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2023 Annual Report

National Atomic Research Institute

Published in August, 2024

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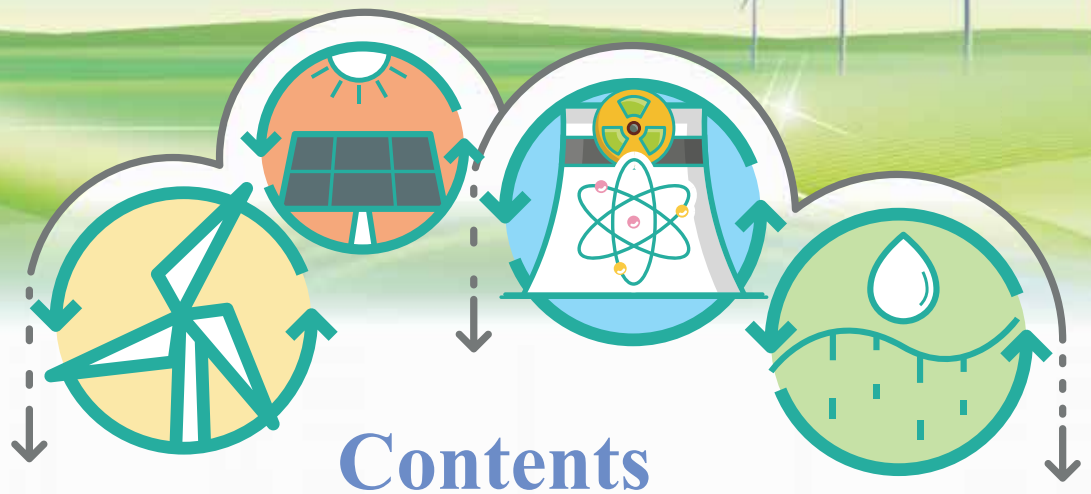

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Preface

Board Chair's Message

The year of 2023 is the beginning of a transformation for the National Atomic Research Institute (NARI). On September 27, in line with the organizational reconstruction of the Executive Yuan, the Institute of Nuclear Energy Research (the predecessor of NARI) which has led the development of atomic energy science and technology for more than half a century of Taiwan, was restructured from a government agency affiliated with the Atomic Energy Council (the predecessor of the Nuclear Safety Commission) to an administrative corporation, supervised by the Nuclear Safety Commission. Through legislative enactment of its establishment Act, it was expressly endowed with important missions including promoting nuclear safety, radiation protection, and the development of atomic energy for peaceful purposes.

Following its transformation into an administrative corporation, the board of directors was thus established. Different from the previous operating model, the new concept of governance is introduced and business responsibilities are emphasized. This move is conducive to enhance the operational performance and service quality of NARI, creating new opportunities for the development of atomic energy technology in our country. In addition, certain moderate relaxation of personnel and financial regulations also give NARI more flexibility in operating its business, making it more efficient to promote some specific public affairs.

As the sole national research institution related to the field of atomic energy in Taiwan, NARI not only focused on the research and development of nuclear energy safety and radiation applications, but had also successfully stepped into the fields of nuclear medicine, high-end medical materials and new energy technologies. Given the broad scope of atomic energy technology research, coupled with the continuous evolution of science and technology, it is anticipated that the applications of atomic energy technology in energy, medicine, and the environment will become increasingly indispensable. Through the years, a considerable foundation has been accumulated in NARI. By fully leveraging the R&D capabilities of NARI, effectively integrating existing resources, expanding into more emerging applications, actively investing in competitive state-of-the-arts technological development, nurturing professional talents to assist the collaboration between industry, government, academia, and research sectors domestically, and playing a key role in the national blueprint for scientific and technological development, NARI will be able to achieve sustainable development.

Looking into the future, I do hope that the transformation of NARI will go smoothly and demonstrate its operating functions and efficiency as an administrative corporation. With the concerted efforts of all colleagues in NARI, more breakthroughs and innovations in the fields related to atomic energy science and technology will be achieved. While, to promote the research results to people's livelihood and industry, the goals of NARI are to bring benefits to people's lives. Through our concerted endeavor we can become a pioneer in the development of science and technology in our country, and meanwhile make National Atomic Research Institute internationally renowned.

Board Chair *Dr. Shin Chang*

President's Message

On September 27, 2023, the Institute of Nuclear Energy Research (INER) under the Atomic Energy Council (AEC), Executive Yuan, concluded its 55-year history and embarked on a new chapter as a legalized administrative corporation as the National Atomic Research Institute (NARI). This transformation, a significant testament to the evolution of nuclear energy technologies in Taiwan, marks a pivotal milestone in the future of atomic energy. NARI, with a strong commitment to deepening research in nuclear safety, radiation safety, nuclear waste management, and nuclear medicine, is poised to explore the potential of atomic energy technology for civilian applications. NARI has emerged as the most reliable and influential atomic energy technology research institution in Taiwan.

The reimagined NARI builds on the foundation of the nation's achievements in atomic energy technology. Moving forward, NARI aims further to broaden its impact through the following strategic aims:

Aim 1: As an applied science research unit, NARI will employ substantial and agile problem-solving capabilities for national and global-level impact. In 2023, with support from the Executive Yuan, NARI began execution and construction of the 70MeV Medium-sized Cyclotron, with the target of completion within four years. Further, as part of Executive Yuan's "Infrastructure Foresight Development Plan," NARI has successfully secured funding for the "Power Grid Resilience Analysis Towards Net Zero Emissions Project," which aims to develop an integrated energy system for island operations within the next five years. Meanwhile, to push towards new frontiers, NARI is actively involved in research on emerging technologies such as Probability Risk Assessment (PRA) for critical infrastructure, small modular reactors, nuclear fusion, diverse hydrogen production, energy storage, carbon capture and storage, seawater mining, and more. These endeavors are intended to support the government in achieving our country's 2050 net-zero emissions goal.

Aim 2: NARI continues strengthening efforts in employing the OKR (Objective Key Results) framework to prioritize the most critical Research & Development (R&D) tasks and drive innovation. Under the OKR framework, NARI has made significant progress and achieved remarkable

results, as evidenced by numerous international R&D honors in the past three years. Following the consecutive R&D 100 Awards won by the Department of Electrical Engineering and Information Technology in 2021 and the Department of Physics in 2022, the Department of Chemistry also received this honor in 2023. With three consecutive years of R&D 100 recognition and the support of the OKR system, NARI strives for excellence.

Aim 3: NARI strongly values talent recruitment and cultivation, leveraging the administrative corporation's flexible personnel mechanism to attract outstanding colleagues and train high-quality personnel. This effort aims to equip our colleagues with solid research and development capabilities, an international perspective, and foster a sense of belonging and a shared vision for NARI's future. In addition, a performance incentive mechanisms will be established to implement talent cultivation initiatives within NARI, further reinforcing our commitment to nurturing the next generation of nuclear energy researchers and professionals.

Aim 4: NARI leverages its new status as a legalized administrative corporation to reach new heights. INER's R&D achievements over the past 55 years have become the cornerstone from which NARI builds on and evolves its future breakthroughs. Seizing the opportunity presented by this organizational restructuring, we adopt a proactive approach to innovation, striving for continuous progress in serving Taiwan's most pressing societal needs of the 21st century.

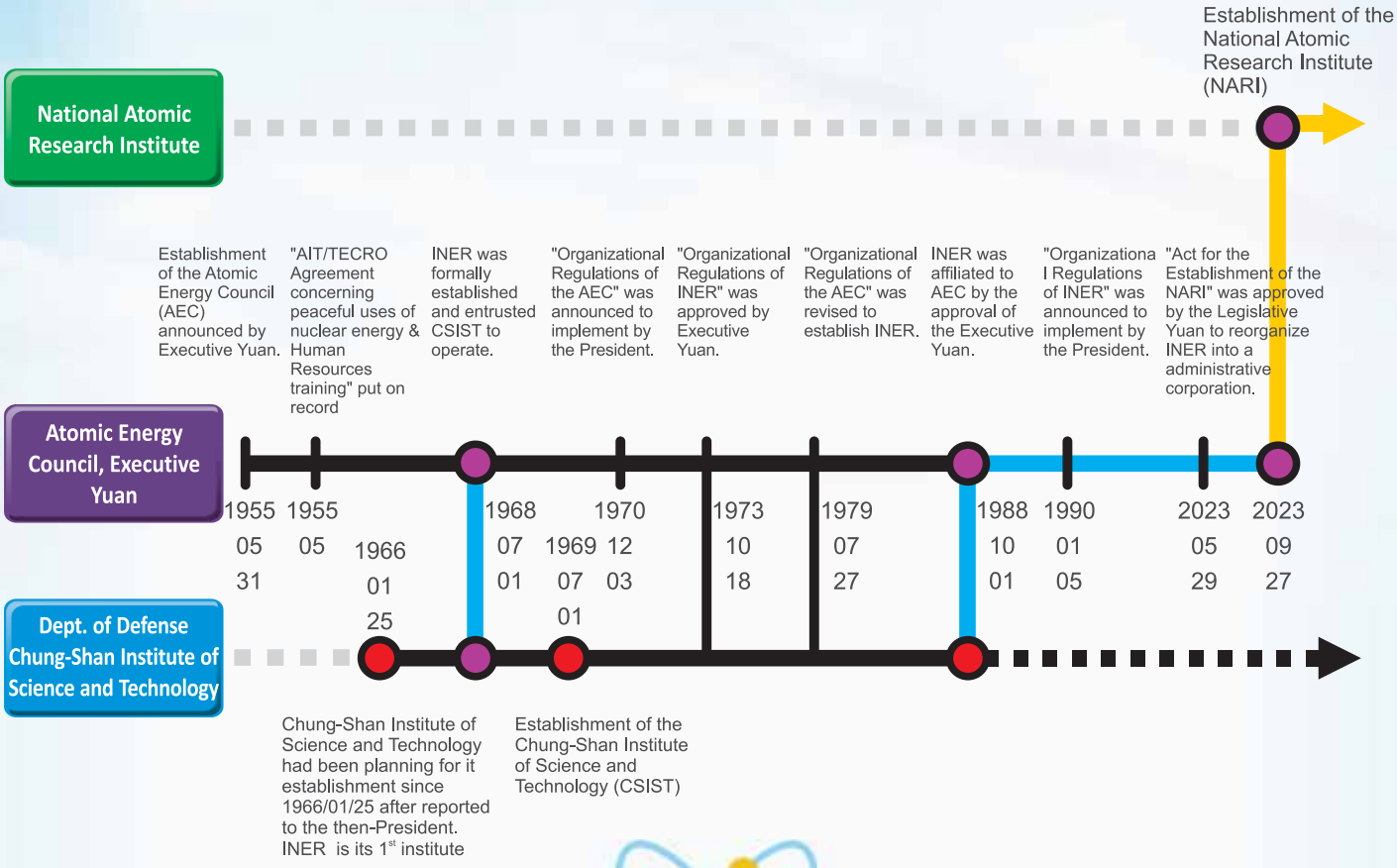
Looking ahead to the future of nuclear energy technology, we strive to positively impact nuclear safety, nuclear waste management, nuclear medicine, radiation applications in daily life, and new energy and system integration. Collaboration is critical for our success. As the saying goes, "If you want to walk fast, walk alone. But if you want to walk far, walk together." I hope all NARI colleagues will harness the power of collaboration as we strive for a better future.

President *Dr. Tsu-Mu Kao*

June 21, 2024

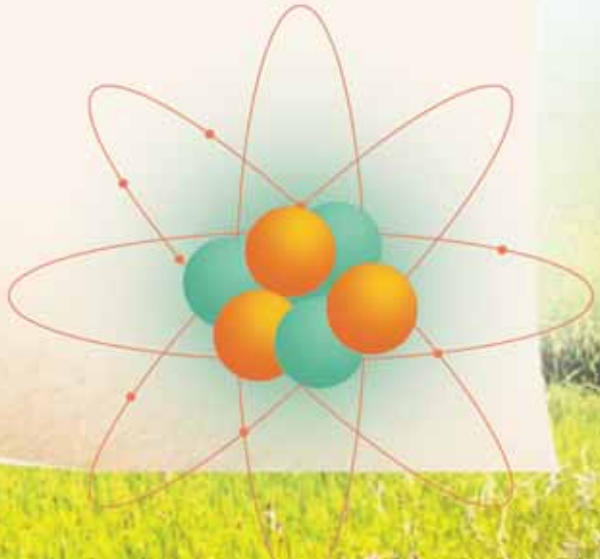
Historical Development

Organizational history of NARI



Establishment of the National Atomic Research Institute

1. National Atomic Research Institute (NARI), formerly known as the Institute of Nuclear Energy Research (INER), is the sole nuclear energy research institute in Taiwan. INER had been planning for it establishment since 1966/01/25 after reported to the then-President.
2. On 1968/05/09 the "Atomic Act" was announced to implement by the then-President. It is stated in the Article 4: For the purpose of promoting research and development of nuclear science and technology, exploiting nuclear energy resources and expanding nuclear applications to agriculture, industry and medicine, the Atomic Energy Council may establish research organizations. On 1968/07/01 INER was formally established and entrusted the Chung-Shan Institute of Science and Technology to operate.
3. On 1973/08/29 the "Organizational Regulations of the Institute of Nuclear Energy Research"was approved by the Executive Yuan.
4. On 1973/09/04 "Organizational Regulations of the Institute of Nuclear Energy Research" was announced to implement by Atomic Energy Council(AEC). It is decided that the date of anniversary of INER is on the 4th September by the Chairman of AEC.
5. On 1988/10/01 INER was affiliated to AEC by the approval of the Executive Yuan.
6. On 1990/01/05 the "Organizational Regulations of the Institute of Nuclear Energy Research" was announced to implement by the then-President.
7. On 2023/05/29 the "Act for the Establishment of the National Atomic Research Institute" was approved by the Legislative Yuan to reorganize INER into a administrative corporation.
8. On 2023/06/21 the "Act for the Establishment of the National Atomic Research Institute" was announced to implement by the President.
9. On 2023/09/27 the National Atomic Research Institute (NARI) was formally established.



R&D Achievements Summary

Nuclear Safety & Backend Technologies

As domestic nuclear power plants enter the decommissioning phase, and the National Atomic Research Institute (NARI) research reactor and other nuclear facilities are also carrying out decommissioning and cleanup tasks, the execution of nuclear backend work in Taiwan will be intensified. Additionally, in line with the rise of renewable energy, the resilience of the domestic power system is also widely expected by society. Therefore, in response to the evolving situation and national needs, NARI has strengthened research and development in the fields of nuclear safety and nuclear backend, with key focuses including safety assessment technologies for spent nuclear fuel dry storage and high-level waste disposal, accumulation of experience in the dismantling of in-house nuclear facilities and radiation protection, and optimization of radioactive waste storage and management techniques. In cross-disciplinary applications, NARI has also actively promoted the application of quantitative risk assessment technology in other fields and the strengthening of national power grid. Moreover, in response to the issue of the Fukushima power plant's discharge of radioactive treated water, NARI has actively responded in accordance with the government's handling principles. Significant research and development achievements in the fields of nuclear safety and backend for the year 2023 by NARI are summarized as follows:

1. NARI has assessed the seismic integrity of spent fuel pools (SFP) at nuclear power plants to address safety concerns arising from beyond design-basis earthquakes. This assessment, developed in reference to the earthquake risk reassessment requirements proposed by the U.S. Nuclear Regulatory Commission after the Fukushima accident, aims to ensure the safety of SFPs during earthquakes through seismic margin assessment methods. Through comprehensive structural and non-structural analysis, this study has provided a set of evaluation methods that meet international SFP integrity standards for our nuclear power plants.

