wet waste, namely evaporation residue, filter sludge, and spent bead resins, is first solidified with cement in galvanized steel drums then stored in structurally safe warehouses. DAW consists mainly of paper, cloths, plastic, wood, etc. Incineration and supercompaction are the two main techniques used for volume reduction of DAW.

Table 1 The Commercial Dates of Nuclear Plants in Taiwan

Station:	**Chinshan NPP (BWR)**		**Kuosheng NPP (BWR)**		**Maanshan NPP, (PWR)**	
Units:	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2
Commercial Date:	Jan. 5, 1979	Sep. 6, 1979	Dec. 28, 1981	Mar. 15, 1983	Jul. 27, 1984	May 18, 1985

RADWASTE MANAGEMENT

The “Radwaste Management Policy” (RWMP) proclaimed by the Executive Yuan (the Cabinet) in 1988 and revised in 1997, and the “Atomic Energy Application and Development Policy” proclaimed by the Executive Yuan in 1991, respectively, provide the principal guidelines of radwaste management in Taiwan. The RWMP defines the goals of radioactive waste management as being “to protect the safety of public, maintain the quality of the environment and avoid detrimental effects at the present and in the future“. Under this policy, the Radwaste Administration (RWA), the predecessor of the FCMA, pursues the following strategies:

1. To oversee waste producers in reducing the quantity and volume of waste.
2. To ensure that waste producers bear the cost of waste management.
3. To raise efficiency by keeping the legal and regulatory framework up to date and by improving management and information systems.
4. To strengthen research, development, education and dissemination of information.
5. To strictly monitor waste treatment, storage and transport to ensure safety.
6. To oversee implementation of radioactive waste final disposal and to regulate the future repositories for safe operation.

These strategies continue to be in effect.

RADWASTE REDUCTION REGULATIONS

Realizing the importance of radwaste reduction, the RWA issued the “Radwaste Reduction Strategies” in 1993. The present FCMA is still following these strategies, pushing the waste producers to take active and concrete measures to minimize LLRW production rate and reduce the volume. The Strategies set targets on annual solid radwaste production for each NPP (Table 2), and also strict annual radwaste production limits for new NPP, for example, wet radioactive waste from new reactor unit of 1000 MWe capacity shall not exceed 250 drums per year. In response to this requirement and thanks to efforts implemented by Taipower, the annual radwaste production for all three NPPs has been decreased from more than 12,000 drums before 1990 to less than 8,000 drums afterwards. In 1996, the number went down further to about 5,200 drums. Figure 1 presents statistics annual radwaste productions from the nuclear power plants.

Table 2 Target of NPPs’ Solidified LLRW Production

Station	**Basis* (Drums)**	**Target (Drums)**			**1996 Production**
		1993 ~ 1995	1996 ~ 1998	1999 ~ 2001	(Drums)
Chinshan NPP	1657	1500	1300	1100	729
Kuosheng NPP	2314	2000	1650	1300	1114
Maanshan NPP	550	450	400	350	388

* Basis is the average production of the former three years (1990~1992).

