ISSN: 1812-3155

Institute of Nuclear Energy Research

Atomic Energy Council, Executive Yuan

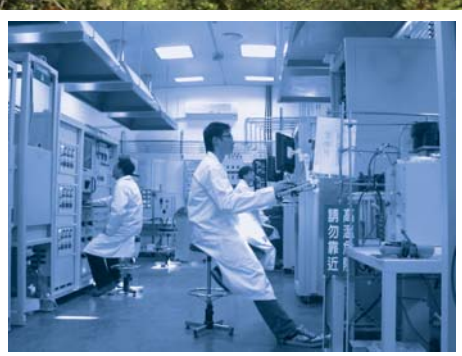
2009 Annual Report

Published in June, 2010

2009 Annual Report

Institute of Nuclear Energy Research
Atomic Energy Council, Executive Yuan

Published in June, 2010



2009 Annual Report
Institute of Nuclear Energy Research

Contents

1

Technology Development and Applications of Nuclear Energy

– Future Prospects and Sustaining Development for INER

INER, as founded a national laboratory on nuclear technology research, in recent years extends into the development of carbon-free energy, low-carbon energy, and industrial radiation applications. With "Professionalism, Innovation, and Safety" as its motivating core-value, INER strives to earn international recognition as a world-renowned research institute in these fields. Our immediate tasks are to follow out our national policy in regard to technical developments on nuclear energy and new energy, on global warming and carbon-reduction issues, and on atomic energy related public healthcare betterment issues.

This guides INER in setting year-2009 annual priority of research programs to achieve the following:

- Enhance research and development on nuclear safety and nuclear technologies that are vital to the establishment of a carbonless nuclear homeland.
- Contribute to the technology development of new energy that promotes the economic development of green energy.
- Strengthen atomic energy related healthcare applications and quality that aim to enhance public health.

INER has been assessed as an outstanding governmental research institute two times in sequence and takes part in three national-scale research programs on energy-technology, nano-technology, and biomedical technology. We take pride in presenting to you our achievements as detailed in this annual report.

As for future prospects, INER must take a positive attitude to meet forthcoming challenges that are fundamental to our sustaining growth. Change management, innovative approach, and strategic positioning are instrumental in our planning for the future. I would like to share with you three such important developments that were planned in 2009 and have been in implementation or will be carried out in the coming years:

- Structuring INER as a contributive research center for both nuclear energy and new energy in Long-Tan District: INER will follow out governmental policy of promoting six leading industrial sectors, especially the carbon-free option of nuclear energy and the carbon-reduction option of green energy.

Preface

- Promoting the construction of a Southern Taiwan Low-Carbon Demonstration Community in the Kaohsiung region: By constructing a Southern Taiwan Low-Carbon Demonstration Community, INER will contribute to formation of communities that combine low-carbon life circles and renewable energy production clusters. This will be a positive step toward accomplishing the governmental policy of promoting carbon-reduction, as well as a low-carbon energy production industry.
- Expanding into the Central Taiwan Advanced Research Park in the Nan-Tou county: In compliance with the "New Clustering of High-Tech Industry in Central Taiwan" program, INER plans to implement a "Low-carbon Energy Technology Development and Application Program" at the Chung-Hsing Villiage site. This will establish an environment centering on basic research for the green energy. INER envisions that advanced research on green energy will lead to the development of a green energy industry and provide solutions that conform to our national goal for a safe, economical and environmental-friendly energy supply.

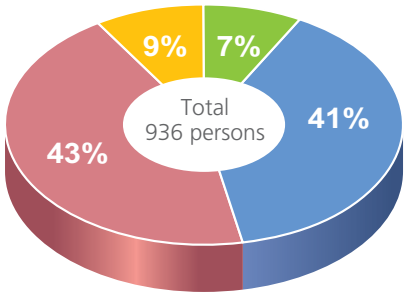
During the past twenty years, INER has encountered a major change in organizational structuring in 1989 and a suppressing 8- year period of "nuclear-less homeland" between year 2000 and 2008. INER persists on sustaining betterments in innovative R&D performance and has received recognition from both our nuclear regulatory agency AEC and nuclear power plant operator TPC. We have diversified our research scopes into renewable and new energy areas, encountering carbon-reduction and environmental issues, and toward atomic energy healthcare applications. The assessments by the National Science Council on INER as an outstanding governmental research institute two times in sequence in 2003 and 2006, as well as our expanding international cooperation programs with leading industrial organizations and renowned universities are convincing facts that present INER's past performance and future growth potential. With these words INER calls upon the continuing supports from TPC and all cooperating organizations. INER appreciates greatly the full guidance from AEC and the whole-hearted devotions by all INER staffs and families.

Director-General 

2 Human Resources and Budgets

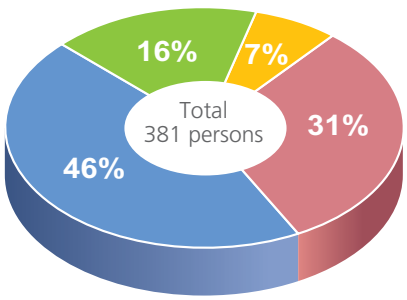
(Time of data: December, 2009)

Manpower Distribution of INER



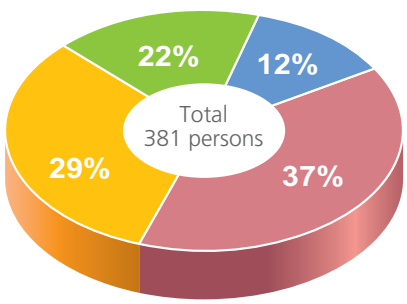
Research Staffs	381 persons	(41%)
Technicians	398 persons	(43%)
Administrative Staffs	89 persons	(9%)
Other Staffs	68 persons	(7%)
Official Staffs	936 persons	

Statistics of Educational Background for Research Staffs



Ph.D.	117 persons	(31%)
Master	174 persons	(46%)
Bachelor	62 persons	(16%)
Vocational School	28 persons	(7%)
Research Staffs	381 persons	

Statistics of Job Category for Organizational Research Staffs



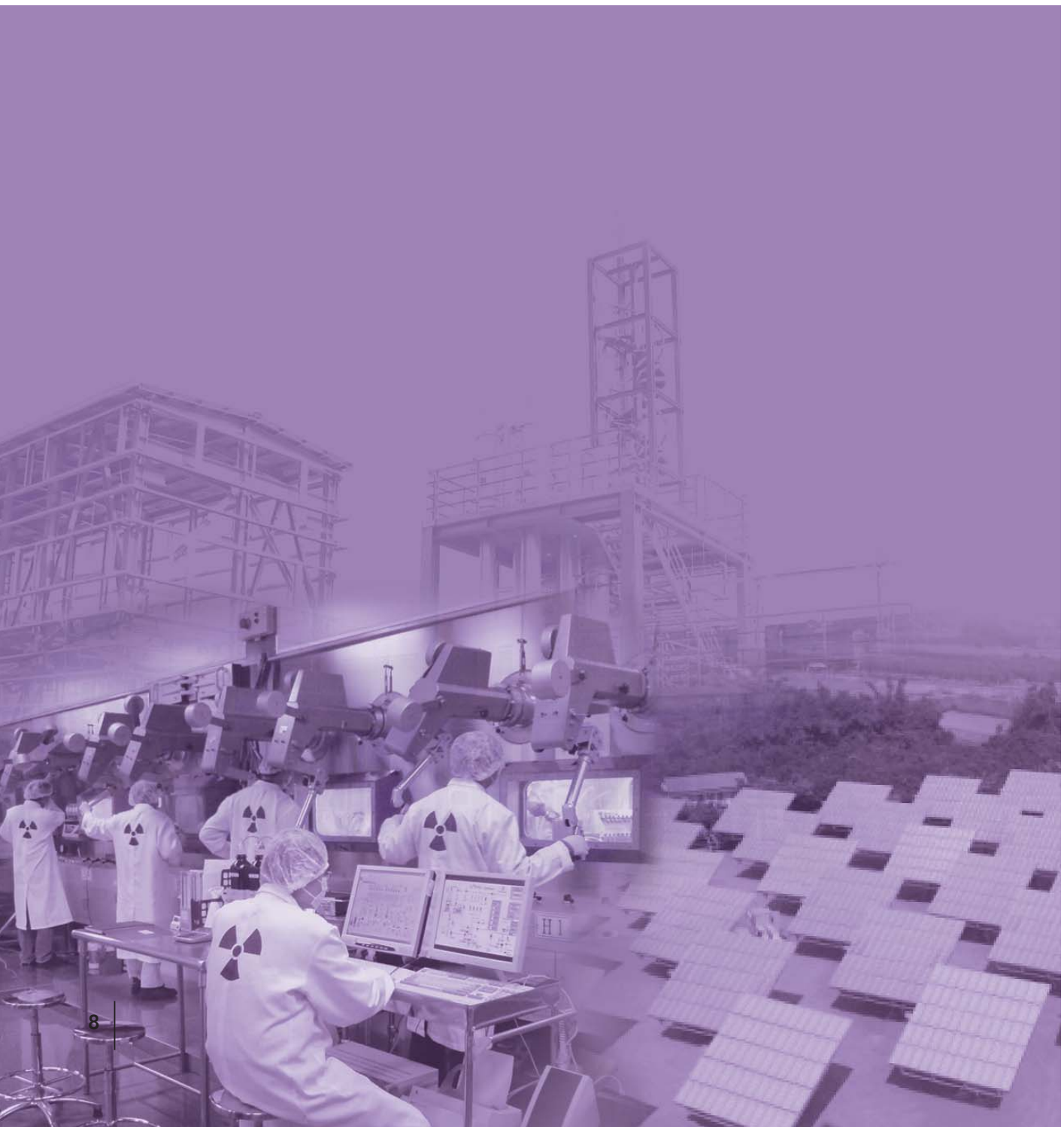
Researcher	46 persons	(12%)
Associate Researcher	140 persons	(37%)
Assistant Researcher	110 persons	(29%)
Research Assistant	85 persons	(22%)
Research Staffs	381 persons	

2009 Annual Budget

Unit：Thousand NTD

Administration and Safety	**1,337,705**	45.51%
Management, Operation and Maintenance	**195,667**	6.66%
R&D Projects	**1,278,398**	43.49%
■ Nuclear Safety Technology	235,196	8.00%
■ Environmental and Energy Technology	748,530	25.46%
■ Radiation Application Technology	265,401	9.03%
■ Atomic Energy Technological Cooperation Research	29,271	1.00%
Technology Promotion and Service	**127,911**	4.35%
Total	**2,939,681**	**100%**

3 Events of the Year



3-1 Establishment of HCPV Demonstration Plant at Lujhu

Cherng-Tsong Kuo, Yingling Wang

The completion ceremony of HCPV demonstration plant at Lujhu was held on Dec. 22, 2009. VIPs from both governmental institutes and industry were invited to witness the historical moment of HCPV system development. The ceremony was supported by several groups from the local residents. The exhilarant moment was unveiled by the traditional music playing of I-Chia Primary School, and the famous Sung-Chiang Parade of Chih-Chien University. Final pushing button move was executed by VIPs, official representatives, and tycoons from industry simultaneously. 141 sets of HCPV subsystem were operated subsequently, and started tracking the sun automatically. The ceremony was heated up to the ecstasy at this unforgettable moment. The demonstration plant occupies two hectares; every subsystem is equipped with sun-tracker. There are two different types of subsystem: one with 60 cell modules, and the other with 40 cell modules. The power generating capacity for 60 cell modules is 7.5 kW, and for 40 cell modules is 5 kW. The total number of concentration cell modules is 8040. Total capacity of power generation is approximately 1MW.

The establishment of MW grade HCPV system had experienced several complicated situations such as land acquirement, permission of enterprise plan and development plan, forced removal of occupied residents, removal of the trees, reimburse for the renting residents, changing land use, and the problem of partition of the land, etc. All the difficulties listed above were overcome item by item by the efforts of all our colleagues. The installation and testing were fulfilled within three months after the land problems were solved. Generally speaking, the establishment of MW grade HCPV system includes five major constructions:

1. **Land preparation -** MW grade HCPV system site is an original abandoned land. There were abandoned houses, big trees, and electric poles, telephone wire poles and lamp poles, and sparse residents, etc. All these factors together had brought about the difficulties for land preparation. The tedious jobs were done cooperatively by our colleagues, and the personnel from Kaohsiung county and Taiyen Corporation. Removal of occupied residents, tree re-planting, and all wire poles removal are executed respectively. Finally the safety fence was built on the west and the south sides. The east and the north sides took existing natural obstacles as the safety fence.
2. **Construction of foundation -** foundations for 120 sets of 7.5kW subsystem and 21 sets of 5kW subsystem were built. The jobs inclused lofting, base excavation, the bottom layer of cement mortar work, base steel banding and RC watering, and sample fixed bolt reinforcing bars etc. Cement was sampled to ensure its quality. The wiring of weak power and communication was distributed from the main wire, and total wiring used approximately 11,300 m wire and 14,973 PVC tubings.
3. **Subsystem installation -** there were ten items of work to be done including bracket installing, module assembling, level calibration, series and parallel wiring, wiring of power and communication lines, inverter installing, and testing of subsystem, etc. Performance optimizing was performed by the help of the advanced laser leveling technology to make the four tips of the modules to be less than 0.1 degree. After the brackets, modules and columns installed, the power and communications wiring was undertaken. Afterward, the inverters were installed

and wired. Direct current generated by HCPV system was conversed to alternate current by the inverter. The power generated was finally connected to switchyard. At last, the calibration and testing was performed to ensure the excellent function of all subsystems.

4. **Power system engineering -** power system engineering includes installation of collection system, establishment of switch yard, and installation of anti-lightning system and voltage boost to on-grid connection. The major purposes of power system engineering are to provide the power to drive the trackers and to collect the power generated from HCPV system to switchyard and to protect the system from lightning. The anti-lightning system included copper bar and copper network, and underground wire according to standard. Finally the power generated by MW grade HCPV system is boosted to 11.4 kV to connect on-grid of Taipower.
5. **Central control engineering -** the functions of central control system are monitoring, controlling, warning, searching, and diagnosing, etc. The remote mode is used to control the tracker, collect, search, and analyze the information of prompt power generation. Malfunction of the system was detected automatically and warning signal provided. Prompt information of the direct normal irradiance (DNI) was acquired by meteorology station on-site. Pyranometer, pyrheliometer, UV irradiation meter, anemometer, thermometer and hygrometer are used to measure the environmental parameters. All information will be gathered by central control system, and the control system also provide automatic tracking strategy to avoid the damage from high wind speed.

HCPV demonstration plant at Lujhu for the time being has the largest capacity among HCPVs in Asia. It means that the HCPV technology in Taiwan is kept in the international level. On the other hand, the establishing of this demonstration plant has provided an opportunity of effective integration of local HCPV industry, and the cultivation of personnel in HCPV industry. Accordingly, the domestic PV industry are led into a brand new era.

▲ Start-up of the Demonstration Plant in the Completion Ceremony at Lujhu

▲ The MW-Grade On-grid Type HCPV Demonstration Plant

3-2 The Feasibility Study of Developing Low Carbon Energy Communities for Kaohsiung

Chin-Jen Chang

The development of low carbon community is now a mainstream for reforming the usual carbon intensive community into a modern energy efficient and clean society. Essentials of propelling this transformation are the general awareness of global climate change, trend of deficiency and price swelling of fossil fuels, and new economic competitions resulted from carbon trading and carbon economics. Most vigorous countries and their local governments have been developing policies and action plans to guide the transformation of their communities.

In response to this global trend, several important top-down initiatives have been brought up in our country, which include promoting the multiplicity of national energy resources, increasing the proportion of low carbon energies, and strengthening the development of low carbon economics, societies and living styles. The government has also declared a Low Carbon City Program setting an objective of establishing four low carbon living spheres with each one located in the northern, central, southern as well as the eastern Taiwan to be completed by 2020.

In 2009, the Council for Economic Planning and Development (CEPD) contracted a project with INER, The Feasibility Study of Developing Low Carbon Energy Communities for Kaohsiung, to conduct the conceptual planning for developing low carbon communities associated with the promotion of renewable energy industry. This project arrested great attentions from Kaohsiung County Government (KCG). KCG has announced thereafter to open up a land with area of 25 hectares for The Initiative of Low Carbon Industry R&D Park. INER has now cooperated with KCG to integrate R&D proposals at this park submitted by research institutes and industrials located at Kaohsiung area. Moreover, KCG also planned to contract with INER a project, The Strategic Planning of Low Carbon Industry for Kaohsiung, in 2010. Altogether, the engine for low carbon development at Kaohsiung is started, and INER has joined both as a major consultant and as a technical participant for promoting the low carbon industrial structure and helping to achieve mid and long term goals of carbon reduction for Kaohsiung.

▲ The Conceptual Planning for Developing Low Carbon Energy Communities at Kaohsiung

▲ The Conceptual Planning for Kaohsiung Low Carbon Industry R&D Park

3-3 2009 Taiwan Smart Grid Forum

Yung-Ruei Chang

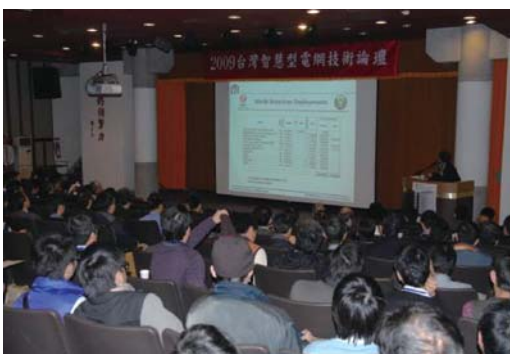
According to the development trend of international smart grid technology, Department of Engineering and Applied Sciences, National Science Council (DEAS, NSC) took the initiative in holding a smart grid forum in Taiwan and Institute of Nuclear Energy Research (INER) was commissioned to host the first-year 2009 Taiwan Smart Grid Forum. Through canvassing various opinions in this forum, we try to seek a new niche market of the international smart grid industry for Taiwan.

With more than 3 preliminary meetings discussed with academics, research institutes, specialists as well as scholars, 2009 Taiwan Smart Grid Forum was successfully held in December 30, 2009. More than 280 participants as well as more than 20 research units joined this forum, including Industrial Technology Research Institute (ITRI), Academia Sinica(AS), Institute of Information Industry (III), etc. Eight expertise sessions were held in this forum, including Taiwan Smart Grid Technical Vision, Advanced Metering System, Communication Infrastructure and Cyber Security, Micro Grid, Automation Dispatch System, System Control and Decision Support, Protocol and Standards, and Industry Development.

Three conclusions were made in the panel discussion as followings:

1. Forum Chair Prof. Faa-Jeng Lin, will visit Council for Economic Planning and Development (CEPD) and report to the Minister Hsung-Hsiung Tsai on the fruitful results and achievements of this forum and try to move the government to carry out some valuable polices in smart grid industry in Taiwan.
2. Taiwan Institute of Economic Research (TIER) is commissioned to promote a Taiwan smart grid industry association.
3. ITRI is commissioned to host the 2010 Taiwan Smart Grid Forum.

▲ Panel Discussion



▲ Conference Live

3-4 Development of NaF-18 – the Impact and Resolution on the Shortage of Tc-99m

Li-Yuan Huang, Jenn-Tzong Chen

Tc-99m is a radioisotope derived from the mother nuclide Mo-99 mainly produced from nuclear reactors that have been used for over 40 years world wide. In July 2009, the operational capacity of the reactors almost reached the limit. With the additional concerns on the radiowaste disposal, some of the reactors were forced to be shut down. This caused a sudden shortage of Tc-99m all over the world. As Tc-99m is utilized in roughly 80% of all nuclear medicine, it obviously plays an important role in performing functional imaging studies. For example, Tc-99m is used to diagnosis the diseases of skeleton, heart, kidney, lungs, and certain tumors.

The sudden shortage has brought crisis to hospitals and patients who are in need of medical tests. In order to overcome this global isotope shortage impact, Canada, the major producer of the world's medical isotope, rapidly proposed to replace Tc-99m-MDP with NaF-18. Although the U.S. Food and Drug Administration (FDA) approved sodium fluoride F-18 injection (NDA 17-042) as a bone imaging agent to define areas of altered osteogenic activity in 1972, it was withdrawn from the market later on, however, and now in the Orange Book's "Discontinued Drug Product List" section. Due to the isotope crisis and the long term effects, the U.S. Centers for Medicare and Medicaid Services (CMS) opened the Positron Emission Tomography (PET) National Coverage Determination to evaluate the effectiveness of NaF-18 for PET bone imaging. PET bone imaging is a nuclear medicine procedure that is sensitive for the detection of the spread of many common cancers, such as breast, lung, and prostate, to the bone. It also can be used to detect fractures when x-rays are not sufficient to provide a definitive diagnosis, particularly in pediatric patients.

According to the current situation, the global nuclear reactors in producing of the isotopes for nuclear medicine will not operate normally in a short period of time. Hence, radiopharmacists suggested to artificially produce radioisotopes by using cyclotrons. Cyclotrons could be used to generate isotopes F-18, Tl-201, and I-123, which could be further utilized to transform to NaF-18, Tl-201 Chloride, and NaI-123 that are used in skeletal, heart, and thyroid gland imaging, respectively. With Atomic Energy Council's instruction, INER successfully developed the synthesis and method of "INER NaF-18 Injection" in three months. In the meanwhile, 94.12% of the domestic hospitals show the urgent needs of INER NaF-18 Injection for skeletal imaging, examination, and evaluation. Currently, "INER Sodium Fluoride [F-18] Injection" is in the application process as a new drug. We expect it will be approved by Department of Health recently to provide the medical care of skeletal cancer patients.

3-5 External Communication and Information Exposure

Hseau-Yieh Yang

To provide transparent information to its neighborhood has always been INER's aspiration. INER takes the initiative to understand their worries about nuclear safety and radiation with the aim of clarifying uncertainties while publicizes the development and contribution of nuclear technology toward daily life. Related tasks are categorized as following:

1. Communicating with the Neighborhood

(1) Listening the voices: To visit and concern the worries of the neighbors about nuclear energy.

(2) Caring the neighborhood: To sponsor local activities and low-income people.

(3) Sponsoring medical examinations.

(4) Technical tour for general public.

(5) Inviting the neighbors to participate in the sampling operation of the surroundings, estimating the impact of radiation effect to the neighborhood by radioactivity analysis and establishing database on radiation background.

2. Press Conference

To improve the effectiveness of communication, INER has held press conference according to four guidelines:

(1) Reaching people's lives

(2) Popularizing the knowledge

(3) Publicizing the point of view

(4) Soothing the anxiety of people

The following is the summary of the press conferences held in 2009:

Date	Title
2 / 9 / 2009	Any One Can be a Radiation-Proof Pioneer Home-Made Environmental-Conserving Innovation - Intelligent High Speed EMF Meters Embedded in Cell Phones
4 / 20 / 2009	A Niche of Wind Industry in Taiwan - The Development of Small/ Medium Size Wind Turbine
6 / 8 / 2009	The Application of Radiation and Radiopharmaceuticals on Scientific Chinese Herb Medicine -Let People Eat Much Safer and Live Much Healthier
10 / 5 / 2009	An Example of Industry - Academia Cooperation That Heralds the Domestic Maintenance Industry for Nuclear Power
11 / 9 / 2009	New Therapeutic Radiopharmaceuticals for Colorectal Cancer: Development of Nano-targeting Therapeutic Radiopharmaceuticals

3. Workshop and Exhibition

a. Workshop and Conference:

(1) 2008 Joint Symposium of the AEC Contracted-out Research Program and the AEC-NSC Mutual-Fund Sponsored Research Program
(2) The 2009 Cellulosic Ethanol Technology Development Workshop
(3) Nuclear Technology Industrialization Development Workshop
(4) The 2009 Taiwan SOFC Workshop
(5) The 2009 Taiwan SOFC International Symposium
(6) ANS Nuclear Technology Application Development Workshop
(7) International Workshop on Autonomous Nuclear Instrument Digital Control Technology
(8) 2009 Civilian Nuclear Power Cooperation Conference of Taiwan and the United States
(9) The Ninth Nuclear Cross-strait Academic Exchanges Workshop
(10) 2009 Taiwan Neuroscience Conference
(11) 2009 Annual Meeting of Nuclear Energy Society and Spent Fuel Management Strategy Workshop
(12) Business Meeting of the National Research, Development and Evaluation Units.
(13) 2009 Conference of Smart Grid in Taiwan
(14) 2009 Joint Symposium of the AEC Contracted-out Research Program and the AEC-NSC Mutual-Fund Sponsored Research Program

b. Exhibition:

(1) Taipei Int'l Show of Environmental Protection & Energy
(2) 2009 Taipei International Invention Show & Technomart
(3) 2009 Taiwan Nano Exhibition
(4) Taiwan International Green Industry Show 2009
(5) 2009 Consumer Protection Carnival of A New Advocate for Secure consumption

4. Reception for General Public

In 2009, there were 54 receptions for general public to promote government's technology policy and INER's achievements in R&D so that the general public has the opportunity to understand the application of atomic science and technology in life and the status of low-carbon energy development.

4 Current Major R&D Activities

1 Nuclear Safety Technologies

Establishment of Indigenous Technologies for Nuclear Safety and Regulation

Tsu-Mu Kao

To keep pace with the global revival of nuclear power, the Project entitled, "Establishment of Indigenous Technologies for Nuclear Safety and Regulation" was performed in the year of 2009. The Project sets goals at continuously improving the safety of operating nuclear power plants (NPPs) and the construction quality of the Lungmen NPP, establishing appropriate techniques to implement dry storage of spent nuclear fuels, and supporting the Atomic Energy Council (AEC) in their safety review and inspection of regulatory concerns. Priority objective is to establish indigenous capacity in the safety analysis and assessment technologies for NPPs. In 2009, the Project submitted 15 patents applications, published 37 journal papers, 51 conference papers, 91 technical reports, and completed R&D contracts worth over 400 millions of NT (New Taiwan) dollars (around 12 millions of USD). Compared with previous years, these performance indicators demonstrated substantial progress we made in 2009 and obviously reflected technical achievements of the Project. Major works are briefly described as follows.

The Project incorporates three Sub-projects focusing on establishing core technologies for domestic needs, including the nuclear fuel cycle management strategy evaluation, the reactor safety analysis, the risk-informed decision-making assessment, the domestic assessments for radiation protection, emergency response tools, dry storage technology, and repairs and replacement for NPP large components. The technologies developed will enhance the operational safety of domestic NPPs and provide technical support to AEC in their regulatory activities to ensure the safety of NPPs. The three Sub-projects include (1) Establishment of the independent validation capabilities in nuclear safety analysis and engineering evaluation, (2) Development of tools and guidelines as required by AEC for nuclear and radiation safety regulation, and (3) Enhancements of a validation platform for the domestic nuclear industry.

Major achievements on the nuclear safety technology field during 2009 as summarized by major topics are as follows: (1) Current status of GEN-IV reactors, (2) Applications of TITRAM licensing safety analysis methodology on power uprating, (3) Regulatory research on the construction and operational safety of nuclear power plants, (4) Radiation measurement instrument calibration facility capable of lowering scattered radiation and shielding background radiation, (5) Developing dispersion models for radiological dispersal devices, (6) Development of high capacity dry storage system for spent nuclear fuels, (7) Assessments of stress corrosion cracking of alloy 152/52 welds in simulated reactor coolant environments.

1.1 Current Status of GEN-IV Reactors

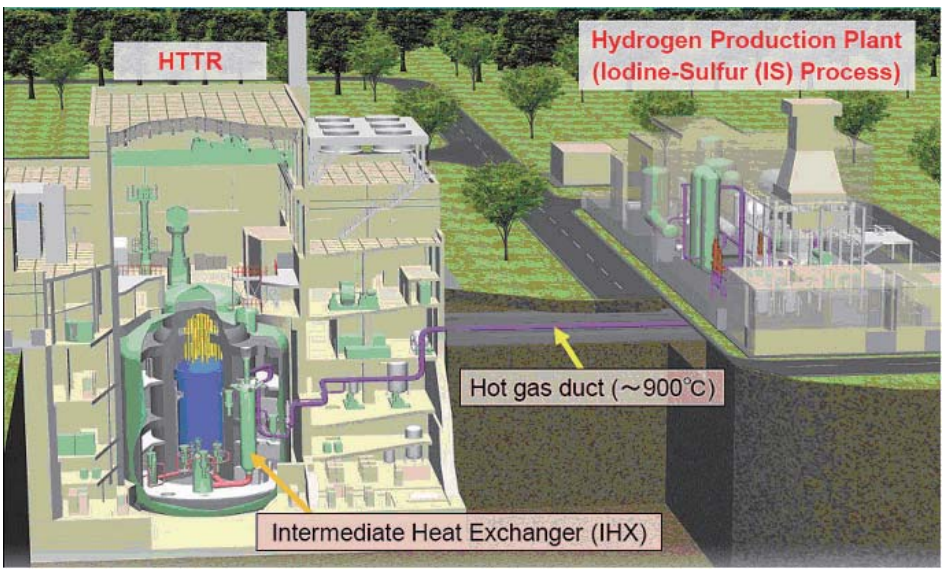
Jau-Tyne Yeh

In the long run, the reprocessing of spent fuel will come in line with the modern concept of recycling and volume reduction of nuclear waste. Since the Generation-4 (GEN-4) systems are designed to reach the goal of greater reactor safety and less waste generation, they will certainly lead the trend in future nuclear development from the nuclear fuel management perspective. In this study, two methods, namely, literature review and patent analysis are used to investigate the technical development of GEN-4 reactors. Patent analysis of the USPTO (US Patent and Trademark Office) was performed using WIPS database as a tool.

We found that parts of GEN-4 reactors are ready to be built and commercialized. For example, the first commercial Very High Temperature Reactor (VHTR) will be built in South Africa, the 200,000KW commercial VHTR reactor will be built in China, Liquid sodium reactor TOSHBIA-4S will be carried out in Alaska by Japan, and 500MWe liquid sodium reactors followed by 1,000 MWe reactors will be developed by India in the future.

Applications other than generation of electricity are pursued by GEN-4 reactors. For example, the SMART reactor developed by Korea will included the function of sea water desalination. Related patents in hydrogen production and heat reuse in VHTR can be dated back to 1975.

The development of GEN-4 reactors will change the strategy of fuel management, improve the usage of resource as well as decrease the amount of nuclear waste. This study gives a brief review of GEN-4 technology development in different countries using the previously mentioned patent analysis and literature review.



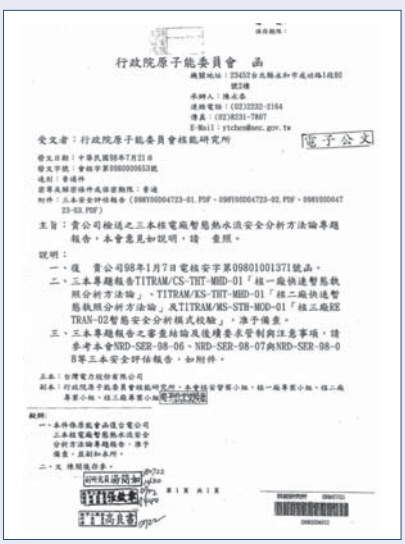
▲ Illustration of Hydrogen Generation Facility for HTTR
Picture Source : Yan, X.L., "Development of High Temperature Gas-Cooled Reactor and Nuclear Hydrogen Production in Japan", International Symposium on Generation IV Reactors, 2009, Taipei, Taiwan.

1.2 Applications of TITRAM Licensing Safety Analysis Methodology on Power Uprating

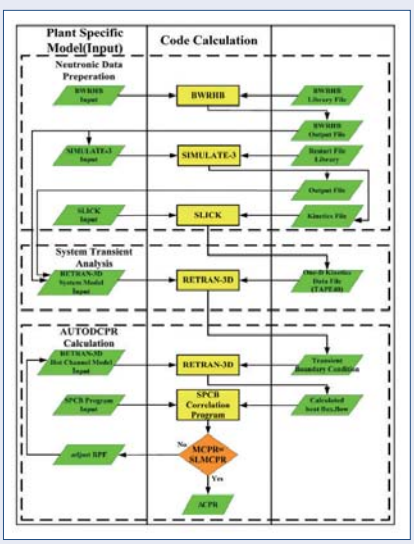
Jan-Ru Tang

The development of an independent safety analysis method for licensing, named TPC/INER Transient Analysis Method (TITRAM), has been progressing for quite a period of time. For the first stage of the project, TITRAM completed 20 Topical Reports submittals to the licensing authority, the Atomic Energy Counsel (AEC). The analysis techniques include system and core thermal hydraulics for non-LOCA transients. The current used CMS neutronics code packages and the fuel management data base for the Chinshan, Kuosheng, and Maanshan Nuclear Power Plants (NPPs) can be connected to the TITRAM tools and models for complete thermal-hydraulic transient analyses. Conservative assumptions are used in TITRAM in order to comply with regulatory requirements in the calculation of thermal hydraulic transient responses of the NSSS systems, including pressure, CPR/DNBRs, and fuel temperatures. 20 Topical Reports describe in detail the computer codes, plant specific models and qualifications, conservative transient safety analysis assumptions, uncertainty quantifications, and thermal hydraulics limits determination implemented in TITRAM. It can be used to support plant operation including power uprating, Tech. Spec. renewal, and set-point evaluation to improve plant operational efficiency. Through rigorous review by the review committee, Safety Evaluation Reports (SER) were issued.

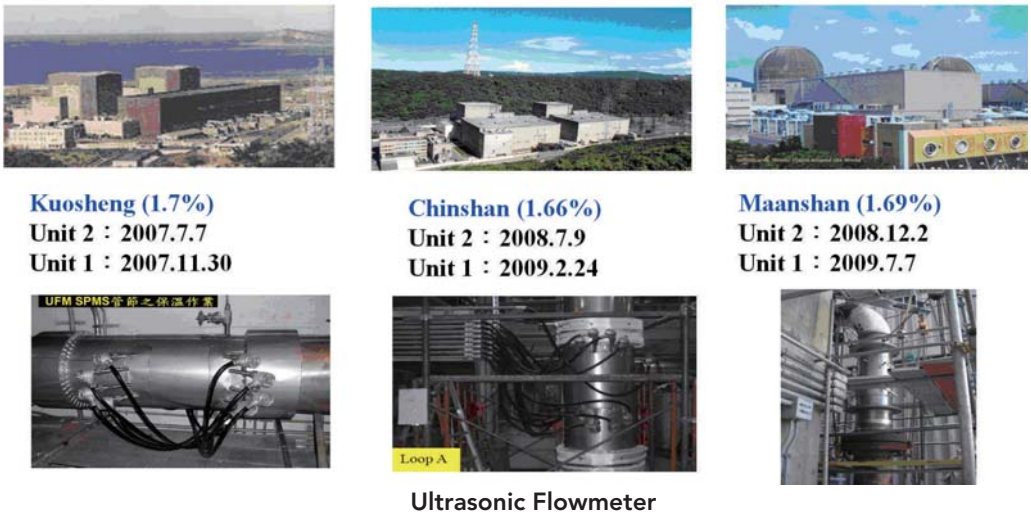
The analysis team supported the Measurement Uncertainty Recapture power uprate projects, including 1.7% power uprate for Kuosheng Unit 2 on July 7, 2007 and for Unit 1 on November 30, 2007, 1.66% power uprate for Chinshan Unit 2 on July 9, 2008 and for Unit 1 on February 24, 2009, 1.69% power uprate for Maanshan Unit 2 on December 2, 2008 and for Unit 1 on July 7, 2009, and totally with 56MWe or 220,000 tons of CO_2 reduction. Currently, the team is supporting the Stretch Power Uprate (SPU) project for the Chinshan NPP and preparing for the SPU projects for the Kousheng and Maanshan plants.