2. NARI's nuclear criticality safety analysis technology has been applied to the dry storage systems of spent nuclear fuel, significantly enhancing the nuclear criticality safety margin of spent fuel canisters by integrating burn-up credit models and complex canister geometry models. This technology not only improves safety but also brings the technical level to international standards. NARI is the only entity in Taiwan with comprehensive nuclear criticality safety analysis capabilities, providing a professional solution for the nuclear criticality safety of spent nuclear fuel in the country.

3. Based on the technical and licensing foundation of the UMS system by NAC International, NARI has successfully completed the license amendment application for BWR's high burn-up and damaged fuel. Through technology transfer and collaboration with NAC, NARI has made localized improvements, enabling INER-HPS system to store BWR's spent fuel with an increased capacity from 45 GWd/MTU to 60 GWd/MTU and to store damaged fuel. Additionally, the material of the dry storage canisters was upgraded to 316/316L steel to improve weather resistance and corrosion resistance. In 2021, it passed the review of the U.S. Nuclear Regulatory Commission, becoming a pioneering success story of dry storage technology in Taiwan and enhancing the competitiveness of domestic dry storage systems.

4. In collaboration with Taiwan Power Company, NARI conducted monitoring, inspection, and characteristic research on dry storage systems for spent nuclear fuel under simulated conditions, aiming to understand the characteristics and behavioral changes of spent nuclear fuel during dry storage. The study used actual spent fuel rods and simulated the dry storage environment in Taiwan for monitoring and accelerating experiments. Through specially designed storage canisters and thermal chambers, the study completed pre-experiment analysis of fuel rod characteristics and non-destructive testing of full-size fuel rods, establishing a first-of-its-kind inspection platform internationally. This research not only provides important data on the storage characteristics of spent nuclear fuel but also offers strong evidence for future dry storage license renewals.

5. NARI developed a multi-modal integrated framework for the final disposal study of spent nuclear fuel, aiming to quantitatively analyze the shear failure of radioactive fuel canisters due to earthquakes and the impact of groundwater flow on the transport behavior of radionuclides. By integrating earthquake analysis, fuel canister failure modes, and groundwater flow and transport models, this framework can quantitatively express the shear failure location of fuel canister under seismic impact and potential transport behavior with characteristic parameters. This technology is designed to address the frequently occurred earthquakes in Taiwan, ensuring the performance and safety of geological disposal of spent nuclear fuel.

6. For the decommissioning plan of the Taiwan Research Reactor (TRR), NARI independently developed a technology for dismantling the biological shield and conducted engineering verification. Considering the need for radiation characteristics and contamination control, NARI developed a dismantling method using dry drilling and dry diamond chain saw cutting techniques to dismantle the biological shield, avoiding the contamination problems associated with traditional wet cutting. This technology not only effectively enhances the efficiency of dismantling but is also the first instance of using dry dismantling techniques for nuclear facilities in Taiwan.

7. NARI developed an engineering information management system specifically for the decommissioning project of TRR's Dry Storage Pit (DSP), to effectively manage the massive amount of waste generated concrete, soil, and fuel storage holes from dismantling. Through the integration of the "On-Site Management APP" and the "Radiation Measurement Device Capable of Continuous Feeding and Discharging," this system can instantly record and provide feedback on the measurement data of the large amount of waste, improving management efficiency and ensuring the synchronization of operational processes. Moreover, the system combines 3D engineering visual assistance design to instantly monitor radiation protection situations, ensure the safety of operators, and effectively reduce manpower, schedule, and costs.

8. NARI developed a set of intelligent visual technologies applied to welding quality inspection techniques, aiming to improve the efficiency and accuracy of welding inspections. By integrating 2D and 3D vision sensors, Artificial Intelligence (AI), and automated inspection technologies, this system overcomes the disadvantages of traditional visual inspections, such as reliance on professional operator, slow speed, or subjective judgment. Additionally, NARI's

technology can quantify defect characteristics and perform statistical analysis within permissible ranges, not only allowing for real-time monitoring of welding quality during the process but also offering data analysis and recording for causation tracking and predictive analysis, thereby preventing potential issues. This technology can effectively reduce costs, improve yield, and enhance market competitiveness without altering existing process conditions, contributing to the overall industry's upgrade and development.

9. NARI promoted the application of Probabilistic Risk Assessment (PRA) technology to explore the vulnerability of the power grid and the supply reliability of gas-fired power plants, in response to previous large-scale power outages in Taiwan and future challenges of electricity instability. The institute has been developing PRA technology since 1983 for safety analysis of nuclear power plants and now extends its application to power grids and gas-fired power plants to enhance the resilience of national critical infrastructure. Through systematic analysis, NARI evaluates the risks of Taiwan's power grid and gas-fired power plants, including power flow, hazards, vulnerability, internal event pilot case analysis, and PRA modeling. The research aims to provide a prioritization of measures to improve the power grid, enhancing grid resilience and supply reliability.

10. Celebrating the 40th anniversary of introducing PRA technology to Taiwan, NARI held an international symposium focusing on the wide application of PRA technology in both nuclear and non-nuclear industries, and its contribution to national security, economic development, and social welfare. The symposium covered global significance of PRA technology, best risk assessment methods, applications of artificial intelligence, and challenges and opportunities faced.

11. NARI is committed to developing small modular high-energy density independent power supply system technologies to enhance the resilience of critical infrastructure and national security. Considering that power disruptions can severely impact the national economy, social development, and other critical infrastructures, NARI proposes using Small Modular Reactors (SMR) combined with cogeneration units to construct independent power systems that can operate in island mode. Such systems can provide stable and independent power supply during regional power shortages or outages, reducing dependence on external power or equipment. The long-term goal is to enhance national energy security through the construction of these power systems and support achieving net-zero emissions targets.

12. Since July 2021, NARI has established the country's first biological tritium inspection laboratory, which was inaugurated in August 2022. The purpose is to monitor the tritium content in the marine species near Taiwan and in the distant oceanic economic zones, assessing the impact of the Japanese Fukushima power plant's release of radioactive treated water on the marine ecology. In 2023, NARI in collaboration with multiple government departments, completed 525 biological tritium inspections, with results published on the Nuclear Safety Commission's "Radioactive Substance Marine Dispersion Ocean Information Platform," providing real-time monitoring information to the public. To ensure food radiation safety, the institute will continue to expand inspection capacity and conduct inter-laboratory comparison tests to enhance confidence in inspection quality.

Research and Development in Radiation Application

NARI has long been committed to the development of radiation technologies that can be applied to people's livelihood, focusing on the research of radioactive precision medical applications, developing new radiopharmaceuticals, expanding the production capacity of nuclear medicines and promoting radiation application research to provide the public with those nuclear medicines needed for radiological diagnosis and radioactive treatment. Moreover, in order to meet the increasing needs of civil applications, NARI began to build a 70 MeV medium-sized cyclotron in 2023 to develop key nuclear medicines for medical diagnosis and treatment, by introducing novel cyclotron technologies. In addition, NARI strives to develop space-radiation simulation test facilities and proton measurement standard technologies to strengthen space science technology research and industrial development domestically. In the radiation application field, NARI endeavors to establish the application of neutron technology in the semiconductor industry, aerospace industry, nuclear medicine design and research and atomic energy technology etc. In summary, those important research and development achievements in the field of radiation application for people's livelihood in 2023 are listed as follows:

1. **Research of radioactive precision medical applications :** The research achievements include: (1) Dolacga liver imaging agent had been developed for assessment of severity of chronic hepatitis and liver cancer. This marker product has highly specific targeting properties for liver receptors and has completed phase I and II clinical trials. (2) Multivalent glyco-complex and imaging agent had been developed for early diagnosis and early treatment of malignant tumors. It can quickly enter tumor cells, improve the signal contrast between tumors and surrounding normal tissues to increase detection efficiency. (3) DOTA-ENPY drug had been developed. It can selectively label radioactive isotopes for PET or SPECT imaging, making it a valuable companion target drug for breast cancer diagnosis and treatment. (4) Tumor hypoxia imaging agent had been developed. It is non-invasive and can be directly applied in human clinical trials, does not cause an immune response, and reduces hepatic uptake. It is expected to be used as a routine clinical diagnostic tool to improve the accuracy in judging the degree of tumor hypoxia. (5) Preparation method of imaging agent precursor S-Bz-MAG_3 had been developed for Improving diagnosis of kidney function and urinary system. The overall yield and purity of the production process are both improved, making it easier to expand the process to 10 grams or more. (6) Production, purification and assay methods of pharmaceutical grade Ac-225 had been developed. This technology can be used for helping production of radioisotopes by the under building 70 MeV cyclotron in the upcoming future.
2. **Applications in the fields of space and semiconductor industries :** The research achievements include: (1) Space Solar Cell for Satellite is one of the innovative technologies that has been committed in the research and development by investing in concentrate III-V multi-junction solar cell technology. NARI had extended its existing III/V solar cell technology to the development of space solar cells to increase the domestic production of key components in the space industry. The highest efficiency of the NARI space solar cell battery has reached the level of commercial applications. This technology was also selected as one of the 15 highlight technologies by the 2023 Taiwan Innotech Expo (TIE) conference. (2) A space electronic component soft error rate testing system had been developed. By combining the 30 MeV cyclotron in NARI and domestic proton therapy platforms for testing electronic components' soft error rates (20-200 MeV), domestic space radiation verification of electronic components could be strengthened so as to support the local space industry. (3) Development and application of compact accelerator-based neutron sources is currently under is developing in NARI. Accelerator-based neutron sources will be provided for use in semiconductor wafer soft error rate testing and thermal neutron imaging. It is also planned to build a 70 MeV cyclotron to further expand neutron scattering applications for advanced R&D and stable isotope production for civil industries.
3. **Improvement of the performance of medical device products :** The research achievements include: (1) A machine learning method Harmonizing nuclear medicine imaging and precision in dementia diagnosis had been developed. Standardizing nuclear medicine imaging interpretation and imaging quality become possible. The advantage of quickly providing information on brain function decline and activity can improve the accuracy of dementia interpretation and diagnosis. (2)3D high-precision digital X-ray spectrum imaging simulation technique had been developed. It is a X-ray imaging technique innovation tool by combining exiting radiology imaging equipment R&D experience of NARI with new X-ray imaging numerical simulation technology. It is expected to assist domestic industry players in accelerating the development of radiography technology and establishing procedures related virtual clinical trial in Taiwan.

New Energy and System Integration

In compliance with the national energy policy, the National Atomic Research Institute (NARI), the successor of INER, has committed to the research and development on the environmental and green energy technologies. Currently, the government has set the pathways and strategies for the net zero emissions (NZE) by 2050 and launched the "Energy Transition" policy, "5+2 Innovative Industries Program" as well as "Six Core Strategic Industries". As a national research institute, NARI has been strategically demanding to support the national energy policy and aims to develop diverse energy technologies so as to facilitate the implementation of energy transition, promote the industrial applications and strengthen the national competitiveness. In the past three years, NARI has been successively recognized and honored R&D100 awards for its remarkable innovations and impressive achievements. Additionally, NARI has been successively won four Platinum Medal Awards and other awards in the Taiwan Innotech Expo (TIE) Invention Competition. Some remarkable achievements on the green energy and system integration technologies are briefly outlined as follows.

1. **FixCarbon Technology :** breakthrough technologies with saccharification, high-throughput screening of strain and novel purification are employed. The lignin residuals and wastewater from the processes can be converted into green energy for the manufacturing plant, eliminating the need for fossil energy, achieving a green process with negative-carbon footprint and zero-waste. This technology is currently the first-of-its-kind in the world, to demonstrate the potential of lignocellulosic waste for valuable bio-chemicals production by providing a groundbreaking solution. A 2023 R&D 100 Award was rewarded for its "FixCarbon Technology: Carbon-Negative Bioplastics from Afforestation".

2. **Innovative Electrochromic Glass :** cutting-edge green manufacturing and low-carbon production methods are invented to develop a unique high-density arc plasma source. It replaces the current sputtering process to produce novel nano-porous films, which are the main components of electrochromic (EC) energy-saving windows. In the top 100 global R&D revolutionary technology competition, NARI was honored a Mechanical/Materials Award for the EC glass technology innovation.

3. **Intelligent Distribution Network Management System (iDNMS) :** this system is the integration of Supervisory Control and Data Acquisition (SCADA) System with Geospatial Information System (GIS) and distribution power flow program. With the assistance of iDNMS, the intermittency of power generation produced by renewable energy devices can be managed, and the resilience as well as performance of grids can be strengthened. This system has been operating in Yunlin Branch of TPC, and it can manage more than 300 feeders and renewable energy devices whose total capacity is more than 700 MW along with the power consumption status of 580 thousand users over the whole Yunlin County effectively. A 2021 R&D 100 Award was rewarded for the iDNMS.

4. **Method of Fabrication Green Desiccant Whee :** an extracting process from waste in the aluminum industry is invented to produce aluminum hydroxide or activated alumina with complement by plasma. It reduces mineral extraction, extends material life cycles, and implements a circular economy and energy conservation to reduce carbon emissions. Associated with patented technology, applications of the products to create energy-saving eco-

friendly dehumidification wheels and heat capacitor components are being implemented to the industry sector. Practical applications, such as technology transfers and technical services are under way. A Platinum Medal Award was received in the 2023 Taiwan Innotech Expo (TIE).

5. **Multi-Segment Load Transfer for Power Restoration :** as the green energy industry flourishing, large amount of renewable energy has to be integrated into distribution feeders. The research team develops a strategy of multi-segment load transfer for power restoration incorporating renewable energy generation estimation to mitigate the potential outages of feeders attributed to the surge of renewable energy sources. Based on the installed capacity and location of the renewable energy devices, temperatures, illumination, time, and the current and voltage values of Feeder Terminal Unit (FTU), the actual electricity consumption of the feeder by power flow analysis are evaluated so as to provide correct information to operators. It delivers a clearer message for decision-making of load transfer, to speed up troubleshooting, and restore power supply to downstream healthy area. A Platinum Medal Award was honored in the 2022 Taiwan Innotech Expo (TIE) Invention Competition.

6. **Voltage Control System and Method for Microgrid :** the penetration of renewable energy causes power system instability and voltage fluctuation at the Point of Common Coupling (PCC) of feeder. By integrating Power Conversion Systems (PCS), renewable energy and loads, microgrid can provide a solution to improve power quality. This technology consists of voltage control strategies built in the PCS to suppress the inrush to prevent power system blackout under the threshold protection of the PCS while the microgrid operates in standalone mode. A Platinum Medal Award was honored in the 2021 Taiwan Innotech Expo (TIE).

7. **Load Transfer Incorporating Green Energy for Distribution Feeder :** using the data visualization method, various dynamic information of the distribution network, such as on/off statuses of switches and outage areas, can be displayed on the map. When a fault occurs, the system is capable of performing Fault Detection, Isolation, and Restoration (FDIR). By the integration of power flow calculation, the load transfer solutions are proposed, and the information of capacity allowance, highest/lowest voltage values with their corresponding locations, feeder line loss, and the proposed load transfer options are shown for the dispatchers' reference. The dispatchers can intuitively obtain the real-time operating information of the network, the electricity supply/outage ranges and the fault areas, and then take proper actions to restore the power system. A Platinum Medal Award was honored in the 2020 Taiwan Innotech Expo (TIE).

