

## Our Vision >>> A Word from the Minister

During my three years as Minister of the Atomic Energy Council, I have worked diligently alongside my colleagues. Placing colleagues in positions best suited to their interests and abilities has created a spirit of teamwork and resulted in outstanding performance. As a result of AEC's achievements in inspection and control of nuclear power plants over the past few years, both annual radioactive waste generation and trip events have reached all-time lows. Moreover, excellent R&D results have been attained in the areas of nuclear safety, environmental protection, nuclear medicine and renewable energy. I'd like to applaud each and every AEC employee, because our tireless efforts have made AEC a shining star among government agencies.

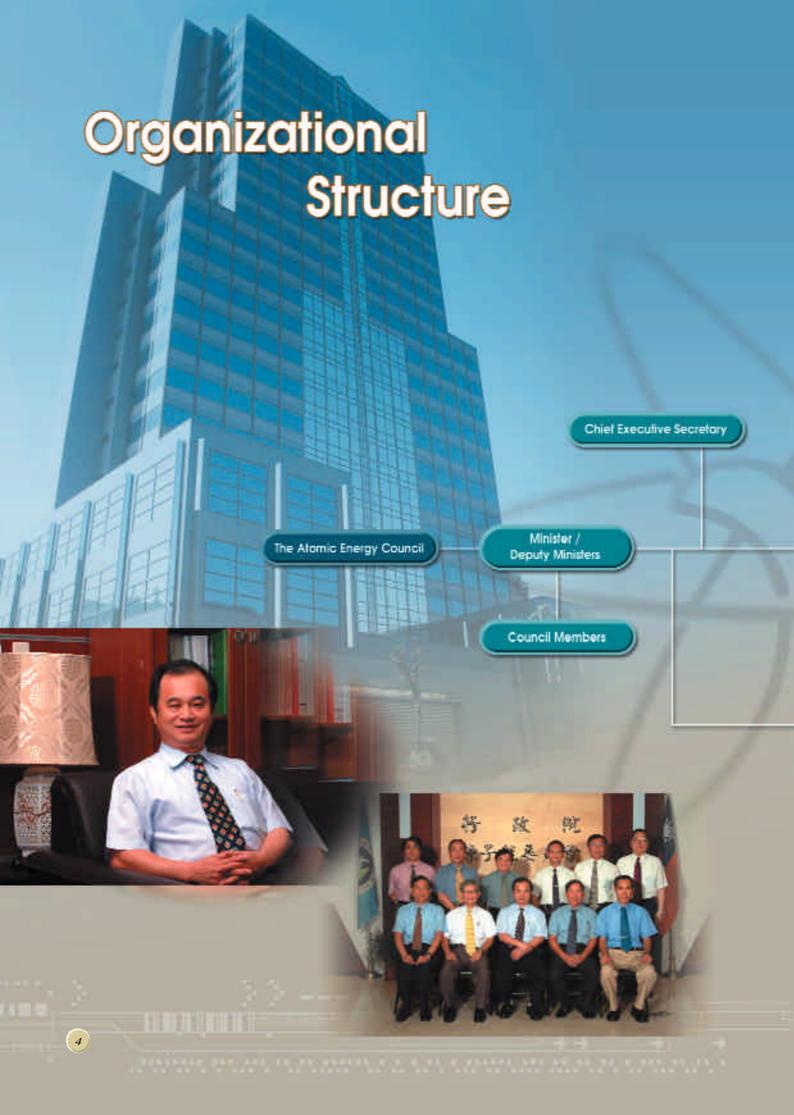
I hope that you will all continue to be frank and sincere in ensuring the public's right to know, be open to the opinions of both opponents and supporters of nuclear energy; and make use of our nuclear safety control and R&D achievements to win the trust of the public. In other words, to ensure nuclear safety, AEC must place importance on public safety and the interests of society as a whole.

I would like to emphasize that in order to win the public's trust, it is necessary to develop a closer relationship with them. You must not only possess a high level of professional knowledge, but also be able to communicate this knowledge to the public in clear and simple language. Only in this manner will it be possible to achieve complete transparency in AEC's regulatory operations, and make the public broadly aware of our R&D achievements. Let us join together in achieving ongoing innovation and reform, and persevere in creating a sustainable future for both AEC and our country.

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## Mempower and Budget

## The Atomic Energy Council of the Executive Yuan (AEC)

#### • 2004 Human Resources Breakdown

General administration	43	(24.5%)
Atomic energy science development	34	(19%)
lonizing radiation protection	33	(19%)
Nuclear installation safety control	43	(24.5%)
Nuclear technology applications	23	(13%)
Total	176	

#### • 2004 Employee Ranking Breakdown

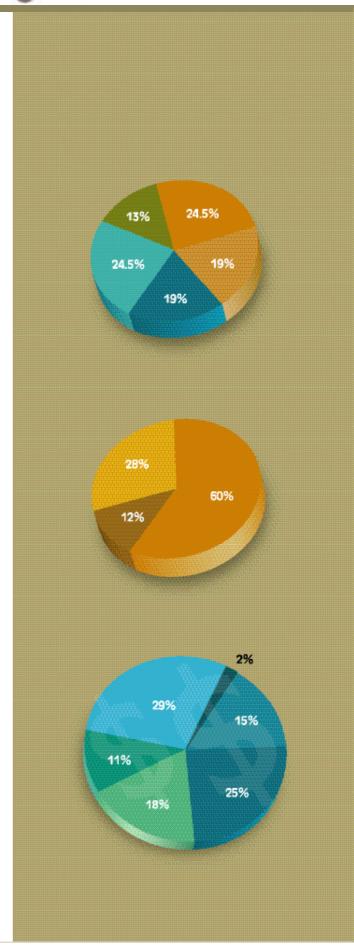
Selected appointment rank (10-14)	49	( 28%)
Recommended appointment rank (6-9)	105	(60%)
Designated appointment rank (1-5)	22	( 12%)

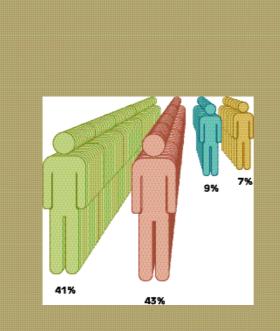
Total 176

### • 2004 Budget/Expenditure Allocation

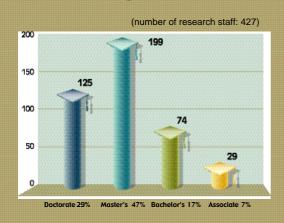
(Unit	: Thousar	nd NTD)
General administration	104,828	(29%)
Atomic energy science development	51,136	(15%)
Nuclear installation safety control	87,485	(25%)
Ionizing radiation protection	63,509	(18%)
Nuclear technology applications	37,813	(11%)
Equipment/facility acquisition	6,363	(2%)

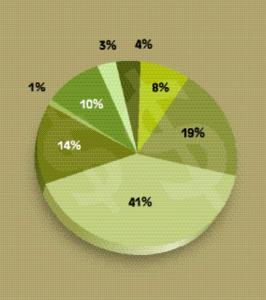
Total expenditure 351,134





#### Academic background of research staff



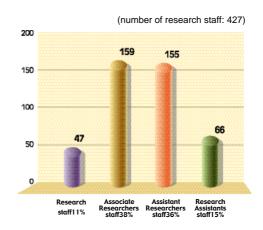


### The Institute of Nuclear Energy Research (INER)

#### • 2004 Human Resources Breakdown

Research staff	427	(41%)
Technicians	457	(43%)
Administrative personnel	93	(9%)
Manual workers	77	(7%)
Total	1,054	

### • 2004 Research Staff Ranking Breakdown



### • 2004 Budget/Expenditure Allocation

	(Unit : Thousand N	TD)
General administration	78,386 (3	3%)
Strategic Planning	92,513 (4	<b>!</b> %)
<ul> <li>Facility operation and engineering services</li> </ul>	178,668 (8	3%)
<ul> <li>Research in radiation application technology</li> </ul>		9%)
<ul> <li>Research in environment and energy technology</li> </ul>	946,943 (41	%)
Research in nuclear safety technology	324,192 (14	<b>!</b> %)
<ul> <li>Academic cooperation in atomic energy science</li> </ul>		<b>%</b> )
<ul> <li>Fostering of nuclear technology applications</li> </ul>		)%)
Total expenditure	2,293,741	

# Manpower and Budget (cont.)

## The Fuel Cycle and Materials Administration (FCMA)

#### • 2004 Human Resources Breakdown

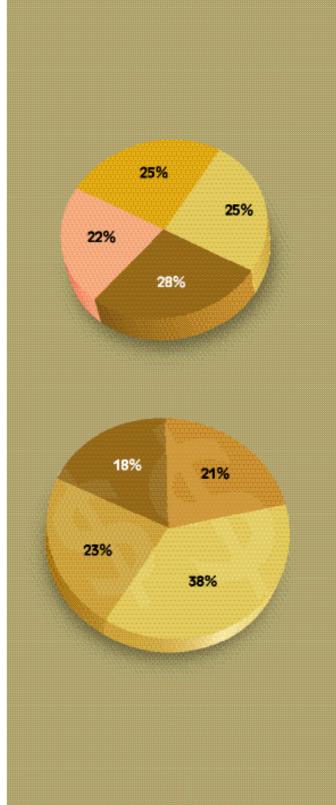
General administration	9	(25%)
Radioactive materials administration	9	(25%)
Safety control of radwaste managemen	10	(28%)
Safety control of nuclear materials and radwaste from small producers	8	(22%)
Total	36	

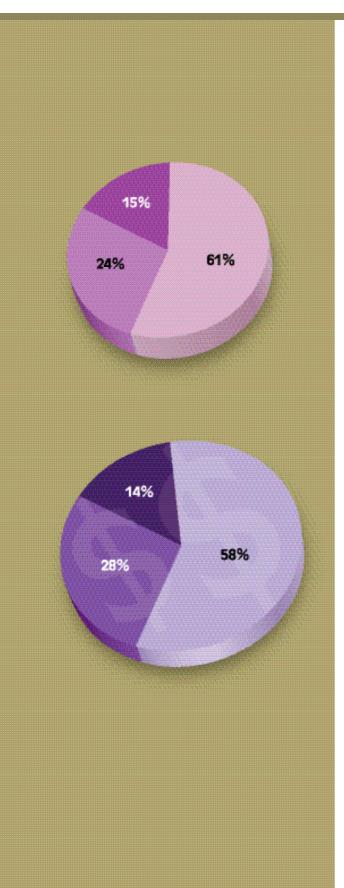
### • 2004 Budget/Expenditure Allocation

(Unit: Thousand NTD)

General administration	13,866	(21%)
Radioactive materials administration	25,700	(38%)
Safety control of radwaste management	15,535	(23%)
<ul> <li>Safety control of nuclear materials an radwaste from small producers</li> </ul>	d 12,343	(18%)

Total expenditure 67,444





### The Radiation Monitoring Center (RMC)

#### • 2004 Human Resources Breakdown

General administration
Natural ionizing radiation monitoring
Manmade ionizing radiation monitoring
(61%)

### • 2004 Budget/Expenditure Allocation

Total

(Unit : Thousand NTD)

33

- General administration 17,203 (28%)
- Natural ionizing radiation monitoring 8,733 (14%)
- Manmade ionizing radiation monitoring 34,588 (58%)

Total expenditure 60,524

### **Department of Planning**

## Service Innovation—The 3-in-1 Performance Assessment Mechanism

Each year performance assessments are made by the oversight and evaluation function at every level of government to provide a basis for raising government efficiency and reviewing progress.