行政院原子能委員會 函

▲ AEC's Letter of Licensing Approval



▲ TITRAM Analysis Flow



▲ Chinshan, Kuosheng, Maanshan NPPs MUR Power Uprate Operation

1.3 Regulatory Research on the Construction and Operational Safety of Nuclear Power Plants

Tsung-Chieh Cheng, Jyh-Der Lin

In 2009, INER completed the following tasks related to the safety of digital I&C and risk-informed analysis:

(1) Establishing the general Diversity and Defense-in-Depth (D3) Facility, including PCTran plant simulation code and Anticipated Transients Without Scram (ATWS) mitigation test system (as shown in the system architecture diagram). By integrating Field Programmable Gate Array (FPGA) technique, this system simulates the failure of the initiation of the digital reactor scram which is induced by the software common mode failure; and ATWS mitigation system is the diverse backup for the digital system. In the study, a variety of software failures and the effects of diverse measures on the system responses are studied in this research.

(2) To develop a human factors engineering (HFE) human error analysis technique. This study addressed human errors (such as omissions and commission errors) that may be occurred by the operator in an automatic system. The soueces of human error may be resulted from the missing or false alarm of specific information on the video display units and wide display panel. The human error analysis technique emphasizes the human tasks, including the monitoring of the automated functions and the backup manual actions which may be required if an automated function fails. To prevent such human errors, Content Category Analysis and Performance Evaluation Matrix methods are used to explore the potential problems in the Main Control Room (MCR) of the advanced Nuclear Power Plant (NPP). The technique proposed in this study could be useful in the areas of the deployment of the operator, the establishment of training course as well as the improvement of the MCR environment.

(3) Based on a series of proposed security standards such as the National Institute of Standards and Technology (NIST) System Protection Profile - Industrial Control Systems (SPP-ICS) and North American Electric Reliability Corporation (NERC) Critical Infrastructure Protection (CIP);

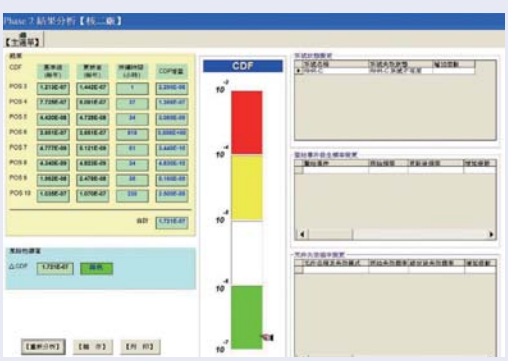
we propose five categories of assets to be protected in the NPP: safety systems, information, software, personnel and cyber security systems. In addition, we proposed a risk assessment program and a vulnerability scanning program for the Digital Instrumentation and Control System (DICS) of Lungmen NPP. The main goal is to evaluate the security management system of the NPP and establish an Instrumentation and Control Networks Security Management System (ICNSMS).

(4) To continue promoting risk-informed applications, introducing and establishing domestic standard for internal events PRA, developing shutdown SDP function in PRiSE, updating kernel PRA model in the PRiSE for internal events, and transferring one set of INERFT software to the Chia Nan University of Pharmacy & Science.

The general D3 test facility provides a platform for evaluating the effects of real software faults on the system-level responses of nuclear power plant. Meanwhile, the related system control logic simulation tests of Engineered Safety Features Actuation System (ESFAS) are ongoing, which can validate the D3 capability.

The performance of Human Factors Engineering (HFE) under integrated system information is used to evaluate the operator manual control in the MCR. The minimum inventory (MI) of Human System Interfaces (HSI) in the MCR should be developed to assist the plant staff to organize and to establish the ICNSMS, which looks over the configuration management and security issues within a comprehensive perspective. Furthermore, the establishment of Probabilistic Risk Assessment (PRA) standards will enhance the quality of PRA models used in risk-informed applications.

▲ Digital I&C test bed for Diversity and Defense-in-Depth



▲ Shutdown Risk Evaluation in PRiSE for Kuosheng NPP

1.4 Radiation Measurement Instrument Calibration Facility Capable of Lowering Scattered Radiation and Shielding Background Radiation

Jeng-Hung Lee

To solve the problems of the interference of the background radiation and scatter radiation to the readout values of the to-be-calibrated instrument, INER installed a radiation measurement instrument calibration facility that is capable of lowering scattered radiation and shielding background radiation. The facility comprised of an INER-made ^{137}Cs irradiator, a collimator, a shielding device, an electric door unit, a control unit and a radiation baffle. Compared with other similar facilities, INER's facility does have the following characteristics and functions:

1. Addition of shielding device: effectively reduce the interference coming from the background radiation and scattered radiation in the laboratory during the calibration.
2. Using the collimator to control the radiation zone of the primary radiation beam to reduce scattering coming from radiation interaction with the shielding device and using the radiation baffle to reduce the back-scattered radiation and background radiation.
3. Using a video monitor, an illuminator and a control unit to remotely control the positioning of the instrument, on-site measurement and observation in data recording.
4. With the design of the attenuator within the irradiator, the calibration and testing can be performed in radiation fields of low-, medium- and high-dose levels.

This calibration facility has been installed and testing results showed that background radiation can be reduced to 0.065 μSv h^{-1}; scattered radiation to 1% of the primary radiation beam. This is much lower than the limit set by ISO 4037 Standard. With the self-made ^{137}Cs irradiator, the measurement deviation maintains within 0.1% for the 25 μGy h-1 radiation dose rate and even within 2.5% for the environment-level dose rate of 0.8 μGy h^{-1}.

A radiation measurement instrument calibration facility capable of lowering scattered radiation and shielding background radiation can effectively reduce the interference of the background radiation and scatter radiation toward the instrument and uplift the measurement accuracy. The establishment of such a facility can strengthen measurement accuracy of the instrument, provide a suitable environment for performing testing, calibration and experiment of the radiation measurement instruments, promote self-fabrication techniques for radiation measurement instruments and peripheral calibration equipment, and secure the safety of radiation professionals and the general public.

▲ Radiation Measurement Instrument Calibration Facility Capable of Lowering Scattered Radiation And Shielding Background Radiation

▲ Self-made ^{137}Cs Irradiator and Collimator

1.5 Developing the Dispersion Models of Radiological Dispersal Devices (RDD)

Shu-Jun Chang

For better assessment of the Radiological Dispersal Devices (RDD)-resulting impact on the critical areas, some models of radionuclide transport and dispersion should be developed. In this year, the main achievement was the development of several short-lived radionuclide-dispersion models along with the accomplishment of dose assessment studies. The models included

atmospheric dispersion, dispersion in complex building environments and terrestrial surface water bodies. According to the simulated pollution characteristics related to the scenarios of RDD events, the RDD dose assessment modules were developed and merged into the Information Integration and Management System for RDD Emergency Response, enabling increased efficiency in providing an immediate impact trend analysis, which is substantial for RDD Emergency Response actions, such as allocation of rescuing resources, arrangement of the personnel, controls of damage, abatement of secondary radiation pollution, and so on. These actions would lead to better management of RDD accidents, as well as reduction of economical damages and society anxiety.

The atmospheric dispersion model was based on the Hotspot theory which was developed and maintained by the Lawrence Livermore National Laboratory, U.S.A. The theory adopted the well-established Gaussian Plume Model to derive the downwind χ/Q distributions down-stream the continuous dispersion point. The model was capable of simulating the pollution characteristics in relation to the scenarios of either explosion or burning dispersion, or both. For the dispersion model in complex building environments, the assumptions of both a uniform mixture and air mass conservation were made to analyze the fluctuations of indoor radionuclide concentrations. Two to five compartments modeling with uniform atmosphere mixing has been completed. As for the dispersion model of terrestrial surface water bodies, both streamline function and velocity-field distribution were derived based on the landscape and flow directions at site. The dispersion of radioactive materials was then obtained by an advection-dispersion equation. This would provide a fast and precise estimation of the concentration distribution, so as to ensure the radiation safety of potable or irrigation water.

▲ The Short-lived Radionuclide-dispersion Models of Rdd: Atmospheric Dispersion, Dispersion in Complex Building Environments and Terrestrial Surface Water Bodies

1.6 Development of High Capacity Dry Storage System for Spent Nuclear Fuels

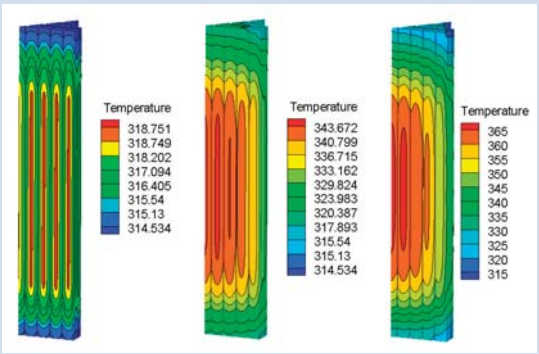
Long-Chyuan Kang

With an aim to increase the capacity of a dry-storage system for the domestic nuclear power plant, INER has developed a new, light-weight, High-capacity Dry-Storage System (HCDSS) based on the tube-type design. Consisting of key components such as fuel basket, transport canister, and shielding structure, The HCDSS can store a total of 61 BWR spent nuclear fuels (SNFs) with 18.3KW design power. After completing the conceptual design, a series of analyses including thermal analysis, criticality analysis and structure analysis are conducted to verify the effectiveness of the design. The major subtasks and results are:

1. A new TSC design with 61 fuel tubes has been completed. Important parameters such as total weight and gravity center are calculated. A 1/12 scale model has been fabricated to test the design functions.
2. Several thermal performance analyses of the system have been completed by applying the Computational Fluid Dynamics (CFD) simulation technique. The results indicate that the system has enough margins in temperature limits under all normal, abnormal and accidental operation conditions. Both the half block and full block accident conditions are evaluated.
3. A thorough computation of the stresses of the TSC (Transportable Storage Canister) and its components has been completed. The TSC retains its structure integrity under the loading conditions for both the normal and postulated conditions.
4. The fuel tube impact analysis shows that the stresses of the fuel tube and its side support structures are all within the design stress limits. Both side impact and end impact at 60g are investigated.

Through some design changes, we greatly improve the heat transfer function of the system. One special analysis shows that natural convection of the system can be enhanced by increasing the gap between VCC (Vertical Concrete Cask) and AOS (Add-On Shield). This leads to more than 10°C of temperature drop of the whole system.

▲ 3d Diagram of the Transportable Steel Canister (Tsc) and Tube-type Basket.



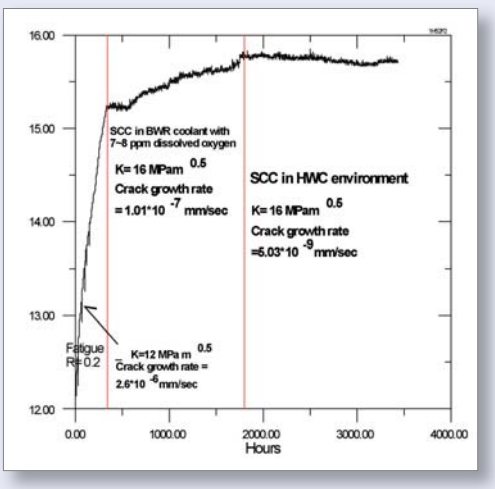
▲ The Transient Temperature Distributions of Fuel Assemblies in the Lid-welding Step.

1.7 Assessments of Stress Corrosion Cracking of Alloy 152/52 Welds in Simulated Reactor Coolant Environments

Jiunn-Yuan Huang

Alloy 82/182 has been used as a filler metal to join the low-alloy steel reactor vessel nozzle and the austenitic stainless steel coolant piping, and other dissimilar metal (DM) weldments of the reactor coolant pressure boundary. Incidences of stress corrosion cracking (SCC) of Alloy 182 weld in both Boiling Water Reactors (BWRs) and Pressurized Water Reactors (PWRs) have been reported since the 1970s. Recently, Alloy 52/152, which has higher chromium content than Alloy 82/182 has been used to repair the defected Control Rod Drive Mechanism (CRDM)/ thermocouple penetration nozzles, Pressurizer (PZR) nozzles and hot leg nozzles, etc. because of its superior SCC resistance. The DM weldments of recirculation nozzles and hot-leg nozzles, etc. are the immediate periphery of the pressure vessel. Therefore, the degradation of the DM weldments is considered a great concern to the integrity of the reactor pressure vessel.

SCC and corrosion fatigue (CF) are the main mechanisms responsible for the degradation of the DM weldments exposed to reactor coolant environments. The stress corrosion cracking and corrosion fatigue behavior of Alloy 52/152/82 welds in high-temperature water environments was investigated in this study. The slow strain rate test results showed that surface cracks, which are a feature of stress corrosion cracking, were found on the 30% and 10% cold rolled Alloy 600 specimens at a strain rate of 1×10^{-7}/sec under a crevice corrosion environment. The Alloy 52 weld specimens were machined to have a gauge length entirely made up of the Alloy 52 weld, which showed no sign of SCC at a strain rate of 1×10^{-7}/sec under a crevice corrosion environment. Ductile dimples were prevalent on the fracture surface of the tested Alloy 52 weld specimens. The corrosion fatigue crack growth rates of the dissimilar metal weldments, Alloy 52-A 508F1, increased with crack extension under the nominally constant ΔK loading mode. It could be a result of an increase in the tensile residual stress and a decrease in the crack closure effect with the weld depth. The post weld heat treatment at 621°C for 24 hours induced Cr-carbide precipitation along grain boundary, which could lead to sensitization and an increase in stress corrosion crack growth rate. The SCC crack growth rate for the dissimilar metal weld, Alloy 52-A 508F1, was 1.6 times the crack propagation rate for the similar metal weld, Alloy 52-Alloy 690, and their threshold values for SCC were also lower accordingly.



Effects of Water Chemistry on the Environmentally Assisted Cracking Growth Rates for the Pwht Dissimilar Metal Weld, Alloy 52-a508, in 300°c Water Environments.

2 Nuclear Facilities Decommissioning and Radioactive Wastes Management

Horng-Bin Chen

In order to achieve the nuclear facilities decommissioning, and to establish the mission requirement of radioactive waste treatment technologies, INER drafted the following four objectives of general plan to establish the independent technology, so as to apply on the nuclear facilities decommission. The first is to devote to decommission plan and execution ability of nuclear facilities. The second is to achieve clearance and reuse of the plant by cautiously dismantle and retrofit of the nuclear facilities. The third is to develop aggressively on radioactive waste restoration, decontamination, size-reduction, stabilization, and safe storage technologies. The fourth is to establish domestic low-level radioactive wastes final disposal technology.

This year, the difficult technical works (including treatment of spent fuel, spent resin, and Uranium sludge within TRR fuel pool, and dismantle of transuranic related experimental facilities within 016 Hall) have under careful ongoing planning. Dismantle of transuranic related experimental facilities within 016 Hall is currently focused on removal of contaminated pipeline, toward the goal of α pollution-free laboratory. The stabilization procedures of TRR spent fuel include: hot cell operation, sealing welded of outer storage cask, and neutron measurements of nuclear materials. After verified by competent authority, we have completed the operation of placing 2 sets of stabilize products into temporary storage box. High-level spent resin is now with the need of developing the technology of removing TRU from greater than class C spent resin. The wet oxidation and supercritical water oxidation technologies for the degradation of organic waste are developed. The final disposal of low-level radioactive waste has considered both near-surface and tunnel disposal methods. The migration behavior of nuclide in different disposal methods is the main focus. High-level radioactive waste disposal is currently focused on assessing the feasibility of long-term storage.

We also pay attention to international cooperation in this project. The cooperation with the laboratory of U.S. DOE, under the Taiwan-US Nuclear cooperation conference, showed significant achievement on material inventory (SPCC、BPCC) on spent fuel. We also participate in OECD/NEA Cooperative Program on Decommissioning (CPD). With an non-NEA Member State status, INER has been accepted to participate as an official CPD Member. At the same time, we participate in East Asia Forum on Radwaste Management Conference (EAFORM) to establish the regional technical cooperation platform with country like Japan and Korea. This year, we signed "Letter of Intent on Radioactive Waste Management Technical Cooperation" with Japan's Central Research Institute of Electric Power Industry (CRIEPI), which helps our technical corporations.

2.1 Sample Analysis of TRR's Biological Shielding and Waste Classification Evaluation

Ling-Shiau Li

One of the most important tasks during the planning phase of nuclear facility decommission is waste survey. In order to understand the biological shielding of TRR, we implement sampling procedure of biological shielding through drilling holes, sample slicing and analysis. The results of the analysis characterize the activation condition of biological shielding and could be an important source for subsequent dismantle method and waste inspection.

In 1999, the biological shielding had been inspected by taking hole drilling samples at 4 different positions. In order to get an extensive understanding of the activity change after long-term storage, and evaluate the quantity of radioactive waste generated during dismantle and clearance waste, 17 holes have been planed to drilled on horizontal and vertical surfaces of biological shielding. The distance of the hole varied from 1m to 4m to the side of the TRR, and will be renumbered. A total of 297 samples will be made to implement the activity analysis.

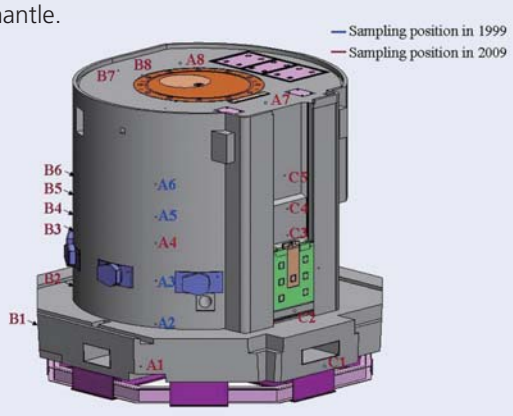
According to the sample analysis results of biological shielding, we can classify 3 activation region: (1) base on the analysis of A, B, and C sampling location, the biological shielding are normally activated due to neutron irradiation; (2) the activation caused by the asymmetry of shielding (on top of the thermal neutron chamber); (3) the activation caused by the bottom layer of ventilation duct (at the bottom of TRR).

In combination with the CAD model and sampling analysis data of biological shielding, we use figuration to show the activated region within the biological shielding. The advantage is to replace the complicated sample analysis data by easy understanding visual graphic, which is very helpful to subsequent planning on cutting and removal.

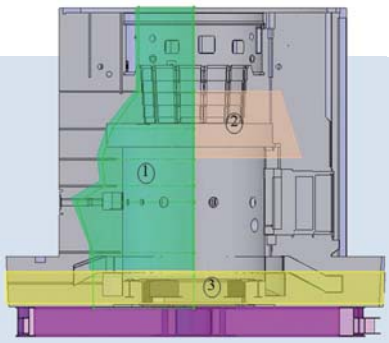
The evaluation result of the sample analysis data showed that the overall volume of activated region is about 145m^3, which equivalent to 350 tons; the volume of potential released region is about 650m^3, which equivalent to 1,500 tons.

The more detailed and complete investigation on activation of biological shielding and waste survey, the better we can control the planning and developing of the cutting and removal methods. Therefore reduce the possibility of cross contamination during the cutting and handling period, clearance the waste, reduce the quantity of radioactive waste, accomplish the size reduction, and enhance the work efficiency on dismantle.

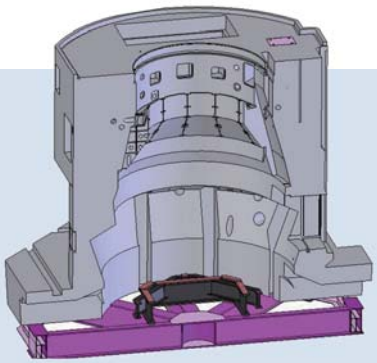
▲ Drilling Samples on Top of Biological Shielding



▲ Sampling Position



▲ Activated Region of Biological Shielding



▲ Profile of Potential Clearance Region

2.2 Sampling Device of High-Level Spent Resin within TRR Fuel POOL

Kuo-Yuan Chang

Cleaning TRR Fuel Pool is an important work, it needs to remove all the wastes out of fuel pool. In order to develop appropriate technology for stabilization treatment, thus implement the sampling and analysis of spent resin to survey its attributes. Major work in this year is, after verify with the analysis data from 1998, to establish the activity inventory data of spent resin as the source of subsequence procedures planning.

Spent resin comprises high-level fission products leak from the failure fuel rod. In order to analyze the nuclide and specific activity of spent resin within the cask, we need to design rigorously and perform carefully the sampling procedures. Key point is to remove the spent resin out of the cask by using the sampling device in the condition of not to disturb the spent resin within the cask so as to obtain the representative samples from different depths.

The sampling device comprises of sampling pole, control unit, pneumatic cylinder, sampling container, and depth guide device. Operator sticks the sampling pole into the cask, using the depth guide device to locate the position, then control the pneumatic cylinder by control unit, and suck the spent resin into the sampling container. After removing the sampling pole out of the fuel pool, control the pneumatic cylinder by control unit, and squeeze the spent resin out of the sampling container.

The sampling device has completed its function testing, and has been successfully implemented in sampling 31 cask of resin within fuel pool radiation area. The operator can implement the sampling by long-distance operation, which effectively reduce the radiation dose of operator, and protect their safety.

▲ Sampling Process

▲ Sampling Device

2.3 Dismantle Facilities with Trans-Uranium Contamination

Chung-Shin Lee

The goal of dismantle facilities with Trans-Uranium contamination at building 016 is to cleanup the building and make it an α contamination-free laboratory. Two large-scale α-contaminated glove boxes (Unit 20 and Unit 21) have been successfully dismantled and the final report has been approved by AEC. In year 2009, the dismantle and decontamination of 5 small grove boxes and conveyer system within the analytical line lead-cell and inspection, categorization, packaging and treatment of radioactive wastes was performed at isolated operation areas in building 016.The final report of this task has been approved by AEC. Beside, the checking, inspection, surface decontamination, and dismantle planning of α-contaminated piping systems (include under ground, through walls and, through floor) was successfully finished with no security and safety issues.

▲ The Analytical Line Lead-cell in Building 016

▲ The Analytical Line Lead-cell After Distentling

2.4 Quality Accreditation and Technology of Measurement Traceability Established by Clearance Measurement Laboratory

Huang-Sheng Chiu

The Clearance Measurement Laboratory (CML) was formally established in October 2007 in aims to comply with the policies on waste reduction and resource reuse, and conform to the decommissionings and cleaning plans for a part of the old nuclear facilities in the Institute of Nuclear Energy Research (INER). The duties of us are to solve the problems with the radiowaste clearance measurements and study all kinds of waste measurement procedures and technologies. We are also engaged in researching and designing the local large-scale equipments of radioactivity measurement, and providing the accurate results of specific activity measurement in accordance with the domestic regulations for the determination of clearance or release.

To assure the measurement quality and credibility of radiowaste release, we had applied for the international quality accreditation ISO/IEC 17025 of testing laboratory in the field of ionizing radiation from the Taiwan Accreditation Foundation (TAF) in 2008. On Jan. 21, 2009, we were accredited to be the first professional laboratory of radiowaste measurement in Taiwan.

We participated in the proficiency testing held by the National Radiation Standard Laboratory (NRSL) in 2009 to enhance and prove the measurement ability. It showed that all of the analysis results could meet the prescribed settings based on accuracy and precision. Therefore, the analysis results were traceable to the national standard of ionizing radiation, and the measurement qualities of clearance or release were proved to carry more public confidence.

In the future, we will continue to comply with the authority policies, cooperate with the TAF, and improve the technologies and the norms of radioactivity measurement to establish the domestic traceability system on radiowaste measurement as well as making the measurement results geared to international standards. We will also continue to study all kinds of the measurement procedures and technologies of radiowaste activity. With the practical experiences of clearance or release, we will provide more accurate measurement results of specific activity for the technical services and the third-party verification of the clearance of the nuclear facilities in Taiwan, and solve the problems of the customers relating to radiowaste release. The ultimate goals are integrating the related technologies and the instruments of clearance, transferring the technologies to the domestic manufacturers, and helping the nuclear facilities at home and abroad create the business opportunities with radiowaste clearance.

▲ Clearance Measurement Laboratory

▲ TAF Certification

2.5 Proficiency Test for Measurement and Analysis of Clearance Samples

Huang-Sheng Chiu

Domestic nuclear facilities perform the classification, measurement, release, and storage of radioactive waste generated from decommissioning or operations of the facilities by following "Regulations on Clearance Level for Radioactive Waste Management" enacted by the Atomic Energy Council (AEC). Looking into the competence requirements of the measurement laboratories, National Radiation Standard Laboratory (NRSL) perform the proficiency test of clearance measuring instruments according to the technology criteria draft for the radiation waste clearance measurements.

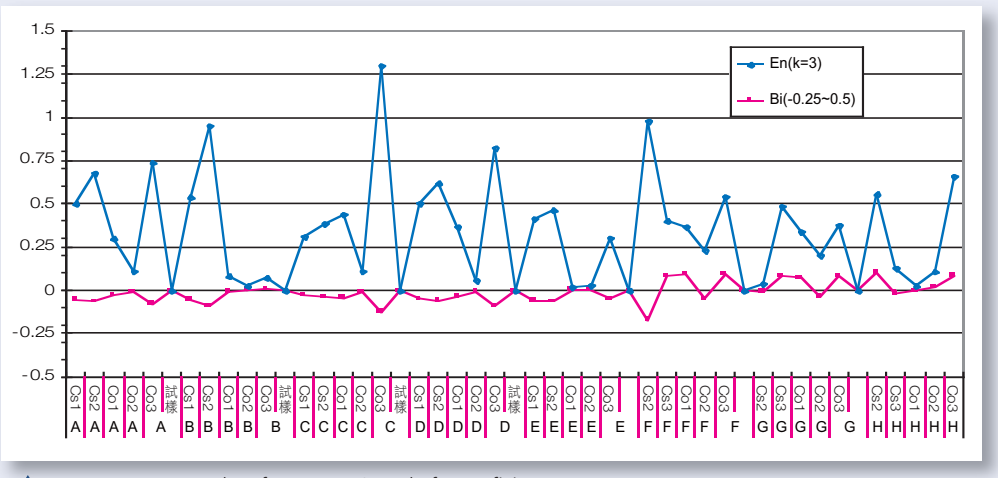
There are two types of measurements for measuring instruments: barrel and box. The detector used in the measurement included plastic scintillation detectors and germanium detector.

The density of the tested sample was~1.0 g/cm^3, the specific activity range was 0.01 Bq/g~0.1 Bq/g, and the radionuclides used were Cs-137 and Co-60. The test box was a 34cm wide, 36cm tall, and 0.1cm thick stainless container with an internal diameter of 34cm. The test barrel was a 0.1cm thick iron container with an internal diameter height of 86cm and diameter of 56cm. In order to calibrate all kinds of measurement systems and acquire counting efficiency, 1.0 g/cm^3 solutions of Cs-137 and Co-60 were prepared respective in boxes as the standard calibration source.

5 laboratories with a total 8 measuring instruments participate in this proficiency test. The results showed that (with 18 drum-type samples and 30 box-type samples) except one box-type sample's En＞1, all the other samples' En ≦1, deviation between -0.25 to 0.5, and combined uncertainty ≦20%. Also the minimum detectable activity (MDA) of ^{60}Co and ^{137}Cs met the release requirement of 0.1Bq/g defined by IAEA.

▲ Drum-type Solution Sample

▲ Box-type Solution Sample



▲ Measurement Results of Box-type Sample for Proficiency Test

2.6 The Implementation of SWAM3 Integrated Clearance Monitor

Mao-Chen Liu

The SWAM3 Integrated Clearance Monitor is designed for the clearance measurement of radioactive solid wastes. The integrated monitor can measure the activity of the solid waste and the surface dose rate of the drum. The Integrated Clearance Monitor can detect up to 455kg or 55 gallons of solid waste for each batch. The monitor has high throughput by quick integral measurements and the power driven feed door. The throughput is approximately 1,200 kg/hr. To achieve quick integral adjustments, some settings are automatically made via the PC and

periodically checked by the system program. The layout of the unit is like a classical 4 π monitor with 6cm lead on backside of detectors. It comprises 10 500mm x 500 mm x 100mm plastic detectors that are mounted inside a lead-shielded rectangular cabinet fitted with a 4cm lead shielded door. The detectors are arranged on four sides and on top and bottom of the assembly. The outer dimension of the cabinet is 1800mm high, 1590mm long, and 1450mm wide. The sensitivity which results from a large geometrical factor and high probability of response enables a fast measurement to be made with low detection limits. MDA of the SWAM3 Clearance Monitor is less than 65Bq for Co-60 within 120sec and 200Bq for Cs137 within 120sec under 0.1μSv/h background radiation. With three surface dose rate modules, the SWAM3 can also monitor the surface dose rate of the drum simultaneously.

▲ SWAM3 Integrated Clearance Monitor

▲ Surface Dose Rate Subsystem

2.7 Research on Treatment for Radioactive Spent Ion Exchange Resin of Greater Than Class C

Yih-Ping Chen

Some 20 m^3 of radioactive spent ion exchange resin has been generated after decommission of Taiwan Research Reactor (TRR) in the Institute of Nuclear Energy Research. The spent resin, containing α, β and radionuclides (Pu, Am, Cs, Sr and Co), is categorized as radioactive waste of greater than class C (GTCC). Since no commercial application for treatment of this type of waste is currently available, it is urgent to develop technologies to reduce the volume of the waste and make it stable for the benefit of the environment.

With this in mind, the three-year project, research on treatment for radioactive spent ion exchange resin of greater than class C, has been devoted to several approaches to achieving the goal. A couple of performances were completed in the project in 2009. In terms of improvement of the process of *wet oxidation and high efficiency solidification technology* (WOHEST), a total of 9 materials were employed for anti-corrosion test (300 hr) in the wet oxidation process and the qualified one has been screened. In addition, the nickel-based catalyst has been developed and is able to decompose ammonia into nitrogen and hydrogen between 750°C and 850°C for above 550 hours without losing its activity. Meanwhile, the optimal strategy was developed for the GTCC waste treatment by removing TRU from the spent resin first, proceeding to employ WOHEST for the decomposition of TRU-deprived resin, which assorted as class C or class B. The

optimal removal rate of Nd^{3+}(surrogate of Pu^{3+}) from resin with 10% sulfate acid and 100 ppm Ce^{4+} is 99.86% while the optimal coprecipitated rate of $Nd^{3+}$with $Fe(OH)_3$ is 98.7%. The pre-separated TRU waste can be further conditioned by vitrification to form a stable waste for interim storage or disposal.

Experimental Result on Desorption of Simulated TRU Elements

Desorption conditions	Desorption efficiency (%)
10% sulfuric acid at ambient temperatures	**76.70**
10% sulfuric acid at 80 °C	**80.65**
10% sulfuric acid	**76.72**
10% sulfuric acid + 100 ppm Ce^{4+}	**99.86**
10% sulfuric acid	**72.95**
10% sulfuric acid enhanced by ultrasonics	**75.18**

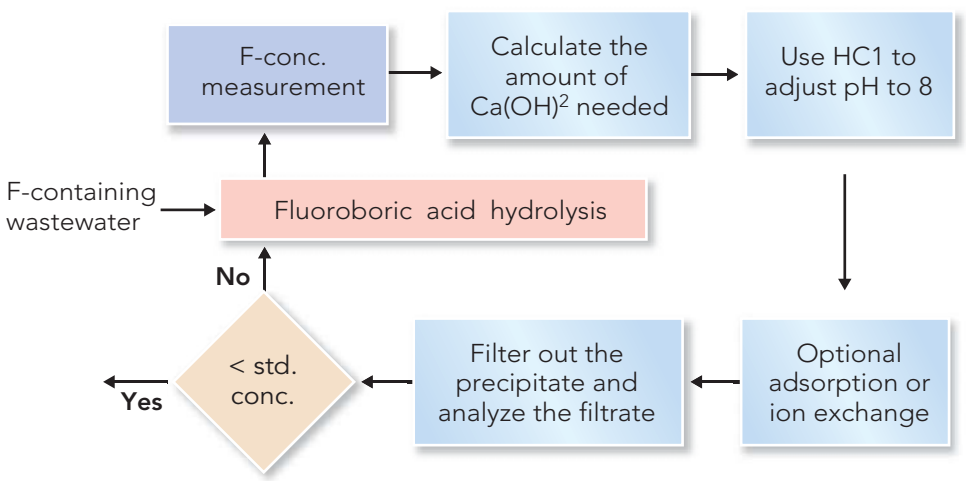
Corrosion Test for Several Materials in the Process of Wet Oxidation

No.	Material	Initial weight (g)	50hr weight (g)	100hr weight (g)	200hr weight (g)	300hr weight (g)	300hr corrosion rate mm/year
1	Hastelloy-B2	64.7764	19.7982	—	—	—	309.590
2	UNCO -50	23.1464	23.1466	23.1469	23.1616	23.1682	0.000
3	Nb	10.9605	10.9532	10.9464	10.8636	10.4244	0.938
4	Hastelloy-C276	23.0544	23.0438	23.0336	23.0032	22.9723	0.127
5	Inconel-600	14.3793	14.3806	14.3926	14.3963	14.4084	0.000
6	Ti -Gr2	20.4902	20.4058	20.2571	20.0919	19.8511	1.628
7	Ni -200	59.3552	55.9262	55.1597	47.4496	34.3145	30.106
8	Ni -2200	70.2868	69.6203	68.5350	63.3581	54.2205	18.168
9	Zirco-702	38.8505	38.8478	38.8476	38.8637	38.8472	0.005

2.8 Treatment of Fluoride-Containing Wastewater Generated from Metal Decontamination

Chi-Hung Liao

Two types of decontamination technologies, mechanical and chemical decontamination, are adopted by INER to treat metal scraps from nuclear decommissioning. Among these, chemical method is best suited for treating metal scraps that have complex geometry. For the decontamination of stainless-steel scraps, fluoroboric acid-based decontamination agent is used; as a result, acidic fluoride-containing wastewater will be generated. A pretreatment step therefore is needed to lower the fluoride level in wastewater before delivering to the wastewater treatment plant of INER. In this study, calcium hydroxide precipitation method was used to treat wastewater containing high level of fluoride. Such method has the advantage of simple and low cost. The mechanism is to have the added calcium ions reacted with fluorine ions in wastewater to form calcium fluoride precipitate ($Ca^{2+}(aq) + 2F^{-}(aq) \rightarrow CaF_{2(s)}$), which can be subsequently removed by filtration. In addition, it was found in this study that adding hydrochloric acid (maintained at pH 8) may further improve fluoride removal efficiency. This is because hydrochloric acid will react with calcium hydroxide to form calcium chloride ($Ca(OH)_{2(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + 2H_2O_{(l)}$). This will increase the solubility or the utilization of calcium hydroxide in wastewater. Furthermore, calcium chloride will also release calcium ions to form calcium fluoride precipitate with fluorine ions ($CaCl_{2(aq)} \rightarrow Ca^{2+}_{(aq)} + 2Cl^{-}_{(aq)}$; $Ca^{2+}_{(aq)} + 2F^{-}_{(aq)} \rightarrow CaF_{2(s)}$), hence, improving fluoride removal efficiency. It is known that fluoroboric acid will dissociate into BF_4^- and H^+ ions in water. However, BF_4^- is a stable complex which will not dissociate immediately but rather slowly in time. Therefore, it is suggested that a hydrolysis step, usually thermal or catalysis hydrolysis, is performed on the wastewater before carrying out calcium hydroxide precipitation. By implementing the above-mentioned techniques, the fluoride-containing wastewater in INER was successfully treated to give a fluoride-removal efficiency of 99.9% and the quality of the treated wastewater was in conformity with the requirements.