8. **Diversified Applications and Innovative Business Model for Forest Waste :** the natural carbon sink is recognized as a promising strategic tool to realize the vision of zero carbon emission in response to the global warming trend. Based on the full-wood utilization strategy, the NARI has fostered multi-party collaboration with Inspira Applied Bio Solutions and NZ Bio-forestry, using Pinus radiata as the feedstock to develop diversified value-added technologies

for forest waste valorization. This further establishes the innovative business model for the forest carbon sinks, mitigating carbon emissions with maximized benefits. The collaboration is aimed to establish an energy and resources production technology with low carbon footprint, strengthen international connection, gear NARI's technology to international standards, and seek for an innovative business model for forest carbon sink.

9. **Solid Oxide Electrolysis Cell and Hydrogen Production :** Solid Oxide Electrolysis Cells (SOECs) are power-to-gas devices that can convert electricity into fuel gas with a high conversion efficiency. NARI has committed to the development and applications of solid oxide cell (SOC) technologies, including cells, sealant, stacks, catalysts, components of balance of plant as well as integration of power generating systems. In this study, a 30-cell stack is assembled and tested with a hydrogen production efficiency of around 71.2%. Progressive improvement is being persistently pursued. Through the linkage with domestic industries, cooperation projects relevant to SOC technology have been conducted. Two bronze medals were rewarded in 2023 Taiwan Innotech Expo.

10. **Development and Field Testing of the New 30 kW Wind Turbine :** in Taiwan, dispersed areas with favorable wind conditions suitable for installing small wind turbines are yet to be fully developed. Additionally, the feed-in tariff for small wind turbines below 30 kW suffices to provide domestic niche market for further development. Thus, the NARI has assisted domestic manufacturers in developing a new 30 kW wind turbine to further improve system efficiency and conduct field testing. We aim to create a fully localized technical team, developing domestically commercial small wind turbines. In the future, we will drive the establishment and operation of decentralized power plants, achieve industry localization, and further promote the application of international energy markets.

In brief, NARI has devoted to developing novel and renewable energy technologies for years with remarkable progresses and reputation in the international communities. For the perspective vision towards "2050 Net-Zero Emissions", NARI will continuously comply with the national energy policy, master indigenous key technologies, and pursue a sustainable prosperity carbon neutral society.

Achievements and Honors

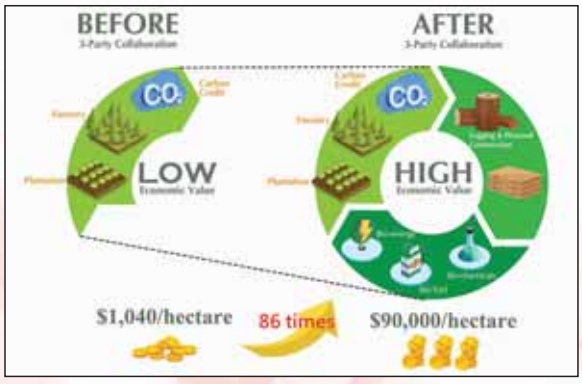
R&D 100 Awards

FixCarbon Technology: Carbon-Negative Bioplastics from Afforestation

The National Atomic Research Institute (NARI) won a 2023 R&D 100 Award for its "FixCarbon Technology: Carbon-Negative Bioplastics from Afforestation". The award-winning work is based on the collaboration among NZ industry, domestic industry and NARI, and successfully verified the conversion of low-value forestry residue into high-value bio-plastics. Overcoming technical bottlenecks of utilizing non-food biomass, NARI is able to effectively utilize all components of lignocellulose to produce high-value bio-based products using its breakthrough technologies with saccharification, high-throughput screening of strain and novel purification. Furthermore, the lignin residuals and wastewater from the processes can be converted into green energy for the manufacturing plant, eliminating the need for fossil energy, achieving a green process with negative-carbon footprint and zero-waste. As a result, this technology is currently the first-of-its-kind in the world, to demonstrate the potential of lignocellulosic waste for valuable bio-chemicals production by providing a groundbreaking solution.

The important value of this award demonstrates that NARI's FixCarbon technology creates an innovative forest management model that integrates forest carbon sinks with biorefinery. It has been verified by Inspira and NZ Bio Forestry through a tripartite collaboration that utilizes the residual wood processing and forestry waste from New Zealand's trees to create bio-plastic products, leading to a more than 86 times increase in economic value. The technology effectively promotes the sustainable development of artificial forests, solves the waste problems in existing industries chains and creates the value chain of revolutionary bio-circular technology. NARI's FixCarbon technology contributes to the reduction of greenhouse gas emissions, fighting the impact of climate change, and achieving a balance that aligns economic growth, social well-being, and environmental protection. NARI will continue to expand the research results, to help domestic industries to achieve the efforts of carbon reduction, create economic value, and enhance independent manufacturing resilience.

NARI honored a 2023 R&D 100 Award



Value estimate for New Zealand forestry after NARI's FixCarbon technology

Low-carbon and low-cost mass production technique for innovative electro-chromatic glass

The "low-carbon and low-cost mass production technique for innovative electro-chromatic glass" developed by the National Atomic Research Institute (NARI) won the "2022 R&D 100 Awards", widely considered to be the Oscars of the technology industry. The electro-chromatic energy-efficient window product based on this technology has the following outstanding attributes:

(a) Energy Saving: Energy is only consumed when changing colors and the maximum power consumption rating is just 2.5W.

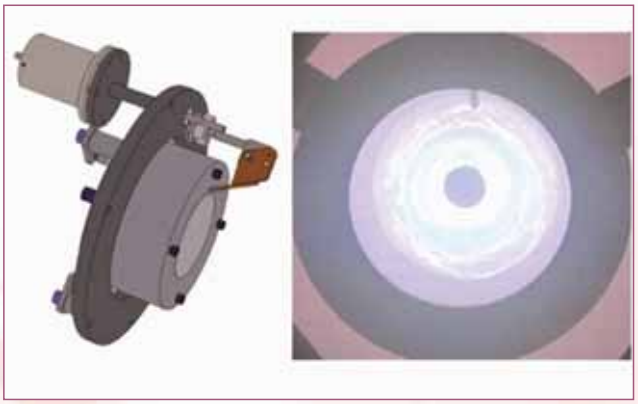
(b) Excellent Memory Effect: Just 4% color change after 4 days when disconnected from a power supply.

(c) Excellent Thermal Insulation: Effectively blocks IR radiant heat and UV damage from sunlight. Colored mode blocks up to 99.1% of infra-red and uncolored mode still blocks 67.3%.

(D) Large Variance in Visible Light Transmission Rate: Light transmittance is 8% when colored and 60% when uncolored, with a transmittance variation of 52% (⩾50% commercial standard).

The mass production technique for electro-chromatic glass developed by NARI is based on a type of innovative high-density arcing plasma. An energy-efficient and responsive electro-chromatic coating was developed based on the novel nanoporous material. This technique is 5 to 10 times faster than the sputtering process now in mainstream use. Power consumption is also reduced by up to 75% so it qualifies as a green production technique with low-carbon, low energy consumption, and low contamination. The major reduction in greenhouse gas emissions balances economic development and environmental protection by mitigating global warming and reducing environmental pollution.

Electro-chromatic glass developed by NARI.



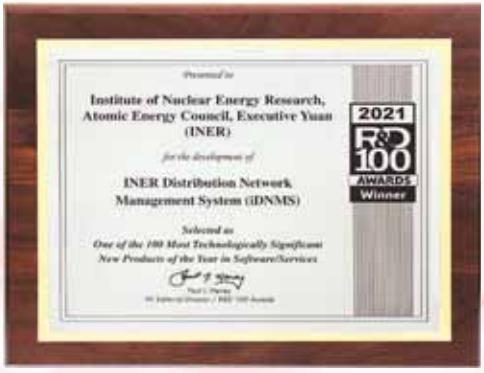
A type of innovative high-density arcing plasma.

Technology of Intelligent Distribution Network Management System (iDNMS)

With the government's policy goals of renewable energy enhancement and net zero emission in recent years, a great deal of renewable energy is going to be integrated into the power grids. Therefore, there is an urgent need of developing a control technique which is different from the ones used for conventional grids. With the development of key techniques for microgrids and distribution systems, the intermittency of power generation produced by renewable energy devices can be managed, and the resilience as well as performance of grids can be strengthened. The Executive Yuan approved the "Smart Grid Master Plan" in 2012, and NARI is one of the members of the Smart Grid Task Force. The research team has devoted to the technique development of autonomous regional (micro) grids, and has laid the foundation for the key technologies of microgrids in Taiwan. In cooperation with the Executive Yuan's rolling adjustment made in February 2020, the research team has developed domestic distribution network management system, aiming at the composition of grid management, to assist Taiwan Power Company (TPC) with enhancing the abilities of dispatching feeders and managing renewable energy sources.

This system is the integration of Supervisory Control and Data Acquisition (SCADA) System with Geospatial Information System (GIS) and distribution power flow program. The direction of electricity supply obtained according to the power flow calculation result can be shown on GIS. When electricity is conveyed inversely due to the increase of power generated by the renewable energy devices, GIS can also show the inverse direction of electricity supply. This allows the dispatchers to identify the power supplement sources of each section and master the power generation of renewable energy on the feeders, which enhances the usability of this system. And SCADA provides the intelligent load transfer function, and it's integrated with Analytic Hierarchy Process (AHP), which serves as the basis of weighting factors. The dispatchers can adjust these weighting factors, including the current margin of transferring feeder, the main substation that the selected transferring feeder belongs to, the highest/lowest voltage on the feeders after load transfer, the types of switches (manual/automatic) used for load transfer, and line loss, etc, manually. This system has been operating in Yunlin Branch of TPC, and it can manage more than 300 feeders and renewable energy devices whose total capacity is more than 700 MW along with the power consumption status of 580 thousand users over the whole Yunlin County effectively.

iDNMS is operating in Yunlin Branch of TPC



R&D 100 Awards

Taiwan Innovation and Technology Expo Invention Competition Platinum Award

Method of Fabrication Green Desiccant Wheel

tie Platinum Awards 2023

The technology develops a process for extracting aluminum from waste in the aluminum industry. It produces aluminum hydroxide or activated alumina with complement by plasma. It reduces mineral extraction, extends material life cycles, and implements a circular economy and energy conservation to reduce carbon emissions. The products can not only be directly sold but also be processed for specific applications using patented technology to create energy-saving eco-friendly dehumidification wheels and heat capacitor components. The integrated dehumidification wheel system has been proven feasible. Currently, a volatile organic compound adsorption and desorption treatment system is under research, with potential applications in the field of air pollution control.

The aluminum purification processing capacity exceeds 100 kg/hr with the product purity >99.9%. On the base of the above materials, the established manufacturing products involves eco-friendly desiccant wheel with specification of 50 cm in diameter and 40 cm in thickness. The final integrated adsorption equipment systems have verified by conducting on-site testing. The energy efficiency is improved by 20%. The recycled materials and their derivative products, equipment, and systems lead to a 30% cost reduction and creating new business opportunities for economic and environmental sustainability.

Technology transfers (6 projects totaling at least 8 million) and technical servicea (8 projects totaling at least 2.5 million) are stably conducted. Industry investments and expansion of relevant machinery and equipment are promoted (facilitating investments of at least 60 million TWD).

Aluminum dross purification

Desiccant Wheel sintering

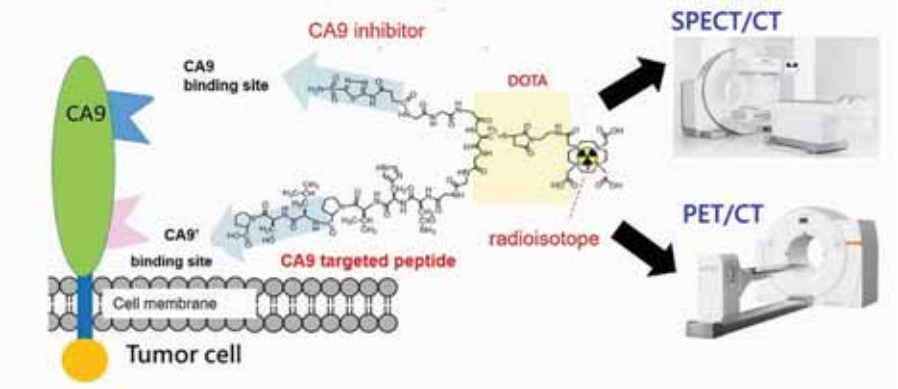
On-site verification

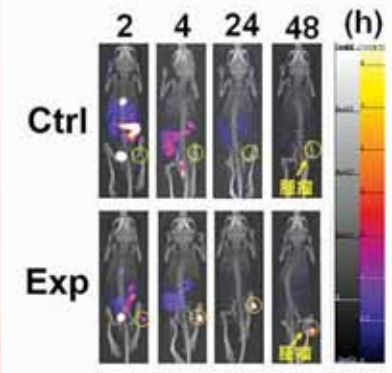
tie Platinum Awards 2023

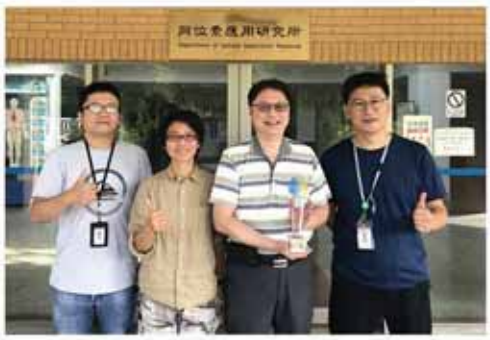
Dual-Targeted Carbonic Anhydrase IX Complexes and Imaging Agents

The phenomenon of tumor hypoxia is an essential factor leading to the ineffective outcomes of radiotherapy or chemotherapy. Therefore, practical assessment of tumor hypoxia status is critical to the success of treatment. The existing clinical diagnostic tool, polarographic oximetry, has drawbacks such as invasiveness, significant human operational errors, and the inability to test deep-seated organs. Therefore, NARI has designed a dual-targeted probe with a tumor hypoxia biomarker (carbonic anhydrase IX protein) as the target site and a radioisotope as a tumor hypoxia imaging agent. The imaging agent is injected intravenously, circulates through the bloodstream, specifically binds to the surface of tumor cells. Imaging of the tumor hypoxic areas is then obtained by Positron Emission Tomography (PET) or single-photon computed tomography (SPECT).

The tumor hypoxia imaging agent developed by NARI combines features such as non-invasiveness, direct applicability to human clinical trials, lack of immune response, and reduced hepatic uptake. In addition, its low cost, easy synthesis, reproducibility, and high aggregation of tumor hypoxia sites with high affinity can enhance the accuracy of tumor hypoxia level determination and grasp the golden treatment time for precise medical treatment. In addition, this drug has a wide range of clinical applications, including diagnosing the degree of hypoxia before treatment, evaluating the efficacy of treatment, and tracking whether the tumor has recurred or metastasized to other tissues in the future.







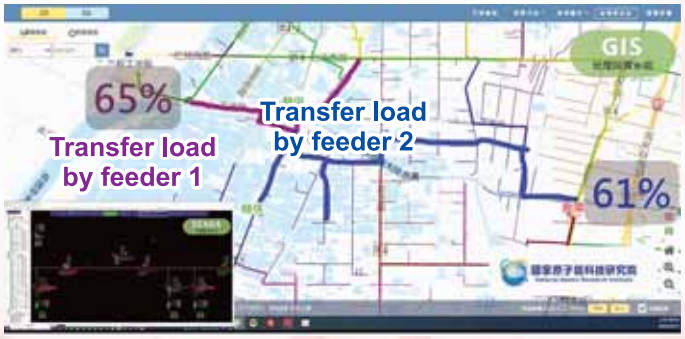
tie Platinum Awards 2022

Strategy of Multi-Segment Load Transfer for Power Restoration

As domestic electricity consumption is increasing year by year, especially in urban area, when a fault occurs in a feeder, the downstream healthy area of the fault should be transferred to other feeders. If the load in the downstream healthy area is heavier than the capacity of single connecting feeder, the single connecting feeder may trip after load transferring due to overload, which will lead to larger outage area, and the downstream healthy area cannot be restored. Recently, the green energy industry has been flourishing, hence large amount of renewable energy will be integrated into distribution feeders in the future. When a fault occurs, if the net load is used as the basis for feeder transfer, it may lead to insufficient capacity allowance and low voltage after feeder transfer. Therefore, NARI research team develops a strategy of multi-segment load transfer for power restoration incorporating renewable energy generation estimation to solve the above-mentioned problem.