In the past, oversight and evaluation efforts, while having accommodated differing needs, have been sporadic and repetitive, creating unnecessary difficulties for various implementing entities. To provide a thoroughgoing solution to this problem, the Planning Department in 2004 devised a 3-in-1 performance assessment mechanism based on the concept of innovative service and inspired by the idea of integration and simplification that would reach the goal of simplifying the process and improving the performance assessments.

This mechanism is divided into a 3-in-1 integration of "people" and "tasks" as follows:

- 1. **People:** it integrates the manpower of the performance assessment committee members, in-house senior professionals, and outside specialists and experts as the assessment core, taking into consideration different aspects of oversight and evaluation needs for flexibility of operation.
- 2. Tasks: it uses a one-time, phased rating approach to complete the functional needs of the "administrative and work plan assessment," "overall unit performance evaluation," and "science and technology plan evaluation and top plan selection."

In line with the mechanism described above, the Planning Department used the "2004 Precepts for Mid-Year Performance Rating" and the "2004 Precepts for Year-End All-unit Performance Rating" published in July and October of 2004, respectively, to conduct the 2004 mid-year and year-end rating for AEC. After each oversight and evaluation entity completed its individual phased work, a "2004 Mid-Year Performance Rating Report" and a "Compilation of all-entity 2004 Performance Review Report" were written for examination and use by AEC top executives as reference in policy formulation. This innovative and pro-active approach plays a direct and effective role in AEC's efforts to create a comprehensive and efficient oversight and evaluation system.

#### A Taiwan Achievement—the WIN Award

Nominated by Taiwan, journalism professor Dr. Ying-chun Hsieh of the National Chengchi University won the 2004 WIN Award of the WIN (Women in Nuclear) Global organization, confirming her outstanding achievements in the field of nuclear energy education and communication. The President of WIN Global, Junko Ogawa, came to Taiwan in October as the head of the WIN Japan delegation to preside over the award ceremony and panel discussion on "The Communication of Nuclear Issues and Public Education," which included topics on nuclear safety, nuclear waste management, communication and education presented by several Taiwan and Japanese specialists.

Following the ceremony President Ogawa and delegation called on the Chairman of AEC, Minister Min-shen Ouyang, and other Council members and then visited the National Nuclear Response Center and the AEC Nuclear Safety Duty Center. On the next day the group visited the Lungmen Project now with two advanced boiling water reactor units under construction. These visits were highly successful and received national and international media coverage.

Established in 1996, the WIN Award is given yearly to an individual, or a small group of individuals, who has made significant contributions in advancing public understanding of nuclear energy or the practical use of radiation and who, at the same time, can serve as a model for young women. To date, eight women, from Europe, America and Asia, have received this honor.



WIN Global President Junko Ogawa calls on Minister Min-shen Ouyang.



WIN Global President Junko Ogawa presents the WIN Award to Professor Ying-chun Hsieh.

### **Department of Nuclear Regulation**

### AEC Red/Green Color Designation of Safety Significance

In answer to the government's transparency policy and risk disclosure concept, and to further focus AEC's regulatory activities on nuclear reactor safety, an objective and predictable approach to the nation's nuclear power plants (NPPs) has been adopted. In addition, the Internet has been utilized to provide the public with ample information, expanding their participation in the safe operation of these plants.

The red/green color designation of safety significance consists of three corner stones: initiating event, mitigation system and barrier integrity. Depending upon the performance of the various systems and equipment associated with each corner stone, a safety assessment of NPPs can be made that uses green, white, yellow, and red color designations: green - very low safety significance, white - low to moderate safety significance, yellow - substantial safety significance, and red - high safety significance. At the same time, consistent with the performance, the regulatory agency will readjust the regulatory activities (see note below). The primary goal is to encourage improvement in self-management at the NPPs, to raise the operating safety level, to make the most efficient use of regulatory resources and to ensure public safety. In addition, AEC plans to utilize the "significance determination process" software developed by INER. Beginning in 2006, AEC inspectors will apply this software to power plant issues discovered during their daily inspections to determine the risk level-green, white, yellow, or red-and combine the results with their own risk level evaluation, thus bringing inspection findings and nuclear safety closer together.

Note: Green-maintain current frequency of inspections; White-call a regulatory meeting to monitor corrective measures; Yellow-increase frequency of inspections, additional regulatory measures; and Red-the power plant shall submit a performance improvement plan and, if necessary, cease operation of the unit.

### Mihama NPP Pipe Rupture Incident: Assessment and Preventive Measures

On August 9, 2004, an incident involving the thinning of pipe walls and consequent bursting in the feedwater pipe occurred in Japan's Mihama NPP. The

resulting steam leak killed five workers and immediately raised safety concerns among Taiwan officials with regard to Maanshan NPP with two pressurized water reactors of the same type as Mihama's. In fact, following the 1986 Surry incident in the U.S., caused by identical reasons, AEC requested that the Taiwan Power Company (Taipower) establish programs for examining carbon steel piping. Taipower quickly introduced assessment techniques and procedures commonly used in the industry and carefully carried out examinations. Today, more than ten years later, all relevant mechanisms have been set up and put in place. The Mihama incident prompted the nuclear industry to look again at examining the thickness of carbon steel pipe walls, which had already become a routine inspection item during refueling outages. AEC quickly took the following actions:

- Requested Taipower to carefully review adequacy of its "long-term strategy for examining the thickness of pipe walls" and to enhance the inspection and examination of pipe thickness during the most recent refueling outages, and then present the results to AEC.
- 2. Invited domestic experts to conduct a course on the erosion/corrosion of piping for AEC inspectors to increase their professional knowledge.
- 3. Invited domestic experts to jointly conduct "team inspection of piping erosion/corrosion" at all NPPs.

Aside from making improvements in strategy, training and inspection, AEC continues to pay attention to developments following the investigation of the Mihama incident. Attention has also been extended to related corrective measures taken by the nuclear industry in the hope that with strict regulations and comprehensive inspection a similar incident at a Taiwan NPP may be effectively prevented.

### Stop Work Order on the Circulation Water Pump Building at Lungmen NPP

The construction work of the circulation water pump building was started in January 2004. In February and May of 2004 the first and second concrete foundation slabs were laid. As this project had been delayed for years, quality control or quality assurance work on the contractor had yet to be established by Taipower's Lungmen Construction Office. Nonetheless, AEC started inspection work immediately to

verify that the construction quality and management of the contractor met quality control and quality assurance requirements.

In March 2004, AEC conducted its first verification inspection and indeed discovered deficiencies in construction quality and quality control. Aside from the poorquality concrete work, the installation of the water-stop tape was found not to meet requirements. The poor concrete work caused the water-stop tape to fail to meet its design function. Even after the Construction Office discovered this, it did not take appropriate measures immediately to correct the contractor's work. AEC issued a Memorandum demanding the Construction Office to fix the problem, make out and file a non-conformance report and take charge of the work. At the same time, to further confirm that corrective actions were being taken, AEC demanded that when the contractor carried out the work on the water-stop tape, the AEC resident inspector must be notified for on-site verification. Furthermore, the Construction Office is requested to improve knowledge and training of concrete workers and on-site quality control personnel. Subsequently, AEC carried out follow-up oversight by on-site inspections and document verification. A number of items were discovered requiring correction by the Construction Office. There was, in particular, a need for the Construction Office itself to improve its own position in the area of quality control work. As a result, AEC issued another Memorandum and an Inspection Notice demanding that the Construction Office provide a clarification and explanation of the issue.

AEC had issued numerous requests for corrective actions. Yet on August 31 when the Construction Office notified the AEC resident inspector for on-site inspection of the non-shrink cement and grout, it was discovered that the action of drilling away the concrete for correcting the water-stop tape problem did not meet the requirements specified in the corresponding corrective action plan, and that part of the plan itself was not entirely up to standards. This led to a situation where the on-site work could not be carried out together with the water-stop tape correction plan. AEC then demanded that the Construction Office bring the work to a temporary halt and not begin work again until after it had provided new corrective measures approved by AEC.

At the demand of AEC, the Construction Office filed a report to the Council in late September and AEC inspected and approved a correction plan with the proviso that before resumption of on-site work the AEC inspector be notified and a joint inspection be made. Finally, using an almost completely new approach, the correction work was completed in early November.

### **Department of Radiation Protection**

### Workshop on the Future Trend in Radiation Protection

During October 18 to 19, 2004, a Workshop on the Future Trend of Radiation Protection organized by Dr. Shian-jang Su, Deputy Minister of AEC, was held in the auditorium of AEC. This workshop pulled together professionals from AEC's Radiation Protection Department, Nuclear Technology Department, INER, RMC, Taipower, and the Taiwan Chapter of Health Physics Society.