▲ Process for treating F-containing wastewater

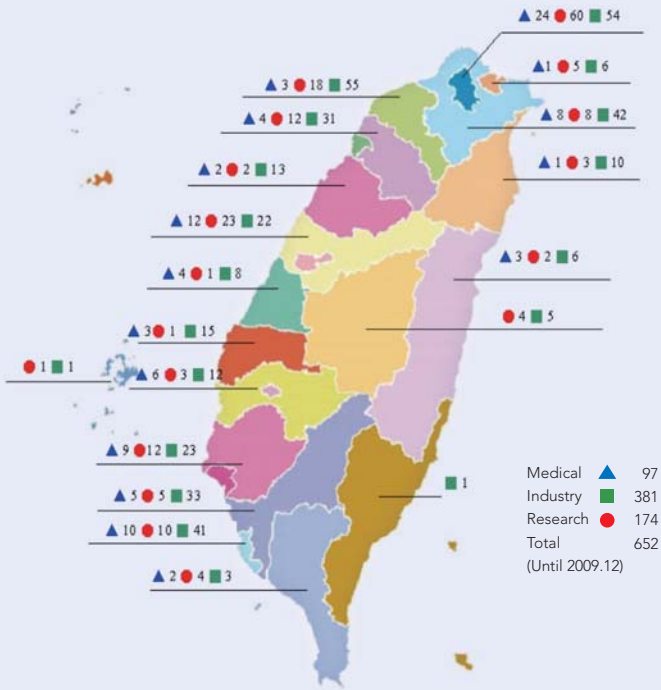
2.9 Study on Establishment of Quantitative Estimation Methodologies and Relevant Strategic Management Plan for Small Users Radioactive Waste Final Disposal

Fu-Lin Chang

Final disposal is the preferred option to solving problem of radioactive wastes from medicine, industry and research (MIR waste or small users waste). The project objective of 2009 focuses on the establishment of quantitative estimation methods for the low-level radioactive wastes generated from small users. The research scopes included investigate the quantitative and characteristic for routine, accepted and decommissioning wastes in INER. Moreover, the quantitative estimation methods including spent sealed radioactive sources in the future were established. Discussions are especially focus on spent sealed radioactive sources and decommissioning wastes from research reactors.

The quantitative estimation methods for decommissioning wastes of non-fuel-cycle facilities were following to U.S. NRC technical reports. It also combines the decommissioning information about Taiwan Research Reactor (TRR) and Zero Power Reactor at Lungtan (ZPRL) in INER, and Tsing-Hua Open pool Reactor (THOR) to establish quantitative estimation methodologies.

Finally, this project finished the important checking items, check lists and tables for quantitative estimation methods to provide the investigation in the future. It's also based on IAEA technical guides and international experience; domestic strategic management plans on small users radioactive waste final disposal are suggested. The project results will helpful for further facility design and safety assessment of low-level radioactive waste repository in Taiwan.



▲ Distributions of the Low Level Radioactive Wastes Accepted by INER and Generated from Small User Facilities

▲ Illustration for Spent Sealed Radioactive Sources

2.10 Feasibility Study for Long-Term Storage of Spent Nuclear Fuels

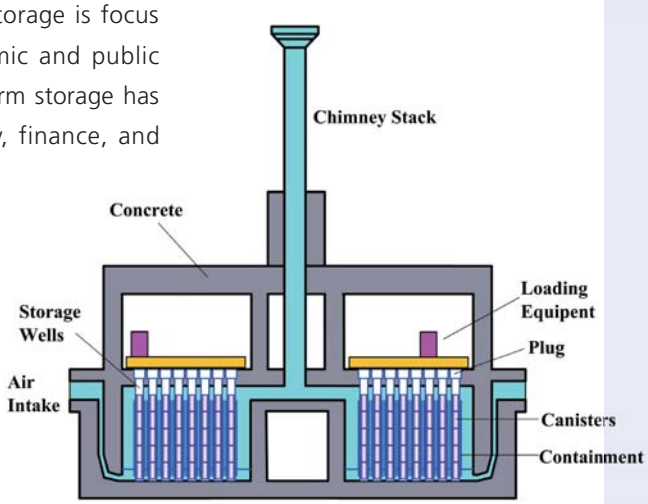
Li-Min Chi

For spent nuclear fuel, the best international consensus option is deep geological disposal. Difficulties have been encountered in most countries, however, in proceeding with the development and construction of disposal facilities for spent nuclear fuel and as yet no such disposal facilities are in operation. In recent years, a long-term storage option has been given consideration seriously in some countries. The INER was requested by AEC to investigate the role of long-term storage in a sustainable program of spent nuclear management, and especially the implications for safety. The schedule of study is from 2007 to 2009. The purpose of the study is to reflect the worldwide status. It is intended for use as reference documents for policy discussions.

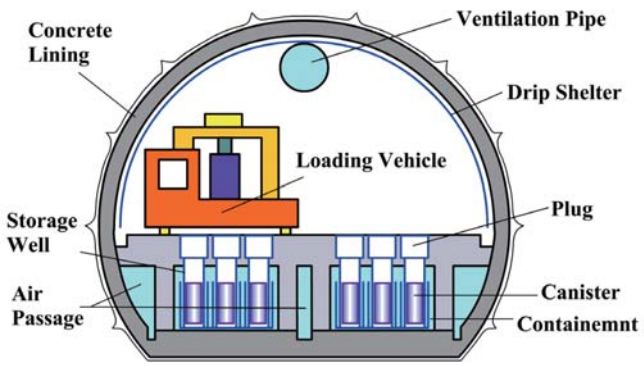
Since reprocessing is one possible option for spent nuclear fuel, in 2009, this study also focus on facilities requirement and operation concept for the long-term storage of vitrified high-level waste. Two types of storage concepts are developed, building and cavern.

Finalize feasibility study of long-term storage is focus on discussion of safety, technical, economic and public acceptance issues. The conclusion is long-term storage has possibility to sustainable if policy, industry, finance, and societal consensus can maintain these responsibilities.

The study results provide the regulatory authority with scientific basis to further make the long-term storage policy decision for spent nuclear fuel management in Taiwan.



▲ Concept of Storage Building.



▲ Concept of Storage Cavern.

3 Biomedical Application of Radiation Technologies

Research and Development of Radiation Biomedical Application

Kuan-Yin Chen

Bio-technology is attached great importance to the new industries in 21st century. It was taken as one of the key plans to follow the acts of "Challenge 2008 National Developing Key Plans" and "Two Trillion, Twin Star" that were gave fresh impetus to industries. Our government was giving every effort on" Diamond Action Plan for Biotech Takeoff" to speed up the development of Bio-technological industries in 2009. The purpose and orientation of development for the Radiation Application Technology Center (RATC) of INER provided the domestic hospital clinical applications for care the people's health and early treatment of related diseases. RATC developed medical radioisotope, new nuclear medicine, and irradiation therapeutic technology for both diagnosis and therapeutic demands, image fusion technology, technical service, created GMP, ISO-9001 (2000) and ISO-13485 with their connected SOP, to promote the competitive ability of country industry, can be described as below:

RATC has published 190 internal reports, 41 papers in international journal (26 papers in SCI), applied patents for 25 items, acquired 10 patents, and received NTD 7,911,000 as the technology authorizing, moreover, NTD 104,238,000 as the technology service, submitted 1 permission license for INER ECD Kit and had 2 seminars, all above are achieved performance in 2009.

As technology developing, fourteen items of technology has been developed and listed below: (1) Beamline Extension and Switching Magnet System of the INER TR30/15 Cyclotron. Thus the production yields of our radioisotopes increased and this was good for the medical diagnostics in domestic hospitals. (2) Development of INER Sodium Fluoride [F-18] Injection. It is expected to provide positive helpful meaning for helping bone cancer patients in routine diagnosis and therapy evaluation. (3) Development and Registration of INER ECD KIT and Multi-center, Registrational Trial for the Dopaminergic D2 Receptor Imaging Agent, I-123-IBZM. These studies were served as the clinical efficacy and safety evidences during new drug application. We anticipate the study can provide a more accurate method for evaluating neural diseases. (4) Development and in vitro Evaluation of Glycol-derivative Drug with Hepatic High-affinity. (5) Multimodality Imaging of Lu-177-AMBA for Human Prostate Tumor-bearing Mice. (6) MicroSPECT/CT imaging of In-111-liposome in NCI-H292 lung cancer bearing mice model, Comparative Therapeutic Efficacy of Re-188-Liposomess and 5-FU in LS-174T human Colon Carcinoma Solid Tumor Xenografts and Development of Co-60 Irradiated Carbon Nanotubes were focused on development of nano-nuclear pharmaceutical detections or therapy for cancer. (7) Pharmacokinetics for an ASGPR Biomarker. (8) Radiopharmaceutical Characterization Laboratory Passed the Inspection of Good Laboratory Practice (GLP) for Nonclinical Laboratory Studies of Department of Health, Taiwan in 2009. (9) The Annual Operation Report of Cobalt-60 Facility in INER. (10) Establishment of dose area product measurement standard.

The current project achievements and future developments are further illustrated as follows:

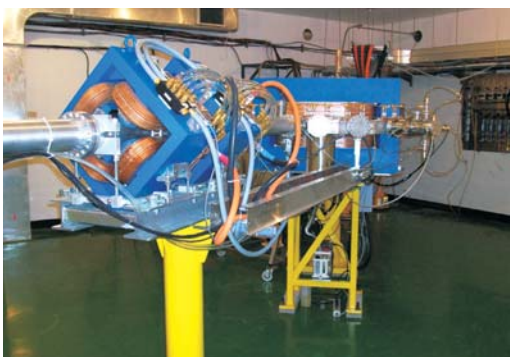
3.1 Beamline Extension and Switching Magnet System of the INER TR30/15 Cyclotron

Ting-Shien Duh

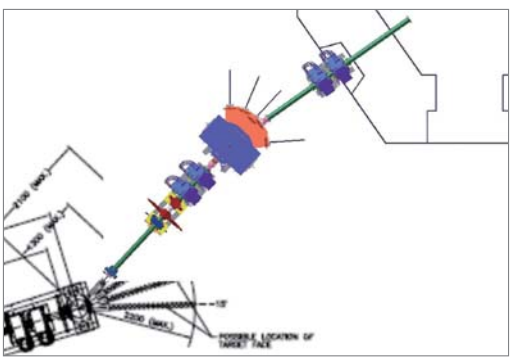
INER TR-30/15 cyclotron, used mainly for radio-isotope productions and proton beam irradiation service, started operation in 1994. The original beamline specification of INER TR-30/15 cyclotron had four beamlines with nine beam exit ports. Up to now, there are eight target stations, including two solid target stations, a gas target station, four liquid target stations and an external beam station. The last beam exit port is used for beamline extension. The project of beamline extension was scheduled to be done by the end of 2009, with design and manufacture in 2008 and installation and test in 2009.

The beamline extension and switching magnet system was completed in 2009. The beamline is extended from beam-port 2B4 in R&D cave, with the beamline components consisting of a gate valve, a vertical steering magnet, an adjustable collimator, a beam stop, a quadruple doublet, a switching magnet with five beam ports and a pumping system. One of the new ports is planned to connect with a high power solid target station in the near future, for that reason a downstream beamline with a quadruple doublet was built in advance. The remaining ports will be used for new research projects in the future.

In summary, there will be five more beam exit ports available for our cyclotron after the beamline extension project finished. With these beam ports more target stations can be set up for new research projects. In addition, after setting up the high power solid target station for our cyclotron, the production yields of our radioisotopes will be increased, and this will be good for the medical diagnostics in domestic hospitals.



▲ A Picture of Beamline Extension.



▲ A Schematic Diagram of Extended Beamline Components.

3.2 Development of INER Sodium Fluoride [F-18] Injection

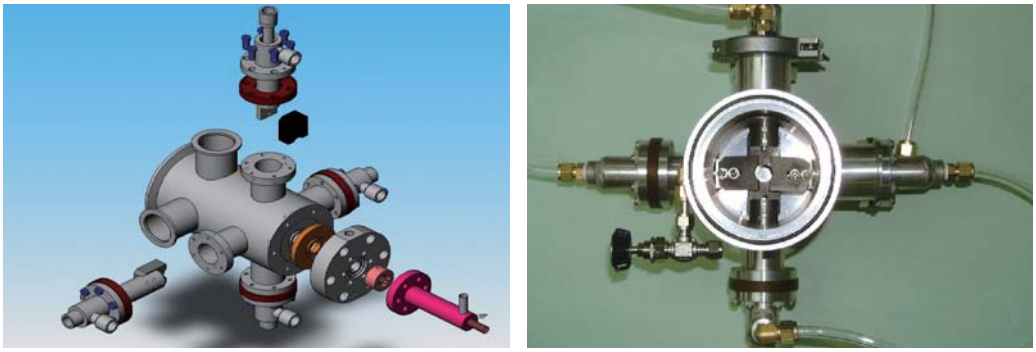
Jenn-Tzong Chen

Because of the global shortage of Mo-99/Tc-99, generator the production of nuclear medicine with this nuclides were decreased. Therefore, Society of Nuclear Medicine in Taiwan recognized the world crisis and requested the new demanding of nuclear medicine to INER. On June 24, 2009 the discussion meeting was held in INER, foreign experts and scholars were invited to attend this meeting for consultation proper responses to this world wild situation. The conclusion is to develop INER Sodium Fluoride [F-18] injection as soon as possible and acts as one of the Atomic Energy Council's policy. Technetium-99m is the most popular and commonly used nuclear medicine for medical purpose. Technetium-99m related nuclear medicines in Taiwan account for about 70% of use and mainly used in bone, heart, kidney function, lung function and other nuclear medicine imaging.

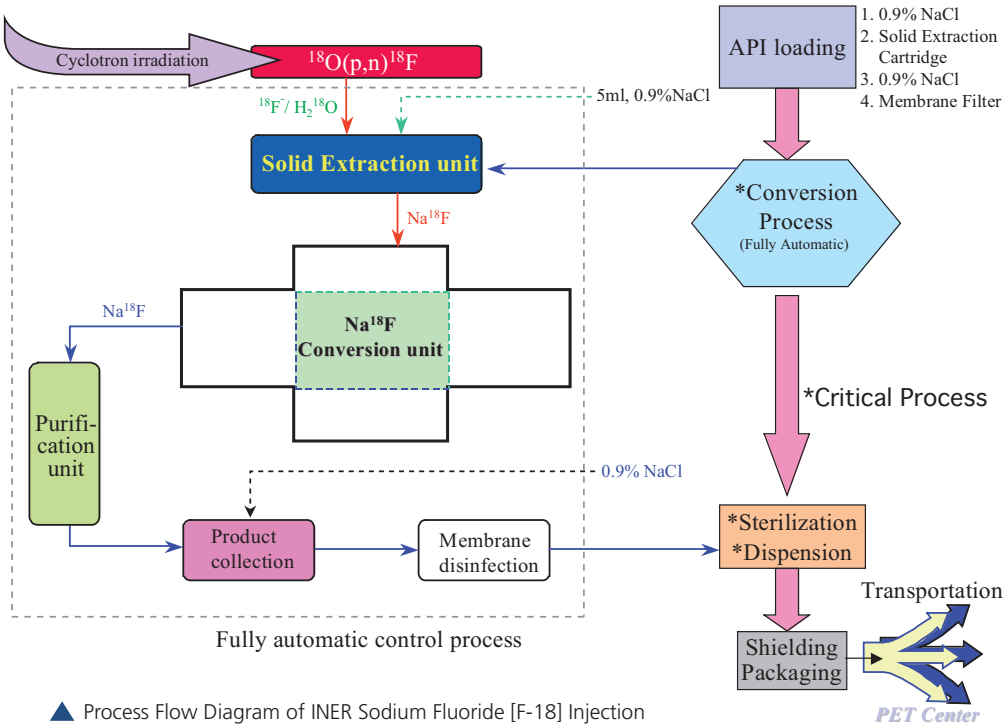
Technetium-99m is decayed product from parent nuclide Mo-99 with the half life of 6 hrs. Mo-99 is the fission product from the neutron bombarded target in a nuclear reactor. In accordance with the current status of the global situation, it will not be a steady supply of technetium-99m by nuclear reactor, because of the life time is limited as well as those arising from the high-level radioactive waste disposal problems. Nuclear medicine community is trying to pursue other alternatives to resolve this dilemma, in order to protect the quality of the relevant patient's medication. The major alternative is to process another medical radioisotopes production equipment - cyclotron. Technetium-99m labeled compound applied in bone imaging applications in nuclear medicine diagnosis accounted for about 80%, and cyclotron produced Sodium Fluoride [F-18] is the best alternative choice of technetium-99m in bone scan imaging nuclear medicine.

The development of INER Sodium Fluoride [F-18] Injection research program have developed a new conversion process from Hydrogen Fluoride in a short time after exchanging the experience with Taiwanese Society of Medical Cyclotron and the consultation from the Society of Nuclear Medicine in Taiwan. The conversion process is based on the liquid target and target material delivery system which is designed and fabricated by Isotope Application division at INER. Process establishment and validation for complying GMP regulation are then accomplished within 3 months. Gradually complete the whole process in the shortest time to evaluate the Hydrogen Fluoride [F-18] produced from the liquid target system to Sodium Fluoride [F-18] solution in an automatic process. The initial conversion rate was about 80 percent, and subsequently developed the conversion process of Sodium Fluoride [F-18] in the manufacturing process with conversion rate up to 90 percent. INER is working on getting the radiopharmaceutical license of INER Sodium Fluoride Injection in equal review standard comparing to the license approving procedure of INER Fludeoxyglucose Injection from TFDA in 2000 in order to shorten the review and clinical trial time required for listing on the identification registration.

INER Sodium Fluoride injection is a new generation bone scan nuclear medicine, and belongs to positron emission nuclide for PET scan application which provides a very good quantitative clinical effect. Sodium Fluoride [F-18] provides the potential to replace the procession of the 80% utilization of nuclear medicine in Taiwan. It is expected to provide positive helpful meaning for helping bone cancer patients in routine diagnosis and therapy evaluation.



▲ INER Sodium Fluoride [F-18] Targetry



▲ Process Flow Diagram of INER Sodium Fluoride [F-18] Injection

3.3 Development and Registration of INER ECD KIT

Mei-Hsiu Liao

Nuclear imaging, such as single photon emission computed tomography, is a powerful non-invasive diagnostic modality that relies on the use of radiolabeled pharmaceuticals and imaging instruments. The physiological and pathological information obtained with nuclear imaging is critical for deciding the most appropriate therapeutic intervention by physicians. Registration of pharmaceuticals for marketing approval, including the radiopharmaceuticals developed by INER, is required before they can be introduced into the market in Taiwan. To meet the local demand for generic radiopharmaceutical tracers, INER started to develop and register for marketing approval of "INER ECD KIT" with the core technology and facility that were established more than 10 years ago. The goal of INER is to develop and manufacture radiopharmaceuticals with high economic value that meet the demand for nuclear imaging in Taiwan.

The development of "INER ECD KIT" started in 2006 and the documents for registration was submitted to the Department of Health (DOH) on June 26th, 2009. The research and development

on the kit formulation, quality control, and various Chemical Manufacture and Control (CMC) documents have been completed and compiled by the time of submission. The supplementary documents, including the analysis method of content uniformity that is critical for process validation, were completely submitted to DOH in December 2009, according to the reviewer's requirements. The registration of "INER ECD KIT" is expected to be approved in March 2010 by DOH. It is a great effort for INER R&D team to keep the registration timeline as scheduled.

The indication applied for "INER ECD KIT" is to image and evaluate local brain blood perfusion in the adult with central nervous system pathology. It is expected that more than 2,000 patients will receive the imaging diagnosis with "INER ECD KIT" at the early stage of marketing in Taiwan. The development and registration of "INER ECD KIT" is a successful project, in which the research conducted in INER can be applied clinically to benefit the public. The marketing of "INER ECD KIT" will also likely bring down the price of the ECD kit to make the cost for brain blood perfusion imaging with Tc-99m-ECD more affordable and therefore benefit more patients.

3.4 Multi-center, Registrational Trial for the Dopaminergic D2 Receptor Imaging Agent, I-123-IBZM

Mei-Hsiu Liao

Parkinsonism is a clinical feature characterized by a heterogeneous group of movement disorder. This type of motor disturbance is seen in several conditions that have in common neuronal degeneration to the nigrostriatal dopaminergic system. The most frequent neurodegenerative causes of parkinsonism are Parkinson's disease (PD), followed by progressive supranuclear palsy (PSP) and multiple system atrophy (MSA). Discrimination between idiopathic Parkinson's disease (IPD) and other neurodegenerative parkinsonian syndromes (non-IPS) is crucial owing to the marked difference in prognosis and therapy.

I-123-IBZM, a benzamide derivative with high affinity to dopamine D2/D3 receptor, has been developed for the visualization of dopamine D2 receptors in vivo with single-photon emission computed tomography (SPECT). In order to market I-123-IBZM, Institute of Nuclear Energy Research (INER) is conducting a multi-center, phase III trial for registration purpose. The clinical trial is contracted with Virginia Contract Research Organization (VCRO). The study aims to evaluate the D2 receptor activities and safety of I-123-IBZM SPECT in the differential diagnosis of Parkinsonian syndromes. A total of 100 cases will be included in this study, including 40 IPD, 40 non-IPD patients (25 MSA patients and 15 PSP patients) and 20 normal healthy volunteers.

The study protocol was approved by Department of Health (DOH) and Joint Institutional Review Board (JIRB). The first case was enrolled in October 2008. Till the end of 2009, clinical evaluation and SPECT scan were carried out in 98 subjects, including 40 patients with IPD, 24 patients with MSA, 14 patients with PSP, and 20 age-matched control cases. Individual study sites are monitored at appropriate intervals to assure satisfactory enrollment, data recording, and adherence to the protocol. The trial is about to achieve subject enrollment and statistical analysis. This study will be served as the clinical efficacy and safety evidences during new drug application. We anticipate the study can provide a more accurate method for evaluating the dopaminergic D2 receptor activity in differential diagnosis of Parkinsonism.

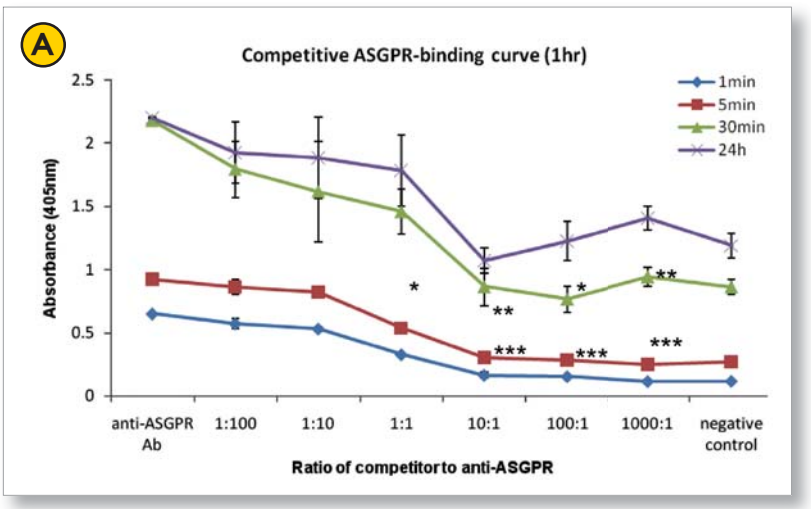
3.5 Development and in Vitro Evaluation of Glycol-derivative Drug with Hepatic High-affinity

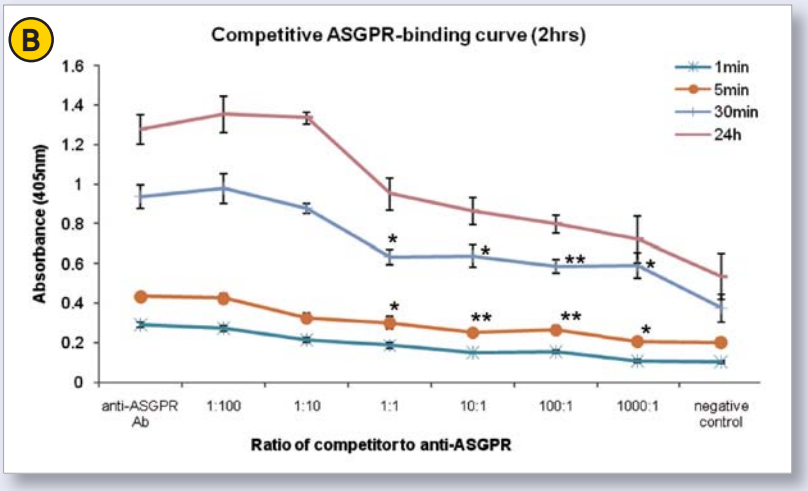
Po-Ching Cheng

Hepatic failure derived from liver cirrhosis or hepatocellular carcinoma continuously to be the leading cause of cancer-related death in Taiwan. The accurate staging of liver fibrosis in chronic liver diseases, especially the early diagnosis of liver cirrhosis, is crucial for prognostic assessment of the disease. Traditionally, liver fibrosis can be diagnosed by biopsy or ultrasonic scanning. However, liver biopsy is an invasive procedure and carries the risk of complications. The sensitivity of ultrasonic scanning is not enough for early diagnosis of liver fibrosis. To overcome these problems, new non-invasive tests based on new laboratory markers glycol-derivative drugs were developed to assess liver functions.

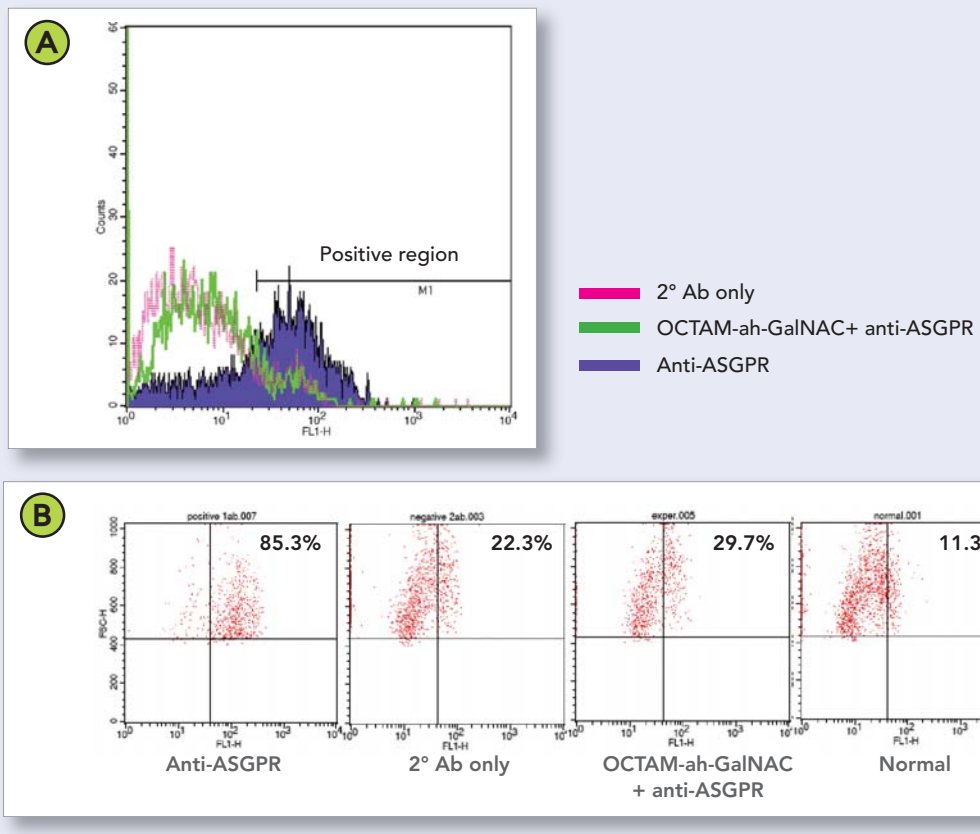
In this study, we used anti-asialoglycoprotein receptor (ASGPR) antibodies to competitively detect the effects of 6-[3′, 6′-Diaza-5′-oxo- 3′-(2″-triphenylmethyl thioethyl)-8′-triphenylmethyl thio] octanamido- hexyl β-N-acetylgalatosamine (abbreviated as OCTAM-ah-GalNAC) that binds on hepatocytes with high affinity and specificity. The ELISA results showed OCTAM-ah-GalNAC in DMSO or 75% alcohols solution were effective to bind on the hepatocytes in high affinity than the competitive test with anti-ASGPR antibody. The effective functional ratios were between 1:1 and 10:1 for anti-ASGPR antibody to OCTAM- ah-GalNAC. Flow cytometry experiments also revealed the frequency of ASGPR positive cells were decreased from 85% to 29% after the competition with OCTAM-ah-GalNAC.

In conclusion, our data demonstrate the efficacy of OCTAM-ah- GalNAC to label liver cells with high affinity. In this study we also successfully established a functional evaluating model of glycol- derivative drugs on binding specificity to hepatocytes. These results are helpful for developing the drugs on hepatic function diagnosis or liver tumor therapy in the future.





▲ Absorbance detected curves on the serial dilution of ratios of OCTAM-ah-GalNAC to anti-ASGPR antibody after **A.** 1hr and **B.** 2hrs hepatocytes competition respectively. The binding competition were administered in 37.5% alcohol with 6.25×10^4 hepatocytes identically. Each line represents the different time-point after ABTS added. Each point represents the mean of at least triplicate values. * $p < 0.05$, **$p < 0.01$, *** $p < 0.001$ when compared with the positive control (anti-ASGPR) respectively.

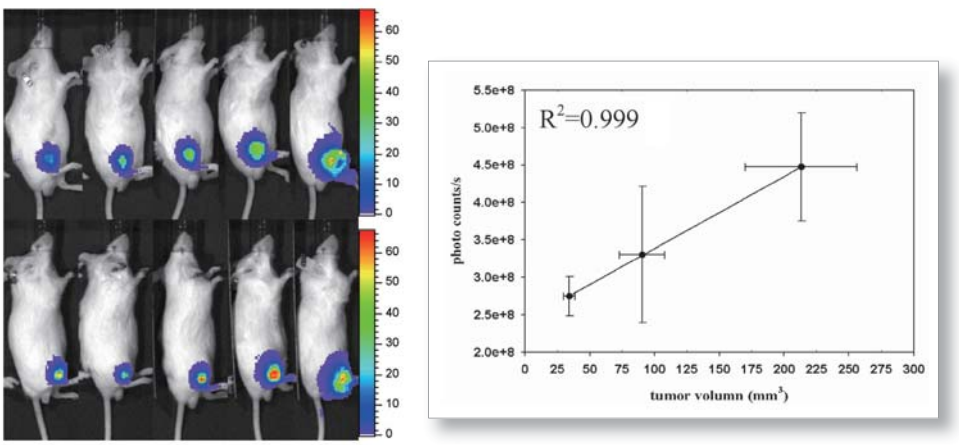


▲ Flow cytometry analysis showed the results of competition between OCTAM-ah-GalNAC and anti-ASGPR antibody after. 2hrs hepatocytes binding. The binding competitions were administered in 37.5% alcohol with 6.25×10^4 hepatocytes identically. (A) Hepatocytes cultured for 2hrs in the presence of anti-ASGPR antibody treatment alone (green line), or OCTAM-ah-GalNAC and anti-ASGPR antibody treatment both (purple shade) were analyzed for anti-ASGPR binding by using flow cytometry. Cells were stained with secondary antibody FITC-anti-mouse IgG1 (pink line) for negative control. The data shown are representative of a typical result. (B) Data of the anti-ASGPR/ FSC-coexpressing liver cells at different treatments of ligand are shown as dot blots for all analyzed samples. The quadrants were set according to the unstained control. Numbers in the right upper quadrant show the cell frequency for each of the different treatments from total hepatocytes.

3.6 Multimodality Imaging of Lu-177-AMBA for Human Prostate Tumor-bearing Mice

Chih-Hsien Chang

AMBA (DO3A-CH_2CO-G-(4-aminobenzoyl)-QWAVGHLM-NH_2), a well-known BN-like compound, is attributed to the high affinity with Gastrin Releasing Peptide Receptor (GRPr) and NMBr (neuromedin B receptor), and Lu-177-AMBA is one of radiolabeled probes which can be used for prostate cancer diagnosis and therapy. Bioluminescent imaging (BLI) is often used to be applied in tumor model system which can monitor tumor growth. PC-3M-luc-C6 is a prostate cell line expressed luminescence. We found that highly positive correlations of tumor growth between caliper and bioluminescent imaging (R^2=0.999). We also analyzed plasma stability of Lu-177-AMBA whether it was added protection buffer, the data showed that the plasma stability of Lu-177-AMBA could still be maintained about 50% within 24 hours when adding protection buffer; compared to without protection buffer, the stability of Lu-177-AMBA was below 15% and completely degraded after 48 hours in normal saline. Biodistribution and microSPECT/CT imaging in PC-3M-luc-C6 tumor showed that Lu-177-AMBA efficiently accumulated in PC-3M-luc-C6 tumor and could be retained for 24 and 48 hours. All of these data indicated that Lu-177-AMBA retained in the PC-3M-luc-C6 tumor, and both BLI and microSPECT/CT dual-modality imaging could be applied to evaluate the growth of tumor and therapeutic efficacy by Lu-177-AMBA.