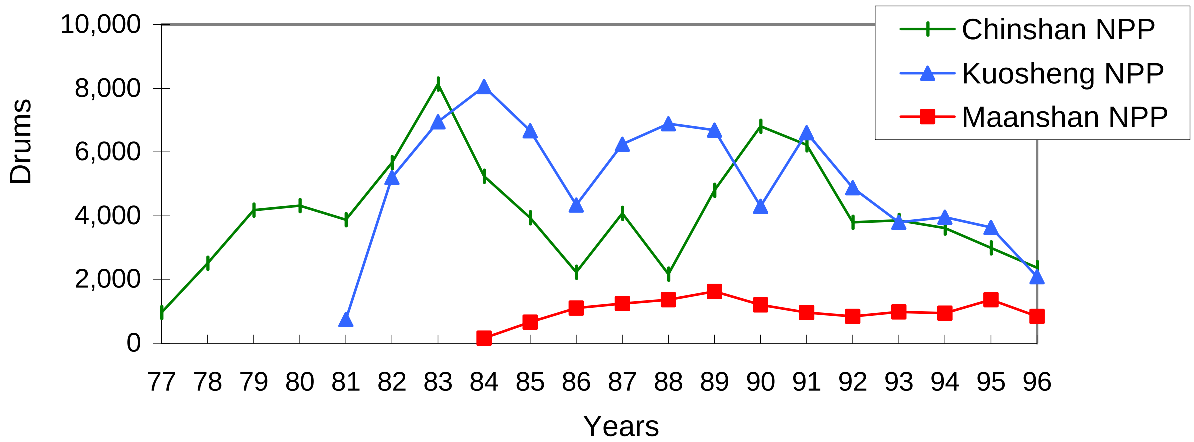

Fig 1 Statistics of the Annual Radwaste Productions from NPPs

Meanwhile, Taipower established a Radwaste Volume Reduction Center (RVRC) in 1991, equipped with an incinerator and a supercompactor. The Center has greatly reduced the volume of radioactive waste. Although Taipower has made progress in volume reduction, the FCMA has requested that the feedwater quantity of the radioactive waste liquid be reduced as far as possible since solid waste production increases as feedwater quantity increases. This relationship is illustrated by comparing Fig 2 – statistics for the annual feedwater quantity of radioactive liquid waste – with Fig 3 – statistics for the annual production of solid radioactive waste.

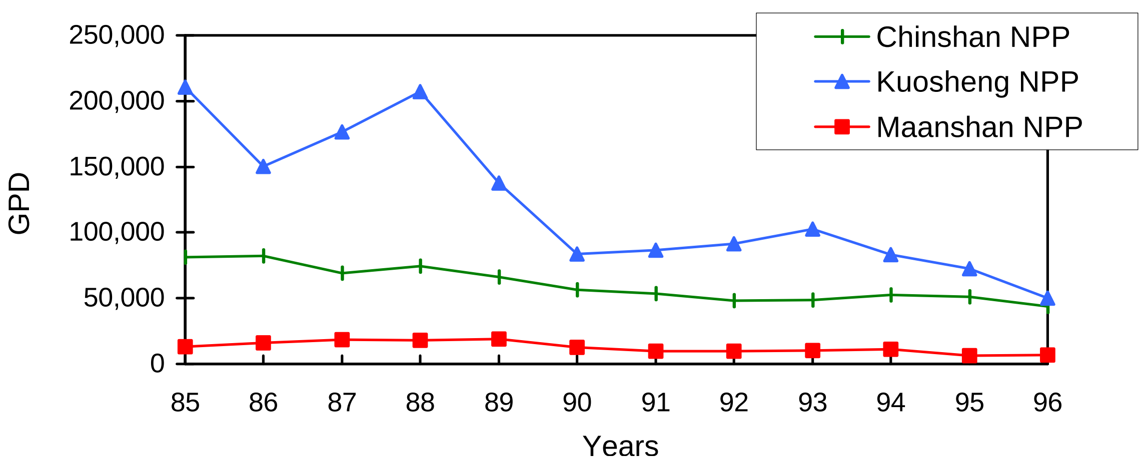

Fig 2 Statistics of Annual Feedwater Quantity of the Radioactive Waste Liquid from NPPs