Some 19 Taiwanese and foreign experts were invited to present papers at the workshop and exchange ideas with workshop participants. Speakers included four experts from Japan: Professor Toshiso Kosako, Mr. Shinji Mitani, Mr. Yoshiyuki Nakashima and Mr. Satoshi Karigome; three from USA: Dr. Chuan-fu Wu, Dr. James C. Liu, and Dr. Casper Sun; and domestic experts from AEC's Radiation Protection Department, INER, RMC, Taipower's Department of Nuclear Generation, Chinshan NPP and Kuosheng NPP, the Tri-service General Hospital, the Mennonite Christian Hospital, the National Tsing Hua University, and the Kaohsiung Medical University.



Minister Min-shen Ouyang speaks at the Workshop on the Future Trend of Radiation Protection.



Speakers of the Workshop on the Future Trend of Radiation Protection

### Communication on Radiation Safety with Residents Living Near the NPPs

Radiation safety at NPPs has always been an important topic of concern for the Taiwan public. To increase the transparency of information regarding the regulation of environmental radiation safety and to exercise joint supervision with the people in the community, on October 29, 2004, AEC held an event at the Chinshan Youth Activity Center on radiation safety for residents living near an NPP. Invited to participate were officials from the villages of Sanchih, Shihmen, Chinshan and Wanli and teachers from local elementary and high schools. Topics covered in the meeting included the application of, and protection against, radiation, an introduction to the Nuclear Safety Duty Center, an explanation of the current state of environmental radiation monitoring, and an introduction to the basic radiation monitoring devices and their use. In addition, 30 minutes were devoted to a general discussion.

When compared with that of other localities, the environmental radiation in the vicinity of an NPP actually reveals no obvious anomalies. In face-to-face communication with the public, the effectiveness of AEC nuclear control measures is emphasized, as is AEC's continued commitment to a spirit of "strict supervision, safety first, tight control, and open information," so that the public will have a deeper understanding of AEC's regulation of ionizing radiation and the implementation of radiation protection operations will be benefited.



Deputy Minister Shian-jang Su presides at the communication meeting.

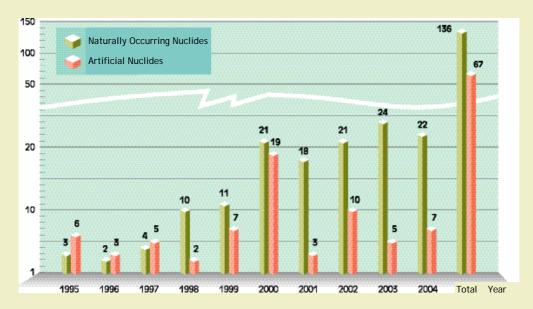


Scene of the Communication Meeting

## Guidance Project on Radiation Detection Practice at Steel Plants

To improve the capacity of steel plants to detect radiation, to raise the level of their radiation detection operation and their management quality, and to build their ability to handle material of radiation anomaly at emergency, starting March 1, 2004, AEC began a guidance project on radiation detection for steel plants with smelting furnaces. This on-site examination gave a good grasp of the situation with regard to radiation monitoring at these steel plants and provided data for a file on their ability to carry out detection, the procedures used and their management of waste materials. By the end of December, 2004, this radiation detection system had successfully identified 203 instances of radiation anomalies in the incoming scrap metal to be smelted and had effectively prevented radiation contaminated materials or discarded radiation sources from being smelted into processed steel, thus fully achieving success in preventing radiation contamination.





Statistics of nuclides in radiation anomalies

### **Review of Applications for Hospital Cyclotrons**

Establishment of cyclotrons requires a three-stage review by AEC. Only after review and approval can the production of radioactive material take place. This three-stage review procedure is as follows:

- Installation Permit: medical institutions must submit a radiation safety assessment report, a radiation protection plan and a radioactive waste management plan; only after AEC review and approval may installation proceed.
- 2. Test Operation Permit: after production facility construction is completed, medical institutions must first submit a test operation plan and the credentials of the operating and radiation protection personnel; only after AEC review and approval may the test operation proceed.
- 3. Production Permit: after the test operation is completed, medical institutions shall, three months prior to production, fill out an application and attach the test operation report; only after AEC review and approval may production proceed.

During the review AEC will invite experts to assist in the review work and perform an onsite examination. Only after review and approval can radioactive material be produced. With this tight review and approval procedure, radiation safety for both public the seeking medical treatment and the medical personnel involved can be assured.



An AEC officer inspects QA procedures for medical exposure of a linear accelerator at a hospital.

### A General Inspection of Radiation Practice at Colleges and Universities

During March to October 2004, AEC completed a general inspection at, and offered guidance to, 71 colleges and universities in Taiwan that use radiation sources. This inspection and guidance project was conducted in response to the enactment of the Ionizing Radiation Protection Act (IRPA) that became enforceable on February 1, 2003. The purpose of this project was two-fold: to promote the spirit and explain the stipulations of the IRPA, and to prevent schools from violating the stipulations through simple oversight because of their unfamiliarity or negligence of the new law. Through the establishment of self-management and self-inspection mechanisms for the schools it was hoped that there would be effective control, as called for by law, of all radiation sources and that the goal of assuring radiation safety could be met.

The principle of documentary inspection was used in the project. Inspection items included the school's management organization for radiation protection, the establishment and implementation of the radiation protection plan, a physical checkup and educational training as well as radiation dose monitoring for radiation workers, division of controlled areas, management of radiation sources, items to be reported periodically and items that should be retained and reported in radiation protection management.

AEC invited representatives of the Ministry of Education (MOE) as well as management personnel of the schools to coordinate and actively participate in this project, with the hope that they appreciate the importance and support thorough implementation of radiation protection operations. The participation of MOE demonstrated the importance AEC has placed for campus safety; and this increased the seriousness with which the school management viewed the issue. Each school is able to take the corrective actions that the results of the inspection called for so that radiation safety is maintained.

### **Guidance of Radiation Practice at Military Agencies**

Since November 2002, AEC has coordinated efforts with the Ministry of Defense (MOD) jointly to carry out a "General Inspection of Radiation Sources at Military Agencies" and establish a complete file of inventory. In order to strengthen education on IRPA and its daughter regulations, AEC also provided guidance to military agencies on implementing the functions of radiation protection management organizations. AEC coordinated closely with MOD to actualize this inspection and guidance project.

Kicked off on March 1, 2004, the project was carried out based on the principle of documentary inspection. Inspection items included radiation protection management meetings and records, the implementation of a radiation protection plan, records of educational training, records of physical examinations and checkups, records of radiation dose monitoring, division of areas and control, records of instrument calibration, radiation monitoring, management of radiation sources and personnel credentials, periodic reports of radiation protection management and oversight of corrective actions. Also included were random inspections of division of controlled areas and marking, displays of accident management process, and radiation monitoring records of the radiation workplace.

The military agency differs from the average business in that its scope of control is countrywide. In addition, military management personnel are frequently transferred from place to place, making management more difficult. The results of this project were excellent. Each agency was able to work hard to correct deficiencies that were identified or act upon suggestions made during the course. It was hoped this would lead the relevant competent authorities to attach importance to, and support, radiation protection operations,

and at the same time carry out a management organization for radiation protection to establish a comprehensive and complete system that could be relied on to achieve the goal of self-management.



AEC representatives describe the purpose and content of the inspection and guidance project.

### **Department of Nuclear Technology**

Change is a State of Mind—the 2004 Nuclear Emergency Exercise

The 2004 Nuclear Emergency Exercise took place over a period of four weeks from Monday, August 30 to Friday, September 24 at the Emergency Planning Zone (EPZ) of Maanshan NPP.

- 1. This exercise was characterized by the following five main points:
  - (1) Organized a "Nuclear Safety Month" emphasizing education and communication among the relevant public, teachers, local representatives and civil servants in advance of the live exercise.
  - (2) Integrated public health medical emergency relief resources and tested the relief and operating capabilities of the Southern Radiation Injury Emergency Treatment Network.
  - (3) The live exercise was centered on the National Nuclear Emergency Management Committee (NNEMC) forward command post with coverage of individual functions as well as overall coordination.
  - (4) Expanded the exercise on the issuance of iodine tablets thereby providing additional training and preparatory work to and emergency response personnel and the public on the distribution of tablets.
  - (5) Conducted for the first time a nighttime mock loss of electric power at a nuclear plant and a firefighting exercise under conditions of heavy smoke.



The Emergency Planning Zone of Maanshan NPP



Fire Drill

#### 2. Active Promotion - Increasing Public Participation

The first week was devoted to nuclear safety education. A short promotional film was broadcast on local Pingnan Cable TV station (running for one month) and a short information piece on the nuclear emergency exercise (running for one month) and interviews with relevant officials were broadcast on Hengchun's Boss Radio Station, all actively promoting information to the public on responses to nuclear emergency. During this time seminars were held for staffers in the NNEMC centers and exercise information officers to heighten their awareness of their rights and responsibilities.

Week Two was devoted to direct communication with the public. In addition to handing out the new "Public Protection Handbook and eBook for Nuclear Emergency Response" to the residents in EPZ, four information seminars were held for Hengchun and Manchou township officials and council members, village, ward and neighborhood chiefs and school teachers. About 250 people participated. Following the seminars, visits were arranged for viewing the public warning system, the pickup points and the accommodation stations.

The third week was designated as a pre-duty education week. The primary activity was to organize exercises for NNEMC members or their designated and to make on-site inspections of the NPP, the public warning system, the pickup points and accommodation stations. In addition, it was arranged for the competent



Vehicle Decontamination

Forward Command Post Exercise

authorities to participate in a round table discussion on nuclear emergency responses held at Pingnan Cable TV.

### 3. Striving to Improve - Demanding the Best

Week Four marked the formal implementation of the exercise. Major activities were as follows:

- On September 20 (Friday) a news conference was held at the Pingtung County Hall and a display of radiation detection equipment was presented. On the morning of September 22 (Wednesday) an emergency response and antiterrorism exercise was conducted at Maanshan NPP, and in the evening there was an on-site firefighting exercise. On the morning of September 23 (Thursday) there was a procedural exercise of the NNEMC forward command post in Maanshan NPP, followed by radiation detection for personnel and vehicles and road decontamination. In the afternoon there was an exercise on radiation injury reporting and patient referral and treatment as well as treatment exercises in the Pingtung Hospital.
- On the morning of September 24 (Friday) live exercises were staged on environmental radiation monitoring, sample analysis, radiation dose assessment, public warning system and mobile broadcasting as well as the distribution of iodine tablets.