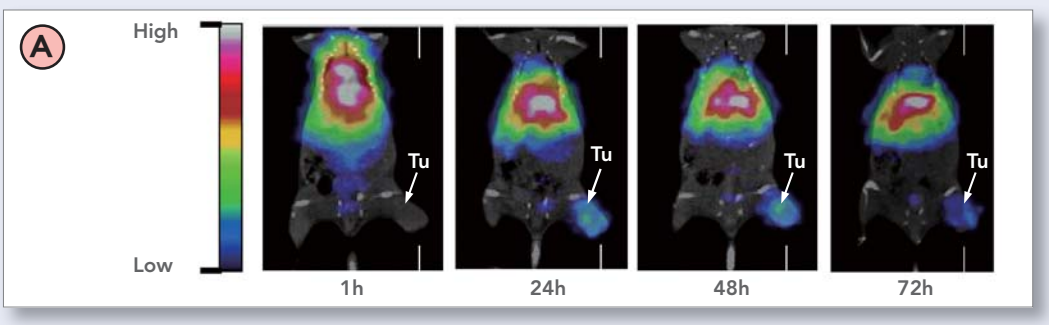


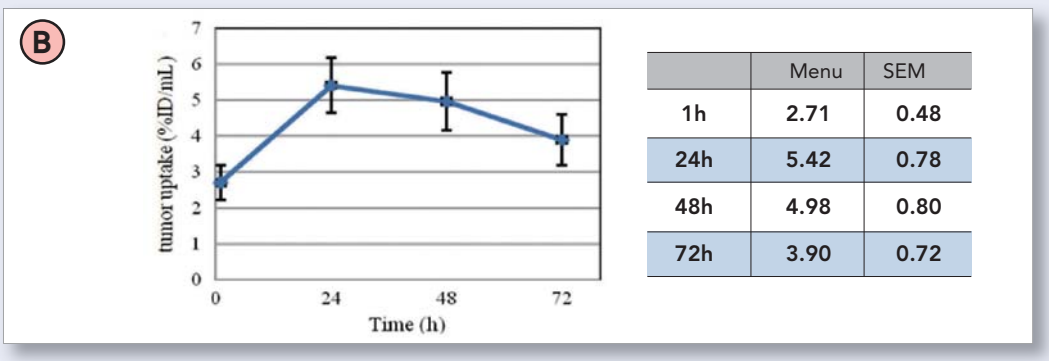
▲ The growth of PC-3-luc tumor in SCID mice was measured by BLI system. Right scheme is the correlation of caliper versus bioluminescence. (n = 5,mean ± SEM)

3.7 7 MicroSPECT/CT Imaging of In-111-Liposome in NCI-H292 Lung Cancer Bearing Mice Model

Te-Wei Lee

Lung cancer is one of the leading causes of death from cancer for human beings. Despite much effort, it is still difficult to predict the response and clinical outcome of the disease. The aim of this study was to investigate the microSPECT/CT of In-111 labeled liposome for lung cancer imaging. Materials and methods were used as followings. The pegylated-liposome was encapsulated with 5 mM DTPA. The liposome was labeled with In-111-oxine. The In-111-Liposome was separated from free In-111-oxine using PD-10 column eluted with normal saline. Mice were intravenously (i.v.) injected of 20-30 μCi In-111-Liposome at tumor volume of ~110 mm^3. The dynamic microSPECT/CT images were scanned at 1, 24, 48 and 72 h after i.v. injections of In-111-Liposome. The following results are observed: The particle size of pegylated-liposome was 99.48 ± 35.79 nm. The labeling efficiency of In-111-Liposome was 96.4%. The microSPECT/CT images of In-111-Liposome showed that the uptake of radioactivity in tumor was peaked at 24 hr after injection, and decreased thereafter. The organs (spleen and liver) of reticuloendothelial system were also accumulated higher radioactivity after injection of In-111-Liposome, but decreased with time. We conclude this study as follows. The microSPECT/CT images showed radioactivity was accumulated in tumor after i.v. injection of In-111-Liposome in NCI-H292 lung cancer bearing mice. The results suggest that microSPECT/CT imaging of In-111-Liposome could be used as a noninvasive method for diagnosis in lung tumor.





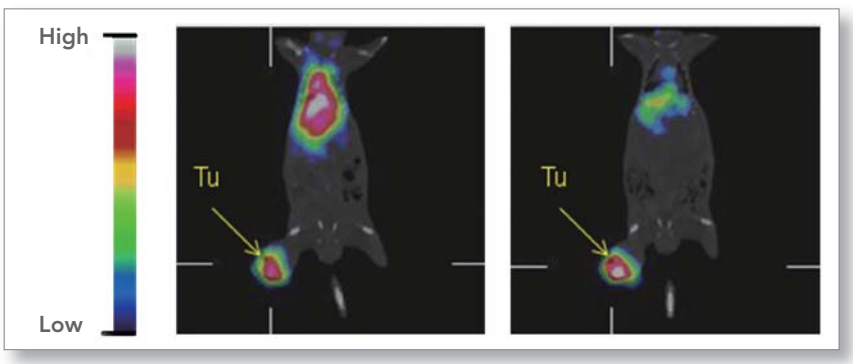
	Menu	SEM
1h	2.71	0.48
24h	5.42	0.78
48h	4.98	0.80
72h	3.90	0.72

▲ (A) microSPECT/CT imaging of In-111-Liposome in NCI-H292 tumor bearing nude mice model. The white arrow indicate the tumor site of the model. The results show that the good uptake of In-111-Liposome in tumor sit.
(B) The quantification of this imaging study show a uptake peak at 24-48 hours after drug administration.

3.8 Comparative Therapeutic Efficacy of Re-188-Liposomes and 5-FU in LS-174T human Colon Carcinoma Solid Tumor Xenografts

Chin-Wei Hsu

Rhenium-188 (Re-188) is a newly developed radioisotope for imaging and therapeutic dual applications due to its short half life with its γ emission and β emission. Radiolabeled liposomes have been approved to show the potential in radiotherapy and diagnostic imaging. The purpose of this study was to investigate the maximum tolerated dose (MTD) of Re-188-Liposomes and 5-fluorouracil (5-FU), one of conventional medicine for treating colon cancer patients, in normal nude mice by intravenous (i.v.) injection. The biodistribution of Re-188-Liposomes administered by the i.v. route in LS-174T human colon adenocarcinoma-bearing nude mice were investigated. MicroSPECT/CT images were performed to evaluate the distribution of drug in mice. Therapeutic efficacy of Re-188-Liposomes and 5-FU in LS-174T colon adenocarcinoma mice was also compared. The results of MTD of Re-188-Liposomes and 5-FU were 29.6 MBq and 180 mg/Kg. For the biodistribution study, the highest uptake in LS-174T tumor was found to be 11.3%±0.99% at 24 h, and the tumor to muscle ratio of Re-188-Liposomes was 16.1%±1.91%. MicroSPECT/CT images of Re-188-Liposomes targeting LS-174T tumors bearing in nude mice, the highest images were acquired at 24 h after injection. The imaging analysis showed a positive correlation of tumor targeting of Re-188-Liposomes between microSPECT/CT imaging and biodistribution. The tumor-bearing mice treated with radiotherapeutics of Re-188-Liposomes showed better tumor growth inhibition and longer survival time than those treated with chemotherapeutics of 5-FU. These results suggested the potential benefit and advantage of Re-188-labeled nanoliposomes for imaging and treatment of malignant diseases.

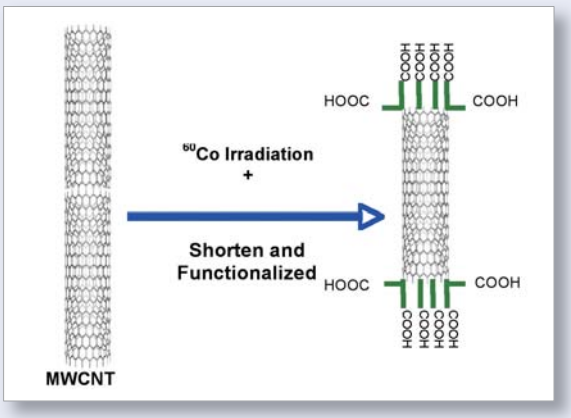


▲ MicroSPECT/CT images of Re-188-Liposomes targeting LS-174T tumors bearing in nude mice. The Re-188-Liposomes containing 18.5 MBq of Re-188 was administered to each mouse by intravenous injection. The images were acquired at 24 and 48 h after injection.

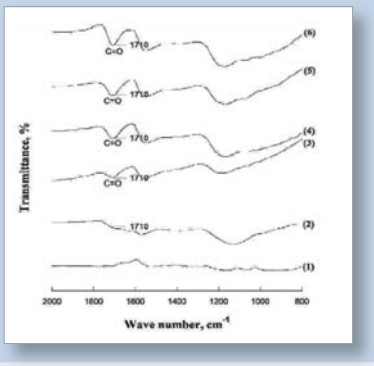
3.9 Development of ^{60}Co Irradiated Carbon Nanotubes

Kuan-Yin Chen

Our purpose is to develop a method to modify the material which is the substrate of diagnosis medicine. It is a sensitive product to evaluate the Nasopharyngeal Carcinoma (NPC) from patient serum as early phase diagnosis. ^{60}Co gamma-ray irradiation and a mixture of some oxidizing agents were as the methods to modify the carbon nanotubes (CNTs) which is a medicine substrate. After ^{60}Co irradiation and oxidization, the carbon nanotubes were activated and some functional groups were formed on both sides of the CNTs surface and both ends. It increased the antigen conjugated with CNTs after functional groups were formed. NPC is associated with Epstein-Barr virus (EBV) infection. For increasing the sensitivity, EBV antigen was added on functional groups of the CNTs. In the future, we will use the EBV antigen to attach on modified CNTs and this will be used to detect patient's serum anti-EBV antibody. Then the antibody are recognized by goat anti-human IgA conjugated ^{125}I. The ^{125}I emits gamma-ray and is detected by gamma-ray detector.



Carboxylic acid groups (COOH) are introduced onto the walls or ends of the individual muti-wall carbon nanotubes (MWCNTs) in a mixture of sulfuric acid/ nitric acid with ^{60}Co irradiation.



FTIR data for functionalization：(1)Raw MWCNTs，(2)Acid refluxed MWCNTs，(3) 50 kGy irradiation +Acid refluxed MWCNTs，(4) 125 kGy irradiation +Acid refluxed MWCNTs， (5)250 kGy irradiation +Acid refluxed MWCNTs，(6) 500 kGy irradiation +Acid refluxed MWCNTs。Functionalization with Carboxylic groups were increased with the ^{60}Co dosage.

Table 1. Acid-base titration of Carboxylic groups after modified treatment on MWCNTs.

Modified treatment on MWCNTs	Carboxylic groups (mmol/g)
Acid-refluxed	0.92±0.13
50 kGy γ -irradiation	1.21±0.29
125 kGy γ -irradiation	1.28±0.42
250 kGy γ -irradiation	1.66±0.23
500 kGy γ -irradiation	2.23±0.44

3.10 The Imperative to Establish a Design, Development and Validation Platform of Medical Imaging Equipment - A Positron Emission Mammography for Instance

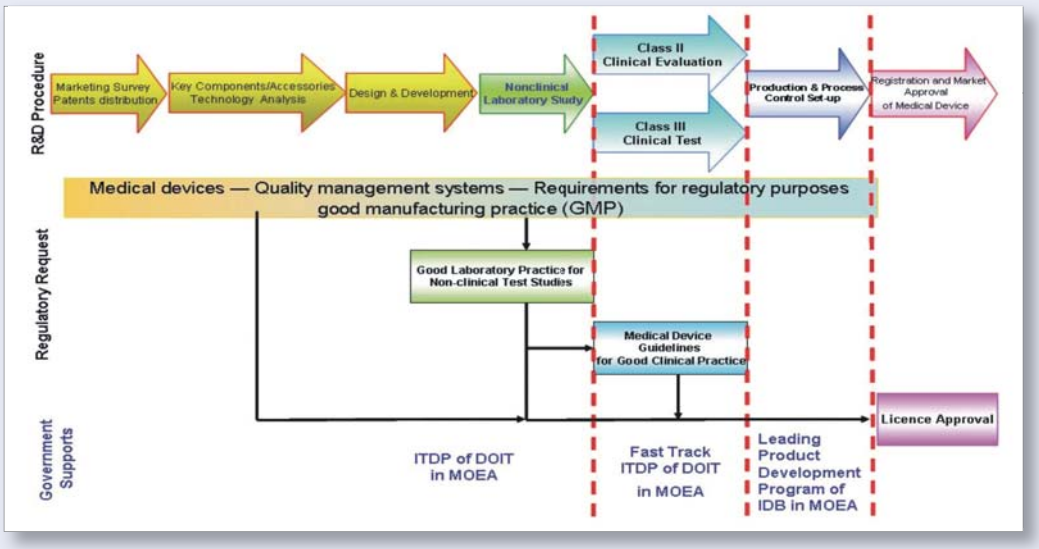
Yu-Ching Ni, Meei-Ling Jan

From research to market for the medical equipment development, testing and validation during R&D stage is an important part, especially for new medical device. It includes quality control process, risk management, software validation, electrical safety certification and EMC tests, system/key component performance evaluation and validation.

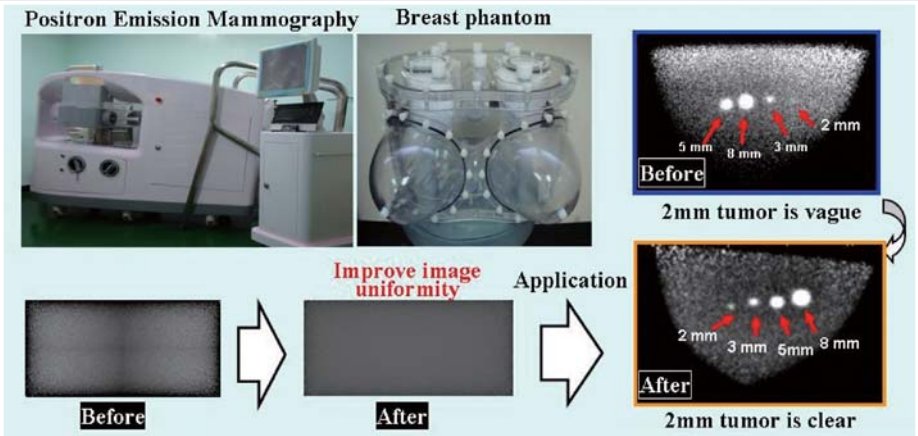
In Taiwan, the concepts and abilities of first three items were established gradually. However, the testing and validation abilities of electrical safety and performances for high level medical equipments still need to be established. For instance, domestic qualified test laboratories often request several sets of equipment for destructive testing and debug. This is not suitable for sophisticated medical equipments, e.g. medical imaging equipments, due to complicated structure and high manufacturing cost. Therefore there is a gap in electrical safety testing and certification of medical equipments while Taiwan government is trying to promote, high level medical equipment industry. Besides, there is an urgent need for system/key component performance testing and validation to establish standards and techniques. Especially the international competition strength is affected by performance evaluation techniques due to it is closely linked manufacturing processes and performance of the product.

In order to solve the above-mentioned problems, INER's R&D team has established system performance standards and evaluation techniques of the high level medical equipment, positron emission mammography (PEM). Image uniformity for example, there is no detail recommendations in IEC 61675-1 and NEMA NU2 standards. The R&D team has not only established measurement and analysis methods suitable for PEM, but also developed more accurate physical model and efficiency correction technologies to reduce image non-uniformity error of 76%. The advantages of these technologies are noise reduction, contrast enhancement, and tumor detection ability promotion. Establishing testing and validation techniques not only improves the product performance but also produces the technical files which are required from authorized registration.

INER will continue develop testing and validation techniques of safety and effectiveness for medical imaging equipment to authorized registration, help industry to pass muster and shorten product development period. Furthermore, INER will assist domestic company to acquire the authorized registration and promote prosperity of the nuclear medicine imaging industry.



▲ A Flow Chart of Medical Equipment from Development to Acquire the Authorized Registration.(Material origin: Promotion Office of Biomedical Technology DOIT, MOEA)



▲ Establishment and Improvement of the Measurement and Analysis Methods in image Uniformity Testing and Validation

3.11 Radiopharmaceutical Characterization Laboratory Passed the Inspection of Good Laboratory Practice (GLP) for Nonclinical Laboratory Studies of Department of Health, Taiwan in 2009

Fu-Lin Chang

'Radiopharmaceutical Characterization Laboratory (RPCL)' was kept following the international requirements and spirit of 'Good Laboratory Practice (GLP) for Nonclinical Laboratory Studies' as the basic guidance in our R&D activities. In 2009, RPCL is the first one among all laboratories of Government that passed the GLP inspection of Department of Health (DOH, Taiwan). Two categories of pharmaceutical R&D activities were approved by DOH, i.e.,

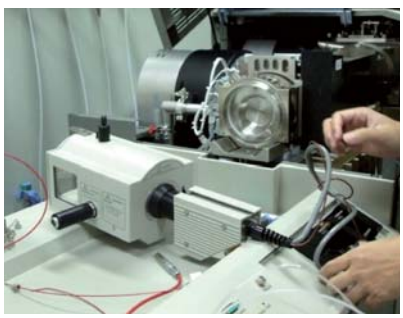
- Pharmaceutical purity and component analysis, and
- Pharmaceutical biochemical analysis.

To date, RPCL is the only testing facility in Taiwan which has been set up in radioactive operation area for providing the chemical and biochemical analytical R&D services for radioactive isotopes and 'Certificate of Analysis (COA)' of Reference Materials (RMs) for Investigational New Drug (IND) and New Drug Application (NDA). The most important core equipments of RPCL are:

- Liquid chromatography-triple quadrupole/linear ion-trap tandem mass spectrometer (LC-QqQ/LIT MS),
- Matrix assisted laser desorption ionization-quadrupole-time of flight mass spectrometer (Maldi-QTOF MS),
- Infrared-elemental analyzer (IR-EA), and more…

In the future, not only can RPCL get more complete implementation of the INER R&D programs of radiopharmaceutical; but also be able to more actively support the nation's biomedical and biotechnology development policy, as well as to provide the GLP analytical platform and technical service of pharmaceutical R&D to institutes, universities, hospitals, or pharmaceutical industry.

Document of Department of Health (DOH) for Certifying the GLP Qualification of RPCL.



▲ Matrix Assisted Laser Desorption Ionization-quadrupole-time of Flight Mass Spectrometer (Maldi-QTOF MS)

3.12 The Annual Operation Report of Cobalt-60 Facility in INER

Chia-Chieh Chen

The Cobalt-60 facility of INER had accomplished its annual operation program this year. In addition to completed the R&D and service operation, this facility also focused and updated several security systems, like source rack system, conveyor system and the motion security system. The IR monitoring system can help the source rack down to the water pool once it detects unknown people intruded into the radiation area.

The total operation time was 4,579 hours this year. During this long operation period, there is no any violation to the safety regulation. The exposure dose for all the operators were under the dose level of annual dose limitation.

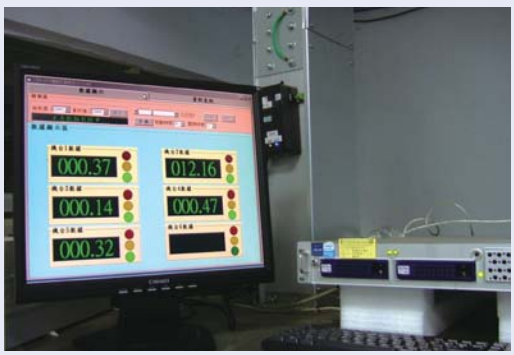
To operate ergonomically this year, the average operation time was 16 hours per day at least. To maintaining the radiation quality, every batch had its own dosimetry measurement. There were several research contracts with other organizations this year. The total income from the research

contract service is almost 1 millions NT dollars. Some other contracts were under discussion yet. these will become the most important service and income in the near future.

This year the radiation service items included disposable medical supplies, medicine and related materials, industrial material, mutation radiation and food irradiation. The total number companies for the radiation service was over 89. The boxes number finished radiation service was over 30,904 and the total income was over 10 millions NT dollars.

The cobalt-60 facility keeps its interesting with the international and civic demand to update their R&D program. Customer satisfy and service always are important to all the staffs. However, the safety will be the most important concern. Keeping no violation and accident to the safety will be the first priority to all the people working in this facility.

▲ Monitoring the Security of Cobalt 60 Facility Indoor and Outdoor.



▲ Recording the Detections of Ionizing Radiation of Instruments in Cobalt 60 Facility.

3.13 Establishment of Dose Area Product Measurement Standard

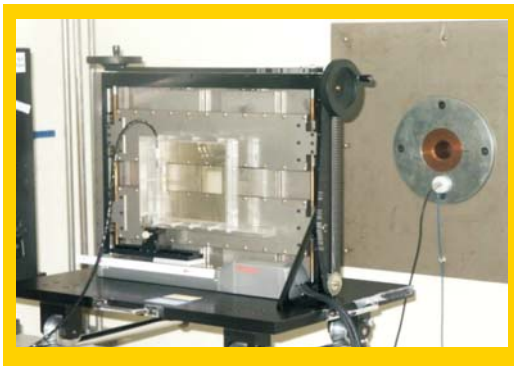
Tzeng-Te Huang

Fluoroscopy is a means to access the patient's dynamic physiological information through a long period of X-ray exposure. It can also cause a lot of radiation dose. To assess health risks from fluoroscopy, we often use the dose area product (DAP) as a dose index, and then estimate the patient's effective dose from this index.

To meet the requirement of dose-area product calibration, we installed an adjustable collimator and a holder of transmission chamber in the existing medium-energy X-ray system, and we established beam qualities of RQR and RQA according to the IEC 61267 and measured the half-value layer of the beam qualities. The differences between the results we obtained and the IEC 61267 standards were less than 5%. We used the free-air ionization chamber to measure the X-ray radiation field, then measured and calculated correction factors of free-air ionization chamber, including the ion recombination, electron loss, photon scatter, air attenuation and window attenuation correction factors and obtained the standard air kerma rate. The uncertainty was evaluated according to the ISO GUM and the expanded uncertainty was 1.8 % (k = 2).

In addition to the establishment of the primary standard of dose-area product, we also bought a dose-area product meter (DIAMENTOR M4-KDK) and a transmission chamber

(TV34044-1) from PTW which were sent to PTB for dose area product calibration. The calibration beam qualities used were RQR and RQA listed in the IEC 61267. We used the correction factor of PTB in the dose-area product meter and measured RQR and RQA beam qualities in our laboratory; the air kerma rate differences between the results and our primary standards were 0.06 % to 2.71 %. As this was not a formal international comparison, the results were still within allowance range. In the future, we will actively participate in more international comparisons to enhance the accuracy of our dose area product system.



▲ Transmission Chamber and Collimator Calibration Beam Qualities

▲ X-ray Machine and Filters

Results of Comparison with PTB

Radiation condition : 150cm, 10mA

Beam code	kV	Added filter (mmAl)	HVL (mmAl)	Kair (Gy/s)	Uncertainty (k=2) (%)
RQR 3	50	2.6	1.74	1.471×10^{-4}	1.8
RQR 5	70	2.9	2.57	2.737×10^{-4}	1.8
RQR 8	100	3.2	3.86	5.087×10^{-4}	1.8
RQR 10	150	4.45	6.52	8.801×10^{-4}	1.8
RQA 3	50	12.6	3.68	1.113×10^{-5}	1.8
RQA 5	70	23.9	6.54	1.159×10^{-5}	1.8
RQA 8	100	37.2	9.95	1.915×10^{-5}	1.8
RQA 10	150	49.45	13.21	$4\ 367 \times 10^{-5}$	1.8

Beam code	DAP meter (PTB)		Free air (INER)		Difference (PTB-INER)/INER	
	DAP ($Gycm^2$)	Dose (Gy)	DAP ($Gycm^2$)	Dose (Gy)	DAP	Dose
RQR 3	0.6810	0.0268	0.6635	0.0265	2.63%	0.81%
RQR 5	1.2679	0.0498	1.2344	0.0494	2.71%	0.83%
RQR 8	2.3353	0.0918	2.2970	0.0919	1.67%	-0.10%
RQR 10	4.0192	0.1578	4.0087	0.1603	0.26%	-1.62%
RQA 3	0.0505	0.00201	0.0502	0.00201	0.60%	-0.09%
RQA 5	0.0527	0.00208	0.0523	0.00209	0.83%	-0.37%
RQA 8	0.0869	0.00343	0.0861	0.00344	0.92%	-0.34%
RQA 10	0.1966	0.00773	0.1965	0.00786	0.06%	-1.62%

4 Renewable and New Energy Technologies

Ying-Sheng Lee

The program of renewable and new energy technology in the Institute of Nuclear Energy Research (INER) has been conducted in accordance with the energy policy of the Taiwan government. The goal is to promote the sustainable use of energy, following the balanced development among economy, energy and environment. The research topics in the program are: high concentration photovoltaic (HCPV) systems, epitaxial silicon solar cells, quantum dot/polymer solar cells, small/medium wind turbine systems, cellulosic ethanol pilot plant and the core processing technology, solid oxide fuel cells, photocatalytic hydrogen production, hydrogen storage materials, micro grid, and energy models.

Substantial progress has been made in 2009. The industrialization of HCPV technology has been pushed forward through technology transfer, patent deployment, and establishment of the MW demonstration system. The fabrication processes of the epitaxial silicon thin film were established and an epi-Si/UMG-Si solar cell device was also developed. For environmentally friendly quantum dot/polymer solar cells, P3HT/PCBM and P3HT/TiO_2 bulk heterjunction structure systems were found to have a conversion efficiency of 3.5% and 1.05%, respectively. The development and installation of a 25 kW (INER-C25A) and a 150 kW (INER-P150) grid-tied wind turbine generator systems were completed. A design certification project for wind turbine system was also conducted in cooperation with an eminent international certification body based on IEC-61400-1 and IEC-61400-2. A process development facility for cellulosic ethanol production with a capacity of one ton dry biomass (rice straw) per day has been established and planned to launch the test-run operations in early 2010. In an effort to reduce the overall production cost, INER has also dedicated to develop the in-house cellulase production technology for the hydrolysis of cellulose in rice straw. Other core technologies, such as xylose fermentation and simultaneous saccharification and fermentation (SSF) for cellulose-to-ethanol fermentation are also developed. In the study of photocatalytic hydrogen production technology, the Pt-doped TiO_2 catalyst showed the highest activities for photo-electrochemical water splitting. To demonstrate the practical applications of the hydrogen storage material, a large cartridge packed with Pt/AC samples was fabricated. This cartridge is used to store and to supply hydrogen to a PEMFC for powering a 120 W scooter. For SOFC development, the manufacturing technology through the tape casting-spin coating-screen printing process for ASC type MEA was established for mass production and technology transfer. A long-term validation test for a 1 kW SOFC power generating system was also completed. A renewable energy park has been established in INER to develop the renewable distributed generation and autonomous micro grid technology. In addition, the establishment and validation of industrial sector settings in MARKAL-MACRO has been the focus for the energy model studies. The concerned major industrial investment was also included in the model and the effects on overall economy and environment were evaluated through energy usage, CO_2 emission and GDP growth.

4.1 Development of High Concentration Photovoltaic System

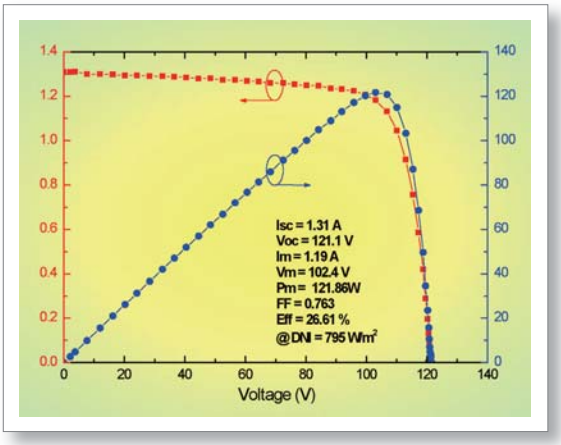
I-Tao Lung

INER has been cooperating with domestic manufacturers to develop III-V solar cells since 2002. In 2009, the energy conversion efficiency of InGaP/GaAs/Ge tandem solar cells under concentrated light have reached up to 37.1% with a short-circuit current ratio of 133. Meanwhile, INER has also captured HCPV technologies needed for solar module, tracker, as well as control and monitoring system. The uppermost records of module efficiency under 476 and 900 geometric concentration ratios are 27.2% and 26.6%, respectively. The tracking accuracy has been improved to be ±0.2 degree, and multi-thread programming is used for data fetching and commands distributing in order to expedite the processing and enhance the management efficiency.

The qualification laboratory of concentration solar module at INER has passed the censorship on the evaluation of Taiwan Accreditation Foundation (TAF) and has become the first official national CPV qualification laboratory on June 11, 2009. Moreover, INER has won international recognition from Underwriters Laboratories, Inc. (UL) on October 13, 2009 to carry out solar module qualification procedures, and INER is the pioneer lab in Asia receiving accreditation by UL to provide qualification services in accordance with international standard IEC 62108.

In addition, a 1 MW HCPV demonstration system was established and launched at Lujhu, Kaohsiung on December 22, 2009. This install capacity is the largest one in Asia and second to that in Spain. Tycoons of CPV sector and guests from related industries were gathered at the opening ceremony, indicating that INER is an important organization in terms of HCPV technology development and will lead Taiwan into a new era of photovoltaic industry.

Through technology transfer, patent deployment, and establishment of the demo system, not only would the HCPV technology have been industrialized, but also expertise has been spurred. To keep up with the "Green Energy Industry Program" in the future, INER will work in conjunction with the industry continuously to push forward the mass production and industrialization of HCPV system, and stride into the international market.



▲ I-V & P-V Curve of Solar Module under 900 Geometric Concentration Ratio

▲ UL Certificate of Qualification for CPV

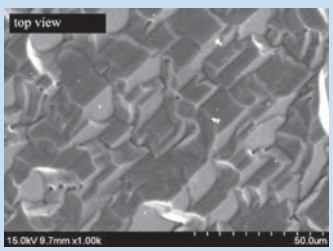
4.2 R&D of the Epitaxial Silicon Solar Cell

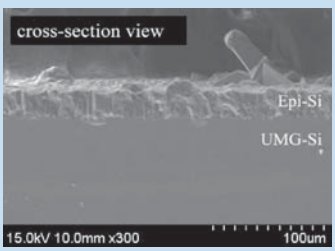
Tsun-Neng Yang

The objective of this program in 2009 is to develop a laboratory-type epi-Si/UMG-Si solar cell with its energy conversion efficiency > 10%. The main working items are (1) to establish the fabrication processes of the epitaxial silicon thin film, and (2) to develop an epi-Si/UMG-Si solar cell device.

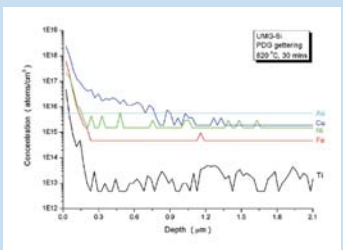
A home-made APCVD system was used to grow epitaxial silicon layer at the temperature of 1100-1200°C. The thickness of ~ 20-30 μm p-type epitaxial silicon layer is successfully grown on the upgraded metallurgical silicon substrate with a purity of 4-5N. The boron doping concentration, which is examined by SIMS, in the epitaxial silicon layer, is about 1.5-6×10^{17} cm^{-3}. In order to eliminate the impurity effect, some impurity gettering techniques were used. After the phosphorus diffusion gettering (PDG) treatment, the impurities in UMG-Si were gathered preferentially within 0.3 μm thickness from the outer surfaces of the UMG-Si. Then, this high impurity contented region was successfully removed by the KOH solution etching process.

INER has established the full spectrum of technical abilities in developing the laboratory-type epi-Si/UMG-Si solar cells, such as fabrication of plasma textured structure, n-type diffusion layer, SiNx anti-reflection coating, screen-printed Ag/Al paste metal contacts, and hydrogen passivation, etc. Under the AM1.5 illumination, the average energy conversion efficiency of the wafer-based UMG-Si solar cell and the best efficiency of the epi-Si/UMG-Si solar cell were found to be 12% and 11.99%, respectively. The cells are about 1 cm^2 in area.

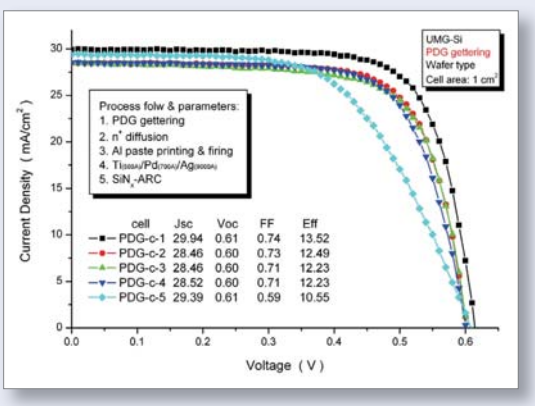




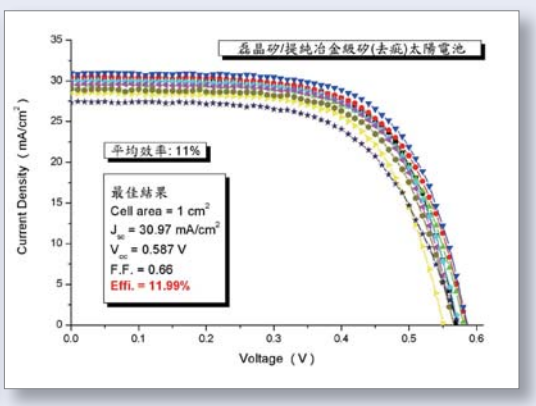
▲ SEM Photos of the Top and Cross-section Views of the p-type Epitaxial Si Layer.



▲ Depth Profiles of the Impurities in UMG-Si after Gettering Treatment.



▲ I-V Curves of the Wafer-based UMG-Si Solar Cell.



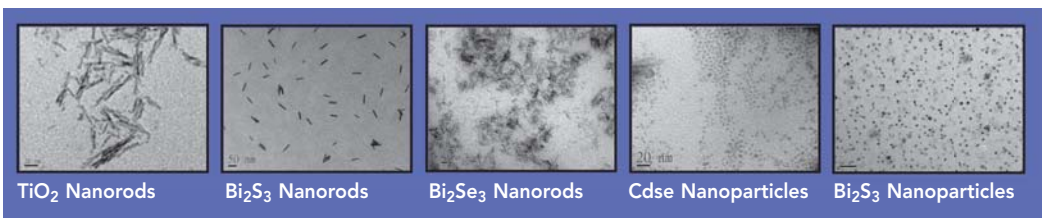
▲ I-V Curves of the Epi-Si/UMG-Si Solar Cell.

4.3 Study of Quantum Dot/Polymer Solar Cells

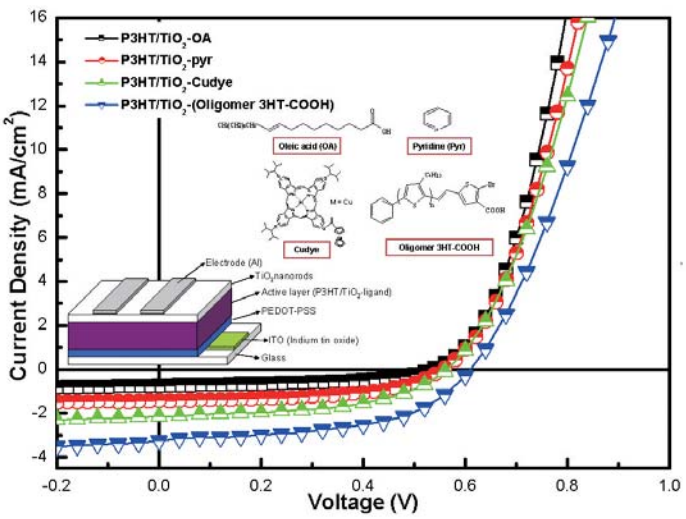
Chih-Min Chuang

The quantum dot/polymer solar cells have become the most promising third generation solar cells due to their advantages of light weight, mechanically flexible, environmental friendly process, and low-cost. The manufacture process has adopted the fast Roll-to-Roll technique which has the merits of large area and low cost. It can be combined with portable consumer electronics products to enhance the practicality and breadth of market applications. With the improvement on the solar cells efficiency, the quantum dot/polymer solar cell will be the mainstream technology of low cost and off-grid portable energy.

In this research, the synthesis of quantum dots and fabrication of solar cells have been studied. The TiO_2 nanorods, Bi_2S_3 nanorods, Bi_2Se_3 nanorods, CdSe nanoparticles and Bi_2S_3 nanoparticles were synthesized by colloidal methods. The transmission electron microscopy images of quantum dots showed that the size of the materials are in nano-scale range, and can be further applied to the active layer of solar cells. In addition, the glove box and thermal deposition system for the fabrication of solar cell are assembled together to manufacture the solar cell in the low oxygen and low moisture content environment which can reduce the oxidation of the active layer. Currently environmentally friendly quantum dot/polymer solar cells of P3HT/PCBM and P3HT/TiO_2 bulk heterjunction structure systems are being developed. The conversion efficiency of P3HT/PCBM system can reach 3.5%. By modifying the surface of the TiO_2 with different conducting molecules to become favorite structure and tuning the fabrication parameters, an efficiency of 1.05% for P3HT/TiO_2 solar cell has been achieved. For the continuous upgrading of the efficiency, techniques for synthesis and properties of quantum dots and manufacturing process of solar cells need to be improved.



