The Challenges and Countermeasures of Human Resources on Nuclear Power in the 21st Century

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Abstract. The paper addresses the situations of nuclear power development and nuclear industry human resources and points out that the development and supply of human resources are becoming the big challenges in the effective and sustainable development of nuclear power. At the same time, the paper analyzes the root causes of human resources shortage and recommends several countermeasures to confront human resources problems. At last, the paper introduces what SNPTC and SNERDI do to overcome the human resources problem and give conclusions.
Key Words: Human Resources (HR), Challenges, Countermeasures, Nuclear Power (NP), AP1000, CAP1400, CAP1700

1. INTRODUCTION

Most IAEA member states have set up Nuclear Power (NP) development program as national policy and energy strategy with the technical progress and successful demonstration of NP to be a safe, clean, ecological and economic energy.

China started to build her first Nuclear Power Plant (NPP) and finally put into operation at the beginning of 90's. AS of now, eleven units up to 9.1GW are in operation and twenty-four units are under construction. In October 2007, China state council had approved the "Nuclear Power Medium and Long Term Plan (2005-2020)" representing NP development policy of China. Until 2020 China planed to complete NPPs with capacity of 40 GW. Recently, it has been adjusted up to 86GW, to increase her NPPs in coastal and inland, which represents 5% of the total national electric power supply.

The contributions of NP to climate change, environmental protection and safety of energy structure are well recognized nowadays. Chinese government would take serious steps to develop NP to overcome the said three concerning issues and to achieve their medium and long term NP target through proper research development and implementation. China will continue to build a number of the 2nd generation improved Pressurized Water Reactor (PWR) NPPs and the 3rd generation NPPs at the same time. There are five NPP projects supposed to perform FCD in 2009, one unit of AP1000 in San Men, one unit of AP1000 in Hai Yang, one unit of EPR in Tai Shan, one unit of CNP600 in Chang Jiang and one unit of HTGR in Rong Cheng.

Such a scale of development on NP needs many engineers and technicians and also provides a good opportunity for professionals in the related fields. NP professional human resources (HR) were in sharp drop at the end of 20 century. The NP industry is very complicated engineering system, many different type of NP professionals will be needed during the life of NPP operation such as in the fields of research and development, mining and prospecting, equipment and manufacturing, construction and project management, operation and maintenance, waste management and disposal. All the countries who want to develop nuclear power like China need a lot of experts, engineers and operation personnel urgently. The development and supply of HR are becoming the big challenges in the effective and sustainable development of NP as all the countries that are willing rapidly to increase the NP ratio in the world are in short of professional nuclear engineers and skilled technicians at present.

The HR bottleneck situation should be seriously considered and tackled down for the safe and economic development of nuclear power.

2. WHERE CHALLENGES OF HR RESULTING FROM

2.1. Firstly challenge coming from the impacts of two severe accidents (SA)

The first challenge was from the consequences of two SAs and it resulting into the stagnation of NP development. The accident of TMI in 1979 and Chernobyl NPP in 1986 had cast a shadow over the NP world; especially the Chernobyl accident caused an environmental disaster. Impacts of two SAs were: Directly resulting into questions on nuclear safety and more safety review requirements imposed, licensing uncertainties increased, nuclear power economy degraded, and low public confidence obtained. The two SAs indirectly resulted into:

- The cancellation of a lot of NP project contracts lead directly to slow down the world's NP development from 1980 to 2004.
- The stagnation of the development of NP influenced the whole nuclear industry including the buildup and training of scientists and engineers. The NP policy in China before 2004 was adequate or moderate not active as present, i.e. low speed development.
- Many nuclear departments, teachers and relevant courses in the various universities had been changed or closed. Only four universities in China kept the NP engineering technology specialty but with no students' enrollment in some years.
- Lots of engineers and scientists left from nuclear related industries and entered other industries.
- Undergraduates and Graduates from universities are directly switched or attracted by IT and commercial industries.

The additional challenge in China was also from great culture revolution (GCR). There was a gap of over 10 years without normal students' graduation. Many NP experts and engineers graduated from 1955 to 1980 were retired. The normal university education was resumed in 1978.

2.2. Secondly challenge coming from high demand of NP development

With the efforts of nuclear industry and safety administration as well as technical innovation, the NP has been demonstrated safe, economical, clean, sustainable energy supply. And the NP is important for energy safety and emission reduction of CO_2. The contributions of NP to the climate change, environmental protection and energy safety make Chinese government take serious steps to develop NP.