Radiation Injury Treatment

Distribution of Iodine Tablets

• Participants in the 2004 nuclear emergency exercise included nine members of NNEMC relevant central government agencies as well as representatives from offices in their respective spheres of responsibility. Also participated in the exercise were Southern Region Secondary and Tertiary radiation emergency hospitals, Taipower's Emergency Planning Executive Committee, its radiation laboratory and Maanshan NPP. In addition, the Coast Patrol Corps and the Hengchun branch of the Police Department also participated in the exercises. All together some 1,200 people were mobilized.

#### 4. A More Attentive Government - The More Relaxed Public

Following the 2004 nuclear emergency exercise, the Research Development and Evaluation Commission of the Executive Yuan once again conducted a public opinion survey on "Views of the Hengchun Public Regarding Nuclear Safety and Related Topics." Compared with the survey done the previous June it showed knowledge that there had been a nuclear emergency exercise at the nearby NPP had risen 6.2%. Satisfaction with the exercise rose 5.4% and confidence in the government's handling of a response to a nuclear emergency had risen 4.8%. The number of respondents concerned with NPP safety fell by 7.2%. The results showed that this exercise indeed had made positive contributions in raising the level of communication with the public and increasing satisfaction with government performance.



**Radiation Monitoring** 



Mobile Broadcasting

Improving day-to-day training and planning exercises are the two most important items of nuclear emergency response work. It is especially this kind of exercises that is necessary to provide a horizontal and vertical communication platform. Deficiencies discovered during this process later function as reference points for planning improvements. Some of the experience can be a basis for revising emergency response plans and measures.

### A Small Step for AEC, a Major Leap for the People's Welfae —House-to-House Distribution of Iodine Tablets

If an accident occurs at a nuclear plant, among the primary protection measures to be taken are sheltering, evacuation and taking iodine tablets. The purpose of taking a certain dose level of iodine tablets at the proper time is to protect against any radioactive iodine that may be released. Maintaining a certain level of iodine in the thyroid can avoid or reduce the damage radioactive iodine might do to the thyroid.

We consider EPZ surrounding the NPP as the distribution area for iodine tablets. The delineation of this zone is a result of computing work, taking into account the type of reactor, the kind of accident that might occur, climate data, topography, and population distribution. It ends up with 5 km zone surrounding an NPP.



Distributed Information on Nuclear Emergency Exercises

#### 1. When Iodine Tablets Are Taken

The optimal time for taking the iodine tablets is before or within six hours of the release of radioactive iodine. After six hours the effectiveness of the tablets begins to decrease gradually. In the event of an accident, NNEMC will inform the public in a timely manner via TV, radio and mobile broadcasting when to take the iodine tablets.

### 2. Stockpile Policy Change

Originally AEC adopted the approach of centralized depositories and unified distribution. In recent years the approach of distributing the iodine tablets to the public for safekeeping prior to an accident has become one of the methods adopted internationally. In light of international trends and the demands of the public, and having weighed emergency response work, AEC decided to adopt a two-track system: distribution before the event and distribution after the event from centralized depositories.

The required number of tablets per individual for a four-day period was taken as a base figure (generally speaking, one day means a 24-hour period during which the drug maintains its effectiveness). Two-day's supply is to be distributed in advance and the remaining two-day supply follows the current system of centralized depositories and distribution to the public after the event as necessary.

### Public Campaign on lodine Tablets

On November 24, 2004, AEC called a "Coordination Meeting on an Update of the Potassium Iodide (iodine tablets) Distribution Method and Storage Areas". A resolution was passed at the meeting requesting local public health units before the



Information Meeting

end of December to hold an "Information Meeting on the Distribution of Iodine Tablets" to explain the function of the tablets, their storage as well as when to use them.

The health stations of Chinshan, Wanli, Shihmen and Sanchih, Taipei County, held nine separate meetings December 13~24, 2004. The Pingtung County Bureau of Public Health conducted ten meetings December 20~31 at Hengchun and Manchou explaining the AEC's policy and listening to the opinions of the public. After 19 meetings with the participation of 2,210 people, the public by and large affirmed the government's new policy.

In 2005 AEC will continue to assist local governments in planning and actual implementation of distributing a two-day supply of iodine tablets to those people living in villages within EPZ and will also request that public health medical personnel repeat detailed explanations regarding the storage of iodine tablets, their timely use and other important information.

Although there was a good deal of preliminary planning and follow-up work im making and implementing this policy change, it was all worthwhile in that it brought more peace of mind to the public and further guaranteed their safety.



Information Meeting

### Institute of Nuclear Energy Research

To comply with government reorganization and planning of a corporate body, INER is endeavoring to strengthen its R&D capacity in depth and extensity. In addition to R&D of Radio-pharmaceuticals, Nuclear Safety and Assessment and Plasma Technology Applications, INER is also investing in the area of New and Renewable Energy Research in order to help resolve our national energy challenges. Thus, in the report, the above mentioned four areas of our R&D activities will be introduced briefly. It shall be noted, however, that the issue regarding the Radioactive Waste Treatment is not addressed in this report due to its length restriction.

### Research and Development of Nuclear Medicine and its Application for the Diagnosis of Neurological and Mental Disorders

As life styles keep changing, and daily living pressure and aging population increasing, the number of people suffering from central nervous system (CNS) diseases such as schizophrenia, anxiety, depression, Alzheimer and Parkinson's disease is growing every year. Not only do they affect life quality of individuals, but have a serious impact on society's resources. Therefore, diagnosis for such neurological diseases, research on pathology, and development for possible therapeutics are certainly of pressing need.

Nuclear medicine involving Positron Emission Tomography (PET) and Single-Photon Emission Computed Tomography (SPECT) provides images of the structure and functionality of the brain. It is a diagnostic tool for CNS and treatment effectiveness assessment.

INER is the key promoter of the Taiwan radiopharmaceutical industry, and involves intensively in the research and development of new, pre-clinical radiopharmaceuticals. It keeps integrating and combining radiopharmacology with molecular imaging technology to promote research and development of brain function and neurochemical radiotracers.

In 2004 R & D works included continuing development of diagnostic radiotracers for dementia (Alzheimer's), Parkinson's disease, depression and schizophrenia. It also applied radiotracer and data analysis technologies on stroke animal model for cerebral glucose metabolism and regional blood flow studies as well as pre-clinical pharmaceutical screening.

#### 1. Fluorine-18-FDDNP

Alzheimer's disease is a degenerative atrophying disease of the brain and is the most commonly seen degenerative disease of the CNS. Accumulation of amyloid beta plaques in the brain is one of the important causing factors.

FDDNP, 2-(1,1-dicyanopropen-2-yl)-6-[(2-fluoroethyl) methylamino] naphthalene, is the first proven radiotracer to detect amyloid beta plaques. In 2003 INER completed work on four-step synthesis of TsDDNP, the FDDNP labeled precursor with purity more than 95%. In 2004 research began on cyclotron produced fluorine-18 labeling on TsDDNP. To reduce radiation exposure during synthesis, a semi-automatic synthesis chamber for fluorine-18-FDDNP has been set up. A genetically modified mouse model of Alzheimer's disease will be applied on microPET imaging for evaluating applications of fluorine-18-FDDNP.

#### 2. lodine-123/124-ADAM

Serotonin is recognized to be closely related to cognitive function of the cerebrum and certain mental illnesses, such as anxiety, depression and schizophrenia. Serotonin transporter is for regulating serotonin concentration in the synaptic cleft.

Radiotracers for serotonin transporting molecules developed by INER include Iodine-123 (SPECT imaging), Iodine-124 (PET imaging) labeled ADAM(2-[[2-[(dimethylamino) methyl]phenyl] thio]-5-iodophenypamine). SnADAM is the labeled precursor. With a new improved procedure, INER could synthesize SnADAM for 300 mg with purity over 95% in one synthesis. The yield of the I-123-ADAM labeled in one procedure can reach efficiency over 40%; radiochemical purity over 90% based on HPLC, labeled product has stability more than 48 hours. At the same time it is offered to the Tri-services General Hospital for animal studies, and clinical trials at the National Cheng Kung University Hospital and the Chang Gung Memorial Hospital.

#### 3. Technetium-99m-TRODAT-1

Parkinson's disease is resulted from insufficient amount of dopamine caused by loss of cells in the midbrain substantia nigra. Current diagnosis is through symptoms observation and experimental use of anti-Parkinson's drugs. Technetium-99m-TRODAT-1, (2beta-((N,N'-bis(2-mercaptoethyl), the recently developed dopamine transporter radiotracer, is the first proven powerful diagnosis tool. Literature reported the multi-vial formulation for Technetium-99m-TRODAT-1 is complex and quite impossible to meet clinical routine examination needs.

INER has developed a new improved production formulation. It takes only one step for technetium-99m labeling with radiochemical purity remaining at 90%; free frozen crystals can be kept for seven months. This new formulation has received ROC patent No. 136931. Animal studies showed low toxicity. The effectiveness and safety for 99mTcTRODAT-1 in diagnosing Parkinson's disease have been evaluated for approximately 2,000 clinical trials. Phase III clinical trial was completed successfully in November 2002. In March 2004 an application was filed for new drug registration. Currently this request is awaiting response from the Department of Health. It is hoped that once the new drug permit is received, the product can be launched on the market and bring the output value.

#### 4. lodine-123-MIPP

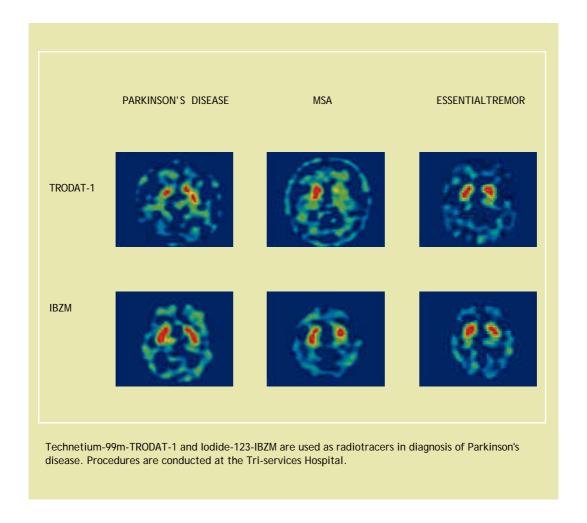
Norepinephrine is one of the important neurotransmitters. Studies show that its regulation is one of the causes or exacerbating factors in many neurological diseases, such as depression, suicide, anxiety and Alzheimer's. (R)-N-methyl-3-(2-iodophenoxy)-3-phenylpropanamine (MIPP) is an iodized imaging agent for brain norepinephrine transporter. INER has successfully synthesized two MIPP precursors, MBPP and MSPP. The institute is in the midst of its research on idodine-123 labeling and expects to have an Iodine-123-MIPP product ready in 2005.