▲ The TEM Images of TiO_2, CdSe, Bi_2S_3 and Bi_2Se_3 Quantum Dots.



▶ IV Curves of P3HT/TiO_2 Solar Cells with Best Conversion Efficiency of 1.05%

4.4 Development of Small-Medium Wind Turbine Systems

Wei-Nian Su, Chun-Ming Chen

The Institute of Nuclear Energy Research (INER) has developed a 25 kW (INER-C25A) and a 150 kW (INER-P150) wind turbine generator system in 2008 and 2009, respectively. Similar to the large wind turbine systems, both of INER-C25A and INER-P150 are equipped with pitch control, yaw control, brake control, and data acquisition systems. The goal is to develop the design and analysis techniques necessary for large wind turbine systems and, furthermore, to assist and integrate local manufacturers in terms of technology upgrade. In cooperation with various local manufacturers, critical components such as variable pitch control system, maxima power point tracking technology, and 150 kW direct drive generator are developed with success. INER-C25A is a grid-tied system and installed on top of a 25m tubular tower. The automatic control system has been tested for more than one year and stable operation is achieved by tuning the control logic and parameters. INER-P150 is also a grid-tied system and installed on top of a 50m lattice tower. Enhancement and testing will be carried out in 2010. Finally, in cooperation with Chung-Shan Institute of Science & Technology, two micro wind turbines were developed in 2009. One is a horizontal axis wind turbine and another one is a vertical axis wind turbine. Both wind turbines are rated at 400 W and power performance testing will be carried out in 2010.

In consideration of the safety and reliability of a wind turbine system, fulfillment of the international safety standard is recommended. A design certification project for wind turbine system was also initiated by INER in 2008. Based on IEC-61400-1 and IEC-61400-2, preparation of the design documents of INER-C25A was completed and reviewed by TUV Nord in 2009. This is the first time in Taiwan that a self-developed wind turbine system has ever been reviewed by a certified body. Besides, in cooperation with the Central Weather Bureau, development of wind forecasting system is undergoing. The goal is to assist the utility company for more stable and efficient power regulation while using wind energy. Currently, there are 25 kW and 150 kW wind turbine systems and 200 kW ground testing system ready for use in INER. In addition, a 600 kW wind turbine system is also under development. Partnership with manufacturers will be established during the design process and critical techniques such as blade design and control system design will be transferred to local companies. Ultimately, a complete supply chain of wind turbine generator system can be established to form a feasible business model in Taiwan in the next 5 years.

▲ Assembly and Installation of Wind Turbine

▲ Dynamic Testing Systems for 25 kW and 150 kW Wind Turbine

4.5 Establishment of Cellulosic Ethanol Pilot Plant and the Core Processing Technologies

Chiung-Fang Huang

In concert with governmental policy for promoting the use of biofuels, the Institute of Nuclear Energy Research has dedicated to the research and development of technologies for cellulosic ethanol production. A process development facility for cellulosic ethanol production with a capacity of one ton dry biomass per day has been establishing since 2007 and planned to launch the test-run operations in early 2010; rice straw is considered as the raw material at the first stage. The operative experiences and the experimental data would provide significant information for the evaluation of production cost as well as the basis for design of commercial production plant in Taiwan. In addition, this facility will also be served as an important platform for validation of technologies related to cellulosic ethanol and biorefinery.

The biomass-to-ethanol process of this plant is based on the route of biochemical conversions. Self-developed acid hydrolysis pretreatment is employed both in continuous and batch mode operation to release xylose from feedstocks while enhancing the conversion efficiency in enzymatic hydrolysis. In an effort to reduce the overall production cost, INER has dedicated to develop the in-house cellulase production technologies. It is expected to be exempted from the additional cost for transportation, storage and concentration of cellulase. The cellulose-rich feedstocks are often required in the cellulase production process in order to induce cellulase-producing microorganism for producing crude cellulase with high hydrolysis efficiency. Through the integration of the experience from self-developed dilute-acid pretreatments and fermentation engineering, INER has thus successfully developed different kinds of rice straw feedstocks, by applying various conditions of pretreatments, as cellulase production inducers.

The in-house produced cellulase for the hydrolysis of cellulose in rice straw has shown a conversion efficiency of 86%, which is higher than 82% for commercial cellulase. This result indicates the great potential of INER-cellulase produced by using low-cost feedstock induction. Other core technologies, such as xylose fermentation and simultaneous saccharification and fermentation (SSF) for cellulose-to-ethanol fermentation technology are also developed giving the high ethanol yields of 80% and 75%, respectively. The scale-up investigation of these fermentation technologies will be conducted by the instruments of INER's tonage scale process development facility in the near future. It is expected to enhance the competitiveness of cellulosic ethanol technologies in Taiwan through these researches.

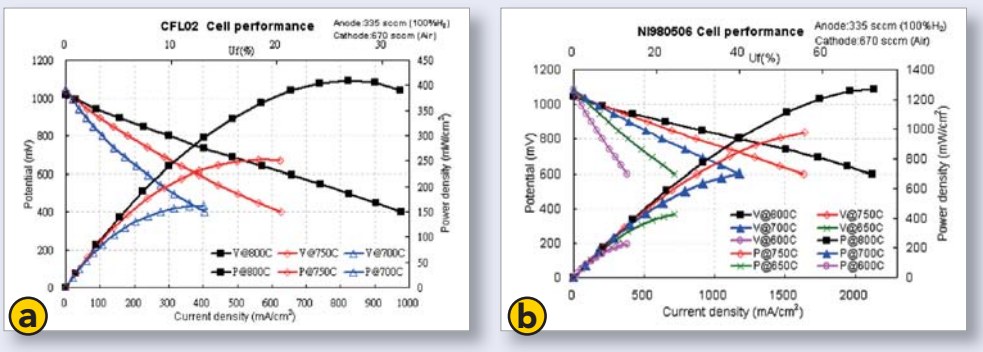
▲The Facilities for Cellulase Production in INER Mini-Pilot Plant

▲The Acid Hydrolysis Pretreatment Facilities of Ton-Scale Pilot Plant in INER

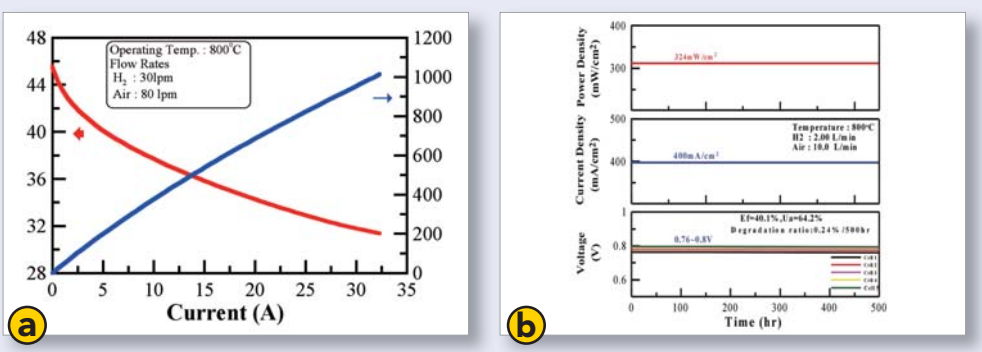
4.6 The Development of Solid Oxide Fuel Cell Technologies

Chien-Hsiung Lee

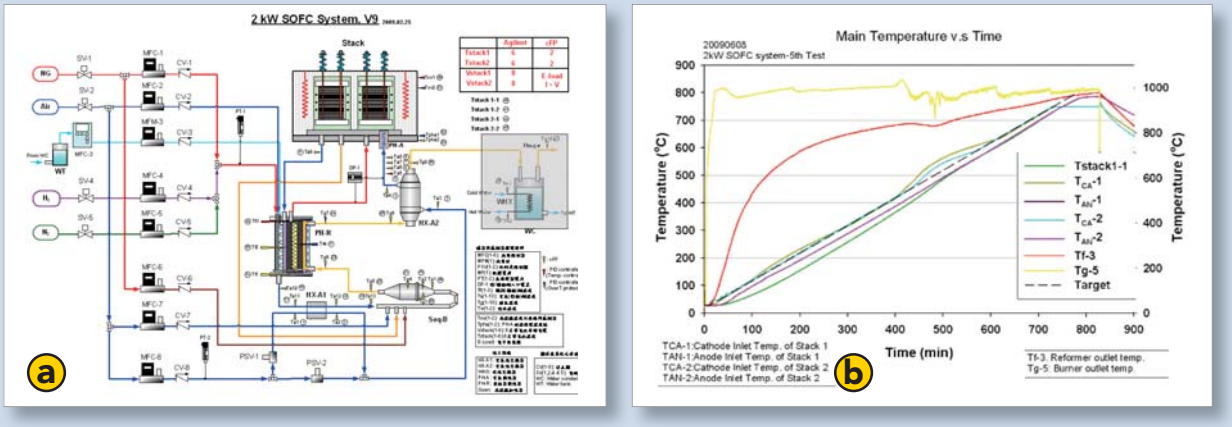
INER's SOFC project was initiated in 2003. The goal is to develop technologies associated with 1~5 kW SOFC power generating system in 2012. The long-term target is to integrate with the gasification combined cycle coal power plant. Progresses achieved in 2009 include: (1) Planar anode supported cells (ASC) of size 10 x 10 cm^2 were successfully produced. The anode, electrolyte and cathode layers were produced by the tape casting, spin coating, and screen printing method, respectively. In addition, 10 x 10 cm^2 metal supported cells (MSC) employing porous nickel substrates were manufactured via the atmospheric plasma spraying process. The ASC and MSC exhibited maximum power density of over 400 mW/cm^2 and 1300 mW/cm^2 (for Φ5-cm cell) at 800°C, respectively. The MSC performance was evaluated to be in the global leading position. (2) A 40-cell SOFC stack has been assembled and tested. Power output exceeded 1 kW at 800°C. For durability testing, degradation rates at 800°C of a single-cell and a 5-cell stack were 0.47%/1000hr (300 mA/cm^2) and 0.24%/500hr (400 mA/cm^2), respectively. Currently, the worldwide stack degradation rate is about 0.5~1%/1000hr. (3) Long-term testing for the 1 kW SOFC validating system has been completed. A degradation rate of 1.55%/1000hr was observed. For the 2 kW SOFC power system, heating-up processes were examined. In addition, simulated steady-state testing with a dummy stack was conducted. The operating condition was set at fuel utilization rate 0.6 and efficiency 40%. This system featured utilizing exhaust heat from the after-burner as the main heat source, significantly saving electricity consumption. (4) A 5-kW power conditioning system was developed, including a DC/DC converter and a DC/AC inverter. The peak efficiency of the system reached over 95%.



▲ The Performance Curves of the (a) Anode Supported Cell (ASC); (b) Metal Supported Cell (MSC).



▲ (a) The Performance Curves of a 40-cell kW-level Stack; (b) Durability Testing Curves of a 5-cell Stack.



▲ The First Generation of the 2 kW Power Generating System: (a) Piping and Instrument Diagram; (b) Heating-up Testing Curves.

4.7 Development of Photocatalytic Hydrogen Production Technology

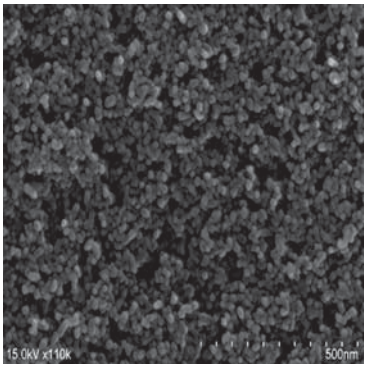
■ *Yu-Chang Liu*

It is essential to develop an effective photo catalyst such as TiO_2 or modified TiO_2 for hydrogen generation via efficient photochemical water splitting process. The properties of the catalysts can be improved by decreasing the particle size, increasing the surface area, loading metal oxides as well as doping heteroatom. Suitable modification of the surface sites might also increase the photocatalytic activity of the catalyst.

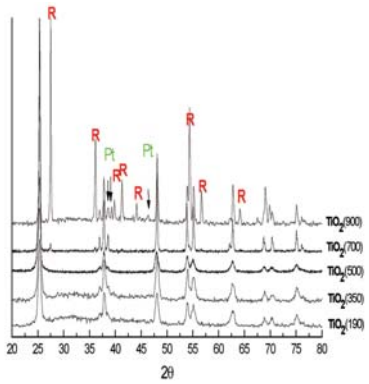
In this study, TiO_2 photocatalysts were prepared by sol-gel method and were further modified through doping Pt、Ag、Ni etc. The effects of different preparation parameters on the photocatalytic activities of the catalysts were also investigated. The catalysts were characterized by using powder X-ray diffractometer (XRD), scanning electron microscope (SEM), and ultraviolet-visible spectrophotometer (UV-Vis). The photocatalytic reaction was carried out in a Pyrex reactor with a 400 W high pressure mercury lamp as light source.

The photocatalysts prepared by the sol-gel method showed that the particles sizes are all nano-sized ranging around 25-35nm. The crystalline structures of the TiO_2 photocatalysts are all anatase with high surface areas. The Pt-doped TiO_2 catalyst showed the highest activities for photo-electrochemical water splitting with a hydrogen generation rate of 6539.5 μmol/hr • g cat. The photocatalytic activity is also strongly dependent on the platinum particle size; smaller particle produces greater amount of hydrogen.

In addition to photocatalysts, photo electrode systems for hydrogen generation were also developed to test the efficiency and reproducibility of the photocatalytic water splitting reactions. A prototype system capable of separate generation of hydrogen and oxygen was fabricated to demonstrate the practical application of this study.



▲ TiO_2 Nanoparticles Synthesized by Sol-gel Method



▲ XRD Pattern of TiO_2 Nanoparticles

	Surface area (m^2/g)	Pore volume (cm^3/g)	Pore size (nm)
P25	52.103	52.103	52.103
TiO_2 (sol-gel)	150.98	150.98	150.98

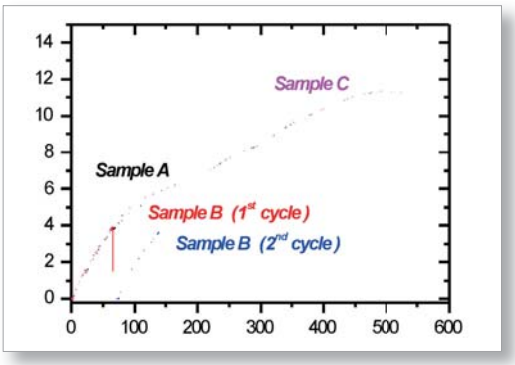
▲ Surface Area of TiO_2 Nanoparticles

4.8 Development of Hydrogen Storage Technology

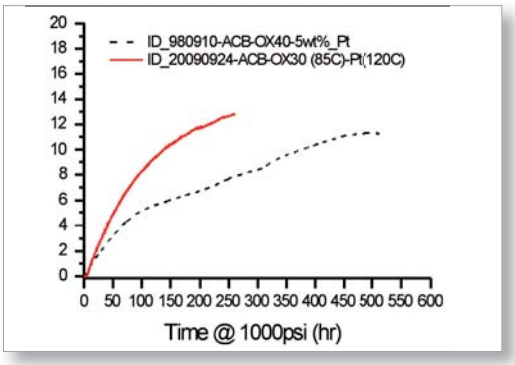
Ming-Sheng Yu

A process was developed to synthesize 10 g of Pt-impregnated active carbon (Pt/AC) per batch with a hydrogen storage capacity of 11 wt% at room temperature and 6.9 MPa. Three different samples from the same batch were shown to have nearly the same storage capacity. By controlling the amount and the size of the Pt particles, the rate of hydrogen uptake can be improved without sacrificing the storage capacity. The hydrogen storage performance was measured using the high-pressure thermal gravimetric analyzer (HPTGA) with small amount of samples (~ 130 mg). To demonstrate the practical applications, a storage cartridge containing 6 ~ 7 g of Pt/AC was prepared. For determining the hydrogen desorption at 1 atm, a mass flow controller to regulate the release of hydrogen at a fixed flowing rate was used; the total amount of released H2 is thus directly proportional to the recorded releasing time. By using this regulated hydrogen desorption system, it was found that the amount of hydrogen released is only 7 Kg H_2/m^3, much lower than that (~ 40 Kg H_2/m^3) stored in the 11 wt % samples. The discrepancy might be due to the blockage of gas transport pathways, which gives rise to the reduction in the accessible surface areas when the cartridge is filled with large amount of closely packed samples. To demonstrate the cartridge's mobile applications, a large cartridge with a volume of 550 cc to carry 55 g of Pt/AC samples was fabricated. This cartridge is used to store and to supply hydrogen for a scooter with a 120 W PEMFC. The field test showed that the scooter can be operated with the loading of a 50 Kg person for 14 minutes.

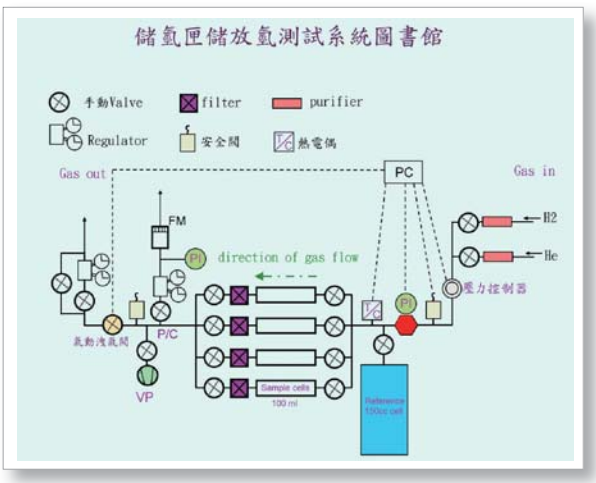
By resolving the discrepancy between the high H2 storage capacity (~ 40 Kg H_2/m^3) measured by the HPTGA and the extremely low amount of released H2 (~ 7 Kg H_2/m^3) in the regulated desorption system, INER Pt/AC sample will be the only material to meet the US.DOE requirements for efficient, safe, and cost-effective hydrogen storage.



▲ Three Different Pt/AC Samples from the Same Batch Showing to Have the Same Hydrogen Storage Capacity



▲ Pt/AC Samples with Different Pt Impregnation Processes Showing Different Hydrogen Uptake Rates but nearly the Same Storage Capacities



▲ Schematic Diagram of the Hydrogen Desorption System for the Cartridge with Large Amount of Pt/AC Samples

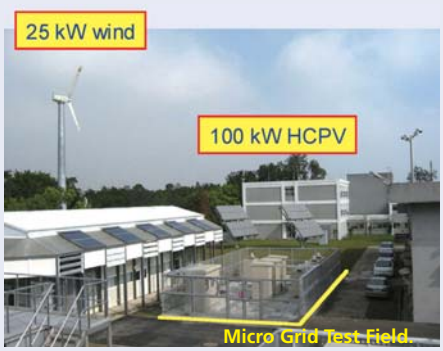
▲ A 120 W scooter Powered by a PEMFC with H2 Fuel Supplied by a Hydrogen Tank of Pt/AC

4.9 The Current Status of INER's Micro Grid Development

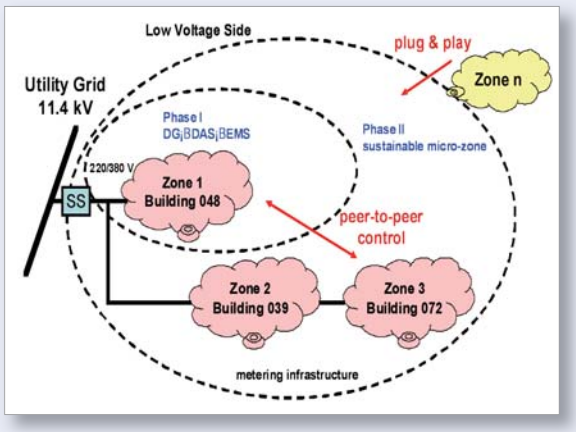
Yung-Ruei Chang

Currently the electricity generated by renewable energy, either in individual house or in small communities, is still under a small-scale dispersed system. The renewable power penetration is restricted by Taipower Company to be < 5% in today's power system infrastructure of Taiwan. To increase the penetration rate, dispersed generation (DG) and micro grid (MG) technology are two possible solutions.

A renewable energy park has been established in the Institute of Nuclear Energy Research (INER) in 2009. The renewable energy sources in this park include a 100 kW high concentration photovoltaic (HCPV) system, a 175 kW wind power system, and a solid oxide fuel cell (SOFC) system, etc. Power electronics as well as power management technology on power conditioning system for these renewable systems have been developed, including a 5-kW high efficiency power conditioning system for SOFC, power conversion systems for 25 & 150 kW wind power systems and SCADA systems which are used to monitor and manage the power status of the energy park. Based on these facilities, INER is moving forward to developing an autonomous micro grid demonstration system in this energy park. It is believed that this demonstration is beneficial to both carbon emission reduction and energy saving in the future.



▲ INER's Micro Grid Test Field.



▲ Micro Grid Block Diagram.

4.10 Energy Model Planning

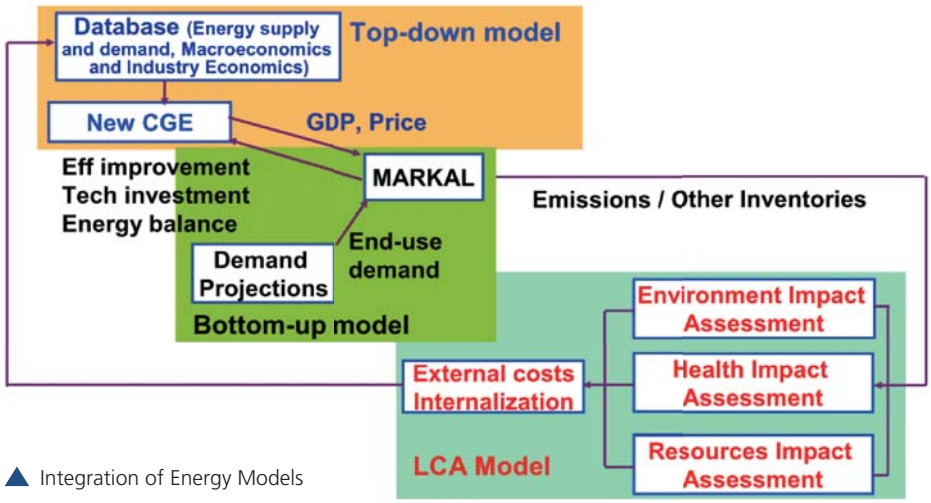
Fu-Kuang Ko, Chang-Bin Huang

The Institute of Nuclear Energy Research (INER) began to establish the energy model, INER MARKAL, from September in 2005, and MARKAL-MACRO (integrated with macro-economy) in 2007. The expert review of relevant analysis for BAU (Business As Usual) and the verification of electricity sector, industry sector and transport sector have been accomplished. The results have been published in international conferences, such as IAEE, and SSCI journal, Energy Policy.

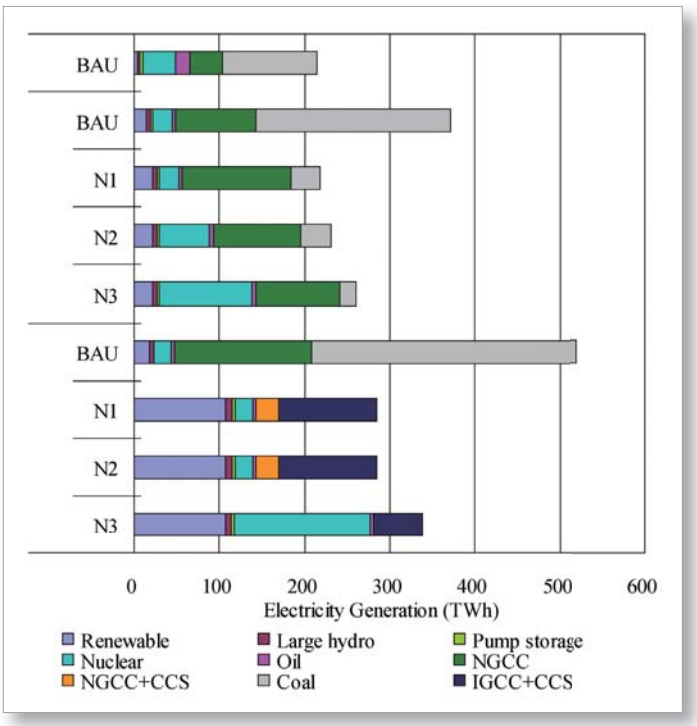
INER has also assisted the National Energy Conference 2009 to support information and analyses of CO_2 abatement scenarios, such as the allocation of electricity generation for the BAU and reduction scenarios. The energy intensity, energy productivity, CO_2 abatement cost and GDP

loss rate were further provided in the analyzed scenarios to relative departments. The Green Tax policy was analyzed to identify the impact of energy tax and carbon tax to national energy deployment, economic impacts and CO_2 reduction strategy.

In the future, the energy model will be well integrated continuously, such as the 3E assessment of each energy technology development. The relative information will be provided to support the policy making.



▲ Integration of Energy Models



▲ The Allocation of Electricity Generation for the BAU and Reduction Scenarios

5 Environmental Plasma Technologies

Development and Application of Environmental Plasma Technologies

Chi-Fong Ai

Both high and low temperature plasma techniques have been widely applied on the development and application of environmental protection technologies. Various green and eco-friendly technologies had already been developed. New researches on the low carbon energy are also being studied in areas like biomass energy from organic waste gasification, high temperature carbon cleaning technique, thin film solar cell etc. In the research subject of high temperature plasma, on the reutilization of plasma vitreous slag a new plasma arc melting and fiber blowing device had been constructed, and various fiber products are tested: the pilot-scale bio-mass plasma gasification power plant had started operation this year, results on studies and optimization on syngas process and electricity generation are presented; exciting outcomes from the conversion of syngas synthesis to liquid fuel like bio-DME is revealed. In the studies on reduction of carbon dioxide, the simulation on the Integrated Gasification Combined-Cycle (IGCC) power plant and the technique developed for high temperature dust removal system have both shown promising results. And in the research area of low temperature plasma, new high power pulsed magnetron plasma sputtering source and large–scale multi-plasma sources coating techniques are being developed, and applied to the material coating and surface modification as a green industrial application. To establish self-reliant capability on key manufacturing technology on thin film solar cell, technique on the large area deposition of silicon thin films had been developed successfully by very high frequency plasma enhanced chemical vapor deposition method. The project's goal on environmental protection and sustainable energy development is realized through the above research efforts.

This year, the current project achievements and future developments are further illustrated as follows:

5.1 Recycling of MSWI Ash Residues by Plasma Melting Process

Wen-Chen Lee

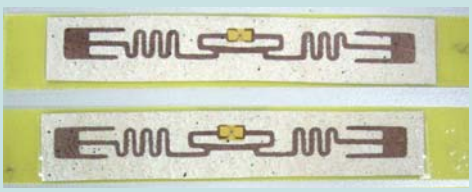
Plasma-melting technique for recycling municipal solid waste incinerator (MSWI) ashes has been developed, and the water-quenched slag was used as a raw material to produce various products like porous lightweight materials, lightweight soundproof materials, man-made vitreous fiber (MMVF), fiber carpet, honeycomb-shaped fiber paper and brake pads etc. To reduce the energy consumption of recycling process, a new arc melting and fiber blowing device which can manufacture MMVF directly from MSWI ashes had been designed and constructed. Furthermore, fiber cement composites, MMVF-reinforced concrete and radio frequency identification system (RFID) antennas from MMVF were fabricated and characterized in this study.

MMVF is added as a base material in manufacturing light-weighted and fire-resisting proven fiber cement composites. With 20 to 40 wt% MMVF addition, the bulk density, porosity and

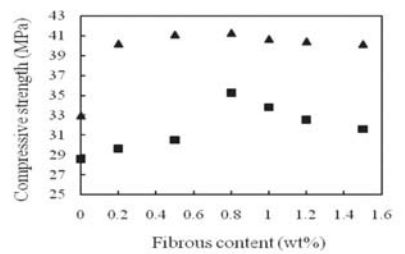
water absorption of the composites specimen ranged from 1.13 to 0.76g/cm^3, 54.88% to 72.57% and 14.81% to 19.28%, respectively. The fire-resistance test results of the composites showed that the smoke index per unit area (C_A) is about 3 which much lower than the class A value (C_A= 30) of CNS 6532/A3113 standard. Furthermore, the MMVF can also be added into the concrete barrier and cement solidification body for protection wall on low-level radioactive wastes disposal. The addition of MMVF into cement-based specimens to improve the mechanical strength is also tested. When the fibrous content was at 0.8 wt%, the measured maximum compressive and flexural strengths of the fibrous reinforcement concrete specimens after 7 days and 28 days were both increased by 23% and 25%, 25% and 24%, respectively. We also fabricated non-woven fiber paper by commixing MMVF with polyethylene fiber, the RFID metal antennas with nickel, nickel-gold and copper could be prepared on this non-woven fiber paper via hot-pressing, inkjet imprinting and electrode-less plating process. The tested performance of the above RFID antennas had shown receiving range up to 2.8 meters with heatproof and waterproof.

We shall continue to develop commercial size products of the fiber cement composites made from MMVF and the micro-porous ceramic heat sinks. Efforts are also focused on reducing the energy consumption rate of melting the MSWI ashes to less than 2.5 kWh/kg while treating MSWI ashes and recycling them directly into slag fibers.

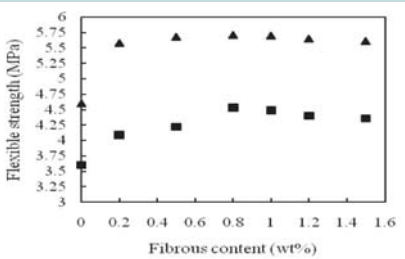
▲ A New Arc Melting and Fiber Blowing Device



▲ Rfid Antenna with Plating Nickel-gold



▲ Compressive Strength of Fibrous Reinforcement Concrete; ■: 7days; ▲: 28days



▲ Flexural Strength of Fibrous Reinforcement Concrete; ■: 7days; ▲: 28days

5.2 Pilot-scale Biomass Plasma Gasification Plant for Electricity Generation

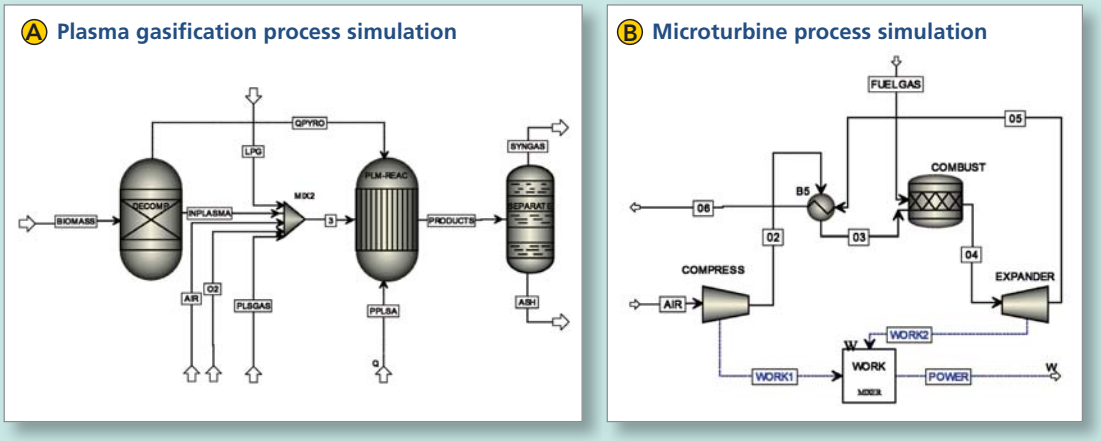
Heng-Yi Li

The Executive Yuan of R.O.C. had announced plans to increase the percentage of renewable energy in total installed electricity capacity from 5.54% to 12% by 2010. To support the government policy on: the carbon reduction along with the aims to provide a technology base to the new alternative energy industry, INER's has developed a novel pilot-scale power plant using plasma-assisted biomass gasification technology along with associative electricity generation.

The pilot-scale plasma gasification plant had been constructed and completed early this year. The plasma-assisted gasifier is designed with the biomass feeding rate of 100 kg/h, the max operating temperature of 1,600°C, the max operating pressure of 10 atm. A set of 4 microturbine generators with the total capacity of 120 kWe and an adsorption chiller were also installed. The main research of this year was focused on the full-system operation as well as system's modification and improvement.

In this year, 10 sets of continuously 24-hour experimental tests had been conducted. Each test lasted for one week. The selected fuel from biomass is wood chips and the feeding rate ranged from 24 to 48 kg/h. With the control on gasifier temperature at 800~1,000°C and a proper atomic ratio of oxygen to carbon (O/C), the produced syngas is around 19% H_2, 29% CO, and 2% C1-C5 (by volume), which corresponds to a heating value of approximately 5.7 MJ/Nm^3. The produced syngas pressurized up to 7 kg/cm^2 through a syngas compressor, and then fueled four 30kWe microturbines in parallel. The electricity generation was achieved at 96 kWe, amounts to a heat-to-electricity efficiency of 25%. The energy of waste heat of the exhaust from microturbines was further recovered by an adsorption chiller, and 22 RT of cooling air were therefore produced. The achieved overall heat efficiency was more than 46%. As for the system' s improvement, the influences of the operating parameters on the gasification or electricity generation had been extensively evaluated with the aid of process simulations by Aspen code. The plasma gasification unit, the gas cleaning unit, and the power generation unit have been individually simulated and validated with the experimental data, and the most important factors had been found. Next planned step on the simulation is to integrate all units for the pilot-scale plasma-assisted biomass gasification power plant for system improvement and optimization.

▲ A Pilot-scale Plasma Gasification Plant for Bio-electricity Generation.



▲ Process Simulation for Plasma Gasification System.

5.3 Synthesis of Dimethyl Ether (DME) – a Clean Biofuel

How-Ming Lee

Syngas produced from biomass gasification not only can be used for electricity generation but also a good raw material of various chemicals/fuels, e.g., methanol, dimethyl ether (DME), alcohols, and biodiesels etc. Such kind of conversion from gas to liquids is so called "Gas-to-Liquid" or "GTL." In terms of economical value, the price of chemicals/fuels is much more valuable than the price of electricity. Accordingly, the syngas generated from biomass gasification is not only used to generate electricity but also to synthesize chemicals/fuels in addition. At present time, INER is focusing on dimethyl ether (DME), which is well recognized as one of clean biofuels.

DME, being regarded as a new energy carrier, has the physical properties similar to LPG. In actual practice, DME can directly replace LPG or blends with LPG in a given ratio. DME can also completely replace diesel to fuel a diesel vehicle with only slight engine modification. It is much cleaner if comparison was made to the exhausts of DME and diesel combustions. For instance, the black smoke, particle matters, NOx, hydrocarbons, and CO can be greatly reduced. Hence, DME is recognized as one of clean fuels. On the other hand, it can be called bio-DME if the DME is produced from biomass. The bio-DME as the research's goal is regard as "carbon-balance" which can reduce the CO_2 emission and ease the global warming.

There are three research objectives in this study: the highly active catalysts for synthesis, DME process simulation with optimization, and the innovative DME reactor. A lab-scale high-pressure high-temperature DME reaction system had been designed and constructed for syngas synthesis experiment. We also had successfully developed a highly active catalysts, and its performance had achieved the world-class DME yield of >2.0 g-DME/g-cat./hr. On the other hand, an innovative technique had been developed in INER by integrating the non-thermal plasma technique into the traditional catalyst preparation method. Thanks to the unique characteristic of non-thermal plasma, i.e., high-energy particles and low-temperature environment, the catalysts can be controlled and modified to enhance the catalytic activity and property. This innovative technique and its successful results had been published in SCI journals.