This strategy can calculate the actual electricity consumption of the feeder by power flow analysis based on the installed capacity and location of the renewable energy devices, temperature and illumination, time of day and hour, and the current and voltage values of Feeder Terminal Unit (FTU). With this strategy, when a fault occurs, if the load of the downstream healthy area is heavier, the optimum switch can be found to cut the downstream healthy area into several segments, then these segments can be transferred to several different feeders, so that load rate of each connecting feeder will be close to each other after the load transfer. With the load transfer by 2 or more feeders, dispatchers can take this strategy as reference for decision-making of load transfer, and speed up troubleshooting, and restore power supply to downstream healthy area.

(a) Inllistration of fault area and outage area



(b) Multi-segment load transfer
An example of multi-segment load transfer

Award Ceremony the Platinum Award at
2022 Taiwan Innotech Expo (TIE)

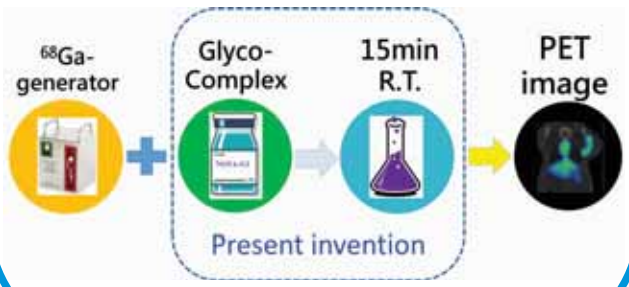
tie Platinum Awards 2022

Multivalent glyco-complex and imaging agent

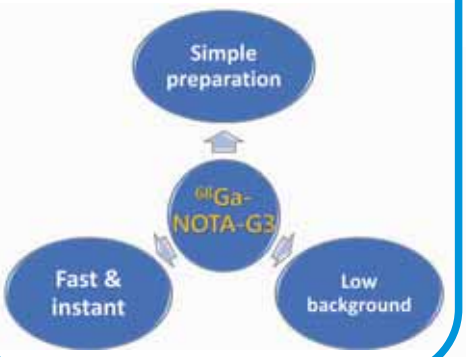
The key to treat malignant tumors is early diagnosis and early treatment. Many cancers have a good prognosis if detected early. [^{18}F]FDG is currently the most commonly used PET cancer imaging agent in clinical practice. Its shortcomings include: (1) Drug preparation is cumbersome: a cyclotron is required to produce F-18. (2) High background values in normal tissues. it is difficult to detect tumors in these organs and their surrounding areas. NARI invented a multivalent glycol-complex contrast agent containing a chelator, a linker and multiple sugar molecules. In order to take advantage of the high glucose usage characteristics of most malignant tumors, it can quickly enter tumor cells, improve the signal contrast between tumors and surrounding normal tissues, thereby increasing detection efficiency. In addition, this glycol-complex with a molecular size is significantly larger than [^{18}F]FDG, and its uptake in the normal brain and heart is significantly reduced. Therefore, it can enhance tumor signal contrast with the surrounding brain and lungs.

The present invention utilizes gallium-68 (Ga-68), which can be obtained from a generator and does not require reliance on a cyclotron. In addition, It can be prepared in the form of a lyophilized kit. Radiolabeling can be completed in 15 minutes at room temperature without purification. It is very convenient for clinical use and can reduce drug costs and the radiation dose for operators. The kit does not contain any radioactive substances, can be stored for a long time and is marketable globally, significantly enhancing the product's convenience of use and its market potential. The present invention can also be applied to the evaluation of cancer treatment efficacy in a non-invasive way.

Invoation value



Technical benefits



tie Platinum Awards 2021

Dolacga Liver Imaging Agent

Competent residual liver function is crucial for the survival of patients with liver diseases. As a significant difference exists between the number of asialoglycoprotein receptors on the parenchymal cell membrane of a normal liver and a diseased liver, asialoglycoprotein receptor imaging can sensitively differentiate between normal and diseased livers. Dolacga Liver Imaging Agent, as known as Ga-68 Hexa-Lactoside, exhibits good targeting to asialoglycoprotein receptors on hepatocyte membrane and has been developed as liver function imaging agent. Due to the high specificity to asialoglycoprotein receptor for Hecxa-Lactoside, it also has the potential to serve as a carrier to transport a cargo of siRNA into the liver for medical therapy.

It can sensitively detect changes in the severity of liver , allowing for the assessment of the severity of chronic hepatitis and liver cancer. It offers a more precise assessment hepatoma scope, discriminates benignity from malignancy, and evaluates liver function. It plays an important role on decision-making in future clinical diagnosis. Its all-in-one lyophilized design with the advantage of instant preparation of Ga-68 Dolacga has been patented in Taiwan, US, Europe and Japan. The phase I & II clinical trials showed its highly liver-targeting and safe. Dolacga liver imaging agent has world-wide patent map and has been developed to give lyophilized formulation that can be used for PET imaging after simple and fast (15 min) Ga-68 labeling. Convenient and rapid labeling (15 minutes), short half-life of Ga-68 (environmentally friendly), and stability (favorable to global distribution) are key features that provide advantages for product commercialization.

tie Platinum Awards 2021

Voltage Control System and Method for Microgrid

The implementation of the energy transition policy increases the penetration of renewable energy, which causes power system instability and voltage fluctuation at the Point of Common Coupling (PCC) of feeder. Microgrid can provide a solution to improve power quality by integrating Power Conversion Systems (PCS), renewable energy and loads. The PCS serves as the voltage source when operating in standalone mode. In the case of switching on transformers due to electricity demand, the huge inrush current induced by the energization of inductive loads could exceed the threshold output current of the PCS instantaneously. It could be followed by the PCS protection tripping and result in the blackout of the regional power system.

The Voltage Control System and Method for Microgrid (Fig.1) is proposed by NARI. This technology consists of voltage control strategies built in the PCS to suppress the inrush to prevent power system blackout under the threshold protection of the PCS while the microgrid operates in standalone mode. It is innovative and cost-competitive by adding value to PCS to maintain the stable operation of microgrid. Also, this technology won the Platinum Award at the 2021 Taiwan Innotech Expo (TIE) Invention Competition (Fig.2).

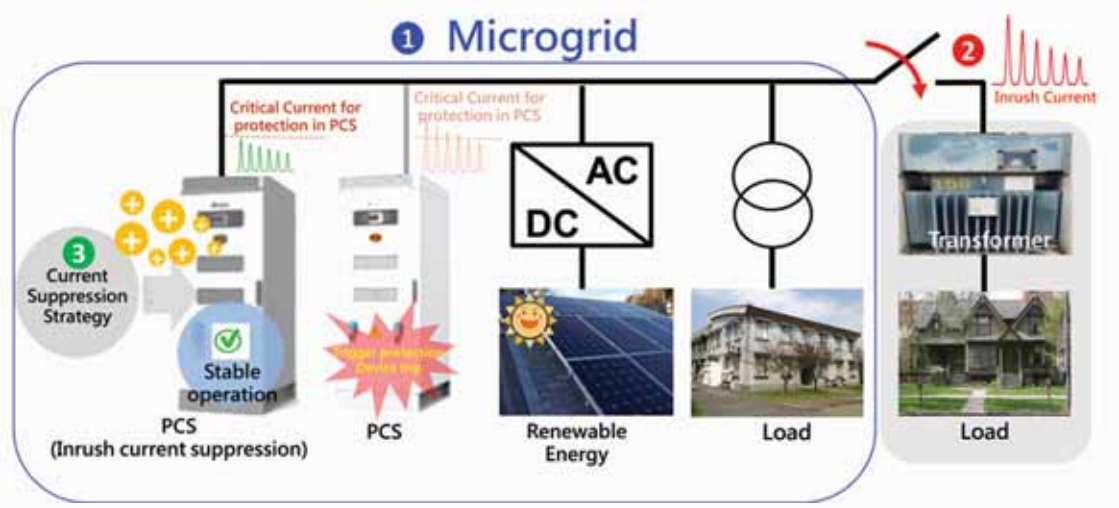


Fig.1. Application of the proposed voltage control method for Micorgrid operating in standalone mode

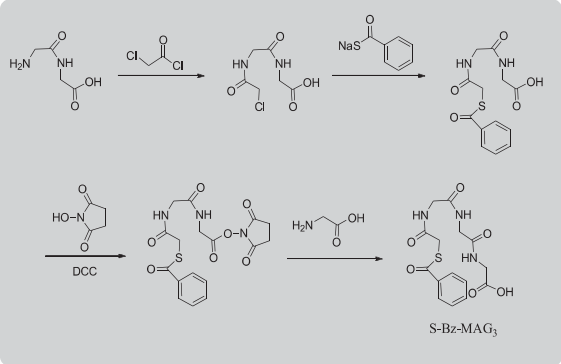
Fig.2. Platinum Award certificate of merit and trophy at 2021 TIE

tie Platinum Awards 2020

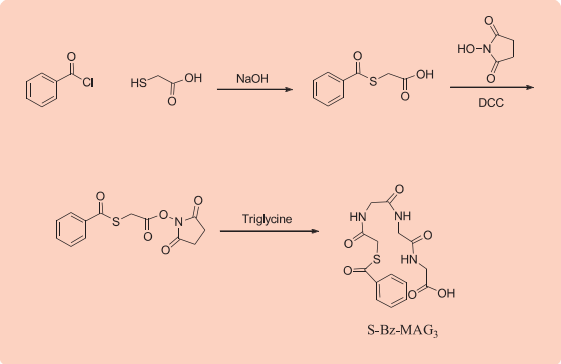
A tool for diagnosing renal function and urinary system - Preparation method of imaging agent precursor S-Bz-MAG_3

Tc-99m-MAG_3 is an effective contrast agent for specific diagnosis of renal blood flow and renal tubular function. It can accurately grasp and analyze the pharmacological characteristics of renal secretion and excretion. It has become an important nuclear pharmaceutical for diagnosing renal function globally renal function diagnosis around the world. As the precursor raw material for renal function contrast agent, the synthesis research and technology of S-Bz-MAG_3 have been continuously improved, leading to the successful production and regulatory approval for Tc-99m-MAG_3. Not only does it provide more precise and effective medical diagnostic services for domestic patients with kidney and urinary system diseases, but it also positions NARI as a model for promoting the localization of nuclear medicine pharmaceutical industry.

NARI have adjusted the synthesis pathway of S-Bz-MAG_3, simplifying it from the original four-step reaction to three steps. The key is to complete the coupling of the three amino acid units in the structure at once, instead of the original process. The total yield of the improved process is 64%, which is higher by 10-15% compared to the old process. The product purity has also reached over 99%, leading to an increase in the melting point by 3-4°C. The yield and purity quality are both improved. Moreover, the products of each step of the improved process do not require complicated column chromatography purification, making it easier to scale up the production to quantities exceeding 10 grams. Multiple batches of verification production have been successfully completed. The future goal is to transfer the large-scale production technology of S-Bz-MAG_3 API to the private pharmaceutical industry, enabling domestic patients with kidney and urinary system to receive more accurate and effective medical diagnostic services.



The original process of S-Bz-MAG_3
(step-by-step grafting of amino acid units)



The improved process of S-Bz-MAG_3
(one-time grafting of amino acid units)

	The original process	The improved process
Step	4	3
Yield	51.16%	64%
Meiting point	195-196°C	198-199°C
Purity	98%	99.3%

tie Platinum Awards 2020

Method of Load Transfer Incorporating Green Energy for Distribution Feeder

In recent years, the renewable energy industry has being flourishing due to the highly-concerned environmental sustainability issue. However, the output power of renewable energy such as wind turbine and PV is likely to change greatly by weather factors, resulting in instability for power system. In practice, dispatchers monitor the real-time status of feeders by Supervisory Control and Data Acquisition (SCADA), which presents feeders' topologies in single-line-diagram style only, instead of geospatial information. When a fault occurs, the dispatcher needs to query maps to confirm the fault location, which leads to delay of power recovery. Therefore, a method of load transfer incorporating visualization technique for distribution feeder was developed. It can assist dispatchers to quickly track the fault locations on feeders. Dispatchers can take this strategy as reference for decision-making of load transfer, and achieve the goal of rapid power restoration.

By the data visualization technology, various dynamic information of the distribution network, such as on/off statuses of switches and outage area, can be displayed on the map. When a fault occurs, the system is capable of performing Fault Detection, Isolation, and Restoration (FDIR). By the integration of power flow calculation, the load transfer solutions are proposed, and the information of capacity allowance, highest/lowest voltage values with their corresponding locations, feeder line loss, and the proposed load transfer options are shown for the dispatchers' reference. The outage range and the fault area can be displayed by various line segments with different colors. With this technology, dispatchers can intuitively obtain the real-time operating information of the network, the electricity supply/outage range and the fault area, so that the decision making of power dispatching, and power restoration can be accelerated.

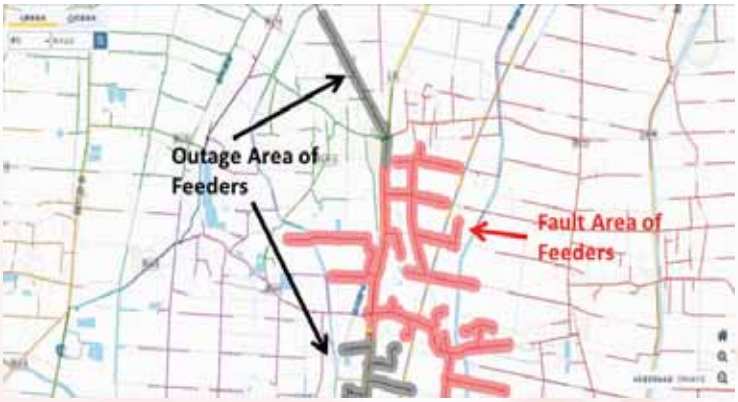


Illustration of outage area and fault area

Award Ceremony the Platinum Award at 2020 Taiwan Innotech Expo (TIE)

MEMO

Date . .

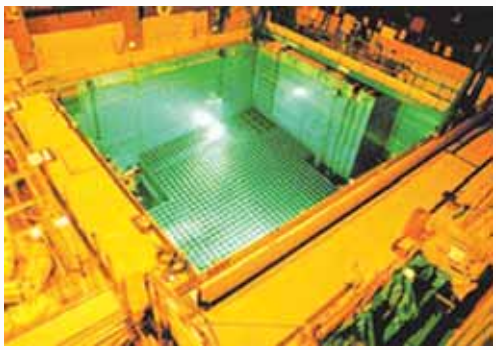
Research and Development

Nuclear Safety and Nuclear Backend

Integrity Assessment of Spent Fuel Pool for Extreme Seismic Events

Following the accident at the Fukushima Daiichi Nuclear Power Plant (NPP) on March 11, 2011, the U.S. Nuclear Regulatory Commission (NRC) required NPPs to deal with extreme natural events. The SFP might fail under an extreme seismic event and lead to a rapid draining, which could cause the uncovering of the spent fuel. This study establishes structural and non-structural criteria for seismic evaluation and develops a methodology for assessing the integrity of Spent Fuel Pool (SFP). The requirements of Near-Term Task Force Recommendations 2.1 (NTTF 2.1) are followed, and the possible extreme seismic events recovered by new evidence specific in Taiwan are also considered.