#### 5. lodine-123-IBZM

The dopamine  $D_2$  receptor has a close relationship to schizophrenia, Tourette's syndrome and Parkinson's disease. As most anti-psychotic drugs bind to the  $D_2$  receptor, molecular imaging is used to monitor  $D_2$  receptor occupancy by these

drugs, and determine dosage levels. IBZM, ((S)-(-)-2-hydroxy-3-iodo-6-methoxy-N-[(1-ethyl-2-pyrrolidiny)methyl] benzamide), labeled with Iodine-123, has an excellent affinity to the cerebral  $D_{\rho}$  receptor.

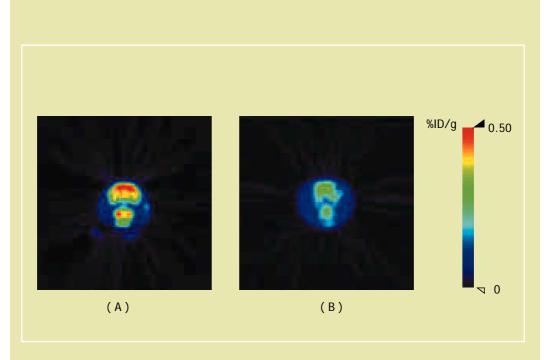
It is supplied to the Tri-services General Hospital, the National Cheng Kung University Hospital and the Chang Gung Memorial Hospital for clinical trials.



6. Establishing in vivo tracer screening technique for anti-stroke drugs.

Cerebral glucose metabolism and blood flow are important indicators of brain function. In the 2004 research plan, INER established a two-sided carotid arterial ligature ischemic stroke rodent model. Cerebral glucose utilization rates were

studied by microPET scanning using F-18-FDG, and cerebral blood flow by micro SPECT using Tc-99m-HMPAO. Imaging results showed the absorption value of F-18-FDG and the blood flows were lower than normal. Long term follow-up studies showed a recovery of cerebral glucose metabolism and cerebral blood flow. By cooperating with academic, these two in vivo assessment techniques should be used as follow-up evaluation for neurological protective capacity of new drugs for stroke.



Use of Fluoride-18-FCG in a microPET scan to assess the cerebral glucose metabolism in a rodent modeling of a two-sided carotid arterial ligature ischemic stroke: A) Normal Fluoride-18-FDG image, B) Radiotracer image showing lack of cerebral blood flow and stroke.

#### 7. Conclusion and Prospects

Given the abundance of CNS diseases and the trend of new drug development worldwide, Europe, U.S. and other advanced countries are pushing forward-looking research and developing dopamine and serotonin receptor and transporter molecular radiotracers as well as effective imaging techniques. These have being

used to explore in vivo nerve cell molecules of biochemical and biophysical changes, to raise diagnosis accuracy, to determine treatment dosage, and to reduce side-effects and long-term medical costs. INER's R & D on CNS disease is certainly the correct strategic entry point.

INER has established core techniques for radiopharmaceuticals development, the radiopharmacology laboratory has acquired microPET and microSPECT/CT facilities for small animals, and plans to develop integrated microPet/microSPECT imaging analytical technique for anti-aging and anti-depressant drugs assessment.

CNS diagnostic pharmaceuticals produced by INER's Radioactive Isotope Drugs Center have been on PET and SPECT clinical trials by various medical centers. The combined cooperative efforts at all levels are generating fruitful results. Some radiopharmaceuticals have already been providing techniques and applications for Taiwan biotech industry. It is hoped that once the new pharmaceuticals hit the market, they will create output value and benefit patients.

### Prospects for the Application of AEC's Risk Assessment Techniques to the Calamity Prevention System in Taiwan

Public safety is the focus of universal attention, and gradually great importance has been attached to the technology of calamity prevention. The experience AEC has gained in twenty years of NPP Probabilistic Risk Assessment (PRA) and non-destructive inspection can assist relevant entities in conducting PRAs and inspections of bridges, buildings, chemical plants, electric power systems, natural gas storage as well as transportation and rail systems (including railroads, rapid transit and high-speed rail). In addition, this experience can also provide suggestions for improvement in calamity prevention.

Risk-based decision making processes include more than the passive management and response after the calamity. If we can analyze the root causes and scenarios of the risk beforehand, we will be able to find the way to avert the incidents. The concept of "prevention is more effective than treatment" can be applied to many areas other than just the medical system. The analysis and assessment of risk prior to an event is less costly than dealing with the aftermath of the event.

After six years of development, INER's NPP Risk Monitor received the attention of the international nuclear energy community. In June and August of 2004 the developed system was selected as one of the subjects in Nucleonics Week and Inside NRC (biweekly). In addition, the International Atomic Energy Agency (IAEA) in its Risk Monitors report

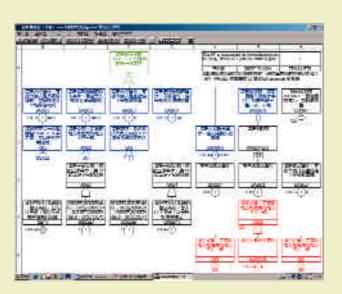


A TIRM-2 Risk Trend Graph for Core Damage Frequency (CDF) and Large Early Relief Frequency (LERF) Under Powered Operation

published in 2005 identified 120 risk monitors from countries around the world as of 2004 and made a comparison among the 12 most representative systems. The second-generation NPP risk monitor (TIRM-2) developed by INER was ranked as the most important and most effective risk monitor of recent times. Based on the aforementioned facts, Taiwan is in the leading position in its development of the TIRM-2 and that nuclear safety in Taiwan's operating NPPs is even more secure.

The NPP Risk Monitor system is a concrete application of PRA-related technique. PRA is a technology that addresses the following basic elements of potential risk for any complex system: 1) What can go wrong?, 2) How likely is it?, and 3) What are the consequences?

Under the guidance of AEC, the first PRA report in Taiwan was issued in 1985, which focuses on the analysis of Kuosheng NPP. Similar reports on Chinshan and Maanshan NPPs were completed in 1987 and 1991, respectively. The development of these three PRA reports laid the foundation for Taiwan's PRA technique. The PRA report of Maanshan NPP suggests the addition of the fifth diesel generator. This diesel generator was proved to be the key component in preventing the 3A blackout from occurring in March 18, 2001. Following advances in PRA and computer technique, in 1995 and 1997 INER and Taipower used these three PRA reports as a



INER Fault Tree Software INERFT (display in Chinese)

foundation and completed PRA living models for the three operating NPPs, making the application of the PRA approach more convenient and in conformity with the international trend.

INER Fault Tree Software (Chinese Version), INERFT, a sister product to its NPP Risk Monitor, is also applicable for industries other than nuclear. The fault tree

analysis (FTA) uses meticulous deductive logic to deduce the cause of a predicted failure. A failure "cut set," a combination of failures that causes the system to fail (including equipment failure or human error) may lead to a complete failure of the system. FTA results can be used to identify, qualitatively or quantitatively, the relative importance of each component and serve as the reference to make improvements in operations and maintenance. When FTA was first developed in the 1960s it was originally applied in the non-nuclear field. It was not until the 1970s that the U.S. began to use PRA, which combines FTA and other analysis methods, in NPPs. In 1986 when Taiwan developed the Ching-kuo fighter plane (also known as the Indigenous Defensive Fighter, IDF), the FTA technique was also comprehensively applied to improve its overall safety.

The FTA technique, the core of the PRA technique, was originally developed at foreign countries. In 1996, AEC began to develop the FTA formula for general industrial use in Taiwan. The development of this independent ability has the following advantages: 1) in sync with rapidly developing PC technology, the formula could be improved at any time; 2) if users in the country encountered problems, they would be able to receive timely support; and 3) when needed, it can be easily modified to fulfill client's specific demand. Together with the well-developed PRA

technique, it could be broadly used for general industrial purposes. Beginning in May 2002 a beta-version of the self-developed "INERFT" was available on INER's website. From March 2004 to date, copies have been purchased by the Aerospace Industrial Development Corporation, the National Tsing Hua University, the Ming Hsin University of Science and Technology, and the Lunghwa University of Science and Technology.

Aside from continued application in the nuclear industry, the PRA technique developed by INER is being actively expanded into other industrial applications. For example, the INER FTA formula has been applied in above-mentioned aerospace industry and in a famous semi-conductor plant in the science park for reliability enhancement. In order to promote PRA applications, INER was invited by the Metro Taipei to hold a three-day-long "Short Course on Safety Assessment Methods" twice between December 2001 and April 2002. It is suggested that PRA planning for fires, tunnel fires and floods at rapid transit stations be conducted during the design stage. In the near future, it is planned to hold a PRA forum in conjunction with the Executive Yuan's Public Construction Commission to expand the PRA technique to Taiwan construction companies and government offices that direct public construction. On December 20, 2004 the first international conference on "Non-Nuclear Safety Assessment (PRA/QRA) Application" was held. This conference focused on issues related to the expansion of PRA application to the aerospace industry, environmental industry, anti-terrorism, rail car systems, natural gas storage and transport, electric power systems, and the catastrophic risk management and insurance industry. The conference was jointly chaired by MIT Professor George Apostolakis and INER Deputy Director Der-jhy Shieh. AEC Minister Min-shen Ouyang and INER Director Li-fu Lin were invited to address in the conference. Five invited international experts also made speeches on the application of PRA to five different non-nuclear areas. The attendants include more than 120 experts from nuclear and non-nuclear industries and academic fields. Aside from the nuclear energy industry, we can see the application of the concept of quantified risk in other areas. For example, after several major accidents, the U.S. NASA has in recent years completed a PRA for its spacecraft. Kaohsiung Rapid Transit has demanded its contractors to complete so-called "system guarantee" assessments, i.e., assessments on reliability, availability, maintainability and system



Testing for Cracks in the Guguan Dam after the September 21, 1999 Earthquake



Testing the Runway at Chiang Kai-shek International Airport with Ground-penetrating Radar

safety. Other application activities can also be observed at the Council of Labor Affairs, the Taiwan Chinese Petroleum Corp. and the electric power industry. The rapid expansion of PRA applications is an indication that the management of risk in Taiwan will gradually become an important tool and even a flourishing industry.