▲High-pressure High-temperature DME Reaction System.

▲Novel DME Catalysts with Plasma Pretreatment.

5.4 System-level Simulation of IGCC Power Blocks

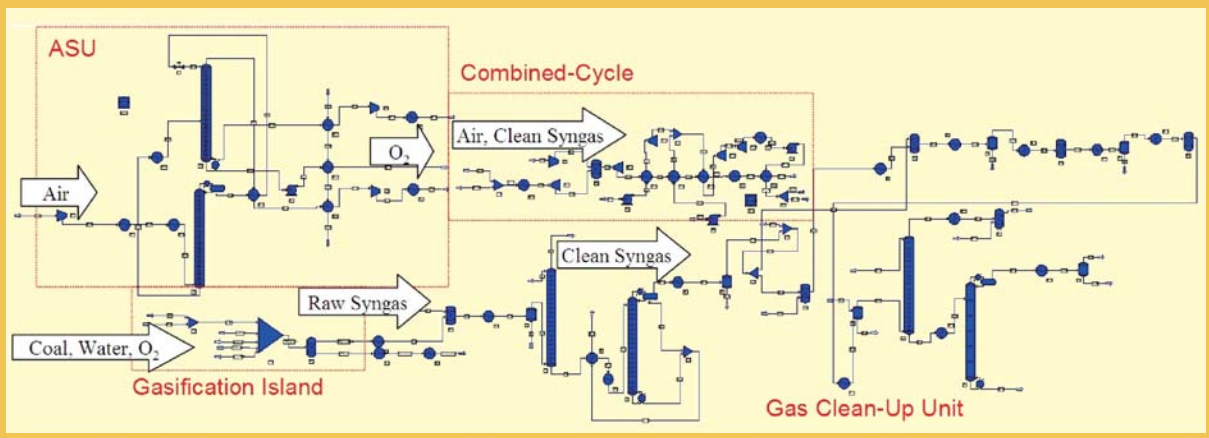
Hsiu-Mei Chiu, Yau-Pin Chyou

The commercial chemical process simulator, Pro/II® V8.1.1 is adopted in this project to simulate the basic model of Integrated Gasification Combined-Cycle (IGCC) for research in advanced fuel technologies. We had accomplished air separation unit, gasification unit, gas clean-up unit in 2008, and then built power block as well as combined subunits into a whole IGCC system model in 2009. The model had been verified with reference data and the simulation results coincided well with the reference data.

To simulate the basic model of combined-cycle power block in this study, we first build a basic model to simulate Dah-Tarn natural gas combined-cycle (NGCC) power plants, and verify the feasibility of the basic model by analyzing the electricity output. Then, the model can be applied to the power block of an IGCC. The simulation results of Dah-Tarn NGCC show that the gas turbine output gross is 225.22 MW, with the corresponding specification output as 233.9 MW, of which the difference in output between specification and simulation is 3.71%; while for steam turbine output, the simulation results, specification and difference are 260.28 MW, 256.9 MW and 1.32%, respectively. Due to the fact that the differences in electricity output are below 4%, the feasibility of combined-cycle model is verified. Hence, the basic model can be used to simulate combined-cycle systems.

The simulation of power block of IGCC is based on the report "Environmental Footprints and Costs of Coal-Based Integrated Gasification Combined Cycle and Pulverized Coal Technologies" from United States Environment Protection Agency. The gas turbine type is decided by the gas turbine exhaust temperature. The simulation results show the minimum difference in temperature as 0.21% for the type number of GE-PG7221(FA); hence, we use the GE-PG7221(FA) type gas turbine to simulate the power block. The simulation result of the gas turbine output gross is 412.31 MW, which contains the expanding work from syngas before combustion; as a consequence, the difference in output between reference and simulation result is 5.54%. Furthermore, the steam turbine gross output is 126.50 MW and the difference in output between reference and simulation results is 0.78%.

We will continue to modify the simulation model to an optimized one, and apply the whole IGCC simulation model for parametric study in future work.



▲ IGCC Simulation Model

Simulation Results of Combined- Cycle Output

Gas Turbine Generator System	EPA	Simulation Results- Gas Turbine		
		Air Compressor	Gas Turbine	Syngas Expander
Consumption of Work (MW)	–	286.51	–	–
Generation of Work (MW)	–	–	691.12	14.40
Net Work[1] (MW)	–	404.61		–
Net Work[2] (MW)	–	–		419.01
Output[3] (MWe)	436.5	398.14		412.31
Error (%)	–	8.79		5.54
Steam Turbine Generator System	EPA	**Simulation Results- Steam Turbine**		
		High Pressure Steam Turbine	Intermediate Pressure Steam Turbine	Low Pressure Steam Turbine
Generation of Work (MW)	–	27.56	34.40	66.60
Total Work (MW)	–	128.56		
Output[3] (MWe)	127.5	126.50		
Error (%)	–	0.78		

1. Net Work = Gas Turbine-Air Compressor
2. Net Work = Gas Turbine-Air Compressor + Syngas Expander
3. Generator Conversion Efficiency 98.4%

5.5 Development of High Temperature Dust Removal System

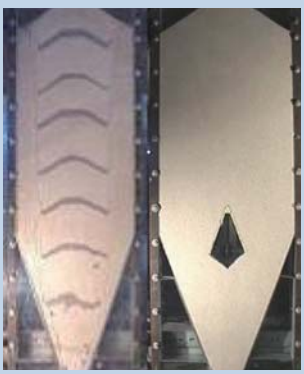
Yi-Shun Chen, Yau-Pin Chyou

Experimental studies on the flow patterns in a transparent two-dimensional (2D) model of hopper were accompanied by funnel flow and stagnant zones in granular moving bed. Proper design and placement of flow-corrective insert can change funnel flow with stagnant zones into mass flow with uniform steady-state flow in the 2D model of hopper. Design of insert is described in this study, together with verifying experiments.

In this project, two kinds of filter media with different particle size is to be put in a 2D filter vessel system to study flow pattern and mixing behavior. The results from 2D experiments will be utilized to find optimal and important parameters, including mass flow rate of filter media, design of louver dimension…etc. Silica sands are prospective granular filter media (GFM) in two-stage granular moving bed filters (GMBF) for hot gas cleanup technology. Two filter media, usually coarse sands and fine sands are used in two-stage GMBFs in order to increase their filter efficiency. GMBF developers fear that fine filter media can bring together flowability problems in granular moving bed. Wall friction of GFM affects flow patterns and stagnant zones of granular filter in moving bed considerably. Measurements of kinematic wall friction angles of different mixtures of fine and coarse silica sands are presented in this project. Uncorroded carbon steel and stainless steel specimens are chosen as wall materials. A brief description of the test equipment used to measure wall friction together with a method of evaluating the kinematic angle of wall friction is discussed. Moreover, the filtration efficiency of 95% and the outlet particle size d_{50} of system less than 10 μm are achieved.

With the results of this project, we can design the 3-D two stage moving granular bed for the cold test. The final goal of the project is to develop the design rules for commercializing moving granular bed filter.

▲ Test Equipment Used to Measure Wall Friction



▲ Flow of Silica Sand in 2-D Hopper

5.6 High Power Pulsed Magnetron Sputtering

Jin-Yu Wu

A novel ionized physical vapor deposition (PVD) technique, also known as high power impulse magnetron sputtering (HIPIMS), was developed specially to solve the conventional PVD coating problems, such as microparticle deposited in film and poor film adhesion. By upgrading the conventional coater with a new modulated pulse power (MPP) source instead of the sputtering power supply, it can get a pulsed high peak target power density for a short period of time (~100μs) and easily generate a high density plasma with the high degree of ionization of the sputtered species. Due to its high plasma density, the HIPIMS technique has been tested and demonstrated to improve coating performances and enhance coating adhesion as compared to continuous dc magnetron sputtering (dcMS). However, one downside of HIPIMS technique is that the deposition rate is lower than the dcMS because some of the ions are attracted backward to the target and captured by the negative potential on the cathode.

We had achieved some substantial results including a HIPIMS coating system with application of high density plasma on TiN and CrN film coating. A high performance HIPIMS coating system had been setup with an average 40KW modulated pulse power and a column-shape rotary Ti target of 70cm in length. This near megawatt high power pulse is applied to the target to form the strongly ionized working gas and sputtered species, and the ionization rate is ranged from 70% to 100%. The plasma density measured at a position located 10cm from HIPIMS Ti target is up to a valve of $10^{19}/m^3$, about three orders higher than that of conventional magnetron sputtering. Therefore HIPIMS can effortlessly deposit films with very good quality on substrate. A 24-hour test of anti-corrosion comparison was conducted for TiN film with same film thickness coated by HIPIMS and conventional cathode arc, respectively. The results revealed that the film coated by HIPIMS shown obviously to resist acid corrosion longer than the film by cathode arc. Finally, a functional film coating by HIPIMS for commercial application like CrN film was coated successfully on a cell phone mould. From the above results presented, HIPIMS technique presents a strong advantage to enhance film properties and to replace the existing traditional coating in PVD industry.

▲ High Power Pulsed Magnetron Sputtering Coating System

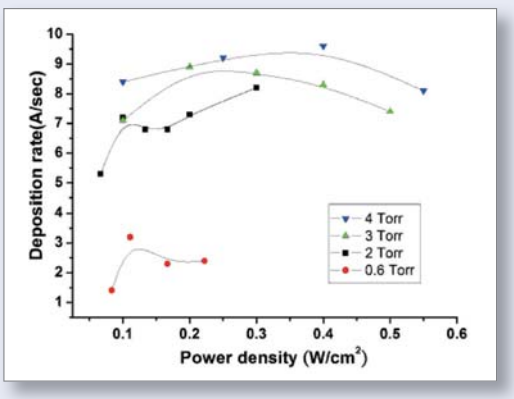
▲ Protective CrN Film Coated on Commercial Cell-phone Mould by HIPIMS

5.7 Large Area Deposition of Silicon Thin Films by Very High Frequency Plasma Enhanced Chemical Vapor Deposition

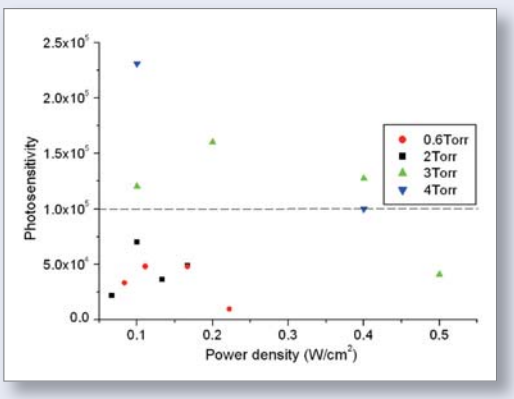
Der-Jun Jan

Solar cell, converting the sun ray directly into electricity without moving parts and emitting pollutants, would help to reduce carbon emissions and the threat of global warming. If its costs can be lowered, photovoltaic (PV) electricity could become a competitive source of energy, and thus improve the security of Taiwan's energy supply. Among the Photovoltaic technologies, thin-film solar cells based on amorphous (a-Si:H) and microcrystalline (μc-Si:H) silicon are emerging as leading solutions for low-cost, large-scale PV applications. The main objective of this program is to develop a high rate thin film deposition method in order to increase the throughput of roll-to-roll production system and thus reduce the cost of the solar modules. New cathode electrode of showerhead type and high flow range control system of SiH4 were installed in the self-made very high frequency plasma enhanced chemical vapor deposition (VHF PECVD) system. The size of the showerhead cathode is 400×400 mm/mm. The modification of hardware allows us to incorporate more SiH_4 into the plasma and leads to higher deposition rate. Furthermore, the dilution gas was changed from Ar to H_2 to reduce the bombardment on Si film during deposition, which can avoid radiation damage of the film structure. The deposition rate was studied as a function of chamber pressure. It was found that the deposition rate reached the highest value of 1 nm/s when the chamber pressure was kept near 4 torr in our deposition system. The other parameters such as photosensitivity, optical band gap, and activation energy also showed that the films we deposited had fulfilled the criteria for device quality amorphous and microcrystalline silicon films.

In the second stage of this program, the deposition conditions used to prepare i-layer of a-Si:H and μc-Si:H were being systematically varied to optimize the film properties. The focus of these studies is on optimizing the film properties while maintaining deposition rates around 1 nm/s. The information obtained from these studies is being used to prepare high efficiency flexible cells with high growth rates. In the later stages of the program, roll-to-roll hardware designs will be developed which would allow for the incorporation of this high rate technique into a thin-film solar cells production line environment.



▲ The Variation of Growth rate as a Function of Power Density at Different Chamber Pressures in a VHF PECVD System



▲ The Photosensitivity of I-layer of amorphous Silicon Films as a Function of Power Density at Different Chamber Pressures Deposited in a VHF PECVD System

5.8 Development of Multi-Plasma Sources Coating Techniques for Industrial Applications

Cheng-Chang Hsieh

Multi-plasma sources coating technique is one of the most advanced eco-friendly manufacturing techniques for modifying surface properties of materials with zero pollution. It is also the most novel alternative especially for the highly environment-polluted electroplating industry for ensuring compliance to the requirements for the RoHS (Restriction of Hazardous Substances) Directives for the European Union. It can be used to resolve not only the trade barrier of exporting products into the European market but also help to prevent the environmental pollutions induced by the electroplating industry domestically.

In year 2009, three advanced plasma coating apparatuses had been constructed in the plasma engineering laboratory at INER. The first one was an advanced large plasma coating integrated system which consists of a deposition chamber with dimension ϕ 2.4m(D)×5.5m(H), one column target plasma source, 40 flat plasma sources, PLC control system and vacuum pumping system. Uniform plasma can be produced for large plate and special-shaped stainless steel building materials and it is the largest coater ever in Taiwan.

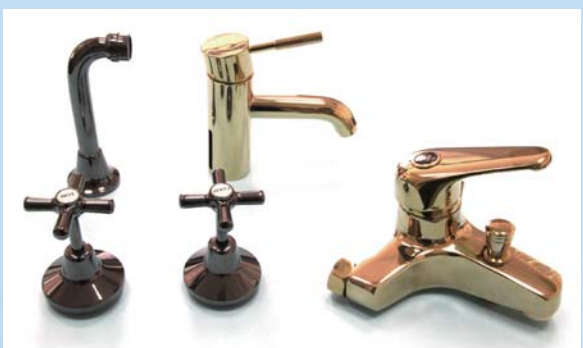
Second, a huge vertical plasma coating integrated system with volume size of 5 meters in height, 1.3 meters in diameter was developed. There are 21 disk-target plasma sources mounted on the chamber wall, which can produce uniform plasmas for the deposition of TiN and CrN films on a 3m long jet screws. The film adhesion is up to 75N and the coating products have passed both the anti-corrosion and wear resistance test in plastic injection hazard environment.

Third, a powerful multi-plasma sources deposition apparatus with size ϕ 1.8m(D)×2.2m(H) chamber was constructed. One long cylindrical plasma source along with 12 pieces of planar-arc sources are mounted inside the coating chamber for the deposition of Cr, Ti, Zr and alloy of these metals or multi-layer ceramic films for various sanitation spare parts.

The plasma techniques used in these three systems, including the plasma generation technology, special plasma coating apparatus and specific manufacturing processes are all developed at INER. We look forward to assist more domestic industries to upgrade their manufacturing techniques and qualities, and also to make more contribution in the environment protection. In the future, we will enhance our competitiveness for the roll-to-roll thin film plasma technique on solar cell fabrication.

▲ Advanced Large Plasma Coating Integrated System

▲ Huge Vertical Plasma Coating Integrated System



▲ Plasma Deposition Applied on Various Sanitation Products

5 Appendices

Patents

1. Lin, M.C., Lan, S.M., Yang, T.N., Wei, T.Y., Chioeu, C.P., Tseng, Y.C., Lee, J.S., Kuo, M.C., Shieh, D.C., Lin, L.F., "InN/InP/TiO2 Photosensitized Electrode", EPU, EP1887592, 2006.08.08-2026.08.08.
2. Fang, H.F., Yang, W.C., Chen, I.J., "Environmental Survey Robot", ROC, Patent M 348676, 2009.01.11-2018.07.21.
3. Hsia, C.C., Shen, L.H., "Rapid Method for Determining Radiochemical of In-111-pentetreotide", ROC, Patent I305263, 2009.01.11-2026.04.12.
4. Yeh, C.H., Yuan, M.C., "Volume Calibration Phantom and Calibration Method Thereof", USA, US 7,479,628 B1, 2007.10.22-2027.10.22.
5. Tsai, Y.S., Lee, S.W., "Sampling Pipe", ROC, Patent M 349489, 2009.01.21-2017.09.24.
6. Hwang, C.C., Liu, T.M., Tyen, J.G., "A Method for Processing Spent Ion-Exchange Resins", USA, US 7,482,387 B2, 2004.02.17-2024.02.17.
7. Yang, T.N., Lan, S.M., "Method for Fabricating Crystalline Silicon Thin Films", USA, US7,485,560B2, 2006.11.22-2026.11.21.
8. Chung, J.C., Chen, M.N., Hwang, C.C., "Lipiodol-Ferrofluid and a Process for Preparation Thereof", USA, US 7,488,431 B2, 2009.02.10-2027.04.27.
9. Cheng, K.J., Yang, Y.T., Lain, R.K., Shih, Y.C., "A Safe Hoist Device Used for Lifting the Spent Nuclear Fuel Dry Storage Canisters", ROC, Patent M350546, 2009.02.11-2017.09.17.
10. Chang, Y.R., Ho, Y.H., Chan, C.M., "Fault-Tolerant Circuit Device in Fuel Cell AC Inverter", USA, US7,492,060B2, 2006.09.01-2026.08.31.
11. Li, M.H., Lin, W.J., Chien, C.H., Tsai, J.C., Lan, W.S., "An Improved Medication Dispensing Device", EPU, EP1882467, 2006.07.28-2026.07.28.
12. Yeh, H.Y., Lee, C.D., Chen, M.H., Liu, P.C., Tseng, Y.C., "Hybrid Mode Sun-Tracking Apparatus Having Photo Sensor", USA, US7,507,941B2, 2006.09.11-2026.09.10.
13. Yang, S.J., Chyou, S.L., Chen, M.H., "Radwaste Warehouse Area Monitoring System", USA, US7,508,311B2, 2006.09.13-2026.09.12.
14. Wu, C.H., Chang, K.S., Shin, H.Y., Tseng, Y.C., "Optical Switch Structure", USA, US7,508,573B2, 2006.05.25-2026.05.24.
15. Fang, H.F., Chioeu, Y.F., Pan, T.L., Liang, K.H., Chen, I.J., "Airborne Radioactive Particles Sampled in a Draft Flue", ROC, Patent M354151, 2009.04.01-2017.07.31.
16. Chung, J.C., Leu, Y.F., Wei, T.Y., Tseng, Y.C., "Preparation and Application of Titanium Dioxide Slurry", ROC, Patent I308554, 2009.04.11-2026.11.19.
17. Liang, Y.P., Lin, K.H., Hong, H.F., Shin, H.Y., Kuo, C.T., "Cable for Use in a Condensing Photovoltaic Apparatus", ROC, Patent M354861, 2009.04.11-2017.11.19.
18. Cheng, C.T., Huang, W.M., "Electrode Structure of Thin Film Fuel Cell With Catalyst Deposited on Nanosize Carbon Material", ROC, Patent M355465, 2009.04.21-2017.11.27.
19. Yang, T.N., Ma, W.Y., "Spark-Gap White Fluorescent Lamp Having Silicon Quantum Dots and Preparing Method Thereof", ROC, Patent I309057, 2009.04.21-2026.06.01.
20. Yu, Y-H., Chang, C.H., Shyu, J.S., Liu, Y.H., Lin, T.Y., Tseng, K.Y., Chiu, W.J., "Tube Cutting Device and Method Thereof", ROC, Patent I309185, 2009.05.01-2027.01.02.

21. Shih, Z.H., Hong, H.F., Lin, K.H., "Insulating Device of Concentration Photovoltaic Heat Sink", ROC, Patent M356354, 2008.05.01-2017.06.11.
22. Li, H.Y., Tzeng, C.C., "High Power-Factor AC/DC Converter With Parallel Power Processing", USA, US7,535,734B2, 2006.10.19-2026.10.18.
23. Yang, T.N., Ku, C.T., "White-Light Fluorescent Lamp Having Silicon Quantum Dots and Fabricating Method Thereof", ROC, Patent I310205, 2009.05.21-2026.05.17.
24. Chen, C.Y., Liao, C.H., Hwang, C.C., Liu, C.S., "Vermiculite Supported Catalyst for CO Preferential Oxidation and the Process of Preparing the Same", USA, US7,541,311B2, 2009.06.02-2029.12.02.
25. Lee, T.W., Chen, D.R., Hsu, Y.M., Chang, H.J., Chyi, S.Y., Chang, C.H., Fan, K.H., Hsu, W.C., Fu, Y.K., Huang, C.Y., Wu, M.H., Chang, K.P., Kao, C.F., "Radioactive Arsenic-containing Compounds and Their Uses in the Treatment of Tumors", EPU, EP1477174B1, 2004.04.22-2024.04.22.
26. Fang, H.F., "Management System With Real-Time Interaction for Environmental Monitoring and Method Thereof", USA, US7,545,265B2, 2006.12.20-2026.12.20.
27. Peng, C.C., Yang, C.W., Wu, C.M., "Fuel Channel Temporary Hanging Device", ROC, Patent M358819, 2009.06.11-2017.10.29.
28. Luo, A.J., Huang, T.C., Chen, C.C., Kao, H.C., "Manufacturing Method for ^{123}I-ADAM and Automatic Manufacturing Device Thereof", USA, US7,556,780B1, 2006.09.11-2026.09.11.
29. Wu, C.H., "Light-Collection Apparatus", ROC, Patent I312053, 2009.07.11-2027.07.18.
30. Chen, W.F., Huang, C.C., Lee, C.D., "Solar Tracker Having Louver Frames", ROC, Patent I312054, 2009.07.11-2027.05.16.
31. Yang, S.J., Chyou, S.L., Chen, M.H., "Radwaste Warehouse Area Monitoring System", ROC, Patent I312079, 2009.07.11-2026.08.23.
32. Lin, D.W., Shyu, H.F., "Reactor Internal Pump Weld Inspection Simulator", ROC, Patent M361630, 2009.07.21-2018.04.09.
33. Wu, C.H., Chiu, H.S., Chang, K.S., Chu, K.Y., "Wafer Clamp Having Changeable Supporting Part", USA, US7,562,922B2, 2007.05.14-2027.05.13.
34. Hwang, W.S., Kuo, M.C., Men, L.C., Chen, W.H., Liu, H.S., Lee, M.C., Chen,Y.C., Chen, K.Y., Chen, C.C., Lin, B., "Algae Mass-Producing Device Having Radiation Source for Hormesis", JP, Patent 4350124, 2006.12.27-2026.12.26.
35. Wu, T.H.,Chen, K.S., Chen, C.C., Shen, L.H., Yeh,Y.C., Tsai, N.C., "Plasma Method for Tiox Biomedical Material onto Polymer Sheet", ROC, Patent I312689, 2009.08.01-2026.06.08.
36. Chien, C.C., Cheng, C.T., "Method of Fabricating Platinum Alloy Electrocatalysts for Membrane Fuel Cell Applications", ROC, Patent I312699, 2009.08.01-2026.06.01.
37. Kuo, M.S., Hong,T.M., Hsieh, C.C., Lee, W.C., "Feeding System for Plasma Melting-Furnace", ROC, Patent I312703, 2009.08.01-2026.06.08.
38. Cheng, W.Y., Ma, C.C.,Yu, K.H.,Yang, C.T., "Fuel Crane Control System", ROC, Patent I313012, 2009.08.01-2026.10.18.
39. Yang, T.N., Lan, S.M., Ma, W.Y., "Silicon-Rich-Oxide White Light Photodiode", USA, US7,569,864B2, 2006.05.03-2026.05.02.
40. Yang, T.N., Ma, W.Y., "White-Light Fluorescent Lamp Having Silicon Quantum Dots and Fabricating Method Thereof", USA, US7,569,984B2, 2006.06.19-2026.06.18.

41. Tsai, Y.C., Chiang, L.K., Huang, C.L., Huang, W.P., Lee, C.H., "Solid Oxide Fuel Cell Stack of Modularized Design", JP, Patent 4354647, 2005.12.20-2025.12.20.
42. Lee, Y.M., Shih, Z.H., Hong, H.F., Huang, J.J., Shin, H.Y., "With Heat Dissipation of the Solar Cell Packaging Structure and Its Heat Dissipation Aluminum Plate", ROC, Patent M362979, 2009.08.11-2018.03.05.
43. Chen, C.C., Chen,Y.C., Chen, K.Y., Liu, H.S., Lin, B., Lee, M.C., Kuo, M.C., Hwang, W.S., Fu, Y.K., Lin, W.J., Shen, L.H., "Method of Hormesis for Seaweed Through Irradiation", JP, Patent, 2006.07.25-2026.07.24.
44. Yeh, C.H., Yuan, M.C., Wang, J.J., "Measurement Device for Low-Activity Gamma Radiowaste", ROC, Patent M363665, 2009.08.21-2018.04.02.
45. Yang, T.N., Ma, W.Y., "Spark-Gap White Fluorescent Lamp Having Silicon Quantum Dots and Preparing Method Thereof", USA, US7,579,770B2, 2006.08.28-2026.08.27.
46. Tsai,Y.M., Hwang, S.R., C.H., Chen, J.T., Chang, M.H., Duh, T.S., Lin, W.J., "Separation Device of Radioisotope TI-201", USA, US7,578,935B2, 2006.09.11-2026.09.10.
47. Tsai,Y.M., Hwang, S.R., Lu, C.H., Chen, J.T., Chang, M.H., Duh, T.S., Lin, W.J., "Radioisotope TI-201 Production Process", USA, US7,578,982B1, 2006.08.09-2026.08.08.
48. Tang, S.Y., Lin, W.J., "Method for Recycling Thallium-203 Isotope in Remnant Solution", ROC, Patent I314064, 2009.09.01-2024.09.23.
49. Jrir Smid, Shiau, S.S., Tzeng, C.C., Chen, Y.S., Hsu, J.Z.,Yu, Y.J., "Adjustable Dual-Blade Dust Filter Using Granular Bed Flow", ROC, Patent I314062, 2009.09.01-2027.01.17.
50. Chang, H.L., Tsao, C.S., Chang, H.R., Shieh, K.L., Cheng, P.S., "Preparation Method for Oil-Based Magnetic Fluid", EPU, EP 1964874, 2007.02.12-2027.02.12.
51. Hwang, W.S., Kuo, M.C., Men, L.C., Chen, W.H., Liu, H.S., Lee, M.C., Chen,Y.C., Chen, K.Y., Chen, C.C., Lin, B., "Method for Fabricating a Proton Exchange Membrane Having a Relational Selective Coefficient", ROC, Patent I314437, 2009.09.11-2026.11.29.
52. Chung, J.C., "Algae Mass-Producing Device Having Radiation Source for Hormesis", USA, US7,591,960B2, 2006.02.15-2026.02.15.
53. Tzeng, C.C., Chen, S.H., Lin, D.L., Yang, M.S.,Yan, J.M., Yu, Y.J., "High-Voltage Discharging Reactor Processing Exhausted Hydrogen Gas", USA, US7,594,810B2, 2005.10.28-2025.10.27.
54. Tsai,Y.M., Hwang, S.R., Lu, C.H., Chen, J.T., Chang, M.H., Duh, T.S., Lin, W.J., "Radioisotope TI-201 Production Process", ROC, Patent I315214, 2009.10.01-2026.06.28.
55. Su, S.H., Yuan, M.C., Chen, C.L., "Penetration Ionization Chamber", ROC, Patent I315540, 2009.10.01-2026.07.27.
56. Chang, Y.R., Ho, Y.H., Chan, C.M., "Fault-tolerant Circuit Device in Fuel Cell AC Inverter", ROC, Patent I315592, 2009.10.01-2026.06.21.
57. Wu, C.H., Cheng, C., Chang, K.S., Chu, K.Y., "Wafer Dicing Method", USA, US7598157B2, 2007.05.14-2027.05.13.
58. Chen, C.Y., Hsu, C.Y., Huang, C.L., Yang, P., Lin, Y.B., "Structure of Fuel Cell Assembly", ROC, Patent I315920, 2009.10.11-2026.06.12.
59. Chiang, L.K., Tsai, Y.C., Huang, C.L., Huang, W.P.,Lee, C.H., "Solid Oxide Fuel Cell of Multiple Tubular Electrodes", JP, Patent 4397886, 2005.12.15-2025.12.15.
60. Chang, M.H., Chen, D.C., Chu, K.Y., Huang, P.Y., Chen, J.T., Duh, T.S., Lin, W.J., "Circulated Cooled Target", ROC, Patent I316559, 2009.11.01-2026.06.28.

61. Yang, T.N., Ku, C.T., Lan, S.M., Chen, Y.R., Chiang, C.C., Ma, W.Y., ”Preparing Method of CNT-Based Semiconductor Sensitized Solar Cell”, USA, US7,615,492B2, 2006.07.21-2026.07.20.
62. Luo, A.J., Huang, T.C., Chen, C.C., Kao, H.C., ”Manufacturing Method for ^{123}I-ADAM and Automatic Manufacturing Device Thereof”, ROC, Patent I316931, 2009.11.11-2026.07.27.
63. Hsueh, T.H., Tseng, C.P., Ai, C.F., ”The Modification Method and Its Apparatus of Atmospheric Pressure to Vacuum Plasma Sputtering at Fabric Fibers”, ROC, Patent I316967, 2009.11.11-2026.10.25.
64. Yeh, C.H., Yuan, M.C., ”Volume Calibration Phantom and Calibration Method Thereof”, ROC, Patent I317023, 2009.11.11-2026.10.16.
65. Fang, H.F., ”Management System With Real-Time Interaction For Environmental Monitoring and Method Thereof”, ROC, Patent I317104, 2009.11.11-2026.10.16.
66. Perng, K.N., Lin, K.F., Lee, Y.S., Chen, C.Y., Liu, C.S., Hwang, K.L., ”Fuel-Concentration Detecting and Controlling Device for Fuel Cell”, USA, US7,618,585B2, 2005.08.17-2025.08.16.
67. Lin, M.C., Lan, S.M., Yang, T.N., Wei, T.Y., Chioeu C.P., Tseng, Y.C., Lee, J.S., Kuo, M.C., Shieh, D.C., Lin, L.F., ”InN/TiO2 Photosensitized Electrode”, USA, US7,622,397B2, 2006.03.02-2026.03.01.
68. Jan, M.L., Chuang, K.S., Ni, Y.C., ”Image Reconstruction Method for Structuring Two-Dimensional Planar Imaging into Three-Dimension Imaging”, JP, Patent 4414410, 2009.11.27-2026.04.28.
69. Yan, J.M., Chen, S.H., Yang, M.S., Huang, M.H., Chen, Y.G., ”A Cleaning Device Using Atmospheric Gas Discharge Plasma”, ROC, Patent I317657, 2009.12.01-2026.11.15.
70. Chang, C.Y., Chen, C.Y., Chang, C.L., Liu,T.H., Lin, Y.D., ”Fuel Cell Apparatus and A Charging/Discharging Management System And Method Using Such Apparatus”, ROC, Patent I318472, 2009.12.11-2026.05.18.
71. Hu, H.T., Huang W.T., Chen, Y.P., ”Adjustable Compact High-Frequency-High-Voltage Power Supply”, ROC, Patent I318491, 2009.12.11-2026.10.30.
72. Yu, Y.H., Shyu, J.S., Liu, Y.H., ”Apparatus for Inspecting Springs”, ROC, Patent I318770, 2009.12.21-2027.01.02.
73. Yang, T.N., Lan, S.M., ”Method for Making Red-Light Emitting Diode Having Silicon Quantum Dots”, USA, US7,635,603B2, 2005.12.30-2025.12.29.

Publications and Reports

1 International Journal Papers

1. INER-5897, Chang, Y.C., Lee, M.C., Kao, W.X., Lin, T.N., "Preparatiof a Nano-Scale/SOFC Grade Ytttrium-Stablized Zirconia Material: A Quasi-optimization of the Hydrothermal Coprecipitation Process", International Journal of Applied Ceramic Technology, 5(6), pp 557-567, (2009).
2. INER-5905, Hwang S.L., Lin J.T., Liang G.F.,Yau Y.J., Yenn, T.C.,Hsu, C.C., "Application Control Chart Concepts of Designing a Pre-Alarm System in the Nuclear Power Plant Control Room", Nucl Eng Des, 236(12), pp 3522-3527, (2008).
3. INER-5912, Lai, W.H., Chyou, Y.P., Tsai, Y.C., Lee, C.H., "Experimental Simulation on the Integration of Solid Oxide Fuel Cell and Micro-Turbine Generation System", Journal of Power Sources, 171, pp 130-139, (2008).
4. INER-5928, Lee, J.H., Hwang, W.S., Webb, D.V., Buermann, L., Burns, D.T., Takeyeddin, M., Srimanoroth, S., Meghzifene, A., Chun, K. J., Kadni, T. B., Takata, N., Msimang, Z., "APMP/ TCRI Key Comparison Report of Measurement of Air Kerma for Medium-Energy X-Rays (APMP. RI(I)-K3)", Metrologia, 45(6012), pp 1-38, (2008).
5. INER-5933, Yang, M.D., Liu, Y.K., Shen, J.L., Wu, C.H., Lin, C.A., Chang, W.H., H. H.,Yeh, H. I., Chan, W.H., Parak, W.J., " Improvement of Conversion Efficiency for Multijunction Solar Cells by Incorporation of Au Nanoclusters", Opt Express, 16(20), pp 15754-15758, (2009).
6. INER-5934, Lai, L.W., Chen, J.T., Lou, L.R., Wu, C.H., Lee, C.T., " Performance Improvement of (NH4)2Sx-Treated III–V Compounds Multijunction Solar Cell Using Surface Treatment", J Electrochem Soc, 155(12), pp B1270-B1273, (2009).
7. INER-5936, Jan, T.R., Chiang, C.C., Liao, T.J., Hsu, W.L., Chi, C., Yen, T., Shen, L.H., Kung, M., Wey, S., Wun, T., Liao, M.H., "A Comparative Study on The Binding Capacity of Native Annexin V And Annexin V-Kunitz Protease Inhibitor Fusion Protein to Apoptotic T Cells", Eur J Nucl Med Mol I, sup2(35), pp s163-s163, (2009).
8. INER-5944, Wang, T.C., Wang, S.J., "Analysis of Severe Accident Management Strategy for a BWR-4 Nuclear Power Plant", Nuclear Technology, 2005(12), pp 253-265, (2004).
9. INER-5945, Lee, C.Y., Wey, S.P., Liao, M.H., Hsu, W.L., Wu, H.Y., Jan, T.R., "A Comparative Study on Cannabidiol-Induced Apoptosis in Murine Thymocytes and EL-4 Thymoma Cells", Int Immunopharmacol, 8, pp 732-740, (2009).
10. INER-5953, Chang, C.T., Chen, Y.P., Chen, Y.Z., "Characteristics of Au/MgxAlO hydrotalcite Catalysts on CO Selective Oxidation", J Mol Catal A-Chem, 300, pp 80-88, (2008).
11. INER-5959, Lee, S.C., Chuang, C.H., Sheu, B.S., Yao, W.J., Yang, H.B., "Gender Difference of Circulating Ghrelin and Leptin Concentrations in ChronicHelicobacter Pylori Infection", Helicobacter, 14, pp 54-60, (2009).
12. INER-5963, Tung, H.M., Huang, J.H., Tsai, D.G., Ai, C.F., Yu, G.P., " Hardness and Residual Stress in Nanocrystalline ZrN Films: Effect of Bias Voltage and Heat Treatment", Mat Sci Eng A-Struct, 500, pp 104-108, (2009).
13. INER-5964, Hwang, S.L., Liang, G..F., Lin, J.T., Yau, Y.J.,Yenn, T.C., Hsu, C.C., Chuang, C.F., " A Real-Time Warning Model for Teamwork Performance and System Safety in Nuclear Power Plants", Safety Sci., 47(3), pp 425-435, (2008).
14. INER-5969, Ju, S.J., "On the Distribution Type of Uncertain Inputs for Probabilistic Assessment", Reliability Engineering & System Safety, 94(5), pp 964-968, (2008).
15. INER-5970, Yu, C.T., Chen, W.H., Men, L.C., Hwang, W.S., "Microscopic Structure Features Changes of Rice Straw Treated by Boiled Acid Solution", Industrial Crops and Products, 29, pp 308-315, (2008).