Two NPPs are undergoing decommissioning and one NPP is still in operating in Taiwan, but all of them still have spent fuels left in SPF. According to the different operating conditions, the criteria for evaluating both the structural and non-structural aspects of the SFP are determined. With systematically considering all seismically induced failures that could result rapid draining, the capability of SFP to deal with such extreme seismic events are confirmed. The result ensures the safety of SFP in Taiwan and releases the public concerns on nuclear safety.



Items	Results
SFP seismic margin assessment	☑More than acceptance criteria
Failure of SFP piping penetrations	☑Seismic cass I
Failure of refueling gates	☑The gates are made of stainless steel
Siphon	☑The pipeline is equipped with anti-siphon
Sloshing & Boil off	☑More than acceptance criteria (72hr)

Assessment of SFP Area & Items

A Significant Increase in Safety Margin - Challenges in Introducing Burnup Credit Method into Criticality Safety Analysis for Spent Nuclear Fuel Final Disposal Project

When neutrons collide with heavy atomic nuclei, they can induce the splitting of the nucleus into two or more lighter atoms, releasing a significant amount of energy and additional neutrons. This process, in turn, initiates nuclear fission reactions, setting off a chain reaction, as illustrated in Fig.1. Due to the immense energy generated by nuclear fission chain reactions, they serve as the foundation of commercial nuclear power generation. However, if this reaction is not controlled well, it may lead to accidents and disasters, commonly referred to as 'nuclear criticality' incidents. For over a decade, NARI has been committed to the field of nuclear criticality safety analysis, positioning it as the sole domestic entity equipped with comprehensive nuclear criticality safety analysis technology. NARI's nuclear criticality safety analysis technology offers a comprehensive solution, guaranteeing the criticality safety of spent nuclear fuel for Taiwan.

NARI's nuclear criticality safety analysis technology has demonstrated widespread practical applications, such as in Phase 1 of the spent nuclear fuel disposal project for Chinshan Nuclear Power Plant, NARI conducted the criticality safety analysis of the dry storage cask system and gained approval from the regulatory authority. Additionally, in the analysis of spent nuclear fuel pools, NARI introduced a burnup credit method. This technology advancement played a crucial role in retrofitting cask loading pools at Kuosheng Nuclear Power Plant, effectively addressing capacity challenges and averting premature shutdowns.

In the spent nuclear fuel final disposal project, we took the lead in integrating the burnup credit method with complex geometric models for disposal canisters, as illustrated in Fig.2. The resulting benefits include the potential to significantly improve the criticality safety margin of disposal canisters, reduce the number of canisters required, and minimize the underground disposal site area. This development, in turn, constitutes a noteworthy contribution to both safety and economic efficiency.

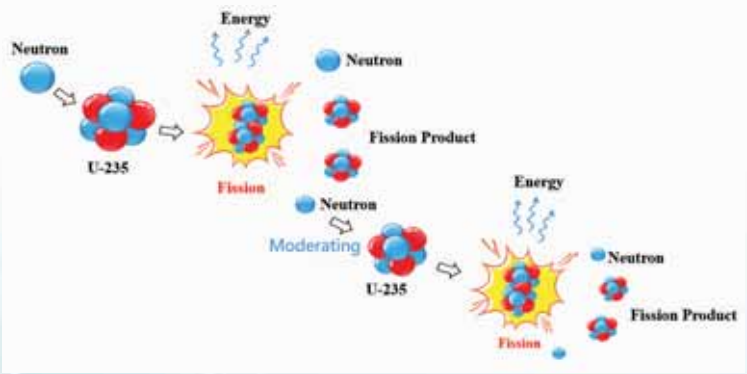


Fig.1. Fission Chain Reaction

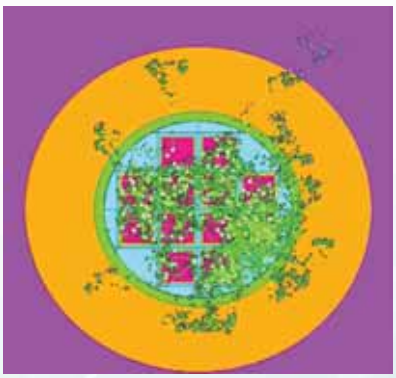
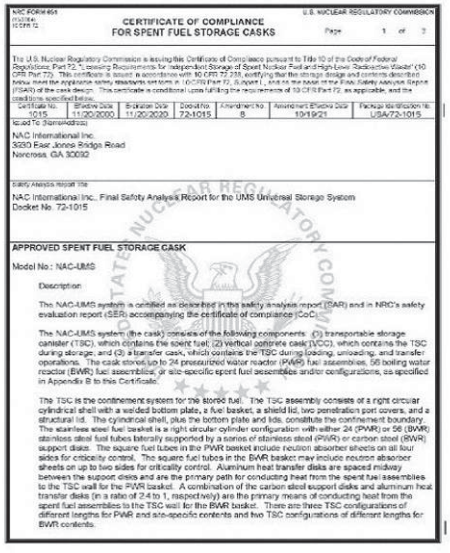


Fig.2. Tracking Neutron Physics Behavior Using Monte Carlo Method

The License Application Technology Development of Dry Storage for BWR High Burnup and Damaged Fuel

In August 2005, Institute of Nuclear Energy Research (INER) (now is National Atomic Research Institute, NARI) introduced the Universal Multipurpose Systems (UMS) developed by Nuclear Assurance Corporation (NAC) into Taiwan. With technical support from NAC, INER had successfully developed INER-HPS (INER-High Performance Systems). The NAC-UMS that initially gained approval from U.S. Nuclear Regulatory Commission (NRC) for the storage of spent nuclear fuel was limited to a maximum burnup of 45 GWd/MTU for Boiling Water Reactors (BWR). However, the approval for damaged fuel was not yet finished, and the material used for Transportable Storage Canister (TSC) in UMS was 304/304L, didn't include 316/316L, the materials of better weather resistance and corrosion resistance. Therefore, INER initiated a "The License Application Technology Development of Dry Storage BWR High Burnup and Damaged Fuel project" leveraging INER's expertise in analysis, design, quality assurance, and system integration. Building upon the already licensed NAC-UMS, INER adapted it to align with the specific conditions of domestic nuclear power plants, established a localized technology for the dry storage of spent nuclear fuel. INER played a pivotal role in the technology transfer from NAC, actively engaging in and supporting the NAC-UMS license amendment application to the USNRC and acquiring proficiency in key technologies related to license modifications.

The license amendment No. 8 for NAC-UMS successfully underwent the comprehensive safety evaluation conducted by the USNRC and was officially issued on September 24, 2021, (Certificate of Compliance, CoC No. 1015), as illustrated in Figure 1. The amendment came into effect following its publication in the U.S. Federal Register on October 19, 2021, as depicted in Figure 2. This pivotal development empowers the INER-HPS to accommodate dry storage applications for damaged and high burnup (up to 60 GWd/MTU) BWR spent nuclear fuel. With the successful completion of this project, NARI now possesses the essential technological capabilities for the dry storage of high burnup and damaged fuel, aligning with the requirements of three domestic nuclear power plants. Thise project also actively participated in the International Conference on Precision Machinery and Manufacturing Technology (ICPMMT) in May 2021, presenting two papers that were subsequently published in an international journal (EI). Additionally, the project was honored with the "Excellent Award" in the R&D Achievements and Business Innovation Competition in the 55th anniversary of INER.



CERTIFICATE OF COMPLIANCE
FOR SPENT FUEL STORAGE CASKS

U.S. NUCLEAR REGULATORY COMMISSION

Certificate No.	Effective Date	Expiration Date	Docket No.	Amendment No.	Amendment Effective Date	Package Identification No.
1015	11/20/2000	11/20/2020	72-1015	8	10/19/21	USA/72-1015

Issued To: (Name/Address)

NAC International Inc.
3930 East Jones Bridge Road
Norcross, GA 30092

Safety Analysis Report for
NAC International Inc., Final Safety Analysis Report for the UMS Universal Storage System
Docket No. 72-1015

APPROVED SPENT FUEL STORAGE CASK

Model No.: NAC-UMS

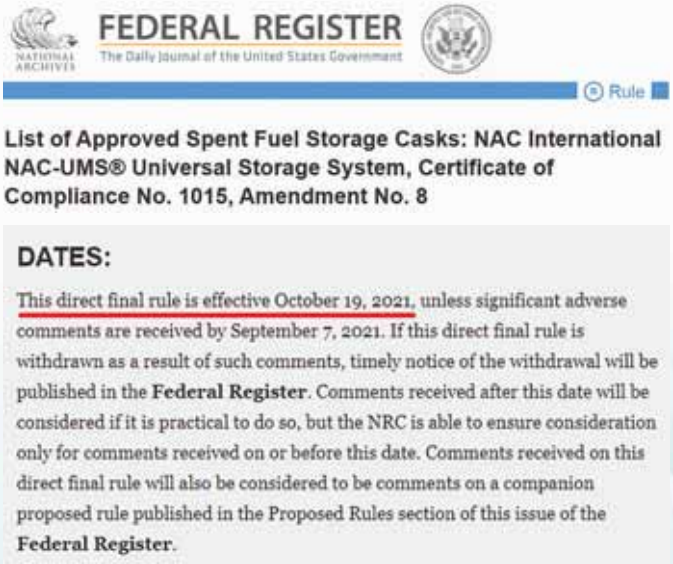
Description

The NAC-UMS system is certified as described in the safety analysis report (SAR) and in NRC's safety evaluation report (SER) accompanying the certificate of compliance (CoC).

The NAC-UMS system (the cask) consists of the following components: (1) transportable storage canister (TSC), which contains the spent fuel; (2) vertical concrete cask (VCC), which contains the TSC during storage; and (3) a transfer cask, which contains the TSC during loading, unloading, and transfer operations. The cask stores up to 24 pressurized water reactor (PWR) fuel assemblies, 56 boiling water reactor (BWR) fuel assemblies, or site-specific spent fuel assemblies and/or configurations, as specified in Appendix B to this Certificate.

The TSC is the containment system for the stored fuel. The TSC assembly consists of a right circular cylindrical shell with a welded bottom plate, a fuel basket, a shield lid, two penetration port covers, and a structural lid. The cylindrical shell, plus the bottom plate and lids, constitute the containment boundary. The stainless steel fuel basket is a right circular cylinder configuration with either 24 (PWR) or 56 (BWR) stainless steel fuel tubes laterally supported by a series of stainless steel (PWR) or carbon steel (BWR) support disks. The square fuel tubes in the PWR basket include neutron absorber sheets on all four sides for criticality control. The square fuel tubes in the BWR basket may include neutron absorber sheets on up to two sides for criticality control. Aluminum heat transfer disks are spaced midway between the support disks and are the primary path for conducting heat from the spent fuel assemblies to the TSC wall for the PWR basket. A combination of the carbon steel support disks and aluminum heat transfer disks (in a ratio of 2:4 to 1, respectively) are the primary means of conducting heat from the spent fuel assemblies to the TSC wall for the BWR basket. There are three TSC configurations of different lengths for PWR and site-specific contents and two TSC configurations of different lengths for BWR contents.

Fig.1 NRC officially issued CoC No. 1015 for license amendment No. 8



FEDERAL REGISTER
The Daily Journal of the United States Government

Rule

List of Approved Spent Fuel Storage Casks: NAC International NAC-UMS® Universal Storage System, Certificate of Compliance No. 1015, Amendment No. 8

DATES:

This direct final rule is effective October 19, 2021, unless significant adverse comments are received by September 7, 2021. If this direct final rule is withdrawn as a result of such comments, timely notice of the withdrawal will be published in the **Federal Register**. Comments received after this date will be considered if it is practical to do so, but the NRC is able to ensure consideration only for comments received on or before this date. Comments received on this direct final rule will also be considered to be comments on a companion proposed rule published in the Proposed Rules section of this issue of the **Federal Register**.

Fig.2 License amendment No. 8 became effective upon its publication in the U.S. Federal Register

Monitoring and Evaluation of Spent Nuclear Fuel in a Simulated Dry Storage Condition

The spent nuclear fuel management strategy in Taiwan follows a progression of "short-term storage in SFP, intermediate term on-site dry storage, and long-term in final disposal." As part of the national policy of a nuclear-free homeland, dry storage of spent fuel is a necessary measure in the decommissioning of domestic Nuclear Power Plants.

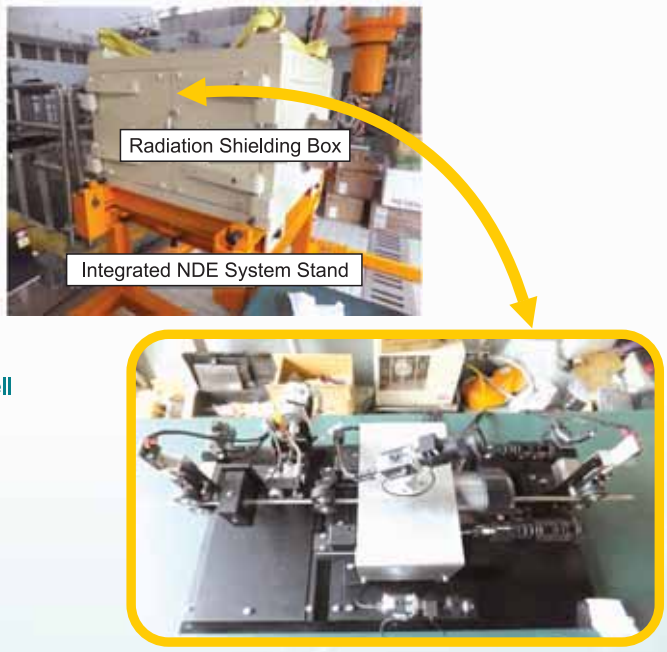
To better understand the characteristics of domestic spent nuclear fuel during dry storage, Taipower collaborates with NARI on a project. This involves loading actual discharged nuclear fuel rods from the Chinshan and Kuosheng NPPs into a simulated storage casks and storing them inside NARI's Hotcell.

NARI had completed the installation and testing of special design storage casks inside the Hotcell, as well as the pre-storage characteristics analysis of experimental fuel rods. The simulated dry storage condition has been executed, and periodic non-destructive inspections will be carried out to obtain the key characteristics of full-length nuclear fuel rods during storage.

The Non-Destructive Examination System for Full-Size Fuel Rod has been built and is capable of performing multiple inspections simultaneously, reducing inspection time and the potential risk of damaging the fuel surface.

After the completion of this project, key information such as the degradation of cladding, oxidation of fuel pellets, and fission gas release rate will be obtained. By comparing and verifying the research results of this project with those from international researches, it can serve as the technical bases for spent fuel backend management and the decommissioning plan of nuclear power plants in Taiwan.

Special design storage casks installed in Hotcell



The Non-Destructive Examination System for Full-Size Fuel Rod

Seismic-Induced Fracture Shear of Canister Failure and its Integrated Framework for Groundwater Flow and Transport

The characterization of the transport behavior of radioactive nuclides of damaged canister is an essential task for the performance and safety assessment of geological disposal. Frequent earthquakes pose a significant challenge to disposal issues, as seismic events induce shear displacement leading to shear damage of canister. This study introduces an integrated model framework that connects three numerical analysis models (Fig.1), including seismic-induced shear displacement in fractures, shear damage rate of canister (Fig.2), and groundwater flow and transport model. This comprehensive framework characterizes the location and transport behavior of seismic-induced shear damage of canister.