Now, in China, there are twenty-four units under construction with the capacity approximates 25.40 GW. Up to 86GW of NPPs would be put into operation and about 30GW under construction until 2020. Meanwhile, National Key Research Project "Large Passive Nuclear Power Plant and High Temperature Gas Cooled Reactor" is in progress and China is speeding up the research of the technology for Sodium-cooled Fast Reactor and promoting the construction of demonstrating NPP.
China is making great efforts to establish and optimize her NP rules and regulations, standards and specifications to match with the international operation and management standards. The challenge is enormous as so large amount of HR are required in such short time for all nuclear industries to meet the highly demands of quick NP development. To achieve our goals, we need not only professionals in reactor, nuclear chemical, nuclear fuel, and radioprotection but also non NP professionals in finance, legislation and environmental protection.

China Nuclear Power plant siting resources are illustrated by the Fig.1

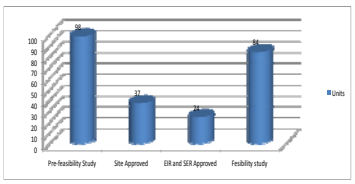

Fig. 1. China Nuclear Power Plant siting resources (as of August, 2009)

Originally, China has 3 holding companies directly involved in NPPs; they are China National Nuclear Corporation, China Guangdong Nuclear Power Corporation and China Power Investment Corporation. At present, four other government owned electric power corporations are allowed to join this field; they are China Huaneng Group, China Datang Corporation, China Huadian Corporation and China Guodian Corporation. All these new comers to NP industry are hunger for professionals in NP. It's also a great motivation and chance for youngsters, but only can professionals and technical personnel promote the sustainable development of nuclear power. We have human resources but how to educate and train them? Still exists a challenge!

2.3. Thirdly challenge coming from the natural law for HR development

It depends mostly on the domestic overall scientific, educational, technical level and industrial systems capabilities including various infrastructures and qualified teachers. There are the minimum time period required for engineers to cover education, training, practice and the time period required for infrastructure establishment. Rome is not built in one day.

In China it takes eight to ten years to train a qualified NPP reactor operator. Most of the NPP operators are graduates. A qualified NPP reactor operator not only has go through various strict training, but also has gone for three thousand hours of practical training before officially taking up the duty, the practical training which includes operating conventional power stations, other NPP control room operation "shadow training", simulation training and NPP commissioning operation. An operator has pass written and oral test which include theoretical, legal written examination, and simulation machine operation, and then he will be awarded a certificate from the national nuclear safety administration as a qualified NPP operator. The qualified operator is labeled as "Golden Man", meaning long period training and high cost spent.

3. HOW TO CONFRONT HR PROBLEMS FOR NP DEVELOPMENT

Therefore, several countermeasures and ways should be adapted to enhance the nuclear power HR development to meet the demands of nuclear power development.

3.1. Subjects change and adjustment for NP development

Coordination with the universities set up and change subjects to be suitable for NP, and set force the training of graduates with more nuclear knowledge before their leaving universities.

China started her nuclear program and technical education in 1955. The universities and colleges are selected to start nuclear engineering related courses aiming to develop Chinese nuclear weapon and technologies for industry use.

Follow the economy and education reformation and development. The ministry of education had fine-tuned these courses as “Nuclear Engineering and Technology” which includes the follow four subjects as below:

- Nuclear Energy Science and Engineering
- Nuclear Fuel Cycle and Materials
- Nuclear Technology and Applications
- Radiation and Environmental Protection

To improve the employees’ abilities, enterprises choose students when they are in junior class and train them one year in senior class additionally for nuclear engineering knowledge. These students could get more nuclear knowledge before their leaving universities and adapt the NP job quickly after their graduation.

3.2. More universities having NP engineering subjects

More and more universities enhance the enrollment of NP subjects and set up NP courses to meet the requirements for all kinds of talents.

Following the growth and market demand in NP professionals, universities in China like Tsinghua University, Xian Jiaotong University, Shanghai Jiaotong University, and Harbin Engineering University are restructuring their NP subjects one after another to enhance their training and enrollment in bachelor degree, master degree and Dr. degree. Other universities like Beijing University and other more than ten universities are setting up Nuclear Technology and Applications, Nuclear Fuel Cycle and Materials and other relevant courses as their new programs for the training of NP professionals.