16.INER-5971, Farn, S.S., Yeh, Y.H., Lin, W.J., Shen, L.H., "Development and Validation of CIDG Impurity Analysis in [^{18}F]FDG by Three Potential-time Waveforms of HPLC/PAD", Nucl Med Biol, 36, pp 225-231, (2008).

17.INER-5973, Lee, J.H., Lin, M.S., Hsu, S.M.,Chen, I.J., Chen, W.L., Wang, C.F., "Dosimertry Characteristics and Performance Comparisons : Environmental Radiophotoluminescent Glass Dosemeters Versus Thermoluminescent Dosemeters", Radiat Meas, 44, pp 86-91, (2008).

18.INER-5980, Tsao, C.S., Yu, M.S., Wang, C.Y., Liao, P.Y., Chen,.H.L., Jeng, U.S., Tzeng, Y.R., Chung, T.Y., Wu, H.C., "Nanostructure and Hydrogen Spillover of Bridged Metal-Organic Frameworks", J Am Chem Soc, 131, pp 1404-1406, (2008).

19.INER-5981, Chen, L.C., Chang, C.H., Yu, C,Y., Chang, Y.J., Wu, Y.H., Lee, W.C., Yeh, C.H., Lee, T.W., "Pharmacokinetics, Micro-SPECT/CT Imaging And Therapeutic Efficacy of ^{188}Re-DXR-Liposome in C26 Colon Carcinoma Ascites Mice Model", Nucl Med Biol, 35(2008), pp 883-893, (2007).

20.INER-5983, Young, M.C., Huang, J.Y., Kuo, R.C., "Corrosion Fatigue Behavior of Cold-Worked 304L Stainless Steel in a Simulated BWR Coolant Environment", Mater Trans, 50(3), pp 657-663, (2008).

21.INER-5984, Tseng, H.J., Hsu,.S.H., Hsueh, T.H., Wu, M.W., Tu, P.C., "Nylon Textiles Grafted with Chitosan by Open Air Plasma and their Antimicrobial Effect", Fiber Polym, 10(1), pp 53-59, (2008).

22.INER-5987, Hsieh, C.L., Lin, H.T., Wang, J.R., Chiangc, S.C., Weng, T.L., Shih, C.K., "A Sensitivity Study of BWR Instability over Global and Regional Modes at Different Exposures", Nucl Eng Des, 238(12), pp 3468-3474, (2008).

23.INER-5998, Li, Z.Y., Lan, S.M., Chen, Y.R., Chen, M.C., Huang, Y.H., Ku, C.T., Liao, S.M.,Yang, T.N.,Wang, S.C., Chi,.G.C., "Growth of InN on Si (111) by Atmospheric-Pressure Metal-Organic Chemical Vapor Deposition Using Inn/Aln Double-Buffer Layers", J Vac Sci Technol A, 26(4), pp 587-591, (2009).

24.INER-6014, Wang, J.J., "Low-Level Radioactivity Proficiency Testing Program in Taiwan", Appl Radiat Isotopes, 67, pp 687-691, (2009).

25.INER-6016, Luo, T.Y., Tang, I.C., Wu, Y.L., Hsu, K.L., Liu, S.W., Lin, W.J., Lai, B.S., Kung, H.C., " Evaluating the Potential of ^{188}Re-SOCTA-Trastuzumab as a New Radioimmunoagent for Breast Cancer Treatment", Nucl Med Biol, 36, pp 81-88, (2009).

26.INER-6018, Chang, H.T., Lin, C.K., Liu, C.K., "High Temperature Mechanical Properties of a Glass Sealant for SOFC", J Power Sources, 2(189), pp 1093-1099, (2008).

27.INER-6019, Huang, C.F., Lin, T.H., Guo, G.L., Hwang, W,S., "2009 Enhanced Ethanol Production by Fermentation of Rice Straw Hydrolysate without Detoxification Using a Newly Adapted Strain of Pichia stipitis", Bioresour Technol, 100, pp 3914-3920, (2008).

28.INER-6020, Wei, H.J., Tsai, T.L., Wang, T.W., Wang, J.J., " Clearance Measurement of Metal Scraps for Nuclear Facility at INER in Taiwan", Applied Radiation and Isotopes, 67 (5) pp 944-949, (2009).

29.INER-6027, Maa, K.H., Huang, W.S., Huang, S.Y., Cheng, C.Y., Chen, C.Y., Shen, L.H., Liu, J.C., Fu, Y.K., "Imaging Serotonin Transporters Using [^{123}I]ADAM SPECT in a Parkinsonian", Appl Radiat Isotopes, 66, pp 1799-1803, (2009).

30.INER-6034, Chu, C.H., Chen, I.J., Hsieh, P.T., Lin, W.T., Chen, W.L., "Dosimetry Study for β-radiation Treatment of in-stent Restenosis", Radiat Prot Dosim, 134(1), pp 49-54, (2009).

31.INER-6039, Chen, H.L., Lee, H.M., Chen, S.H., Chang, M.B., Yu, S.J., Li, S.N., "Removal of Volatile Organic Compounds by Single-Stage and Two-Stage Plasma Catalysis Systems", Environ Sci Technol, 43(7), pp 2216-2227, (2009).

32.INER-6046, Huang, H.W., Shih, C.K., Hong, H.C., Chen, M.H., "Development and D3 Application of ABWR Feedwater Pump and", Nucl Eng Des, 239, pp 1136-1147, (2009).

33. INER-6052, Liang, G..F., Lin, J.T., Hwang, S.L., Huang, F.H., Yenn, T.C., Hsu, C.C., "Evaluation and Prediction of On-line Maintenance Workload in Nuclear Power Plants", Hum Factor Ergon Man, 1(19), pp 1-14, (2008).

34. INER-6068, Huang, C.C., Wu, T.Y., " A Study on Dynamic Impact of Vertical Concrete Cask Tip-over Using Explicit Finite Element Analysis Procedures", Ann Nucl Energy, 36, pp 213-221, (2008).

35. INER-6069, Yuan, M.C., Yeh, C.H., Chen, I.J., Wang, C.F., Wang, J.J., " The Calibration and Evaluation of a Radioactive Waste Drum Counting System", Appl Radiat Isotopes, 67, pp 931-934, (2009).

36. INER-6074, Weng, Y.H., Huang, C.P., Wei, H.J., Tsai, T.Y., Chen, W.H., Wei, T.Y., Hwang, W.S., Wang, J.B., "Separation of Acetic Acid from Xylose by Nanofiltration", Sep Purif Technol, 67, pp 95-102, (2009).

37. INER-6077, Smid, Jrir., Hsiau, S.S., Tsai, S.A., Tzeng, C.C., Chyou, Y.P., "Study on Gravity Flow of Granules in Beds Supported by Louver-sublouver System", Adv Powder Technol, 20, pp 127-138, (2009).

38. INER-6078, Jou, Y.T., Lin, C.J., Yenn, T.C., Yang, C.W., Yang, L.C., Tsai, R.C., "The Implementation of a Human Factors Engineering Checklist for Human-System Interfaces Upgrade in Nuclear Power Plants", Safety Sci., 47(7), pp 1016-1025, (2008).

39. INER-6080, Wang, J.R., Lin, H.T., Cheng, Y.H., Wang, W.C., Shih, C.K., "TRACE Modeling and its Verification Using Maanshan PWR Start-up Tests", Ann Nucl Energy, 36(4), pp 527-536, (2008).

40. INER-6086, Guo, G..L., Chen, W.H., Chen, W.H., Hsu, D.C., Hwang, W.S., "Characterization of Enzymatic Saccharification for Acid-Pretreated Lignocellulosic Materials with Different Lignin Composition", Enzyme Microb Tech, 45(2), pp 80-87, (2008).

41. INER-6089, Cha, H.C., Chen, C.Y., Shiu, J.Y., "Investigation on the Durability of Direct Methanol Fuel Cells", J Power Sources, 192, pp 451-456, (2009).

42. INER-6090, Lin, C.G., Chiang, L.K., Chyou, Y.P., "Thermal Stress Analysis of Planar SOFC Stacks: Effects of Sealing Design", J Power Sources, 192, pp 515-524, (2009).

43. INER-6098, Yeh, M.K., Tai, N.H., Chen, B.Y., " Effects of Anisotropic Material Property on the Spring Constant and the Resonant Frequency of Atomic Force Microscope Cantilever", Rev Sci Instrum, (80), pp 43705-43705, (2009).

44. INER-6099, Huang, S.K., Hsieh, L.L.,,Chen, C.C., Lee, B.H., Hsieh, P.T., "A Study on Radiation Technological Degradation of Organic Chloride Wastewater-Exemplified by TCE and PCE", Appl Radiat Isotopes, 67, pp 1493-1498, (2009).

45. INER-6110, Chen, C.W., Lee, H.M., Chang, M.B., "Influence of pH on Inactivation of Aquatic Microorganism with a Gas-liquid Pulsed Electrical Discharge", Journal of Electrostatics, 67, pp 703-708, (2009).

46. INER-6113, Liu, K.T., Yang, H.H., Hsia, Y.C., Yang, A.S., Su, C.Y., Lin, T.S., Shen, L.H., " Development and Validation of a HPLC Method for the Purity Assay of BZM, the Precursor of Striatal Dopaminergic D2 Receptor SPECT Imaging Agent (^{123}I) IBZM (Iodobenzamide)", Journal of Food and Drug Analysis, 16(5), pp 28-38, (2009).

47. INER-6115, Chang, K.W., Lee, S.Y., Chen, C.C., Shen, L.H., "The Synthesis and Characterization of [^{124}I]IMPY, a thioflavin-S Derivative, in Transgenic Mouse Models of Alzheimer's Disease", Appl Radiat Isotopes, 67(67), pp 1397-1400, (2008).

48. INER-6119, Chen, C.W., Lee, H.M., Chen, S.H., Chen, H.L., Chang, M.B., "Ultrasound-assisted Plasma - A Novel Technique for Inactivation of Aquatic Microorganisms", Environ Sci Technol, 43(12), pp 4493-4497, (2009).

49. INER-6127, Wang, W.H., " Simulation for Indoor Air Quality and Inhalation Exposure from an Outdoor Radiological Release", Kerntechnik, 74, pp 1-4, (2008).

50. INER-6128, Tsai, W.F., Ai, C.F., "Effect of Nitriding Surface Treatment on the Corrosion Resistance of Dental Nickel-Titanium Files in 5.25% Sodium Hypochlorite Solution", Journal of Alloys and Compounds, 475, pp 789-793, (2008).

51.INER-6149, Fang, P.S., Zhao, J.H., Liu, H.L., Liu, K.T., Chen, J.T., Lin, H.Y., Huang, C.H., Fang, H.W., "Molecular Dynamics Simulations to Gian Insights into the Stability and Morphologies of K3 Oligomers from : β2-microglobulin", Journal of Biomolecular Structure & Dynamics, 26(5), pp 549-559, (2009).

52.INER-6152, Chang, K.W., Lee, S.Y., Chen, C.C., Shen, L.H., " Using Two Kinds of Transgenic Mice to Estimate Alzheimer's Disease Radiopharmaceuticals", Journal of Nutrition Health & Aging, pp 14-14, (2009).

53.INER-6153, Chang, K.W., Lee, S.Y., Chen, C.C., Shen, L.H., " Alzheimer's Disease Radiopharmaceuticals: [^{18}F]FDDNP and [^{123}I]IMPY", Journal of Nutrition Health & Aging, pp 11-12, (2009).

54.INER-6173, Chang, D.M., Chou, S.H., Chan, R.Y., "Dynamic Modeling and Analyses of Simultaneous Saccharification and Fermentation Process to Produce Bio-Ethanol from Rice Straw", Bioproc Biosyst Eng, 33(2), pp 195-205, (2009).

55.INER-6177, Lung, I.T., Kuo, C.T., Shin, H.Y., Lee, C.D., Hong, H.F., "HCPV Gets a Boost", INTERPV, June(2009), pp 70-73, (2009).

56.INER-6184, Choua, Y.H., Yang, B.H., Chung, M.Y., Chen, S.P., Su, T.P., Chen, C.C., Wang, S.J., " Imaging the Serotonin Transporter Using ^{123}I-ADAM in the Human Brain", Psychiat Res-Neuroim, 172, pp 38-42, (2009).

57.INER-6189, Huang, F.Y., Huang, L.K., Lin, W.Y., Luo, T.Y., Tsai, C.S., Hsieh, B.T., "Development of a Thermosensitive Hydrogel System for Local Delivery of ^{188}Re Colloid Drugs", Applied Radiation and Isotopes, 67, pp 1405-1411, (2009).

58.INER-6191, Lu, K.P., Fu, Y.K., Lee, S.B., "Hardness of Irradiated Hydroxyethyl Methacrylate", Journal of Applied Polymer Science, 1(113), pp 567-661, (2009).

59.INER-6195, Hung, S.C., Huang, P.J., Chan, C.E., Uen, W.Y., Ren, F., Pearton, S.J., Yang, T.N., Chiang, C.C., Lan, S.M., Chi, G.C., "Surface Morphology and Optical Properties of Zno Epilayers Grown on Si(111) by Metal Organic Chemical Vapor Deposition", Applied Surface Science, 255(15), pp 6809-6813, (2009).

60.INER-6197, Liu, R.S., Chou, T.K., Chang, C.H., Chang, T.J., Lin, W.J., Wang, H.E., " Biodsistribution, Pharmacokinetics and PET Imaging of [^{18}F]FMISO, [^{18}F]FDG and [^{18}F]FAc in a Sarcoma- and Inflammation-bearing Mouse Model", Nuclear Medicine and Biology, 22, pp 693-698, (2008).

61.INER-6198, Chang, C.H., Chang, Y.J., Chen, L.C., Chen, M.H., Chang, T.J., Lee, T.W., Ting, G., "Comparative Dosimetric Evaluation of Nanotargeted ^{188}Re-(DXR)-Liposome for Internal Radiotherapy", Cancer Biotherapy and Radiopharmaceuticals, 23, pp 750-758, (2009).

62.INER-6207, Chang, T.J., Chang, Y.J., Ho, T.Y., Hdisng, C.Y.,Yu, C.Y., Lee, T.W., Lin, W.J., Chang, C.H., " Noninvasive Bioluminescent and micro-PET Imaging for the Regulation of NF-kappa B in Human Hepatoma-bearing Mice", Anticancer Res, 29, pp 987-994, (2008).

63.INER-6210, Chang, C.H., Chou,T.K., Yang, C.Y., Chang, T.J.,Wu, Y.H., Lee, T.W., "Biodistribution and Pharmacokinetics of Transgenic Pig-Produced Recombinant Human Factor IX (rhFIX) in Rats", IN VIVO, 22, pp 693-698, (2008).

64.INER-6211, Ma, K.H., Huang, W.S., Cheng, C.Y., Chen, C.Y., Shen, L.H., Liu, J.C., Fu, Y.K., " Imaging Serotonin Transporters Using [^{123}I]ADAM in a Parkinsonian Primate Model", Applied Radiation and Isotopes, 66, pp 1799-1803, (2008).

65.INER-6212, Ma, K.H., Huang, S.Y., Yeh, C.B., Shen, Y.C., Shen, L.H., Chen, C.C., Liu, R.S., Liu, J.C., Huang, W.S., "Simultaneous [^{99m}Tc] TRODAT-1 and [^{123}I] ADAM Brain SPECT in Nonhuman Primates", Mol Imaging Biol, 11, pp 253-262, (2008).

66.INER-6225, Lin, C.C., Guo, G.L., Tsai, T.L., " A Bi-order Kinetic Model for Poly (methyl methacrylate) Decomposition in HNO_3 Using Microwave Irradiation", AICHE J, 55(8),pp 2150-2158, (2009).

67.INER-6226, Chen, H. C., Li, H.Y., Yang, R.S., " Phase Feedforward Control for Single-Phase Boost-Type SMR", IEEE T Power Electr, 24(5), pp 1428-1432, (2008).

68.INER-6228, Chao, Y., Lee, H.M., Chen, S.H., Chang M.B., "Onboard Motorcycle Plasma-Assisted Catalysis System - Role of Plasma and Operating Strategy", Int J Hydrogen Energ, 34(15), pp 6271-6279, (2009).

69.INER-6245, Wang, C.H., Lee, M.C., Huang, T.J.,Chang, Y.C., Kao, W.X., Lin, T.N., "Breeding Phenomenon of Nickel in Anode of SOFC Via Electrochemical Reaction", Electrochemistry Communications, 11(2009), pp 1381-1384, (2008).

70.INER-6251, Shih, C.F., "Storage in Confined Aquifer: Spectral Analysis of Groundwater Responses to Seismic Rayleigh Waves", Journal of Hydrology, 374, pp 83-91, (2009).

71.INER-6266, Wang, C.D., Lin,C., "Automatic Boiling Water Reactor Loading Pattern Design Using Ant Colony Optimization Algorithm", Ann Nucl Energy, 36, pp 1151-1158, (2009).

72.INER-6277, Chang, Y.R., Wai, R.J., Lin, C.Y., "High Step-Up Bidirectional Isolated Converter With Two Input Power Sources", IEEE T Ind Electron, 7(56), pp 2629-2643, (2009).

73.INER-6278, Jow, J.J., Yang, S.W., Chen, H.R., Wu, M.S., TLing, Z.R.,Wei, T.Y., " Co-electrodeposition of Pt–Ru Electrocatalysts in Electrolytes with Varying Compositions by a Double-potential Pulse Method for the Oxidation of MeOH and CO", International Journal of Hydrogen Energy, 34, pp 665-671, (2009).

74.INER-6283, Chang, C.T., Chen, Y.Z., "Selective Hydrogenation of A,B-Unsaturated Aldehydes over Au/Mgxalo-Hydrotalcite Catalysts", Applied Catalysis A-General, 361, pp 65-71, (2009).

75.INER-6287, Chen, Y.S., Chien, K.H., Tseng, Y.S., Chan, Y.K., " Determination of Optimized Rectangular Spreader Thickness for Lower Thermal Spreading Resistance", Journal of Electronic Packaging, 131(1), pp 011004-1, 011004-8, (2009).

76.INER-6290, Wu, T.H., Lin, H.R., Shen, L.H., Li, J.H., "Wound Healing Based on PU/Hydrogel Nanocompounds Containing FGF-2 and Related Dressings by Radiation Method", Adv. Mat. Res.,79-82, pp.437- 440, (2009).

77.INER-6296, Lin, W.C., Yang, W.D., Huang, I.L., Wu, T.S., Chung, J.C., "Hydrogen Production from Methanol/Water Photocatalytic Decomposition Using Pt-TiO_2-xNx Catalyst", Energy & Fuels, 23, pp 2192-2196, (2009).

78.INER-6301, Chang, Y.C., Peng, Y.C., Lee, S.C., "The Uptake and Partitioning of Nitrogen in Phalaenopsis Sogo Yukidian", Hortscience, 44(4), pp 1072-1072, (2009).

79.INER-6305, Chen, J.T., Lin, S.R., Tsai, J.J., " Fictitious Frequency Revisited", Engineering Analysis with Boundary Elements, 33(11), pp 1289-1301, (2009).

80.INER-6323, Wei, P.J., Liung, W.L., Ai, C.F., Lin, J.F., "A New Method for Determining the Strain Energy Release Rate of an Interface Via Force-Depth Data of Nanoindentation Tests", Nanotechnology 20, pp 025701, (2009).

81.INER-6325, Chen, Y.G., Lee, H.M., Huang, M.H., Chen, S.H., Yan, J.M., Yang, M.S., "A Discharge Reactor with Water-Gas Mixing for Methyl Orange Removal", IJPEST, VOL 2(No. 2), pp 113-118, (2008).

82.INER-6327, Yang, W.D., Lin, W.C., Yang, C.H., Chung, J.C., Huang, I.L., "Preparation and Visible-Light Photocatalyst Activity of Nanometric-Sized Tio_2-Xny Powders from a Two-Microemulsion Process", Journal of Materials Research, 24(8), pp 2574 - 2583, (2009).

83.INER-6346, Chung, C.T., Hong, W.T., Chyou, Y.P.,Yu, D.D., Lin, K.F., Lee, C.H., "Efficiency Analyses of Solid Oxide Fuel Cell Power Plant Systems", Appl Therm Eng, 28, pp 933-941, (2006).

84.INER-6350, Kuo, C.T., Shin, H.Y., Lung, I.T., Hong, H.F., Wu, C.H., Lee, C.D., Hsu, Y.T., " Development of the High Concentration III-V Photovoltaic System at INER Taiwan", Renewable Energy, 34(8), pp 1931-1933, (2009).

85.INER-6364, Lin, C.J., Yang, C.W., Yenn, T.C., Cheng, L.Y., "Allocating Human-System Interfaces Functions by Levels of Automation in an Advanced Control Room", Lecture Notes In Mathematics, 5613(4), pp 741-750, (2009).

86.INER-6365, Lin, C.J., Yang, C.W., Lin, S.B., Lin, S.F., "A Human Factors Model for Enterprise Resources Planning System Implementation", Lecture Notes In Mathematics, 5617(1), pp 123-130, (2009).

87.INER-6366, Liang, H.C., Jan, M.L., Lin, W.C., Shen, L.H., "Development of an LYSO Based Gamma Camera for Positron and Scinti-mammography", Journal of Instrumentation, P8009(4), pp 1-7, (2009).

88.INER-6367, Liang, K.S., Dai, L.C., Yang, C.Y., "Analysis of Low Pressure ECC Injection Bypass of An ABWR during FWLB", Nuclear Technology, 166, pp 146-155, (2008).

89.INER-6378, Wang, S.J., Chien, C.S., "Development of Accumulator Calculation Aid for PWR RCS Injection Strategy", Nucl Eng Des, 236, pp 1330-1333, (2009).

90.INER-6387, Ho, J.J., Wu, S.Y., Lia, Y.R., Hsieh, H.M., " Density Functional Studies of Ethanol Dehydrogenation on a 2Rh/gamma-Al_2O_3(11) Surface", Journal of Physical Chemistry C, 113(2009), pp 16181-16187, (2009).

91.INER-6391, Wu, T.Y., Tsai, W.C., Lee, J.J., " Dynamic Elastic-Plastic and Large Deflection Analyses of Frame Structures Using Motion Analysis of Structures", Thin Wall Struct, 47, pp 1177-1190, (2009).

92.INER-6392, Fu, Y.K., Chang, C.J., Chen, K.Y., Chang, K.W., Hwang, L.C., Chen, C.C., Jan, M.L., Chang, C.H., Wu, K.H., "Imaging of Regional Metabolic Activity by F-18 FDG/PET in Rats with Transient Cerebral Ischemia", Appl Radiat Isotopes, 67, pp 1743-1747, (2009).

93.INER-6394, Ho, C.L., Chen, L.C., Lee, W.C., Chiu, S.P., Hsu, W.C., Wu, Y.H., Yeh, C.H., Stabin, M.G., Jan, M.L.,Lin, W.J., Lee, T.W., Chang, C.H., "Receptor-binding, Biodistribution, Dosimetry and Micro-SPECT/CT", Cancer Biother Radio, 24(4), pp 435-443, (2009).

94.INER-6400, Chiu, H.S., Wang, J.J., " Adsorption Thermodynamics of Cobalt Ions onto Attapulgite", Journal of Environmental Protection Science, 3(2009), pp 102-106, (2009).

95.INER-6412, Jou, Y.T., Yenn, T.C., Lin C.J., Yang, C.W., Chiang, C.C., "Evaluation of Operators' Mental Workload of Human-System Interface Automation in the Advanced Nuclear Power Plants", Safety Sci, 239(11), pp 2537-2542, (2008).

96.INER-6414, Chen, Y.S., Hsiau, S.S., Lai, S.C., Chyou, Y.P., Li, H.Y., Hsu, C.J., "Filtration of Dust Particulates with a Moving Granular Bed Filter", Journal of Hazardous Materials, 171, pp 987-994, (2009).

97.INER-6422, Chu, C.H., Chen, I.J., Lin, U.T., Chen, W.L., Kurosawa, T., "Development of Improved Free Air Ionization Chamber as Absolute Dosimetry Standard for Low Energy X-Rays in INER", Radiation Protection Dosimetry, 138(2), pp 99-106, (2010).

98.INER-6429, Chuang, M.C., Wang, S.J., Fan, S.Y., " Simplification of the Severe Accident Management Guideline for the Containment Flooding in A Mark-Iii Containment", Nucl Technol, 2(167), pp 247-253, (2008).

99.INER-6443, Tsai, W.F., Ai, C.F., Chang-Liao, K.S., Liu, L.J., Wu, T.Y., Wang, T.K., "Charge Retention Improvement of Charge-Trapping Type Flash Device by Plasma Immersion Ion Implantation", Microelectronic Engineering, 86, pp 1852-1855, (2009).

100.INER-6445, Jeng, K.T., Hsu, N.Y., "Application of Low-Voltage Electrophoretic Deposition to Fabrication of Direct Methanol Fuel Cell Electrode Composite Catalyst Layer", Mater Chem Phys, 113(2009), pp 574-578, (2008).

101.INER-6459, Liu, C.S., Tung, C.J., Hu, Y.H., Chou, C.M., Chao, T.C., Lee, C.C., " Calculations of Specific Cellular Doses for Low-Energy Electrons", Nuclear Instruments & Methods In Physics Research Section B-Beam Interactio, 267(10), pp 1823-1829, (2009).

102.INER-6477, Chang, L.K., Zhao, J.H., Liu, H.L., Liu, K.T., Chen, J.T., Tsai, W.B., Ho, Y., "Molecular Dynamics Simulations to Investigate the Structural Stability and Aggregation Behavior of the GGVVIA Oligomers Derived from Amyloid : Peptide", Journal of Biomolecular Structure & Dynamics, 26(6), pp 731-740, (2009).

103.INER-6487, Yang, W.D., Hsieh, C.S., Wei, T.Y., Chung, J.C., Huang, I.L., "Synthesis and Characterizations of Nanometric-Sized TiO_2 Powders as a Photocatalyst for Water Splitting", Journal of Nanoscience and Nanotechnology, 9, pp 3843-3847, (2009).

104.INER-6488, Chiou, C.H., Wang, H.W., Ting, C.F., Hung, M.K., " Three-Dimensional Electrodes For Dye-Sensitized Solar Cells: Synthesis of Indium-Tin-Oxide Nanowire Arrays and ITO/TiO_2 Core-Shell Nanowire Arrays by Electrophoretic Deposition", Nanotechnology, 20(5560), pp 1-9, (2009).

105.INER-6496, Fu, Y.K., Tun, C.J., Kuo, C.W., Kuo, C.H., Pan, C.J., Chi, G.C., Chen, M.C., Hong, H.F., Lan, S.M., "The Effect of Absorption Layer of Different Quantum Well Arrangement on Optoelectronic Characteristics of Nitride-Based Photovoltaic Cells Grown By MOCVD", Physica Status Solidi B-Basic Solid State Physics, C6(S2), pp S873-S876, (2009).

106.INER-6509, Fang, P.S., Zhao, M.H., Liu, H.L., Liu, K.T., Chen, J.T., Tsai, W.B., Lin, H.Y., Fang, H.W., Ho,Y., "Molecular Dynamics Simulations to Investigate the Relationship Between the Structural Stability and Amyloidogenesis of the Wild-Type And N-Terminal Hexapeptide Deletion N6 2-Microglobulin", Molecular Simulation, 35(9), pp 755-765, (2009).

107.INER-6510, Chen, C.K., Liu, K.T., Chiu, T.C., Chang, H.T., "Separation of Amino Acids and Amines by Capillary Electrophoresis Using Poly(Ethylene Oxide) Solution Containing Cetyltrimethylammonium Bromide", Journal of Chromatography A, 1216(44), pp 7576-7581, (2009).

108.INER-6515, Liu, C.K., Yung, T.Y., Lin, K.F., Lee, R.Y., Wu, S.H., "High Temperature Glass-ceramic Seals for SOFC Applications", ECS Transactions, 25(2), pp 1491-1500, (2009).

109.INER-6518, Lan, S.M., Uen, W.Y., Liao, S.M., Lin, T.Y., Li, Z.Y., Weng, L.W., Yang, T.N., Chiang, C.C., Chen, J.W., Huang, Y.H., "Characterization of Ga-Doped Zno Films on Si(111) Prepared by Atmospheric Pressure Metal-Organic Chemical Vapor Deposition", Journal of Vacuum Science & Technology A, 27(6), pp 1260-1265, (2009).

110.INER-6522, Malolepsza, E., Lee, Y.P., Irle, S., Witek, H. A., Hsieh, H.M., Lin, C.F., " Comparison of Geometric, Electronic, and Vibrational Properties for All Pentagon/Hexagonbearing Isomers of Fullerenes C38, C40, And C42", Int J Quantum Chem, 109, pp 1999-2011, (2008).

111.INER-6526, Hsieh, C.L., Wang, J.R., Lin, H.T., Chiang, S.C., Weng, T.L., Shih, C.K., "Effect of Parametric Sensitivity on Stability Boundary of Chinshan NPP", Annals of Nuclear Energy, 36(6), pp 802-809, (2009).

112.INER-6546, Fang, P.S., Zhao, J.H., Liu, H.L., Liu, K.T., Chen, J.T., Lin, H.Y., Huang, C.H., Fang, H.W., "Molecular Dynamics Simulations to Gain Insights into the Stability and Morphologies of K3 Oligomers from : 2-microglobulin", Journal of Biomolecular Structure & Dynamics, 26(6), pp 731-740, (2009).

113.INER-6593, Hsu, C.H., Chen, P.C., Kung, K.Y., Kuo, C.C., "The Gas-assisted Expelled Fluid Flow in the Front of a Long Bubble in a Channel", WSEAS Transactions on Applied and Theoretical Mechanics, 4(1), pp 11-21, (2009).

114.INER-6594, Hsu, C.H., Kung, K.Y., Chen, P.C., Hu, S.Y., "Experimental Visualization of Gas-Assisted Injection Long Bubble in a Tube", WSEAS Transactions on Applied and Theoretical Mechanics, 4(1), pp 1-10, (2009).

115.INER-6617, Chu,C.L., Wang, J.Y., Lee, R.Y., Lee, T.H., Lee, S., "Oxidation Behavior of Various Metallic Alloys for Solid Oxide Fuel Cell Interconnect", Journal of Fuel Cell Science and Technology, 2009(6), pp 1-6, (2009).

116. INER-6624, Pei, K.C., Kan, Y. C., Yen, T., Lin, D.W., " A Preliminary Study on the Fracture Behaviors of Reinforced Concrete Slabs by Monitoring the Load Test Using Acoustic Emission Method", Journal of The Chinese Institute of Civil and Hydraulic Engineering, 21(2), pp 155-168, (2008).

117.INER-6720, Yang, A.S., Chiang, T.C., Liao, M.H., Shen, L.H., "Acute Intravenous Injection Toxicity Study of IBZM and BZM in Rats", Drug Chem Toxicol, 31(4), pp 529-533, (2009).

2 International Conference Papers

1. INER-5891, Shih, J.M., Hwang, L.C., Lee, B.F., Shen, H.R., Chen, C.C., Chen, H.J., " Tc-99m-ECD Brain Image on B6 Stroke Mice Animal Model by Small Animal Multi-pinhole SPECT", World Molecular Imaging Congress, Nice, France, (2008).
2. INER-5892, Hwang, L.C., Shih, J.M., Wu, Y.L., Chen, C.C., Chen, H.J., "Evaluate the Effect of X-911 on LL2 Lung Tumor Bearing Nude Mice by Small Animal PET Imaging", 2008 World Molecular Imaging Congress, Nice, France, (2008).
3. INER-5893, Guan, S.S., Lee, S.C., Ma, K.H., " Searching for the Suitable Condition of MALDI-IMS in Parkinson's Disease Rat", Taipei, Taiwan, (2008).
4. INER-5894, Ma, C.C., Chyou, S.L., Lin, H.J., Lung, I.T., Hsu, Y.T., Kuo, C.T., "An Advanced Central Control System of Hcpv System", International Conference on Solar Concentrators for the Generation of Electricity ICSC - 5, Palm Desert, CA USA, (2008).
5. INER-5896, Liu, K.T., Yang, H.H., Hsia, Y.C., Chen, C.C., Shen, L.H., " Development of an Integrity Assay Method of SMPY By HPLC and LC-MS/MS", 2008 SNM Annual Meeting, Ernest N. Morial Convention Center, New Orleans, U.S., (2008).
6. INER-5908, Jou, Y.T., Lin, C.J., Yenn, T.C. Hsu, C.C., Yang, L.C., Yang, C., "Effects of Adaptive Automation on Situation Awareness and Mental Workload in Main Control Room", 9th Asia Pacific Industrial Engineering and Management Society (APIEMS)Conference, Bali, Indonesia, (2008).
7. INER-5909, Lin, C.J., Jou, Y.T., Yenn, T.C., Yang, C.W., "A Model for Types and Levels of Automation Based on Skill, Rule, and Knowledge Framework", 9th Asia Pacific Industrial Engineering and Management Society Conference, Bali, Indonesia, (2008).
8. INER-5920, Chen, H.J., Hsu, J.W., Chyou, Y.P., Chen, P.C., "A Conceptual Design of Integrated Coal Gasification Combined-Cycle Power Process with Application to Solid-Oxide-Fuel-Cell Cogeneration", 2008 Taiwan/Korea/Japan Chemical Engineering Conference and 55th Taiwan Institute of Chemical Engineers Annual Conference, Taipei, Taiwan, (2008).
9. INER-5923, Chang, K.W., Tu, Y.H., Lee, S.Y., Chen, C.C., Shen, L.H., "Auto-Synthesis and Research Study in Alzheimer's Disease with [^{18}F]-FDDNP", World Molecular Imaging Congress, NICE, (2008).
10. INER-5929, Lee, J.H., Hwang, W.S., Webb, D. V., Buermann,L., Burns, D.T., Takeyeddin, M., Srimanoroth, S., Meghzifene, A., Chun, K. J., Kadni,T. B., Takata, N., Msimang,Z., "APMP/TCRI Key Comparison Report of Measurement of Air Kerma for Medium-energy X-Rays (APMP. RI(I)-K3)", 24th Asia Pacific Metrology Programme General Assembly and TCRI Workshop, Djakarta Indonesian, (2008).
11. INER-5930, Chen, I.J., Yuan, M.C., Lee, J.H., Chu, C.H., "Laboratory Report for 2008 APMP/TCRI Workshop", Djakarta Indonesian, (2008).
12. INER-5940, Huang, J.Y., Chyou, Y., "The Comparison of Metal Based Oxygen Carriers for Chemical-Looping Combustion", 2008 Taiwan/Korea/Japan Chemical Engineering Conference, Taipei, Taiwan, (2008).
13. INER-5943, Chiu, H.M., Chen, P.C., Chyou, Y.P., "A Gasification Island and Clean-up System Model Based on System-Level Simulation", 2008 Taiwan/Korea/Japan ChE Conference and 55th TwIChE Annual Conference, Taipei, Taiwan, (2008).
14. INER-5948, Chang, K.W., Lee, S.Y., Chen, C.C., " Using Two Kinds of Transgenic Mice to Estimate Alzheimer's Disease Radiopharmaceuticals", Gaoxiong Taiwan, (2008).
15. INER-5952, Chang, C.T., Hwang,C.L., "Design of Low Radioactive Waste Concrete Container", EAFORM 2nd Conference, Japan, (2008).
16. INER-5958, Chen, C.C., "Status of Radiation Research and Processing in Taiwan", Sino-Japanese Seminar on Nuclear Safety, Taiwan, Taoyuan, (2008).