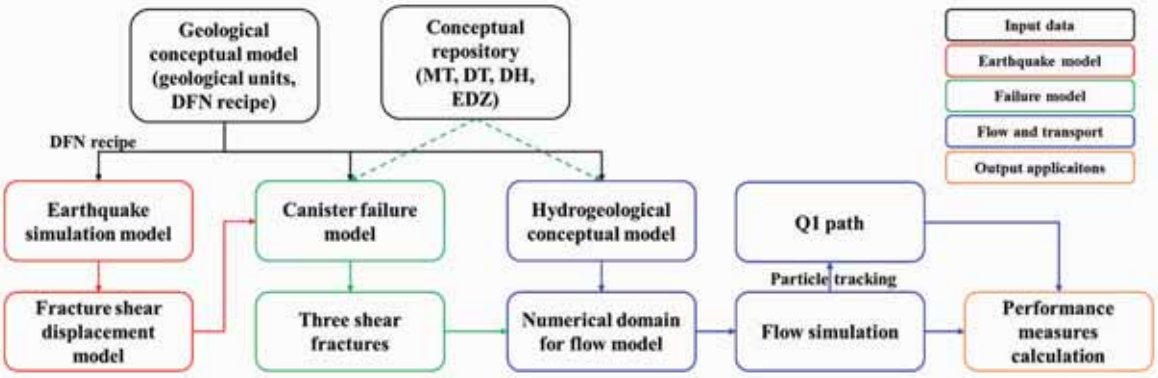


Fig.1. This study proposes an integrated framework that includes input data (black box), Earthquake simulation model (red box), canister failure model (green box), groundwater flow and transport model (blue box), and output applications (orange box), completing a quantitative analysis of seismic-induced shear issues of canisters.

NARI undertakes final disposal of used nuclear fuel projects from TPC. NARI has proposed an integrated framework that links three numerical analysis models. This framework is designed to address the frequent seismic activity in Taiwan and its potential impact on disposal facility. Additionally, it characterizes the potential groundwater flow and transport behavior (Fig.3), providing essential support for the performance and safety assessment of the disposal projects.

This research contributes to the technical advancement and feasibility enhancement of Taiwan's disposal project. The preliminary results have been submitted to relevant disposal journals and accepted for publication. Subsequently, NARI aims to extend the application and seek technical worldwide.

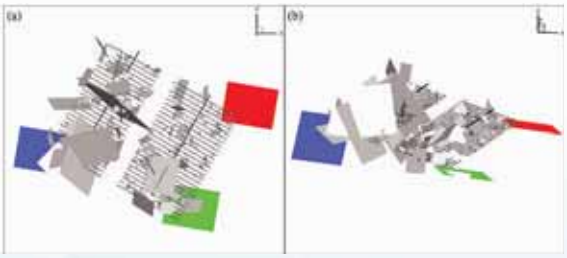


Fig.2. Characterization of intersections between fractures and repository (three shear fractures in red, green, and blue). (a) Top view; (b) Three-dimensional view.

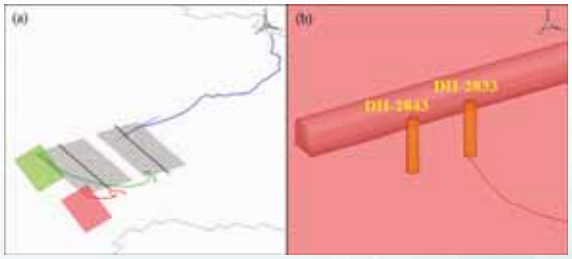
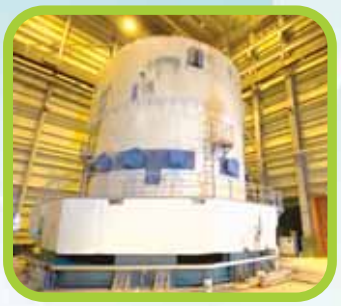


Fig.3. Characterization of trajectories from canisters (example with red Fracture, damaging canisters with DH-2833 and DH-2843).

Yu, Y.-C.; Chen, C.-J.; Chung, C.-C.; Ni, C.-F.; Lee, I.-H.; Wu, Y.-C.; Lin, T.-Y. A Multimodel Framework for Quantifying Flow and Advective Transport Controlled by Earthquake-Induced Canister Failures in a Reference Case for Radioactive Waste Geological Disposal. Energies 2023, 16, 5081. https://doi.org/10.3390/en16135081

Development and Engineering Validation of Biological Shield Dismantling Techniques for the TRR



In response to the implementation of the decommissioning plan for the Taiwan Research Reactor (TRR), independent development of dismantling techniques and engineering planning is underway to establish domestic decommissioning capabilities. Currently, the dismantling of TRR reactor is being carried out in accordance with the plan outlined in the "Taiwan Research Reactor (TRR) Vessel Waste Dismantling Plan (2nd Edition)," approved by the regulatory authority on September 23, 2022.

The TRR reactor primarily consists of internal components and biological shield. Due to mutual interference during the dismantling operations, the dismantling of the biological shield cannot be completed in a single phase. Therefore, the dismantling of the biological shield is divided into three phases (see Fig.1).

Fig.1. Phases of Biological Shield Dismantling Project

Based on the radiation characteristics survey results of the TRR reactor, some concrete components are activated. To prevent contamination spreading, traditional crushing and demolition methods are unsuitable. Therefore, a drilling machine and diamond wire saw technique approach is chosen to cut entire concrete blocks. Moreover, in order to prevent contamination that can penetrate into concrete, a dry drilling and cutting method are adopted, instead of commonly used wet method.

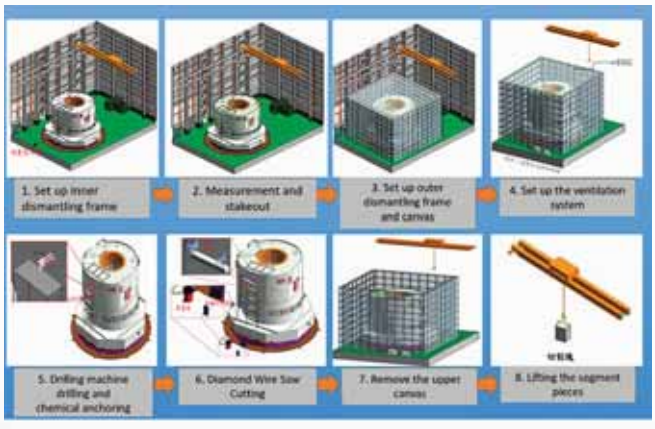


Fig.2. Biological Shield Dismantling Method

The dry dismantling method is depicted in Fig.2. Adapting to the on-site conditions and addressing efficiency issues related to dry drilling, the method were advanced through technical improvements. This technology development and engineering validation application represent the first instance in Taiwan for applying dry drilling and diamond wire saw dismantling methods for concrete in a nuclear facility, as evidenced by the achievements in Fig.3.

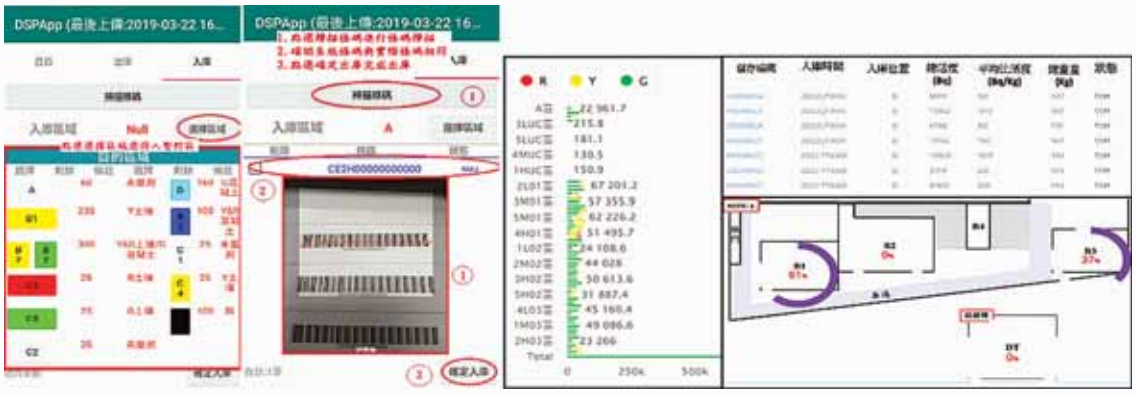
This project, independently planned by National Atomic Research Institute and executed by collaborating with local vendors, promotes the localization of technology and industry. It will help to assist in future decommissioning activities of nuclear facilities in Taiwan.

Fig.3. Achievements in Biological Shield Dismantling of TRR Decommissioning Project

Development of an Engineering Information Management System - A Case Study on DSP Radioactive Waste

The Dry Storage Pit (DSP) clearance is a main task of TRR (Taiwan Research Reactor) decommissioning. Managing the large amount of concrete, soil, and storage holes in DSP requires a substantial amount of manpower and time. Furthermore, the extensive data generated in radioactive waste measurement and classification operations necessitates the development of an information system for radioactive waste management. By simplifying the complex records, this system enables managers to supervise the project's progress and improve operational efficiency.

To ensure synchronization with on-site operations, the system integrates feedback information from on-site devices, which can record various changes during operations, instantly reflect the current situation for radiation protection personnel, implement radiation protection control regulations, and ensure the safety of workers. The "Radiation Measurement Device for Continuous Input and Output" is part of the integration as well. It was developed independently by the National Atomic Research Institute, allowing managers to receive real-time feedback on comprehensive waste measurement data. Finally, by incorporating 3D engineering visual tools to present measurement and statistical data, the system stands as the first-of-its-kind domestically.



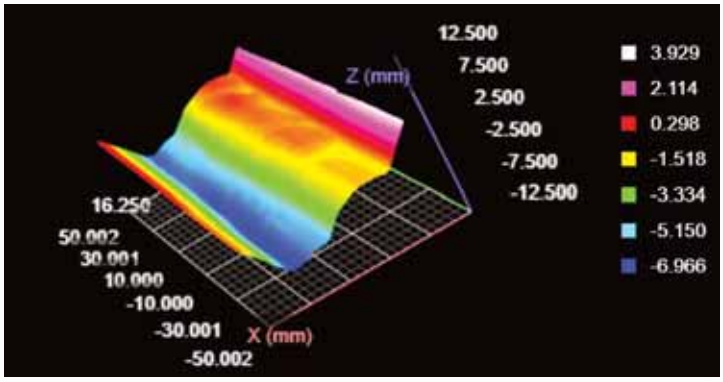
Site Management Application, Waste Statistics Charts, Process Tracking

Radiation Protection Monitoring and 3D Visual Assistance

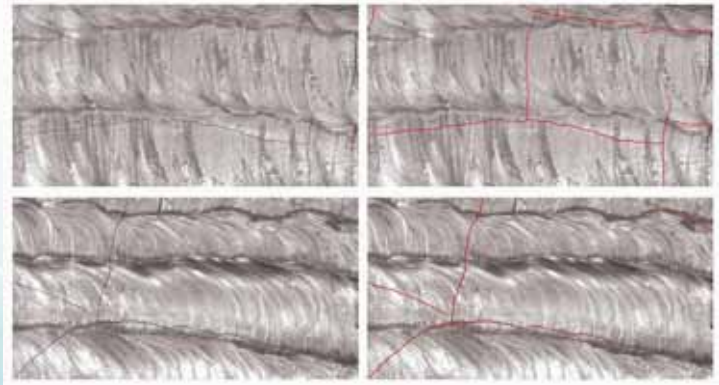
Development of Intelligent Vision for Welding Quality Inspection Technology

According to the domestic welding visual testing (VT) standard (CNS 13021), welded joints of steel structure are not allowed to have any defects such as cracks, incomplete penetration, incomplete fusion, overlap, and unfilled welds. However, there are acceptable ranges for porosity, weld crown, undercut, insufficient leg length, and insufficient throat depth. Traditional VT relies on professional inspectors, but due to slow inspection speed, human fatigue induced variability in inspection, and subjective judgment results, coupled with the inability to accurately record the potential defects leading to difficulty in tracing and unable to inspect the continuous process operations over a long period, resulting in project delays and cost increments. In recent years, with the rapid development of automated equipment, optical sensors, and computer vision algorithms, National Atomic Research Institute (NARI) has proactively integrated related technologies to enhance domestic welding inspection techniques.

Based on the defect characteristics, both 2D and 3D visual sensors are used for data acquisition in NARI, combined with AI and automated inspection technology. The bottleneck of traditional visual inspection has been overcome. In comparison to the common qualitative inspection in industry, NARI has developed quantification technology and can judge if it's acceptable for an allowable range defect by statistical analysis. This technology can be applied for real-time monitoring during manufacturing, enabling timely adjustment of operational parameters. Full data analysis and recording facilitate root cause analysis. By conducting big data analysis with relevant parameters, preventive measures can be taken through predictive analytics. Implementing this technology can effectively reduce costs and enhance yield and market competitiveness without altering existing processes, promoting overall industry advancement.



Point cloud map of welding surface



(a)Sampling image (b)Detection marks

Inspection of micro-defects on welds

Quantitative Risk Assessment Approach to the Management for Power Grid Resilience and Energy Critical Infrastructure Reliability

In recent years, there have been several accidents causing significant power outages, moreover, the challenges caused by the extreme climate and the increasing installation of renewable energy to the grid are even more severe. Consequently, the significance of risk management for the power grid and the energy infrastructure cannot be underestimated.

For forty years, beginning in 1983, NARI has been working on developing the PRA (Probabilistic Risk Assessment) technology, and applying PRA to energy industries, both in the nuclear and non-nuclear applications.

In the "Net-Zero Emissions - Assessment of Power Grid Resilience" project from 2023 to 2025, as illustrated in Figure 1, we have been conducting an assessment of the power grid's vulnerability and importance using PRA method. The investigation integrates reliability models in power plants and ultra-high-voltage substations. Furthermore, a first-of-its-kind risk approach is constructed specifically for a natural gas-fired power plant in Taiwan, to identify the most significant contributors to risk.

Regarding the aspect of the power grid resilience, we investigated the effects of interdisciplinary fields on power plants, substations, and power grids via integration of risk, vulnerability, hazard, exposure, and power flow analysis. The research findings can be utilized to evaluate the priority list for identifying risk contributors and making enhancements to the resilience of the power grid.

Furthermore, regarding the reliability aspect of energy critical infrastructure, we specifically developed an internal event risk model for a natural gas-fired power plant and a substation. This has been accomplished through the application of system and fault tree analysis, based on the PRA concepts. Our goal is to investigate the potential failures that may lead to power outages. This consists of analyzing four primary categories (gas-turbine, steam-turbine, heat-recovery-steam-generator, and others) as well as the supporting systems. The research findings can be utilized to determine potential risk contributors and vulnerabilities, such as the key components, systems, and failure modes, and thus to enhance the resilience and reliability of energy critical infrastructures.