The number of undergraduates’ enrollment in China and graduates major in NP are shown as follows:

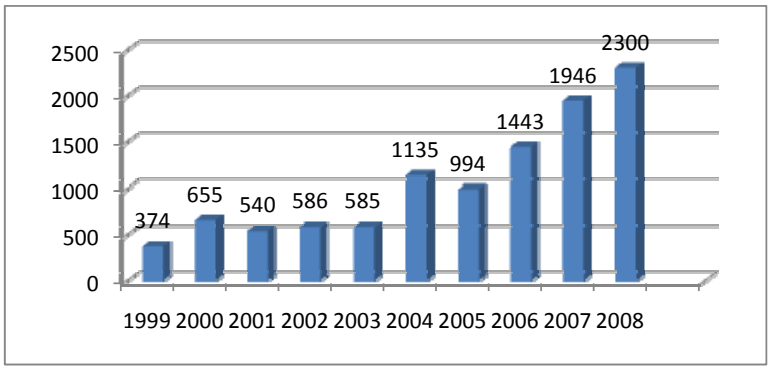

Fig. 2. Number of Undergraduates’ Enrollment in China (1999-2008) [1]

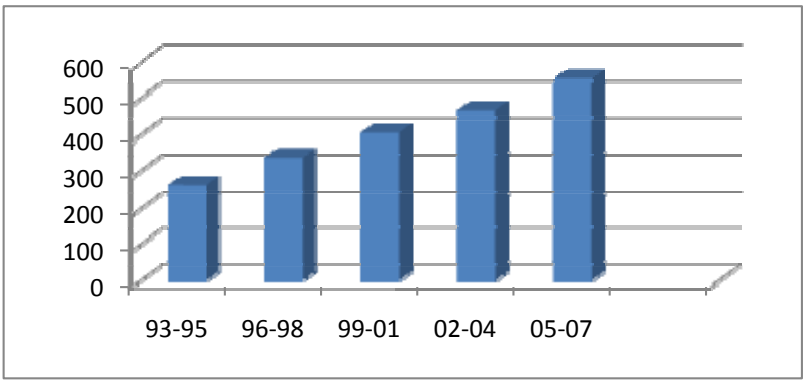

Fig. 3. Number of Graduates major in Nuclear Power (1996-2008) [1]

Considering non NP professionals, the talents demand is comparatively urgent before 2015, because enlarged development brings strong talents need in the context of slow development in the past. After 2015, along with talents growth during practical work, it will come into a saturation period, and this kind of demand will become stable gradually.

Universities have to be more organized and systematic in utilizing the internal and external resources to maximize the efficiency of the training program. The followings are the main problems to be overcome.

- Building up a team of qualified teachers and tutors
- Teaching material and literatures
- Building up laboratory
- Building up practical training base
- Courses to be established
- Education system to be set up

3.3. Demand analysis of HR

The demand analysis of HR should be made to fit for China's NP development plan, and to form the HR strategic development plan and support development initiative.

Strategic plans to speed up NP manpower programs should be set up. All countries which decided to develop NP should make demand analysis of HR and establish their strategy to expedite NP manpower training for the future market needs. The HR development should be properly foreseen, programmed and scheduled.

3.4. Establishment of web education system

Establish NP educational websites to facilitate NP professionals continue education program and distant learning.

The educational website to facilitate nuclear power professional continuous re-education and distant self learning should be established properly. Meanwhile, establish global or regional nuclear technology internet website providing distant learning with various NP educational information and act as an intercommunication centre for NP researchers, lecturers and students.

The corporate NP universities should be established to provide a new education system to train more middle and senior management staffs and fulfill the life long learning needs. The corporate NP universities will offset the short falls in the conventional universities. Corporate universities emphasize more on practically and pertinent needs and provide systematic training and solutions for each different position designated.

3.5. Improvement of HR development

The exchange, interaction and feedback among the government, the nuclear industry and universities should be strengthened to improve effectiveness HR development.

The government, the nuclear industry and universities play an important role in cultivating nuclear engineering professionals. The basic roles and relationships for the three parties must be defined.

Firstly, the role of government should be changed from "control all" to "limited control". The government should pay more attentions to infrastructures such as education system which brings benefits and progress to the present and future of the nation.

Secondly, it doesn't mean abandon of the whole government's right. The government and universities should make corresponding educational plans according to the Macro-Control policies in order to meet the requirements and needs in nuclear industry. In the meantime the government should provide financial supports, policies, consultations and information to assist the universities in NP experts training.

Lastly, nuclear power industry should financially support universities to have more education facilities including teachers. Meanwhile, the most important thing is to establish the feedback mechanism.

3.6. Team and organizational capability buildings

Under the existing conditions of HR, the team and organizational capability buildings are particularly important. Such as:

- Fully using of the limited HR to form an effective organization and team in all NP fields including education, R&D, engineering, project management and etc. For example, universities should employ experience researchers from NP industry as lecturers and tutors. This join operation will provide R&D and also practical training for the students.
- Setting up effective evaluation and supervision system of performance.