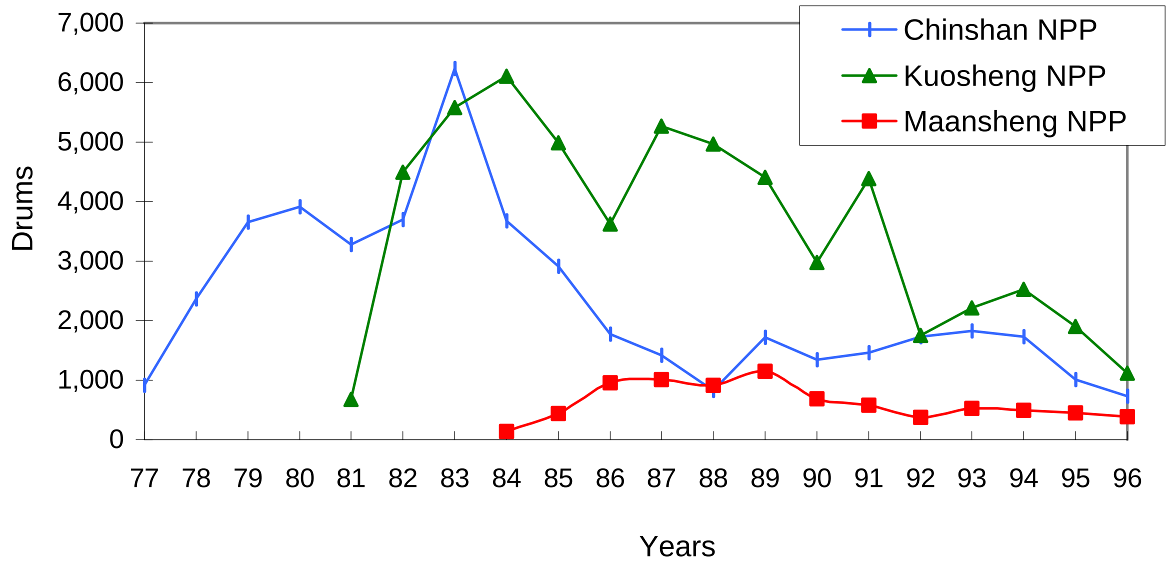

Fig 3 Statistics of the annual Solid Radwaste from NPPs

To further improve performance in this area, the FCMA has set up a Radwaste Reduction Expert Advisory Group to evaluate advanced radioactive waste reduction technologies from around the world and to promote radioactive waste reduction at all nuclear energy facilities.

RECENT ACHIEVEMENT AND FUTURE PROSPECT

High-Efficiency Solidification of PWR Concentration Waste

A high-efficiency process for the solidification of liquid borate waste generated at PWRs and sodium sulphate concentrate generated at BWRs has been successfully developed by the Institute of Nuclear Energy Research (INER) using an elaborately formulated solidification agent with sodium borate solution to form a hardened slurry. This slurry is highly flowable initially and hardens within 30 minutes forming a solidified product with high strength. For example, the compressive strength of waste forms produced from various types of waste are all over 100 kg/cm^2, which is higher than the acceptance criteria of the USNRC regulation. The volume efficiency of this process is more than 8 to 15 times of conventional cementation process. The process has been patented in many nations.

Waste solidification at Maanshan NPP (PWR) currently uses an improved cementation process (in which borate waste liquid constitutes 10~11% by weight compared with 5% in the conventional cementation process). The station plans to adopt the newly developed solidification process. Installation will be completed in February 1998. When the system is in operation, the production of Maanshan NPP's solid waste will be one-fifth below the current production levels.

A feasibility study for high-efficiency volume reduction of the concentrated waste liquid and spent resin has been finished. INER is now cooperating with Kuosheng NPP on a process to co-solidify the two wastes, which could reduce solid waste production by 60%. With these new processes in operation, the production of solid radwaste in Taiwan will go down to one half of the production at present. Table 3 presents estimates of future production of solid radwaste.

Table 3 The Benefit of the High-Efficiency Solidification Technology

Station:	**Chinshan NPP**	**Kuosheng NPP**	**Maanshan NPP**
Source of Solid Radwaste:	Sodium Sulphate	Concentrated Sodium Sulphate	Borate Liquid
Present Annual Production (Drums):	650	1000	450
Annual Production After New Processes (Drums):	Below 200	Below 300	Below 90
Total Waste Reduction:	About 1500 Drums		
Money Saving:	About 5.35 Million US Dollars		

Plasma Technology for Radioactive Waste Treatment

Plasma technology takes advantage to incinerate the combustibles of radioactive wastes for volume reduction and vitrify the non-combustibles simultaneously into glass slags or metal ingots by using the same equipment and without pretreatment steps to separate different waste type. To develop this technology for treatment of various waste, the INER has been running a Plasma Melting Furnace (PMF) development program since 1994. The final goal of PMF program is to construct a plasma plant to treat LLRW. Several cement-solidified surrogate wastes have also been processed by this plasma system. The volume reduction ratios (VRR) of these surrogate radwastes are between 2.6 and 4.6 and the weight reduction ratios (WRR) range from 1.6 to 2.2. The compressive strength of these slags are between 432 and 1602 kg/cm^2, and the average leaching indices of vitrified slags are between 8 and 15. The final stage of PMF program will be executed from 1997 to 2001. The present stage is to establish a plasma furnace using a transferred plasma torch delivering an output power more than 800 kW. The furnace is specified as 250 kg/hr for non-combustible radioactive and hazardous wastes. After the completion of PMF program, the promising benefit could save 285 thousand US dollars per 100 drums. Besides applying to LLRW produced in NPPs, this technology can be applied to treat hazardous wastes from medicine and other industries.

Supercompact the Ash from Incinerating Combustible Radwaste

The RVRC of Taipower proposes a test plan to supercompact the ash after incinerating combustible radwaste. In the past, the RVRC treated the ash by asphalt solidification. Now the RVRC puts the radioactive furnace ash in steel drums for supercompaction. After compaction, steel & ash cakes will be placed in galvanized-steel drums that are temporarily stored on-site. This task has been approved by the FCMA. In the future, volume reduction of the radioactive ash treatment process could reduce costs for storage, transport, and disposal.