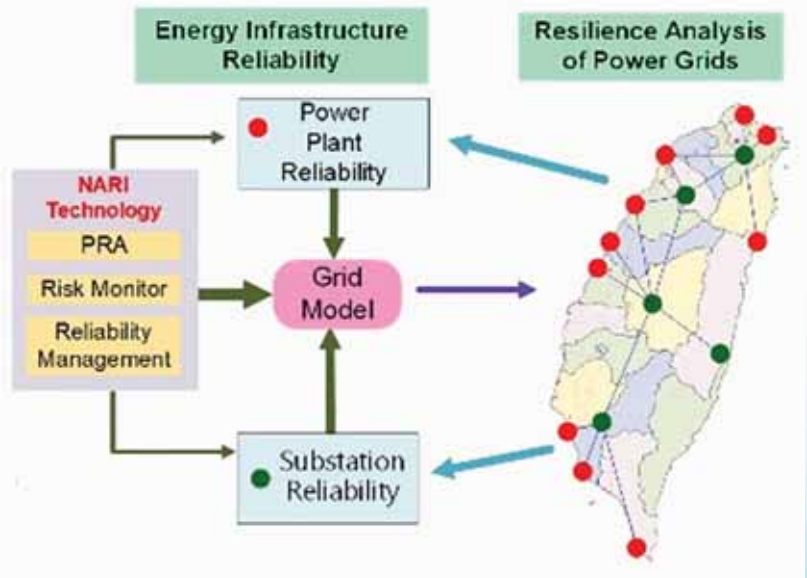


Fig. 1. Assessment of Power Grid Resilience (Scope and overview)

International Conference on the 40th Anniversary of PRA (Probabilistic Risk Assessment) Technology in Taiwan - A New Era of PRA

National Atomic Research Institute (NARI), formerly named the Institute of Nuclear Energy Research, began developing Probabilistic Risk Assessment (PRA) technology in 1983. After 40 years of development and refinement, it has made significant contributions to the nuclear industry.

Fig.1. Invitation Card

Under the leadership of the first President of the NARI, Dr. Tsu-Mu Kao, PRA technology has been expanded to non-nuclear industries such as petrochemicals, critical infrastructure protection (CIP), cyclotron operation and maintenance, liquefied natural gas (LNG) receiving tank, power grids, aerospace, and railway system to strengthen the resilience of facilities.

In 2023, marking the 40th anniversary of the introduction of PRA technology into Taiwan, in order to deepen technical capacity, NARI held an "International Conference on the 40th Anniversary of PRA Technology in Taiwan - A New Era of PRA" on December 13, 2023 (Figure 1), and provided video conferencing for oversea and domestic online participants. President Kao specially invited Prof. George Apostolakis, Emeritus Professor of MIT and former USNRC Commissioner, Dr. Der-Yu Hsia, former AEC Chairman, Prof. Enrico Zio, of Politecnico di Milano, Italy, and Prof. Vincent Ho, of PolyU, Hong Kong, along with other honorable guests (Figure 2) from OHS, NSTC, OSHA, ODM, ITRI, TPC, NTHU, THSR, and Bechtel Energy, in Taiwan.


Fig.2. President Kao with Honorable Guests

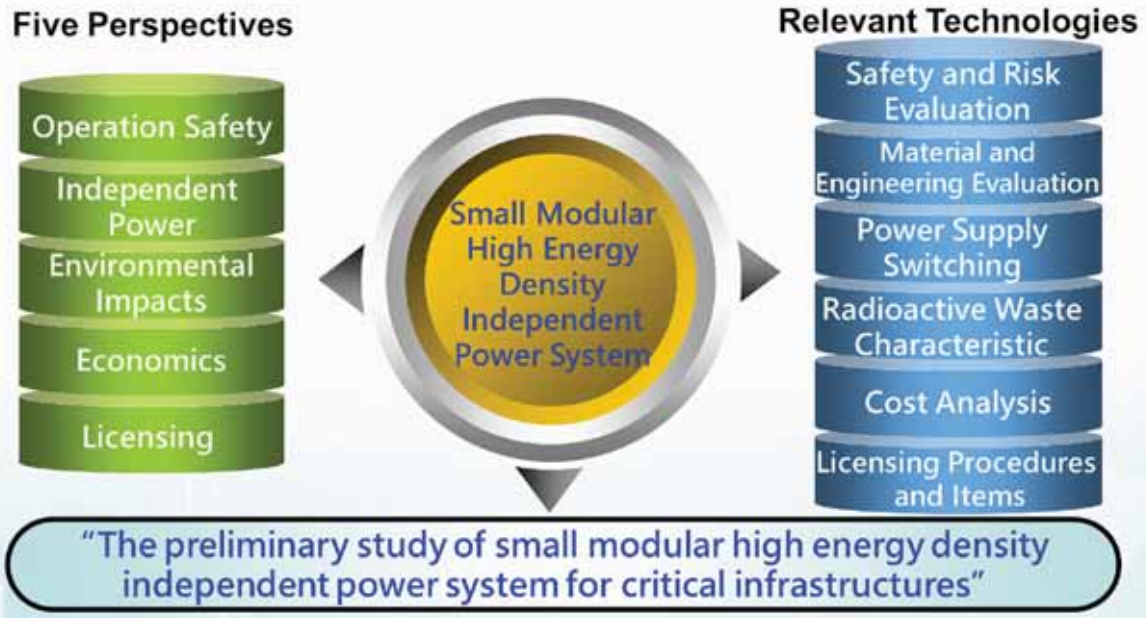

Fig.3. Panel Discussion Panelists

The overarching goal of the conference focuses on four main objectives: (1)discussing the most suitable PRA technology for individual industries, (2)exploring the AI application in PRA for industrial resilience and sustainable development, (3)implementing integrated risk management in public safety infrastructure, and (4)addressing the challenges and opportunities facing the new era of PRA (Figure 3). NARI is honored to host the conference, not only to deepen the development of PRA domestically but also to commemorate Dr. L.S. Tong and thank him for introducing PRA technology to Taiwan 40 years ago, opening the opportunity and development of PRA in Taiwan.

The Technology Development of Small Modular High Energy Density Independent Power System for Critical Infrastructures

The conditions of power supply directly impact a country's economic and society development, as well as national security. Power facilities themselves are critical infrastructure, and their resilience in supplying electricity affects the operation of all other critical infrastructures. Decentralized small-scale independent power facilities can enhance the robustness of the country's critical infrastructure operations. Particularly during times of geopolitical tension, power systems with high energy density require small volumes of fuel and can store fuels needed for long-term operation, independent of international fuel supply disruptions. This ensures the continuous operational capability of the country's critical infrastructure, safeguarding national security.

NARI plans to utilize Small Modular Reactors (SMRs) in conjunction with steam-electricity units to form a Small Modular High Energy Density Independent Power System. It can operate in both "islanded mode" and "grid-connected mode," making it suitable for supplying power to national security facilities and critical infrastructure. Constructing a power supply system with SMRs can also enhance the country's energy security and help the country to achieve its net-zero emissions goals. As shown in the diagram below, NARI is initiating preliminary research from five major perspectives to assist the development in relevant technologies for Small Modular High Energy Density Independent Power Systems, with the aim of enhancing the operational resilience of critical infrastructure in the future.



To ensure food safety - Information disclosure of tritium analysis results and inspection capacity expansion of NARI

NARI began to build the first tritium analysis laboratory in July 2021, and it was officially inaugurated in August 2022, and has gradually expanded its inspection capacity. In June 2023, the capacity was expanded to 500 pieces per year. The purpose of the establishment is to conduct surveys of on tritium content in migratory fish and ecological samples in Taiwan's offshore waters, and economically valuable fish species caught in the ocean fisheries to assess the ecological impact of Japan Fukushima NPP's long-term discharge of ALPS treated water.

In 2023, NARI cooperated with FDA of the Ministry of Health and Welfare, FA of the Ministry of Agriculture and NAMR of the Ocean Affairs Council to conduct tritium inspection on aquatic species and algae product imported from Japan, fish and ecological samples from Taiwan?s offshore before and after Japan's discharge. A total of 525 marine biological samples were inspected on tritium content. The inspection results are compiled and published every Tuesday on the "Inter-ministerial Radiation Monitoring Integrated Dashboard" of the "Ocean Radioactive Information System" to deliver real-time monitoring information to the public.

In response to Japan's discharge of ALPS treated water started from August 24, 2023, NARI has provided scientific evidence to ensure the radiation safety of public eating aquatic foods by assisting in the inspection and analysis on tritium content in various aquatic foods. In accordance with the "Project Implementation Plan for Enhancing Biological Tritium Detection Capacity" approved by the Executive Yuan on September 27, 2023, we will continue to expand the inspection capacity on tritium analysis and conduct inter-laboratory comparison tests to obtain TAF quality assurance certification and ensure the confidence in test results for the public.

Research and Development in Radiation Application

Development and application of compact accelerator-based neutron sources in NARI

Synchrotron X-rays and neutrons are valuable tools for examining the microstructure of natural materials. Neutrons possess electroneutrality and high penetration, which make them ideal for gathering atomic nucleus data and detecting the magnetic properties of materials. Neutrons are well-suited to a variety of studies, such as magnetic materials, chemical reactions, dynamic processes, soft matter, and materials with low atomic order.

Our country has established a synchrotron X-ray source serving a wide range of users. We have also collaborated with ANSTO to construct a cold three-axis spectrometer, enabling Taiwanese researchers to conduct out neutron beam experiments. However, the limited availability of neutron scattering experimental facilities is hindering our capacity to fulfill the domestic demand for training and fostering experts in neutron instruments, conducting research on industry materials and developing new processes.

Accelerator-based neutron sources are currently in development in many countries. A number of advantages exist over research reactors, such as lower nuclear protection sensitivity, deployment in medical facilities, and lower construction costs. Future upgrades can improve their specifications and performance. With the aid of a 30 MeV cyclotron for medical isotopes, NARI is developing compact accelerator-based neutron sources. These neutron sources commenced with the execution of chip soft error rate testing and the evaluation of thermal neutron imaging Furthermore, a new 70 MeV cyclotron has been constructed not only for stable isotope production but also to actively expand the utilization of neutron scattering techniques.

NARI has formulated criteria for domestic neutron scattering instruments, personnel training, and facility management through consultations with neutron experts domestically and internationally. To facilitate technical exchanges and talent training needed for instrument construction and operation, NARI will actively establish international cooperation channels. Aside from providing neutron services for domestic industrial and academic applications, it helps train cutting-edge neutron talent, contributes to advancing key policies such as hydrogen energy and net-zero carbon emissions, and strengthens local economy.

Meeting notice

A group photo of conference participants

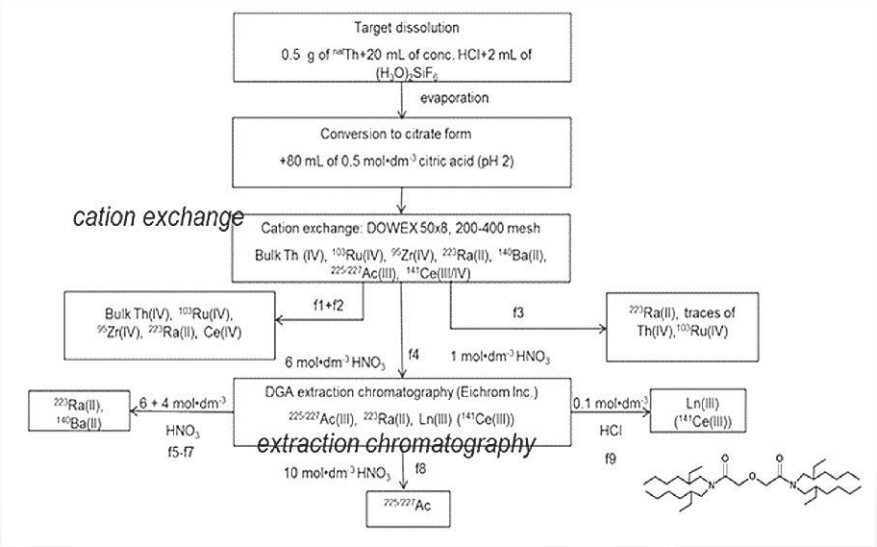
International Advisory Board for Taiwan Neutron Science

Research on technology for producing of radioisotopes by 70 MeV cyclotron - Production, purification and assay methods of pharmaceutical grade Ac-225

A new medium-sized cyclotron with 70 MeV model is being constructed by NARI to produce pharmaceutical-grade Actinium-225 isotopes for research and development in targeted cancer therapy and nuclear medicine. Ac-225 can release alpha radiation, which exhibits a high cytotoxic effect on tumor cells. This study compiled relevant literatures and discussed the medical applications, production methods, quality control items, criteria, procedures for the separation and purifying of Ac-225, removing other impurities and isotopes, as well as the technical details of inspection and analysis to ensure the quality of the final product. These discussions aim to prepare for the successful production of medical-grade Ac-225 for targeted cancer therapy applications once the accelerator construction is completed.

Ac-225 is produced by irradiating the Th-232 target with high-energy protons from the accelerator, and the cost is affordable. After irradiation, the target solution goes through ion exchange chromatography and chelating agent extraction chromatography separation processes to eliminate impurity ion nuclei. Utilizing instruments such as alpha spectrometry, gamma spectrometry, inductively coupled plasma mass spectrometer, or spectrometry, to measure the activity, purity, impurities activity, content and identification of Ac-225. These quality control inspections aim to ensure that Ac-225 meets pharmaceutical quality requirements and guarantees medication safety.

Radiopharmaceutical grade of Ac-225 finished product by ORNL, USA



Procedures of separation of impurities to acquire medical grade Ac-225 from irradiated of Th-232 by high energy proton accelerator at LANL.
*Reference: Radchenko, V.; et al. J. Chromatography A, 1380 (6) 55-63 (2015).

Multi-type Neuropeptide Y(NPY) Derivative for Breast Tumor Therapy

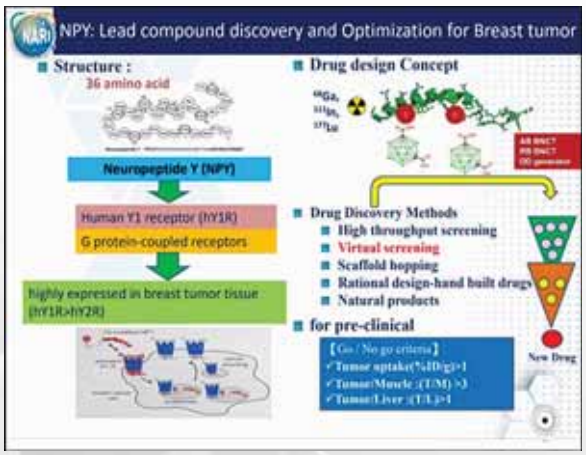
Malignant tumors are the top ten causes of death. End-stage cancer treatment has high side effects and has limitations in clinical. Combining BNCT and proton therapy with traditional radiotherapy and chemotherapy can fill the gap in multiple recurrent cancers and offer therapeutic advantages. utilizes neutron irradiation to induce nuclear reactions with boron-10 in medications, leading to the release of alpha particles (^{4}He) and ^{7}Li recoil particles within a short range (5-9μm) to destroy tumor cells.

This innovation seeks to develop multiple neuropeptide derivatives that can aid in diagnosing and treating triple-negative breast cancer (TNBC) using the PRRT principle (Peptide Receptor Radionuclide Therapy). It serves as a companion diagnostic (CDx) and boron neutron capture therapy, enabling targeted treatment to decrease breast cancer mortality in patients who opt out of surgery, whether for original or metastatic breast cancer.

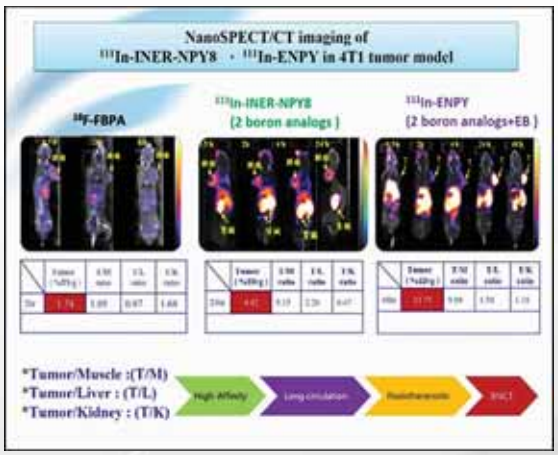
The neuropeptide drug for diagnosis and treatment boasts several advantages, including increased drug accumulation in the tumor, a higher tumor-to-normal tissue (T/M) ratio than currently known BNCT drugs, and high specificity, resulting in reduced drug dosage. The invention has also collaborated with several research units for technical cooperation.