The quality of public construction and the aging issue of civil structure has attracted public attention for some time. In recent years INER has actively pursued applied research in non-destructive testing in civil engineering. It has developed testing techniques like ultra-sound, computer tomography, ground-penetrating radar and the impact-echo technique. Aside from use in NPP testing, it is broadly applied in safety and maintenance tests of public installations, such as tests for cracks in the Guguan Dam, tests of the runway at Chiang Kai-shek International Airport, testing of rapid transit diaphragm wall fissure depth and wall strength, testing for bridge fissure depth and steel tower piling depth, assessment of the strength of the box girder bridges for the East-West Expressways, testing of fissures in tunnel linings and the thickness of tunnel walls, testing of public housing areas,

etc. The INER Non-Destructive Testing Laboratory has established excellent cooperative relationships with many Taiwan universities, engineering firms, engineer associations and the Taiwan Construction Research Institute in public construction safety in Taiwan.

Fire prevention regulations in the three operating NPPs in Taiwan originally followed 10CFR50 Appendix R, a prescriptive code of U.S. federal regulations. Many NPPs in the U.S., having difficulty in obtaining qualified fire prevention material, have asked for the requirement to be waived. In recent years, with advances in fire prevention engineering technology and more thorough experiments on various fire phenomena, PRA can be used in conjunction with the experimental data to provide more accurate estimation on fire risk. Traditional fire prevention techniques are now evolving toward the performance-based designs. To break through the old bottleneck of prescriptive designs, INER plans to establish a fire prevention performance evaluation laboratory for specialized buildings. For example, comparative verification tests could be conducted for a model of electrical cable fire damage and fire duration analysis. We expect this approach could gradually be applied to a national fire prevention system.

In the real world there is no such thing as a completely 100% safe system or facility. What is feasible is to understand risk and to reduce it in a reasonable way. Safety means risk reduction by conducting comprehensive and effective risk management before the event, devoting resources in proportion to the level of risk, and making corrections, i.e., with limited resources to make every penny counts. If any industry is able to understand the potential sources of risk and come up with a method of prevention before the event through PRA processes, risk can then be reduced to a more acceptable level. The above-mentioned 3A event at Maanshan NPP is a good example in explaining the usefulness of PRA application. INER will strive in 2005 to apply PRA technique in its commissioned plan for the petrochemical industry's liquid natural gas (LNG) reception and transport system. The laboratory on fire-fighting equipment is also scheduled for completion next year. In the mid- to long-term it expects to expand applications of related technologies in selected industries. In sum, the day is fast approaching when the potential and benefits of a mature nuclear PRA technique will be applied to a national calamity prevention system.

### The Development and Application of Thermal Plasma Technology

When a material is heated to several thousand degrees it becomes a fourth state of matter, composed of ions, electrons, atoms and molecules, that is called "plasma." Plasmas can roughly be divided into "thermal plasmas" and "cold plasmas." A plasma torch is one source of thermal plasma. The torch's extremely hot internal temperature of over 10,000 °C can produce a working environment of 1,400~1,650 °C. The intense heat radiation makes for a higher heat transfer efficiency and the reaction speed in high temperature zones is more than ten times faster than that of combustion. Since 1980s the application of plasma technology to the treatment of hazardous industrial waste and radioactive waste has attracted growing attention. This technology uses a plasma torch to gasify and solidify respectively combustible

#### **Development of Plasma Torch Technology at INER**

Model No.	Туре	Power Output (kW)	Date Developed
INER-20RF	DC/RF mixed	20	1993~1994
INER-100NT	Non-transferred	100	1994~1996
INER-1200T	Transferred	1,200	1996~1998
INER-10NT	Non-transferred	10	2000~2001
INER-1000NT	Non-transferred	1,000	2003
INER-3000NT	Non-transferred	3,000	2004~2005
INER-3000T	Transferred	3,000	2005~2006

#### **Development of Plasma Furnace Technology at INER**

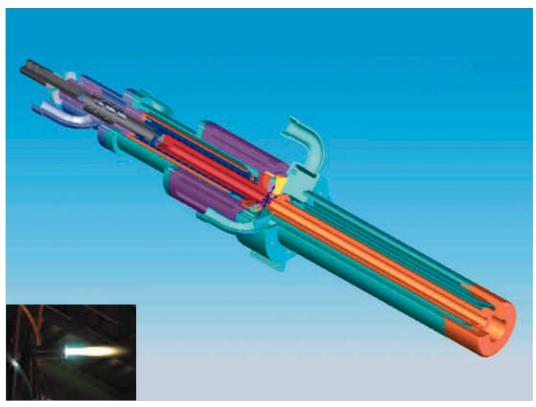
Model No.	Туре	Power Output	Capacity(kg/hour)	Date Developed
INER-PF10	Batch	100 kW <b>×</b> 2	10	1995~1996
INER-PF250	Batch (55 gal. Drums)	1200 kW × 1 100 kW × 1	250	1998~2001
INER-PF250R	Batch (55 gal. Drums)	1200 kW × 1 100 kW × 1	250	2001~2005
INER-PF450	Continuou	1200 kW × 1 100 kW × 1	450	2004~2005
INER-PF1000	Continuous/Batch	1500 kW × 1	1,000	TBD
INER-PF3000	Continuous/Batch	3000 kW × 1	3,000	TBD

and non-combustible materials in the melting furnace all at the same time, yielding a high-quality slag-like solid and achieving the multiple goal of compacting, detoxicating, solidifying and transforming wastes into resource. In recent years countries like U.S., EU and Japan have all actively invested in plasma melting research and development and have achieved good results in its application to the treatment of low-level radioactive waste, hazardous industrial waste and their ashes. In Japan, the plasma furnace has become the chief technique for turning incineration ash into resource, and internationally there are companies that have already been doing solid business in this area.

Beginning in July 1993 INER began a series of R & D works and developed a series of equipment to meet various demands. INER first successfully developed a 20 kW DC/RF plasma torch and used it to evaluate performance and scalability. In 1996 it completed a 100 kW non-transferred DC torch, a crucible furnace and a 10 kg/hr plasma melting system. In various simulation tests on radioactive wastes, excellent volume reduction and high mechanical strength were obtained (compressive strength of  $400 \sim 3,000 \text{ kg/cm}^2$ , element leaching index of  $8 \sim 15$ ), far better than the regulatory requirements of final disposal (compressive strength of  $>15 \text{ kg/cm}^2$ , element leaching index of >6).

In 1997 INER completed a 1.2 MW DC plasma torch system (INER-1200T) and a pilot plasma furnace (INER-PF250) and conducted tests on processing of 55-gallon drum packaged waste and, in 1998, made its own plans to build a plasma incineration furnace plant, the INER-PF250R, that would handle radioactive waste at the rate of 250 kg/hr (6 tons/day). This furnace shared the same off gas treatment system with the existing radioactive waste incinerator for combustible waste materials. The plant was completed at the end of 2001. Its primary equipment has been built and installed by domestic suppliers. The percentage of domestic manufacturing was almost 100%. After very long test operation, the plant reached a phased target of 250 hours of continuous operation in 2004. It is estimated that after the plant goes into formal operation, it will be able to treat 1,000~2,000 drums of low-level radioactive solid waste a year, producing 400~1,000 drums of slag product, equivalent to 1/5 to 1/2 of the original volume. This will effectively relieve the pressure on storage of waste material and save enormous expense related to its final disposal.

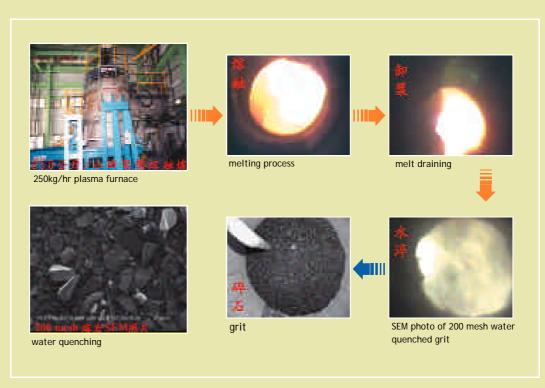
Seeking a way to effectively treat various categories of NPP low-level radioactive solid waste, Taipower contracted INER to carry out research to "develop a procedure to treat NPP low-level radioactive waste via plasma melting technology." Many valuable results followed and can be used as reference for the construction of future plasma plants for NPPs. The total number of municipal solid waste (MSW) incinerator plants in Taiwan in the next few years will reach 27, and the total amount of MSW treated will be about 9 million tons a year. After MSW is incinerated, the production of bottom ash will be about 2 million tons each year, and fly ash will be about 50 tons each year. Leaching tests for fly ash yield results that surpass standards for hazardous waste and so fly ash is considered hazardous and must be appropriately treated and disposed of. To effectively treat MSW fly and reaction ash, the Environmental Protection Administration (EPA) of the Executive Yuan began in November 2003 to develop "plasma melting and reuse technology for MSW fly ash" together with INER. In July 2004 a small-scale plasma furnace system was set up in



Model of a Non-transferred DC Plasma Torch and Photo of Operation

INER for this purpose, thereby establishing domestic capability. This system currently has completed preliminary functional tests and produced high-quality water quenched slag that meets reuse standards and can be directly used for road construction or to manufacture green products such as glass-ceramic ware, water permeable bricks, stone art objects and foamy stones, thus raising the value-added level.

INER has created an indigenous thermal plasma capacity. In addition to vigorously pursuing plasma technology for the treatment of radioactive waste, in the near term it will complete the development of a 3 MW DC plasma torch system, raising the treatment capability to over 70 tons a day to meet industrial needs. Furthermore, to reduce the net costs of thermal plasma treatment, INER will actively develop procedures for slag resource recycling and processing of waste into energy, accomplishing waste reuse and environmental protection at the same time.