CONCLUSION

By comparison with the data of the World Association of Nuclear Operators (WANO), we find that our BWR plants generate slightly more waste than the world average (Fig 4). Accordingly, efforts for future LLRW volume reduction will focus on BWR plants. Although our PWR plant has better performance in terms of waste production rate (Fig 5), we hope the waste production rate in PWR will go down to one-third of the WANO's statistics at the turn of the century. Our final goal is to reduce LLRW production rate to half of the current level by the end of this century.

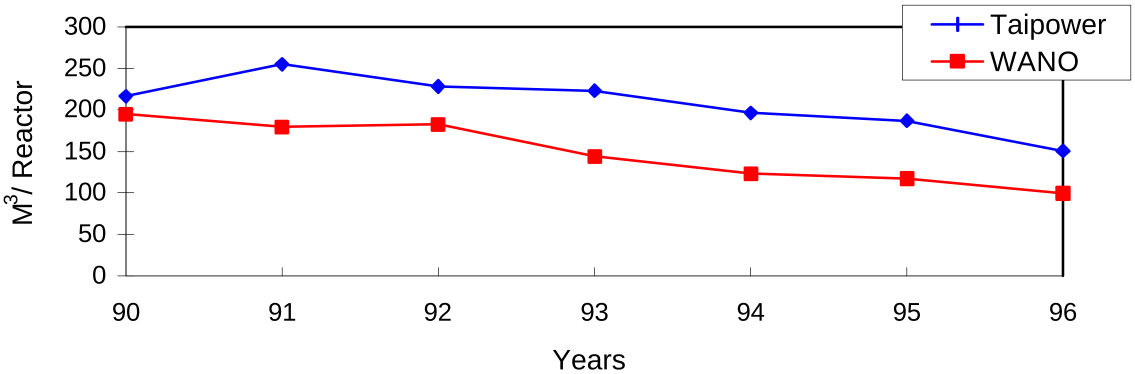

Fig 4 Comparsion of the Average Value of Waste Production of Taipower's BWR and WANO

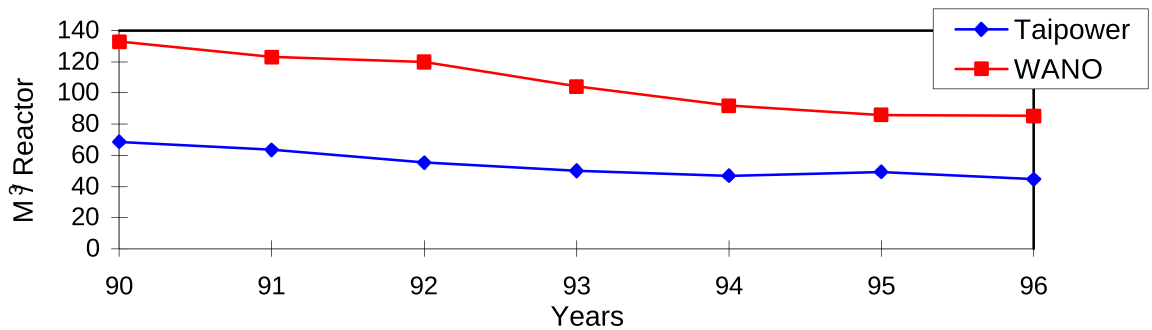

Fig 5 Comparison of the Average Value of Waste Production of Taipower's PWR and WANO

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REFERENCES

Chin-Ching Tzeng and Tsung-Min Hung “Development of Plasma Technology for Radioactive Waste Treatment in INER.” : Proceedings of the International Conference on Radioactive Dosimetry and Safety, Taiwan, 1997, pp 502-505.

T. Huang, “High-Efficiency Solidification of PWR Concentration Wastes”, VOL 2, Proceeding of 10^{th} Pacific Basin Nuclear Conference”, Kobe, Japan, 1996, pp.1295-1296, Atomic Energy Society of Japan, Japan Atomic Industrial Forum, Tokyo, 1996.

S. Liu, & R.T. Lee, ”Strategies For Low Level Waste Volume Reduction In Taiwan”, Proceedings of ROC/ROK joint Symposium On Radwaste Management, 1990, Taiwan, pp. 279-283 INER, Lung-Tan, Taiwan, 1990.

Tony D.S. Liu, & Syh-Tsong Chiou, “Regulatory Control of Low Level Radioactive Waste in Taiwan” Vol 1, Proceedings of International Topical Meeting on Nuclear and Hazardous Waste Management, 1996, Seattle, U.S.A, pp.141-146, American Nuclear Society , Inc. Illinois, U.S.A.