17.INER-5989, Chang, K.W., Lee, S.Y., Chen, C.C." Alzheimer's disease radiopharmaceuticals: [^{18}F]FDDNP and [^{123}I]IMPY", 2nd Asian Society Against Dementia Congress and 3rd Annual Meeting of Taiwan Dementia Society, Gaoxiong, Taiwan, (2008).

18.INER-6017, Chen, C.C., Sun, D.C., Lin, S, Petty, R.W., "On the Uniformity of Crosslinking in Irradiated UHMWPE", (2009).

19.INER-6047, Lin, C. J., Jou, Y.T., Yenn, T.C., Hsieh, T.L., Yang, C.W., "A Study of Control Room Staffing and Workload from the Human Information Processing Perspective", IEEE International Conference on Networking, Sensing and Control, Okayama City, Japan, (2009).

20.INER-6048, Jou, Y.T., Yenn, T.C., Lin, C.J., Yang, C.W., Lin, S.F., "Evaluation of Mental Workload in Automation Design for a Main Control Room Task", IEEE International Conference on Networking, Sensing and Control, Okayama City, Japan, (2009).

21.INER-6053, Yenn, T.C., Lin, J.H., Jou,Y.T., Hsieh, T.L., Yang, C.W., "The Effect of HIP and Workload on Staffing Level in the Main Control Room", NPIC/HMIT 2009, Knoxville, Tennessee, United States, (2009).

22.INER-6054, Yenn, T.C., Yang, C.W., Lin, J.H., Jou, Y.T., "A Skill-Rule-Knowledge Based Model for Ergonomic Automation Design in the Advanced Nuclear Plant Control Room", NPIC/HMIT 2009, Knoxville, Tennessee, United States, (2009).

23.INER-6055, Yenn, T.C., Yang, L.C., Jou, Y.T., "The Experimental Study for Adoption of Automation of Main Control Room", NPIC/HMIT 2009, Knoxville, Tennessee, United States, (2009).

24.INER-6063, Huang, H.W., Pan,Y.J., Yu, Y.C., Liao, B.C., Cheng, T.C., Chen, M.H., "Development and Application of ABWR Feedwater Pump and Controller Model", NPIC&HMIT 2009, Knoxville, Tennessee, USA, (2009).

25.INER-6065, Chen, S.H., Huang, T.F., Huang, M.H., Lee, H.M., Chen, Y.G., "Non-Thermal Plasma for Inactivation of Airborne Bacteria", 2008 Taiwan-Japan Bilateral Tachnology Interchange Project -The Workshop on the Application of Plasma to Bio-Medical Engineering, Lunghwa University of Science and Technology, Taoyuan County, Taiwan, R.O.C., (2009).

26.INER-6066, Tseng, M.S., Huang, H.W., Yu, Y.C., Liao, B.C., Cheng, T.C., "Evaluation Method of Diverse Back-up Means for Digital I&C System", Sixth American Nuclear Society International Topical Meeting on Nuclear Plant Instrumentation, Control, and Human-Machine Interface Technologies (NPIC&HMIT 2009), Knoxville, Tennessee, USA, (2009).

27.INER-6067, Liao, B.C., Yu, Y.C., Tseng, M.S., Cheng, T.C., Huang, H.W., "Establishment of Engineered Safety Feature Instrumentation & Control Devices Automatic Testing Equipment", Nuclear Plant Instrumentation, Controls, and Human Machine Interface Technology (NPIC-HMIT), Knoxville, Tennessee, USA, (2009).

28.INER-6087, Ou, T.C., Gaing, Z.L., "Dynamic Economic Dispatch Solution Using Fast Evolutionary Programming with Swarm Direction", The 4th IEEE Conference on Industrial Electronics and Applications (ICIEA 2009), Xi'an, China, (2009).

29.INER-6088, Tsai, J.I., Wu, R.C., Zhan, T.S., Ou, T.C., Li, W.Y., "Turbine-Generator Blade and Shaft Torisonal Torques Due to Line Faults in Six-Phase Transmission Systems Evolved from Three-Phase Double-Circuit Line Systems", The 4th IEEE Conference on Industrial Electronics and Applications (ICIEA 2009), Xi'an, (2009).

30.INER-6101, Wang, J.R., Lin, H.T., Wang, W.C., Yang, S.M., Shih,C.K., "Trace Analysis of Loss of Feedwater Flow Event in Lungmen", 2009 International Congress on Advances in Nuclear Power Plants (ICAPP '09), Tokyo, Japan, (2009).

31.INER-6111, Hsu, C.H., Kung, K.Y., Chen, P.C., Kuo, G.C., "The Inertial Effects on the Flow Pattern in a Gas-assisted Injection Molding Process", 8th WSEAS International Conference on Applied Computer and Applied Computational Science, Hangzhou, China, (2009).

32.INER-6112, Hsu, C.H., Kung, K.Y., Chen, P.C., Hu, S.Y., "The Visualization of Gas-Assisted Injection Long Bubble in a Tube", 8th WSEAS International Conference on Applied Computer and Applied Computational Science, Hangzhou, China, (2009).

33.INER-6121, Chang, C.J., Wang, T.L., Lin, C.P., ”Measurement Uncertainty Recapture (MUR) Power Uprates Operation at Kuosheng Nuclear Power Station”, 2009 International Congress on Advances in Nuclear Power Plants, Tokyo, Japan, (2009).

34.INER-6122, Chan, Y.K., Chang, C.J., ” Using Neuro-Fuzzy Based Method to Develop Nuclear Turbine Cycle Model”, ICAPP 2009, Tokyo, Japan, (2009).

35.INER-6125, Hsu, P.L., Lo, C.K.,”The Development of a 3-D Risk Matrix for Qualitative Maintenance Risk Management”, The 10th Korea-Japan Joint Workshop on PSA, Jeju, Korea, (2009).

36.INER-6134, Chang, H.T., Lin, C.K., Liu, C.K., ”High Temperature Mechanical Properties of a Crystallized BaO-B_2O_3-Al_2O_3-SiO_2 Glass Ceramic for SOFC”, Seventh International Fuel Cell Science, Engineering and Technology Conference, Newport Beach, California, USA, (2009).

37.INER-6135, Hwang, W.S., Huang, H.C., Guo, G.L., Chen, W.H., ” The Current State of Cellulosic Ethanol Technology Development”, 2009 Cellulosic Ethanol Technology Development Workshop, Taoyuan, Taiwan, (2009).

38.INER-6138, Weng, Y.H., Lu, C.S., Lin, K.J., Shen, L.H., ”Cerebral glucose metabolism in PD patients with and without Dementia”, The Movement Disorder Society's 13th International Congress of Parkinson's Disease and Movement Disorders, paris, (2009).

39.INER-6162, Li, M.H., Duh, T.S., ”A New Gallium-68 Generator Production Using the INER TR30/15 H-/D- Cyclotron in Taiwan”, 2009 Society of Nuclear Medicine, Toronto, Canada, (2009).

40.INER-6163, Li, M.H., ”A New Ge-68/Ga-68 Generator System Using a Higher Sorption Capacity Resin as Adsorbent for Ge-68”, 2009 Society of Nuclear Medicine, Toronto, Canada, (2009).

41.INER-6164, Li, M.H., ”A Novel [^{123}I] ADAM Synthesizer”, 2009 Society of Nuclear Medicine, Toronto, Canada, (2009).

42.INER-6165, Li, M.H.,Chen, J.T., ”A Processing Method of Generator-Produced Ga-68 for Radiopharmaceutical Labeling”, 2009 Society of Nuclear Medicine, Toronto, Canada, (2009).

43.INER-6166, Li, M.H., ”Performance Test for The L- 6- [^{18}F] Fluorodopa Synthesizer Module”, 2009 Society of Nuclear Medicine, Toronto, Canada, (2009).

44.INER-6167, Li, M.H., ”Synthesis of 6-[^{18}F]Fluoro-L-DOPA ([^{18}F]FDOPA) and Quality Control”, 2009 Society of Nuclear Medicine, Toronto, Canada, (2009).

45.INER-6168, Li, M.H., ”A Model of Innovation Capability Innovation in Radiopharmaceutical Industry”, 2009 Society of Nuclear Medicine, Toronto, Canada, (2009).

46.INER-6178, Tsai, C.H., Chen, K.T., Chao, Y., Lee, H.M., ”Hydrogen Generation from Methane Plasmalysis in a Microwave Plasma Reactor”, The 6th International Symposium on Non-Thermal Plasma Technology for Pollution Control and Sustainable Energy Development (ISNTPT-6), Wanli, Taipei County, Taiwan, (2009).

47.INER-6179, Lee, H.M., Yan, J.M., Yang, M.S., Chen, Y.G., Huang, M.H., Huang, T.F., Chen, S.H., ” Diesel Nox Emission Control with Microdischarge Plasmas”, The 4th International Workshop on Microplasmas, Tainan, Taiwan, (2008).

48.INER-6185, Li, M.H., ”Automated Dispenser for Radiopharmaceuticals”, 2009 Society of Nuclear Medicine, Toronto, Canada, (2009).

49.INER-6186, Li, M.H., Chen, J.T., ”Analysis of Pharmaceutical and Biotechnology Collaborations□ A Model of R&D Innovation Capability”, Tenth International Symposium on the Synthesis and Applications of Isotopes and Isotopically Labelled Compounds, Chicago USA, (2009).

50.INER-6187, Li, M.H., Chen, J.T., ”A model of innovation and technology appropriability regimes: an analysis of international pharmaceutical firms”, Tenth International Symposium on the Synthesis and Applications of Isotopes and Isotopically Labelled Compounds, Chicago USA, (2009).

51.INER-6188, Li, M.H, ”The Impact of Regulatory Stringency on the R&D Governance of Global Pharmaceutical Industries”, Tenth International Symposium on the Synthesis and Applications of Isotopes and Isotopically Labelled Compounds, Chicago USA, (2009).

52.INER-6213, Ou, T.C., Lin,W.M., "A novel Z-Matrix Algorithm for Distribution Power Flow Solution", PowerTech 2009, Romania, (2009).

53.INER-6214, Lin, W.M., Hong, C.M., Ou, T.C., Lu, K.H., Huang, C.H., "An Intelligent Maximum Power Tracking Control Strategy for Wind-Driven IG System using MPSO Algorithm", 2009 IEEE/ASME International Conference, Singapore, (2009).

54.INER-6215, Lin, W.M., Lu, K.H., Huang, C.H., Ou, T.C., Li, Y.H., "Optimal Location and Capacity of STATCOM for Voltage Stability Enhancement Using ACO Plus GA", 2009 IEEE/ASME International Conference, Singapore, (2009).

55.INER-6216, Ou, T.C., Huang, C.H., Chen, C.H., Hong, C.M., Lu, K.H., "Probabilistic Neural Network and Polynomial Fitting Approach used to Determine Radio Field Strength under Power Lines in Radial Network", 2009 IEEE/ASME International Conference, Singapore, (2009).

56.INER-6217, Hung, Ch.C., Chiang, C.T., Wu, R.C., Ou, T.C., "TAS/MRC Diversity System Design over Fading Channel Model of Arbitrary Nakagami-m", 2009 IEEE/ASME International Conference, Singapore, (2009).

57.INER-6218, Chen, C.Y., Chan, W.C., Ou, T.C., Yu, S.H., Liu, T.W., "Sliding Mode Speed Control of Brushless DC Motor Using Pulse-Width-Modulated Current Regulator", 2009 IEEE/ASME International Conference, Singapore, (2009).

58.INER-6224, Huang, H.W., Shih, C.K., Hung, H.C., Chang, K.L., Chen, S.C., Pan, Y.J., Tseng, M.S., Chen, M.H., Cheng, T.C., "Development and D3 Application of ABWR Feedwater System Model", ICONE17, Brussels, Belgium, (2009).

59.INER-6227, Ko, F.K., Lin, C.H., Chiu, H.M., "Evaluating the Benefit of Promoting Biofuel Usage from the Viewpoint of CO2 Abatement and Energy Sustainability in Taiwan", The 2nd IAEE Asian Conference, Perth, Western Australia, (2008).

60.INER-6234, Hong, H.F., Liang, Y.P., Shih, Z.H., Shin, H.Y., Kuo, C.T., " Concentrator Solar Receiver Reliability Verify by IEC 62108 Standard", International Conference on Solar Concentrators 5, Palm Desert, CA, USA, (2008).

61.INER-6240, Ko, F.K., Huang, C.B., Tseng, P.Y.,Lin, C.H., Zheng, B.Y.,Chiu, H.M., "Long-Term CO_2 Reduction Target and Scenarios of Power Sector in Taiwan", The 2nd IAEE Asian Conference 2008, Perth, Western Australia, (2009).

62.INER-6248, Tsai, R.Y., Tsai, W.F., Chou G..P., Ai, C.F., "Surface Modification of Ti-6Al-4V Alloys for Biomedical Applications by Plasma Immersion Ion Implantation Technique", 2008 Taiwan-Japan Bilateral Technology Interchange Project - The Workshop on the Applications of Plasma to Bio-Medical Engineering, Tainan, Taiwan, (2008).

63.INER-6253, Huang, C.B., Ko, F.K., "Nuclear Power Generation and CO_2 Abatement Scenarios in Taiwan", EESD 2009 : International Conference on Energy, Environment, Sustainable Development, Paris France, (2009).

64.INER-6257, Wang, J.J., "A Study of Strontium 90 Analysis Method by Liquid Scintillation Counting for the Environmental Samples", 54th Annual Meeting of the Health Physics Society, USA, (2009).

65.INER-6271, Tseng, Y.S., Wang, J.R., Cheng, Y.H., Shih, C.K., "Validation Study of FLUENT for the Application of Dry-Storage SystemThermal Analysis", ICAPP09, Tokyo, Japan, (2009).

66.INER-6285, Huang, C.H., Huang, C.C., Ou, T.C., Lu, K.H., Hung, C.M., "Intelligent Fuzzy Logic Controller for a Solar Charging System", 2009 IEEE/ASME International Conference, Singapore, (2009).

67.INER-6286, Li, H.N., Yang, T.S., Shih, C.k., Wang, J.R., Lin, H.T., "Improvement in Decay Ratio Calculation in LAPUR5 Methodology for BWR Instability", ICAPP09, Tokyo, Japan, (2009).

68.INER-6308, Kuo, P.H., Lin, W.C., Yu, S.F., Jan, M,L., Liang, H.C., "Study of a Novel Imaging Detector Design Offering a DOI Solution", ISRE 08, Hsinchu, Taiwan, (2008).

69.INER-6309, Fang, H.F., " Establishing the Mobile Environmental Survey System for Radiological Emergency", Fifty-fourth Annual Meeting of the Health Physics Society, USA, (2009).

70.INER-6313, Lin, C.J., Yang, C.W., Lin, S.B., Lin, S.F., ”A Human Factors Model for Enterprise Resources Planning System Implementation”, 13th International Conference on Human-Computer Interaction, San Diego, CA, USA, (2009).

71.INER-6354, Chen, W.H., Lin, T.S., Guo, G..L., Hwang, W.S., ” Transcriptomic Analysis of Carbohydrate Metabolism During Ethanol Fermentation by Pichia Stipitis”, 31st Symposium on Biotechnology for Fuels and Chemicals, San Francisco, USA, (2009).

72.INER-6356, Lu, H.C., Jan, M.L., Liang, H.C., Ni, Y.C., Lai, H.Y., Fang, Y.T., Tseng, S.P., Tseng, F.P., ”Feasibility Study of Low Energy DEXA Imaging for Bone-density Measurement of Osteoporosis in Mice Using CCD and CMOS”, International Symposium on Radiation Education (ISRE08), Hsinchu, Taiwan, (2008).

73.INER-6357, Wu, T.H., Chen, K.S., Shen, L.H., Chen, S.C., Tsai, N.C., ”Study on the Surface Modification of Functional Hydrogels on ePTFE Film by Photo-grafting Methods”, 2009 TERMIS World Congress, Korea, (2009).

74.INER-6368, Lin, C.J., Yang, C.W., Yenn, T.C., Cheng, L.Y., ”Allocating Human-System Interfaces Functions by Levels of Automation in an Advanced Control Room”, 13th International Conference on Human-Computer Interaction, San Diego, CA, USA., (2009).

75.INER-6371, Ho, C.Li., Lee, W.C., Hsu, W.C., Chiu, S.P., Yeh, C.H., Chen, L.C., Wu, Y.H., Lin, W.J., Lee, T.W., Chang, C.H., ”Receptor-binding, Biodistribution and micro-SPECT/CT Imaging of ^{111}In-DTPA-Bombesin Analogue in Human Prostate Tumor-Bearing Mice”, The 2009 SNM Annual Meeting, Toronto Metro Convention Centre, Toronto, Canada, (2009).

76.INER-6388, Lee, J.H., Lin, M.S., Chou, C.M., Chen, I.J., ”Performance testing and dose verification for extremity ring dosimetry”, 7th International Conference on Luminescent Detectors and Transformers of Ionizing Radiation LUMDETR 2009, Krakow, Poland, (2009).

77.INER-6405, Chyou, Y.P., ”Clean Carbon Path toward Sustainability - INER's Perspective and Approach”, 2009 International Conference on Sustainable Energy, Taipei, Taiwan, (2009).

78.INER-6413, Liu, R.F., Young, M.C., Jeng, S.L., Huang, J.S., Kuo, R.C., Wang, J.C.,Huang, J.Y., ” Corrosion Fatigue Behavior of Dissimilar Metal Weldments”, 14th International Conference on Environmental Degradation of Materials in Nuclear Power System-Water Reactor, Virginia, USA, (2009).

79.INER-6419, Shih, J.M., Chen, C.C., Shen, L.H., ” Tc-99m-ECD Brain Image on B6 Stroke Mice Animal Model By Small Animal Multi-Pinhole SPECT -Physical Surgical Operation Alter BBB Permeability”, 2009 SNM Annual Meeting, Toronto, Canada, (2009).

80.INER-6426, Wang, W.H., Wang, J.J., Chang, B.J., Chen, I.J., ” Effective Method for Simulation of the Radioactive Material Dispersion in Terrestrial Surface Water Bodies”, the Fifty-Fourth Annual Meeting of the Health Physics Society, Minneapolis, USA, (2009).

81.INER-6450, Chuang, M.C., Huang, I.M., Wang, W.S., Wang, S.J., ”Application of Maap5 Code for Preparing Emergency Response Drill in Taiwan”, 2008 MAAP Users Group (MUG) Meeting, Washington, D.C., USA, (2008).

82.INER-6454, Lo, J.M., Chang, H.Y., Lee, T.W., Cheng,Y.E., ”In vivo Examination of 99mTc(I) tricarbonyl Labeled Hynic-D-Phe1-Octreotide as an Imaging Agent for Pancreatic Tumor”, 18th International Symposium on Radiopharmaceutical Sciences (ISRS18), Canada, (2009).

83.INER-6465, Wang, M.H., Lee, H.S., Lee, Y.C., Lee, R.T., Yu, H.W., Chien, C.Y., Lin, W.J., ”The potential of In-111-Hexa-Lactoside in Estimating Liver Reserve”, 2009 Asian Pacific Digestive Week, Taipei, Taiwan, (2009).

84.INER-6473, Wang, M.H., Lee, Y.C., Lee, R.T., Chien, C.Y., Yu, H.W., Lin, W.J., ” Differential Asialoglycoprotein Receptor Performance between Rat and Mice”, 2009 Taiwanese Society for Molecular Imaging, Taipei, Taiwan, (2009).

85.INER-6474, Wang, M.H., Lee, H.S., Chien, C.Y., Yu, H.W., Lee, R.T., Lee, Y.C., Lin, W.J., ” The Potential of In-111-Multi-Gal Ligand in Estimating Liver Reserve”, 2009 Taiwanese Society for Molecular Imaging, Taipei, Taiwan, (2009).

86.INER-6475, Wang, M.H., Yu, H.W., Jian, C.Y., Lee, R.T., Lee, Y.C., Lin, W.J., " Comparative Radiochemistry and Microspect/CT Imaging of Two Closely Structure Related Hepatic Receptor Agent", European Association of Nuclear Medicine, Spanish, (2009).

87.INER-6476, Wang, M.H., Lee, R.T.,Yu, H.W., Jian, C.Y., Lee, Y.C., Lin, W.J., " A Novel and Efficient Liver Targeting Agent: Biodistribution, Pharmacokinetics, SPECT/CT Imaging, and Autoradiography", European Association of Nuclear Medicine, Spanish, (2009).

88.INER-6484, Li, M.H., Lin, W.J., "A New Synthesis Module and Automation in F-18-FET Labeling", 2009 European Association of Nuclear Medicine, Barcelona, Spain, (2009).

89.INER-6485, Li, M.H., Lin, W.J., "An Innovative Synthesizer for I-123-ADAM Labelling", 2009 European Association of Nuclear Medicine, Barcelona, Spain, (2009).

90.INER-6486, Li, M.H.,"Automated Dispenser for Ga-68-DOTATOC Radiopharmaceuticals", 2009 European Association of Nuclear Medicine, Barcelona, Spain, (2009).

91.INER-6490, Tseng, S.P., Jan, M.L., Ni, Y.C., Liang, H.C., Tsai, T.H., "Feasibility Study of Low Dose DEXA Imaging for Bone-density Measurement of Osteoporosis Mice Model", 2009 World Molecular Imaging Congress, Montreal, Canada, (2009).

92.INER-6494, Wang, J.N., Yeh, C.H., Chioeu, Y.F., Yuan, M.C., "Efficiency Evaluation of Drum-Type Gamma Activity Counting System With Monte Carlo Method", 17th International Conference on Radionuclide Metrology and its Applications, Bratislava, Slovakia, (2009).

93.INER-6497, Fu, Y.K., Kuo, C.W., Kuo, C.H., Chi, G.C., Tun, C.J., Pan, C.J., Chen, M.C., Hong, H.F., Lan, S.M., "The Effect of Absorption Layer of Different Arrangement Quantum Well on Electrical Characteristics of III-nitrides Photovoltaic Cells Grown by MOCVD", The International Workshop on Nitride semiconductors (IWN2008), Switzerland, (2009).

94.INER-6506, Lin, C.K., Huang, L,H., Chiang, L.K., Chyou, Y.P., "Effects of Clamping Load on the Thermal Stress Distribution in a Planar SOFC with Compressive Sealing", Solid Oxide Fuel Cells, Eleventh International Symposium (SOFC-XI), Vienna, (2009).

95.INER-6507, Li, M.H.,"A Model of Innovation And Technology Appropriability Regimes: An Analysis of International Radiopharmaceutical Firms", 2009 European Association of Nuclear Medicine, Barcelona, Spain, (2009).

96.INER-6508, Li, M.H., "The Impact of Regulatory Stringency on The R&D Governance of Global Radiopharmaceutical Firms", 2009 European Association of Nuclear Medicine, Barcelona, Spain, (2009).

97.INER-6519, Ou, T.C., Lee, C.L., Shyu, S.S., "Combine Multiple HCPV with BIPV for DC Power Application at INER", 2009 IEEE Conference on Sustainable Alternative Energy, Valencia, (2009).

98.INER-6520, Ou, T.C., "A Multi-Input Power Converter for Hybrid Renewable Energy Generation System", 2009 IEEE Conference on Sustainable Alternative Energy, Valencia, (2009).

99.INER-6523, Wang, J.R., Lin, H.T., Wang, W.C., Yang, S.M., Shih, C.K., "Trace Analysis of Msiv Closure Direct Scram Event In Lungmen ABWR", American Nuclear Society: 2009 Annual Meeting, Atlanta, Georgia, (2009).

100.INER-6524, Wang, J.R.,Lin, H.T., Wang, W.C., Cheng, Y.H., Shih, C.K.,"Maanshan PWR Loss of Flow Transients Analysis with Trace", Proceedings of the 17th International Conference on Nuclear Engineering, Brussels, Belgium, (2009).

101.INER-6525, Lee, J.H., Wang, J.R., Lin, H.T., Yang, S.M., Shih, C.K., "TRACE Modeling of Chinshan Load Rejection Startup Test", American Nuclear Society: 2009 Annual Meeting, Atlanta, Georgia • Hyatt Regency Atlanta Hotel, (2009).

102.INER-6527, Wu, W.H., Shih, C.K., Wang, J.R., "RCS Pressure Predictions under ATWS for Maanshan with MUR", Proceedings of the 17th International Conference on Nuclear Engineering (ICONE17), Brussels, Belgium, (2009).

103.INER-6535, Shyu, S.S., Lee, C.L., " Introduction of Taiwan's Nuclear Instrumentation and Control System (Tainics)", 2009 International Workshop on the Establishment of Taiwans Nuclear I&C System, Taoyuan, Taiwan, (2009).

104. INER-6543, Yuan, M.C., Yeh, C.H., Yeh, C.Y., Chen, I.J., Wang, C.F., "A Proficiency Testing Feasibility Study for Measurement of Gamma-Emitted Clearance Sample", International Conference on Radionuclide Metrology and its Applications (ICRM 2009), Bratislava, Slovak, (2009).

105. INER-6562, Ni, Y.C., Jan, M.L., Lin, Z.K., Huang, L.T., Lai, H.Y., "Study of maximum-acceptance-angle effects on image quantity", 4th International Symposium on Radiation Education, Hsinchu, Taiwan, (2008).

106. INER-6572, Tseng, F.P., Jan, M.L., Chang, Y.J., Ni, Y.C., Hsu, S.L., Chang, C.H., Lee, T.W., " Quantitative Imaging of ^{188}Re-BMEDA-Liposome in a C26 Murine Colon Carcinoma Solid Tumor Animal Model", 4th International Symposium on Radiation Education, Hsinchu, Taiwan, (2008).

107. INER-6573, Hsu, S.L., Jan, M.L., Tseng, F.P., Yeh, C.H., Chuang, C.H., "Evaluation of Image Restoration Methods for ^{188}Re Micro-SPECT Quantitation", International Symposium on Radiation Education, Hsinchu, Taiwan, (2008).

108. INER-6584, Ni, Y.C., Jan, M.L., Tsai, T.H., Lai, H.Y., Tseng, F.P., Lin, Z.K., "Study of Geometric and Acceptance-Angle Effects In Dual-Plane Positron Imaging System", 2009 World Molecular Imaging Congress, Montreal Canada, (2009).

109. INER-6603, Lee, J.H., Wang, J.N., Huang, T.T., Shih, M.Y., Su, S.H., Chang, B.J., Chen, I.J., "Wall Correction Factor Calculation of Air Kerma Standard and Dose Distribution Assessment for Ir-192 HDR Brachytherapy Source by Monte Carlo Method", Second European Workshop on Monte Carlo Treatment planning, Cardiff, UK, (2009).

110. INER-6604, Chen, I.J., Yang, C.A., Chang, B.J., Chu, C.H., "Calibration Procedures Quality Assurance and Correction Factors Calculations of Mammography Dosimetry Standard", MCTP2009, Wales England, (2009).

111. INER-6615, Chang, Y.J., Chang, C.H., Lee, W.C., Chen, L.C., Yu, C.Y., Chang, T.J., Lee, T.W., Ting, G., "Therapeutic Efficacy of Radiochemo-therapeutics of ^{188}Re-DXR-liposome in a C26 Murine Colon Carcinoma Solid Tumor Model.", 2009 World Molecular Imaging Congress, Montreal, Canada, (2009).

112. INER-6618, Tsai, C.W., Shih, C.K.,Wang, J.R., Lin, H.T., Jing, J.A., Cheng, S.C., "The Limiting Events Transient Analysis by Retran02 and Vipre01 for an ABWR", Proceedings of ICAPP '09, Tokyo, Japan, (2009).

113. INER-6619, Li, C.L., Tsai, C.W., Shih, C.K.,Wang, J.R., Chung, S.C., "RETRAN Application of Turbine Trip and Load Rejection of Startup Test Analysis For Lungmen ABWR", Proceedings of the 17th International Conference on Nuclear Engineering (ICONE17), Brussels, Belgium, (2009).

114. INER-6641, Kan, Y.C., Pei, K.C., Chen, S.Y., Yen,T., "A Model to Monitoring Real-time Fracture of Concrete Subjected to the Load from Tendons by AE Technique", 20th International Conference on Structural Mechanics in Reactor Technology (SMiRT 20), Espoo, Finland, (2009).

115. INER-6644, Hsia, C.C., Shen, L.H., Wang, H. E., "Applicability of Hypoxic Tracers ^{99m}Tc-HL91 and Derivative for the Imaging on Infection Rat", 2009 Annual Congress of the European Association of Nuclear Medicine, Spanish Barcelona, (2009).

116. INER-6647, Chen, Y.P., Chang, C.C., "Preparation of Yap(Ce)\TiO_2 Composite Photocatalyst and Its Application in Radioactive Cationic Exchange Resin Treatment", 2008 EAFORM 2nd Conference, Tokyo, Japan, (2009).

117. INER-6656, Lee, J.H., Hsu, S.M., Yang, H.W., Huang, Y.H., Yu, C.Y., Liao, Y.J., Hung, S.K., Lee, M.S., "Chemical and Physical Characteristics of Self-Fabricated Radiophotoluminescent Glass Dosimeter", 7th International Conference on Luminescent Detectors and Transformers of Ionizing Radiation LUMDETR 2009, Krakow, Poland, (2009).

118. INER-6681, Cheng, S.C., Chang, N.C., Yang, Y.T., Huang, C.C., "INTER-Unit Spent Fuel Transfer with a Modified Storage Cask System", Proceeding of GLOBLE 2009, Paris, France, (2009).

119. INER-6704, Lin, W.C., Huang, L.T., Jan, M.L., Liang, H.C., " Improving Precision of DOI-Location Estimations by Photopeak-index Method", 2009 IEEE Nuclear Science Symposium and Medical Imaging Conference, Orlando, Florida, USA, (2009).

120.INER-6710, Chen, J.T., Chang, K.W., Tu, Y.H., Lin, W.J., "The Autosynthetic and Solid Extraction Method Developed on [F-18]Flumazenil Radiosynthesis", 10th IIS, Chicago, US, (2009).

121.INER-6725, Lee, J.H., Chu, C.H., Tung, C.J.,. Tsai, H.Y., Lin, M.T., Hsu, F.Y., "Half-Value Layer Determination Using Thermoluminescent Dosimeters for Digital Mammography", 7th International Conference on Luminescent Detectors and Transformers of Ionizing Radiation LUMDETR 2009, Krakow, Poland, (2009).

122.INER-6764, Kan, Y.C., Pei, K.C., Lin, D.W., "Using Acoustic Emission Technique for Monitoring Real-time Fracture Behavior within Reinforced Concrete Structure Element under Load Test", The 17th WCNDT, 17th World Conference on Non-destructive Testing, Shanghai, (2008).

123.INER-6765, Tang, I.C., Luo, T.Y., Lin, J.J., Wu, Y.L., Liu, S.W., Lin, W.J., " The Labeling of ^{188}Re-MN-16ET/Lipiodol And Preliminary Study in Hepatocellular Carcinoma Animal Model", SNM Annual Conference, USA, (2009).

124.INER-6768, Wu, Y.L., Liou, C.J., Tang, I.C., Luo, T.Y., Lin, W.J., "Evaluating the Therapeutic Potential of 188Re-HYNIC-Trastuzumab(Herceptin) for Human Breast Cancer in the Animal Model", SNM Annual Conference, USA, (2009).

125.INER-6769, Chang, Y.R., Chan, C.M., Chang, C.J., "The Design of Control System and Power Conditioning System for a 25-kW Active-control Based Wind Turbine System", IEEE 2009 International Conference on Power Electronics and Drive Systems, Taiwan, (2009).

126.INER-6784, Lee, C.H., Lin, K.F., Lee, M.C., Hwang, C.S., Lee, R.Y., Huang, W.P., Shong, W.J., " SOFC Research and Development at INER", 4th Asian Conference of Electrochemical Power Sources, Taipei, Taiwan, (2009).

127.INER-6791, Kao, C.J., Chen, M.C., Liu, K.S., Huang, C.W. Lin, K.H., Wu, C.H., "A Method to Analyze Series Resistance and Diode Ideality Factor of Ingap/Ingaas/Ge Tandem Solar Cell", 2009 International Electron Devices and Materials Symposia, Taipei, Taiwan, (2009).

128.INER-6792, Kao, D.Y., Wen, T.J., Fong, C.L., Liang, T.J., "The Passivation Treatment Performed on the RWCU Piping Surface of ABWR", Symposium on Water Chemistry and Corrosion in Nuclear Power Plants in Asia 2009, Japan, (2009).

129.INER-6793, Wen, T.J., Shen, S.C., Cheng, T.C., Chu, C.F., "Root Cause Study on the High Levels of Reactor Water Silica and Its Measures for Reduction in Taiwan BWRs", Symposium on Water Chemistry and Corrosion in Nuclear Power Plants in Asia 2009, Nagoya, Japan, (2009).

2009 Annual Report
Institute of Nuclear Energy Research

Publisher: Institute of Nuclear Energy Research

Editor Group: Institute of Nuclear Energy Research

Address: No. 1000, Wenhua Rd., Jiaan Village, Longtan Township, Taoyuan County, 32546, Taiwan (R.O.C.)

Tel: 886-2-8231-7717 886-3-471-1400 0800-001-766

Fax: 886-3-471-1064

URL: http://www.iner.gov.tw /library/Publication.htm

Price: NT$ 730

GPN: 2008200099

ISSN: 1812-3155

Published in June 2010

First Issued in June 1993

Frequency: Annual

Sales Outlet:

- Government Publications Bookstore
  1F, No.209, Sung Chiang Rd., Taipei, Taiwan
  TEL: 886-2-2518-0207
- Wu-Nan Book Co. Ltd.
  No. 600, Junfu 7th Rd., Beitun Dist., Taichung City 406, Taiwan (R.O.C.)
  TEL: 886-4-2437-8010

Institute of Nuclear Energy Research
Atomic Energy Council, Executive Yuan

No.1000, Wenhua Rd., Jiaan Village, Longtan Township,
Taoyuan County, 32546, Taiwan (R.O.C.)
Tel: 886-2-8231-7717 886-3-471-1400 0800-001-766
Fax: 886-3-471-1064
http://www.iner.gov.tw
e-mail: iner@iner.gov.tw

GPN:2008200099

Price: NT$730