Water Quenching Process of Fly Ash after Plasma Melting

### Development and Application of New Energy Resource Technology

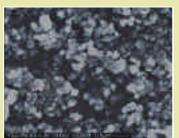
Over the past 30 years the Taiwan GDP and GNP have grown at an average annual rate of 6%, with a corresponding annual growth rate of energy supply near 6.3%. Imported energy supplies grew from 87% (1983) to over 97% (2003), and petrochemical energy resources accounted for 91% of the total. To sustain a continuing economic growth, maintaining the stability of energy supplies has always been an important government policy. Added to this is international environmental pressure stemming from the Kyoto Protocol to reduce greenhouse gases and the twin problems of insufficient domestic production and too high a proportion of petrochemical energy resources. The former involves with national lifeline and development, the latter, a major impact on environmental quality.



Green Products - Manufactured from Water Quenched Grit

In response to the domestic energy supply and environmental protection, the Energy Policy White Paper clearly establishes a strategy for energy technology research and development. The primary thrust of the policy is the development and application of new technology for renewable energy, new energy uses and energy conservation. Responding to this government policy, INER invested in R & D related to new energy resources and engaged in planning and research on hydrogen energy, solar electricity, wind power, biomass and new light sources. In the area of hydrogen energy application, INER has been primarily involved in solid oxide fuel cells (SOFC) and direct methanol fuel cells (DMFC). As for storage, research has been focused on carbon nano materials (CNMs).

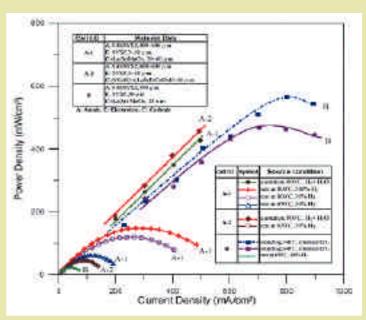
For SOFC, INER moved ahead in developing basic materials, fuel cell stacks, system design, performance testing and assessment as well as simulated analysis. Also developed were: (1) a technique for manufacturing a nano-level powder needed for positive and negative electrodes and electrolyte by a hydrothermal coprecipitation process; (2) a plasma spray coating technology that is capable of spray coating the nano-structure YSZNiO (50/50) on the positive ceramic membrane with



SOFC YSZ Powder (Da-150nm) Manufactured by the Co-precipitation Method



Plasma Spray Coating of the Positive Ceramic Membrane (d=10~30nm) for the SOFC



**Electrical Properties of SOFC Components** 

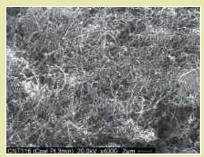
a coating grain size of 10~30nm; and (3) a technique for the rapid measurement of the electrical properties of industrial products. For building fuel cell stacks, INER completed the technique and equipment for automatic sealant coating of connecting plates. In the area of fuel reforming, steam reforming was used to reach a predicted fuel bed temperature of 765~770°C, producing a 75%~77% concentration of hydrogen at 100% efficiency and a methane conversion rate of 97.6%~100%, which meets SOFC fuel gas standards.

Research into hydrogen storage in CNMs has led to the creation of numerous measuring techniques and methods in manufacturing carbon nanotubes. Currently INER achieved the production of sediment carbon about 300% with a daily yield of 1 gram and the hydrogen absorption at 1,400 psi is 3.3wt%.

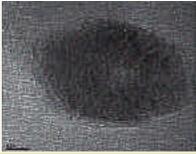
Research on DMFC nano catalysts and their efficiency has led to a gamma-ray altered Nafion proton exchange membrane that represses methanol about 3 times more than Nafion 117. In addition, a manufacturing procedure was developed using the non-aqueous



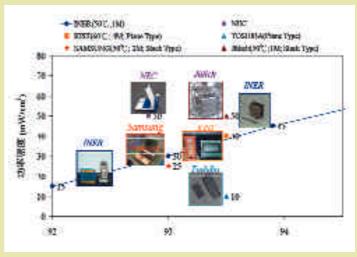
Equipment for Automatic Sealant Coating of Connecting Plates



Development of CNMs for Hydrogen Storage (670°C)



MWCNT -- Cross-sectional View under TEM

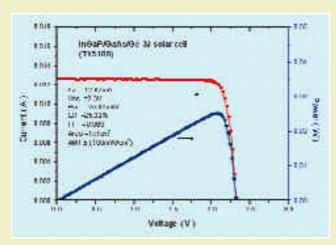


Comparison of INER's DMFC with Other Units on the International Market

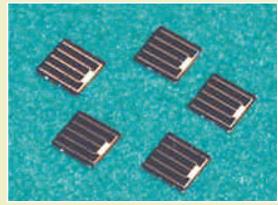
ethanol solution Pt/CNT, Pt-Ru/CNT and Pt-Ru-Ir/CNT to produce catalyst that is used as the negative and positive electrodes of a DMFC and can produce results better than those of commercial products (1.5 times more efficient electrically). The nano-level Pt bundles have a particle size of about 2nm. As for fuel cell construction design, INER has developed the DMFC stack at a highest deliverable efficiency of 17 W @ 70°C. This small-scale DMFC will be a portable electric source for 3 C electronic products.

In solar power technology, INER has concentrated on high-efficiency III-V family of solar cells, sensitized solar cells and concentrator solar cell systems. INER worked together with the industry to develop manufacturing of monolithic III-V multi-junction solar cells with a conversion capacity of 25%. On concentrator solar cells, INER completed the development and manufacture of a concentrator solar cell module with a 100 conversion factor and an efficiency of 19%, better than the commercially used silicon cells at approximately  $10{\sim}14\%$  efficiency. The first refractive concentrator solar energy system (delivering 150W) has undergone performance testing and verification at INER.

According to the draft plan for energy issues developed in a recent conference of the Technology Advisory Group, the Executive Yuan, it is estimated that by 2010 Taiwan's



Current-Voltage Characteristics of INER's InGaP/GaAs/Ge Triple-junction Solar Cell



Solar Cells Manufactured by INER

renewable energy electric power (about 5.14 million kW, composed of wind at 14.5%, solar at 4.7%, biomass at 34.9%, hydro at 41.8% and geothermal at 4%) will make up 10% of the total installed capacity. INER is planning, in the short (1~2 years) term, to develop a high-efficiency (40%) small-scale wind turbine that is 80% manufactured domestically. In the medium (3~5 years) term, INER will develop and manufacture a 100kW wind turbine unit and in the long (6~10 years) term, it will develop and manufacture a 1,000kW (MW) unit as a research vehicle to raise the level of domestic wind turbo-electric technology and get on a par with international standards.

According to IAEA statistics, biomass ranks fourth as an energy source worldwide, only coming behind oil, coal and natural gas. To develop biomass technology, INER developed a 100kW steam plasma torch system in 2004 and began basic research on plasma gasification. It also developed a synthesis gas clean-up mechanism and a processing unit, accompanying the SOFC system under construction. In the next several years, the development for a 5kW alcohol plasma reformer, a catalytic reformer and procedure for manufacturing hydrogen gas will be INER's main focus. INER will also develop systems for the pre-treatment of algaelike biomass material at a rate of 100 kg/hr and an advanced plasma gasification system, aiming at developing a continuous plasma gasification procedure for all types of biomass. In addition, INER will establish a 5kW SOFC electric generating demonstration system with biomass plasma gasification and alcohol plasma reforming, expecting to raise heat efficiency above 60%.

In the area of energy conservation, the development of white light LEDs, with their characteristics of energy-saving, long life, miniature in size, quick response time, shock resistance and wide variety in design, will be INER's focus. INER for quite some time has developed technology and equipment for APCVD and MOCVD epitaxy, and been the first in Taiwan to develop blue LEDs. It also has the capability of manufacturing silicon nitride and metal electrodes such as E-gun and evaporators. On quantum point lighting, INER will focus on the light generating efficiency of the white light LEDs to reach a level of 7-15 lm/W of the incandescent bulb. In the future INER will seek to achieve a 20 lm/W level, surpassing that of the incandescent bulb and meeting market needs.

#### **Fuel Cycle and Materials Administration**

#### Discarding of Test Drums from the Lanyu Storage Facility

On August 10, 2004, FCMA received a call from Lanyu Township Office that some suspected radioactive waste drums from the Lanyu Low-Level Radioactive Waste Storage Facility have been found on a slope next to the Chifeng Sand and Gravel Quarry on Yeyou Village. AEC immediately sent out an inspector to the island and conducted radiation monitoring and investigation work jointly with the township officials. The surface radiation dose rate of these drums was 0.037 to 0.043  $\mu$ Sv/h, within the range of natural background radiation. Since the drums were painted in gray or deep blue instead of yellow, they were provisionally identified to be non-radioactive waste drums.

It all started in 2001. To increase the safety of storage of the Lanyu facility, Taipower decided to carry out examination and repacking program on corroded waste drums. Taipower entrusted Nan Dao Engineering Corp. to construct an Examination and Repacking Center. Nan Dao made non-radioactive test drums to carry out the system and equipment



Discarded drums in Chifeng Sand and Gravel Quarry

performance test. Since it was non-radioactive material, Nan Dao shipped the drums to the Chifeng quarry for disposal after testing.

To confirm the number of these discarded drums and whether or not they were radioactive, on 16, 24 and 25 of August, all the 261 buried drums were dug up. AEC inspectors, together with the township officials, conducted radiation monitoring of these drums. Results showed that the surface dose rate of every drum was within the natural background range and reconfirmed that these were non-radioactive test drums.

On October 8, Leu Hsi-muh, member of the Control Yuan, and investigators invited academics and experts to the site to monitor the radioactivity. Following the investigation, the Control Yuan on November 12, 2004 judged the discarded drums

to have no abnormal radioactivity and that they should be considered normal industrial waste of no radiation safety concern.

Although the event did not involve a question of radiation safety, related practices were poorly managed resulting in contractor's discarding of test drums at will, which would in turn have a negative impact



Leu Hsi-muh, a Control Yuan member, investigates discarded drums.

on the environment. Some of the radioactive warning labels on the discarded test drums had not been cleaned off, causing alarm among Langyu residents. On August 18, AEC issued a press release, describing the actual situation behind the event and the results of the radiation monitoring. On September 10, AEC completed the "Investigative Report on Discarding of Test Drums from Lanyu Storage Facility" and posted the report on its website as public information.