3.7. Professional HR management

The professional HR management should be introduced into nuclear industry. The management includes the introduction of more scientific HR planning, introduction, training, configuration, remuneration, incentive systems, to attract various talents to join the NP industry. We are not only looking for new graduates, also need other professionals in different levels, especially for those with working experience, hard working and creative persons. So, nuclear power HR management should be reviewed its incentives and remuneration from time to time.

3.8. Promotion of HR international cooperation

Promotion of HR international cooperation by using international expert databases which need urgently to be established. Actively introduction of international nuclear talents is important to enrich Chinese NP development in manpower demand. The international cooperation is needed to encounter the world wide shortage of manpower in NP and to facilitate NP for peaceful project to achieve our common goals on a win-win situation. We not only have to upgrade the existing middle and senior NP experts' knowledge but also have to train our young engineers and technicians. Countries pursuing NP plan should work under the guidance of IAEA, through the organizing professional forum, technology exchange workshops and international conference to achieve our goals on future NPP projects.
Establish (regional or private corporate) international NP HR databases, enable NP corporations to source manpower world wide (regional of private corporation).Under the collective effort, the HR databases can be categorized into R&D, design, manufacturing, construct, installation, commissioning, operation, maintenance and upkeep, decommissioning and waste management. The categorized databases will assist NP corporations to find their suitable employees.

4. COUNTERMEASURES USED IN HR DEVELOPMENT BY SNPTC&SNERDI

4.1. Brief about SNPTC/SNERDI

SNPTC (State Nuclear Power Technology Corp.) was formed on May, 2007 under China long term NP plan. She was entrusted by the China state council to sign the contract with oversea on acquisition of 3rd generation NP technology, which include engineering design and project management, through the learning process and build self innovated PWR NPPs in the future. She is the major carrier and R&D platform of the introduction, localization, self reliance design, construction and development and the main organization and body to develop the large advanced pressurized water reactor CAP1400 and

CAP1700.

SNERDI (Shanghai Nuclear Engineering Research and Design Institute) was formed on 8th of February, 1970 with the objectives on research and development of high-tech nuclear engineering. SNERDI is the leader in China on nuclear engineering design. She has the leading edge on nuclear engineering projects which includes the operation and technical support. SNERDI joined SNPTC as one of its core business unit on 25th June, 2007. Besides the technical support and service for operating NPPs, pre-project of sites SER and EAR and etc, SNERDI work scopes cover the design of followings:

- CNP300 self developed by SNERDI
- CPR1000 based on M310
- AP1000 self reliance supportive and follow up projects
- CAP1400
- CAP1700

Same situation is faced by SNERDI. We have lots of projects with the limited HR and with the conditions of:

- Younger staffs and the lack of engineering experience.
- Retirement of the experienced experts and engineers.

Based on strategy of SNPTC&SNERDI, the later has formed the relevant “HR plan and projection 2008-2020”. SNERDI will train high quality staffs and first grade team work to correspond with the development of the institute. We have analyzed our existing condition and future project and found the following actions to be taken to ensure our objectives are achieved.

- Increasing the enrollment of senior NP professionals, to speed up the formation of NP HR team for the market need.
- Upgrading the overall quality of individual and team work using the innovative, scientific and systematic methodology.
- Building performance evaluation system to encourage employees advance together with corporate growth.
- Promoting institute own R&D facilities by opening NP related courses in master and Dr. Degree.
- Setting up NP training website to provide guidance and further study opportunities for the employees, improving self innovative ability and technology advancement for institute.

5. CONCLUSIONS

Last 70’s oil crisis resulted into first quick NP development and then slowed down by the two SAs. Ups and downs are normal for all industries including nuclear industry. The once more fossil fuels high prices and environment protection requirements push forward the big tide of NP development. It’s the best NP time for all of us. And how do we seize such a good opportunity and prevent another down? It is the responsibility of us.

The safety and economy of NP is a topic forever. The safer, more economical and advanced NP is needed to be developed. The world wide shortage of NP professionals is unarguable. Although core competitions in NP are in operation, technology, but the future competitions will be in HR. No matter which country or company, if she needs NP, she will face the problem in shortage of HR. All sectors including government, corporations, colleges and universities should take serious steps to expedite the NP HR training program. All countries need to work cooperatively for a win-win solution. So, international cooperation including technical, philosophical and engineers exchange is strongly proposed.

Under the existing HR condition, it is important to expedite and organize our team efforts in NP HR and attract more professionals to join in NP industry through HR market. We should employ HR experts and introduce scientific HR management systems in manpower planning, training, incentive and remuneration scales. If we couldn't organize effective team works and a comprehensive system, there is no way that we can fulfill the needs in NP development. Meanwhile, the development of diversification, balance and sustainability is indispensable to prevent the great downwards tendency of NP industry, and thus avoid great demands of HR suddenly or lay them off unwillingly.

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