On December 3, 2004, AEC called a review and improvement meeting, requiring Taipower to fully implement the following corrective measures to prevent recurrence of similar incidents:

- 1. Strengthen management and training of outsourced contractors;
- 2. Improve release control of items with radioactive warning labels;
- 3. Improve raw materials access control measures and record keeping; and
- 4. Increase the transparency of the examination and repacking work.

### International Perspective on Reasonable Clearance for Radioactive Waste

To insure health of the public and quality of the environment, the International Atomic Energy Agency (IAEA), the International Commission on Radiological Protection (ICRP) and other related international organizations have reached a consensus and determined that the criteria for radiation clearance is effective dose not to exceed 0.01mSv for an individual, or annual collective effective dose equivalent of 1 man-Sv. This provides room for further reduction of unnecessary

radioactive waste disposal capacity, transport frequency and costs in the future.

To insure public health and environmental quality and to conserve limited resources, international organizations (IAEA, ICRP, EU and WHO) and advanced nuclear countries all actively pursue research on the feasibility of clearance controls on negligible radioactive waste. Germany and Finland have formally formulated their national clearance control regulations. In 1996 IAEA issued TECDOC-855 in which suggested clearance levels for radionuclides in solid materials were proposed. In 1998 IAEA published TECDOC-1000 in which suggested values to clearance of materials resulting from the medical use of radionuclides were proposed. In 2004, IAEA issued RS-G-1.7, formally proposing the application of the concepts of exclusion, exemption and clearance.

The Nuclear Materials and Radioactive Waste Management Act has authorized the competent authority to draw up a "Regulation on Clearance Level for Radioactive Waste Management" to eliminate control over waste of negligible radioactivity. AEC convened the "2004 Symposium on Clearance Levels and Detection on Radioactive Waste" to exchange opinions among all interested groups. A suggestion to adopt IAEA's RS-G-1.7 was made at the symposium. To confirm the applicability of the IAEA standards in Taiwan, FCMA also entrusted INER to conduct verification on important nuclides.

To enlarge the scope of application of these standards, in addition to adopting the suggestions in RS-G-1.7, AEC also took on the suggested values proposed in TECDOC-1000 for medicine, industry and research use. A release plan shall be submitted to the competent authority, i.e. AEC, for approval prior to implementing waste release. The release plan may be integrated in the radiation protection plan for submission in order to simplify the application process.

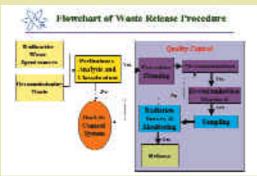
The "Regulation on Clearance Level for Radioactive Waste Management" was promulgated as of December 29, 2004, and has been posted on AEC's website.

#### Dry Storage of Spent Fuel Now Being Realized

As of December 2004, the spent fuel pools at the three NPPs stored about 2,500 metric tons of uranium. After a thorough assessment, Taiwan decided to adopt the dry storage technique for interim storage of the spent fuel. So far eighteen countries



2004 Symposium on Clearance Levels and Detection on Radioactive Waste



Flowchart of Waste Release Procedure



U.S. Surry NPP Dry Storage Facility (Vertical Modules)



U.S. Susquehanna NPP Dry Storage Facility (Horizontal Modules)

and 57 NPPs have adopted this mature technology. In U.S. dry storage is being used at 29 NPPs with outstanding operational results. The U.S. Surry plant already has 20 years experience in dry storage. This year U.S. Nuclear Regulatory Commission renewed Surry's license for an additional 40 years.

Since 1980s, Taipower conducted research on the interim storage of spent The **Environmental Impact** Statements of the Spent Fuel Dry Storage **Programs for Chinshan and Kuosheng** NPPs were reviewed and approved by EPA in 1995 and 1996, respectively. Taipower invited public bidding several times but the tenders failed to go through because of the technical requirements and cost and other factors. In 2004, INER broke through a technological and cost bottleneck to express a willingness to participate in the plan. Currently, the two plants are making improvements on equipment and facilities and also opening up a dialog with neighboring townships. Commissioning of the storage facility at Chinshan plant is anticipated in 2010.

In 1997, INER built two spent fuel dry storage casks and in 1999 implemented a plan sending spent fuel from INER's research reactor back to U.S. It has also conducted numerous inspections of spent fuel from Taipower's NPPs and has accumulated a great deal of practical

experience in fuel loading and unloading, sealing, cask transport as well as related assessment techniques, such as structure, criticality, heat transfer, confinement, and radiation assessment and shielding design. Besides integrating its own resources, INER will also introduce mature technology via technology transfer to coordinate with revisions required by the domestic environment condition and lay the foundation for a localized technology for the spent fuel dry storage while raising the safety level at the same time.

AEC is the competent authority for safety review and issuance of the facility's construction and operating licenses. To insure facility safety, AEC has formed a licensing team that is specialized in structure, material, shielding design, radiation safety, criticality and heat transfer. Through studies and discussion of domestic and foreign regulations and related technology, review criteria are now in place. AEC has organized a steering committee composed of experts and academics with the abovementioned specialties that provides licensing guidance. To insure construction quality, talents are being actively trained in quality assurance, welding and non-destructive testing.

#### Finding a Home for Low-level Radioactive Waste

Because of its low activity and short half-life, low-level radioactive waste (LLRW) decays over time and becomes harmless. With strict control and appropriate long term isolated disposal, these materials will have no adverse effect on the environment. Since the world's first land-based LLRW repository at Oak Ridge, Tennessee, U.S.A. went into operation in 1944, there has been several decades of



Swedish SFR LLRW Disposal Facility



Japanese Rokkasho LLRW Disposal Facility

experience, and more than 100 such disposal facilities are currently operating or having operated at one time internationally.

To solve the LLRW problem, Taipower submitted a "Final Disposal Plan for Low-level Radioactive Waste" in accordance with the "Nuclear Materials and Radioactive Waste Management Act" in December 2003, which was approved by AEC in January 2004. According to the plan, Taipower will carry out the final disposal of LLRW in a five-step sequence: 1) site selection and assessment of disposal concept, 2) environmental impact assessment, 3) site investigation and engineering design, 4) construction, and 5) operation. TPC scheduled to submit its selection of a disposal site to the Executive Yuan in 2008 for approval, and start the disposal operation at the end of 2013.

On July 15, 2004, the Ministry of Economic Affairs invited relevant agencies, academics and experts to form a site selection task force to begin the process. It is estimated that potential and candidate sites will be selected in 2005, following which, in accordance with environmental impact assessment regulations, an assessment will be made of candidate sites. It is expected that, after EIA approval in 2008, a site will be submitted to the Executive Yuan for approval, and a construction license application can be filed.

To ensure the implementation of disposal strictly in accord with the plan on schedule, AEC has demanded that TPC submit the Implementation Report for Final Disposal Plan every six months. AEC has also invited relevant academics and experts to form a "Radioactive Materials Safety Advisory Committee" in the hope of gathering a broad spectrum of opinions and adopting a conscientious attitude toward safety control while pushing for the establishment of a LLRW disposal facility.



French L'Aube LLRW Disposal Facility



U.S. Barnwell LLRW Disposal Facility

#### **Radiation Monitoring Center**

#### **Radioactive Hokutolite**

In 1905, a Japanese by the name of Yohachiro Okamoto discovered some radioactive barite in the Peitou (hokuto in Japanese) hot springs area and called it "Hokutolite." Hokutolite is the only one of the world's more than 4,000 minerals named after a Taiwan location. The hot and highly acidic spring water under the Geothermal Valley caused minerals underground to dissolve. As the temperature dropped, lead, barium and radium sulfate crystals gradually formed and adhered to the surface of the rocks in the Peitou Creek, building to a thickness of about 2 millimeters. Having barium sulfate and lead sulfate in a ratio of 4:1, Hokutolite is a type of barite with a hardness of 3.5 and a specific gravity of 6.1. It has the sheen of glass or a resinoid, is white or light brown in color and contains radioactive Radium-226 with radioactivity much higher than any other rock. In the downstream river valley, traces of this mineral can be found. During the period of Japanese occupation, the mineral was declared a national gem and picking/collecting was forbidden.

In the sediments of the Geothermal Valley, RMC found that the surface gamma radiation dose rate was about three times that of the surrounding area. An on-site sodium iodide gamma-spectrometric analysis together with a pure germanium gamma-spectrometric analysis on sediment samples showed that Thallium-208, representing a daughter nuclide of the Thorium-232 series, was 270 Bq/kg, while Bismuth-214, representing a daughter nuclide of the Uranium-238 series, was 44



Crystallized Minerals on the Surface of Hokutolite



The Peitou Hot Springs Museum

Bq/kg, with a ratio of 6:1. Other analyses showed that radioactivity of Hokutolite came primarily from Bismuth-214 of the Uranium-238 series. After further comparison with other chemical analyses and accompanying alpha spectrometric analysis, no Uranium-238 was found, only its daughter nuclides. Thus it was deduced that the radioactive component of the Hokutolite crystal comes primarily from radium sulfate. Because the half-lives of Thorium-232's daughter nuclides "Radium-228" (T1/2=6.7 years) and "Radium-224" (T1/2=3.66 days), are far shorter than that of Uranium-238's daughter nuclide "Radium-226" (T1/2=1,602 years), after many years of decay the crystallized minerals on the Peitou rocks are left with only radioactivity from Radium-226.

In recent decades, because of over-mining and changes in the ecology, Hokutolite is no longer found. In the Peitou Hot Springs Museum still a few pieces of Hokutolite are in display. The largest piece has a surface dose rate of about 0.34  $\mu$  Sv/hr, but at a distance of one meter, it falls to the background level, and there is no radiation safety concern. Currently, supported by interested citizens and the Taipei City government, a Hokutolite recovery project has been launched and the Geothermal Valley has become a small lake where seed rocks have been deposited in the hope that the Hokutolite-forming environment can be recreated and man-made damage to the area be minimized. RMC made an on-site inspection in August 2004 and discovered very tiny amount of crystal material with higher-than-normal radioactivity. But let's be patient, it may take a few decades or even over 100 years to recover good crystals of Hokutolite!



The dose rate of the Hokutolite at a distance of 30 cm is  $0.34 \mu$  Sv/hr.



The Geothermal Valley, undergoing recovery, is now under water from the hot springs.

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