The Boron Neutron Capture Therapy (BNCT) treatment is highly effective in treating head and neck cancer、GBM and brain tumors. BPA and BSH drugs are commonly used clinically. However, BPA is metabolized quickly , requiring continuous administration to maintain blood concentration levels. A new multi-type breast cancer diagnosis and treatment drug, DOTA-ENPY has been developed that addresses this issue. This structure of compound comprises a breast cancer-targeted neuropeptide NPY derivatives, a metal chelating agent, an albumin affinity compound, a linking group, and a boron-containing molecule BSH analog, which has been proven to achieve high specificity, long-term circulation in the blood, and a reduced dosage. Through matrix drug screening and preclinical animal imaging evaluation, it was found that the drug accumulates in 4T1 tumors 10 times more after 48 hours, with the T/M value reaching 5 times that of traditional BNCT drugs. This drug shows potential as a treatment for breast cancer.

The drug structure design of this invention can also be used for the development of other diagnostic and therapeutic BNCT targeted drugs, serving as a new weapon for personalized medicine. The DOTA-ENPY targeted drug can also selectively label different radioactive isotopes for PET or SPECT imaging, making it a valuable companion target drug for breast cancer diagnosis and treatment. It also has the potential for applications in BNCT.



NPY-lead compound optimization and screening mechanism

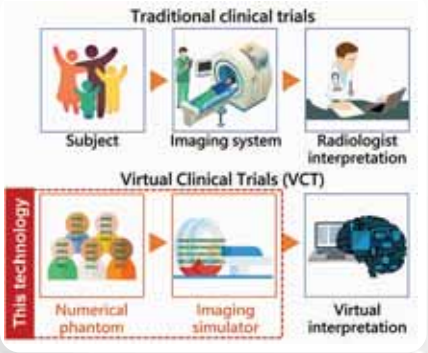


Comparison of NanoSPECT/CT images of the 4T1 tumor-bearing mice after tail-vein injection with In-111-ENPY and In-111-INER-NPY8 .

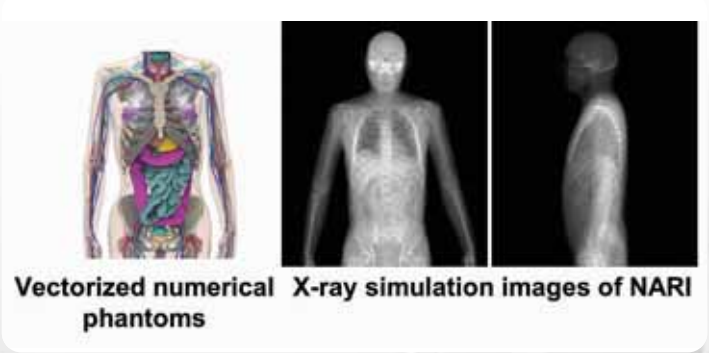
X-ray imaging technique innovation tool- 3D high-precision digital X-ray spectrum imaging simulation technique

Clinical trials are a crucial process for evidencing the efficacy and safety of medical devices. Traditional clinical trials are often constrained by relevant ethical regulations, making it challenging to recruit a sufficient number of participants. Moreover, the trial procedures require substantial financial support, and the lack of true value comparison benchmarks. These trials heavily depend on the diagnostic opinions of clinical specialists. These combined factors may result in prolonged trial durations and delays in product market entry schedules. In recent years, FDA aimed at shortening the development and validation time for medical devices, reducing development costs, and enhancing safety for trial participants. One of the strategies employed is using computer program simulations. This approach is termed Virtual Clinical Trials (VCT). Several X-ray imaging medical devices utilizing simulated data for VCT have already been approved. Therefore, NARI combines past experience in the development of X-ray imaging equipment with state-of-the-art numerical simulation technology. We developed a simulator capable of generating high-precision 3D X-ray spectrum imaging simulation data. The short-to-medium-term goal is to assist domestic businesses in accelerating the development of X-ray imaging technologies. The long-term goal is to help establish procedures related to VCT in Taiwan.

The technique consists of two main parts: the imaging simulator and the numerical phantom. It is a critical component of the VCT process, providing data with true value. It can overcome the limitations of traditional clinical trials and offers advantages such as shortening the time for medical device development, reducing trial costs, and enhancing participants safety. The innovation of this technology lies in the integration of multiple core sub-technologies. For imaging simulator, it integrates analytical modeling software and GPU hardware acceleration technology. This boosts computational speed by more than three orders of magnitude, reaching a level of seconds, thereby overcoming the lengthy computational time associated with traditional 3D X-ray imaging simulation methods. Additionally, it incorporates the X-ray spectrum imaging simulation technology developed by the NARI, providing more diverse imaging data for the development and validation of new X-ray imaging technologies. For numerical phantom, it supports various mainstream forms of numerical phantoms, such as mathematical phantoms, voxelized phantoms, and vectorized phantoms. It allows the design of phantom structures and materials according to application requirements, meeting the high flexibility demands of application development. The relevant achievements of this technology have been published in SCI journals and have obtained multiple patents in different countries. Its applications can extend to the development of medical and industrial X-ray imaging equipment, assisting in preliminary evaluation of system performance and system parameters optimization. This can shorten development time and reduce hardware implementation costs, making it commercially viable with market potential.



Traditional clinical trials and virtual clinical trials (VCT)



3D X-ray spectrum imaging simulation results

Empowering Machine Learning - Harmonizing Nuclear Medicine Imaging and Precision in Dementia Diagnosis

Facing the challenges of an aging society, dementia has become a social issue that cannot be ignored. When structural brain atrophy is detected by Magnetic Resonance Imaging (MRI) and Computed Tomography (CT), it often indicates a stage of cognitive impairment. To diagnose brain abnormalities in the early, nuclear medicine imaging (SPECT or PET) is one of the most effective and sensitive tools available.

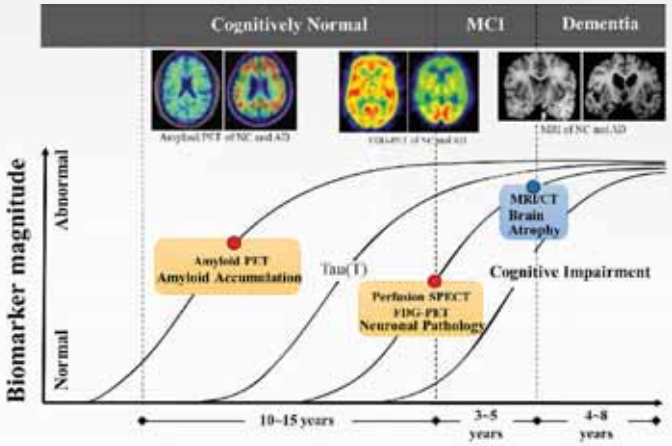


Fig.1. Dementia often presents with brain atrophy (indicated by blue points), while nuclear medicine imaging (red points) can detect brain abnormalities earlier (6-15 years prior) and more precisely.
*MCI: mild cognitive impairment

The interpretations of nuclear medicine imaging are currently subjective and varied across different institutions and machines, frequently resulting in inconsistent diagnoses. Standardizing these interpretations is therefore imperative. Our institute's patented machine learning process (Invention No. I701679) harmonizes imaging quality and quickly identifies brain function changes, addressing these inconsistencies.

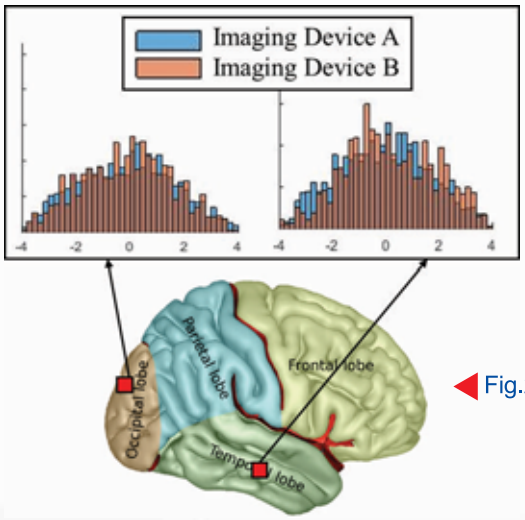


Fig.2. Post-calibration, harmonization nuclear medicine images yield uniform means and deviations in healthy brain scans across various hospitals and devices.

This patented software algorithm standardizes nuclear medicine imaging, requiring fewer images and enabling consistent dementia imaging across hospitals and devices in Taiwan. More cost-effective and scalable than traditional methods, it rapidly detects changes in brain function, assisting in a more objective diagnosis. This innovation was awarded the Gold Award in the 2023 Taiwan Innotech Expo.

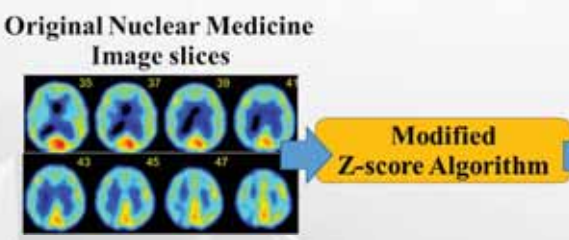


Fig.3. Utilizing patented algorithm technology, nuclear medicine images can be transformed into images indicative of abnormal brain function.

Fig.4. Patent certificate and gold medal award.

Electric Power Source in Space - Space Solar Cell for Satellite

The electric power of satellites is mainly provided by solar cells. If solar cells use III/V compound semiconductors as the main material, they offer superior advantages compared to silicon solar cells in space applications because of its advantages such as high energy density, thinness, lightweight, and high radiation resistance. NARI has been engaging in the development of innovative technologies and investing in concentrate III-V multi-junction solar cell technology for more than ten years, accumulating a significant amount of research and development experience. In recent years, in line with the government's "National Space Technology Long-Term Development Program" policy, NARI has extended its III-V multi-junction solar cell epitaxy, electrode production and other technologies to develop high-efficiency solar panels for satellites. It is the first national research institution in Taiwan that utilize this material to develop space solar cells. This technology utilizes Metal-organic Chemical Vapor Deposition (MOCVD) to perform epitaxy of III-V multi-junction solar cells, combined with photolithography to produce metal electrodes. The final product is a solar cell chip with an area of 30.18 cm^2, which represents the mainstream size for commercial satellite solar sell.

The solar cell with a light-receiving area of 30.18 cm^2 achieves an efficiency of over 30% under the extraterrestrial (AM0) solar spectrum, meeting the basic requirement for commercial applications (28%-32%). The solar cells also undergo radiation environment durability verification in accordance with the international test standard ECSS-E-ST-20-08C to ensure that the cells maintain excellent performance throughout the satellite's operational lifespan. This technology was also selected as one of the 15 highlighted technologies by the 2023 Taiwan Innotech Expo.

Space solar cells are a cutting-edge research field, and the domestic industrial chain is still in its infancy. NARI has extended the existing technology to the development of space solar cells to increase the self-sufficiency rate of key components in the aerospace industry. The space solar cells will have the opportunity to be used on the FORMOSAT-8 and other satellites. It will be the first domestically produced solar cell to be verified in the space environment, driving the growth of the space technology industry in Taiwan and achieve the goal of technological independence.

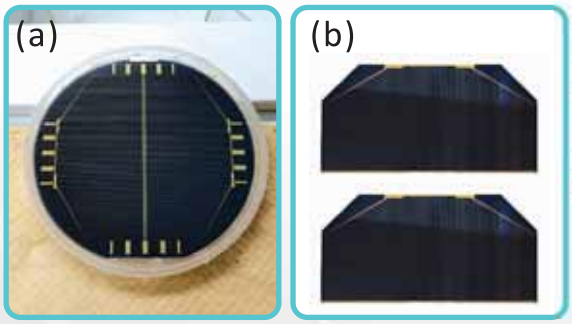


Fig.1. (a) 4-inch solar cell wafer (b) solar cell chips with light-receiving area of 30.18 cm^2 after cutting

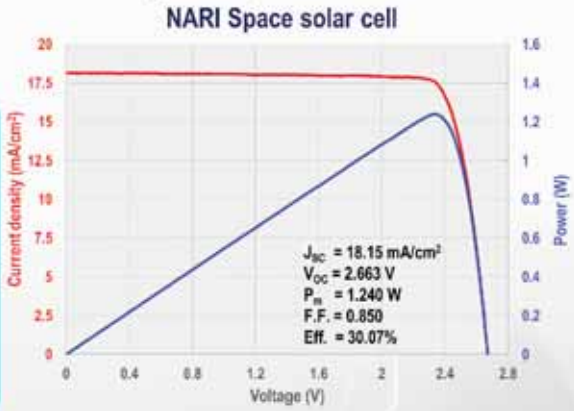
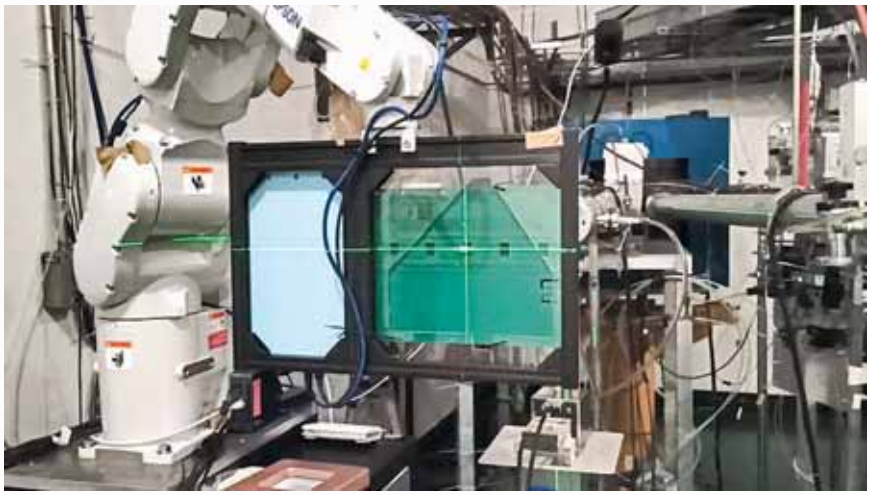


Fig.2. The IV and PV curves of a space solar cell with an area of 30.18 cm^2

Development of a Space Electronic Component Soft Error Rate Testing System

Facing the harsh space environment, radiation-resistant electronic components are core components of space technology, and only a few countries hold the key technological capabilities The space industry has concerned the hazards of single-event effects caused by radiation in these components. With the advancement of semiconductor processes and the shrinking of integrated circuit line widths, electronic components are more vulnerable to high-energy particles. The market for radiation hardened electronics is booming, with projected growth from $1.7 billion to $2.1 billion by 2029. Domestic manufacturers are actively seizing this market, leading to an increased demand for radiation testing.

NARI, in line with the national space industry development policy, has joined the "Taiwan Space Radiation Environment Verification Alliance." NARI provides proton irradiation environments below 30 MeV for space component testing. Referring to ESCC 25100, NARI has developed a Space Electronic Component Soft Error Rate Testing System, utilizing its cyclotron and domestic proton therapy platforms (20-200 MeV) to test the soft error rates of electronic components. This strengthens domestic space radiation environment verification technology and supports the development of the domestic space industry.



30 MeV Cyclotron Platform

Interface of Single-Event Effect Testing System

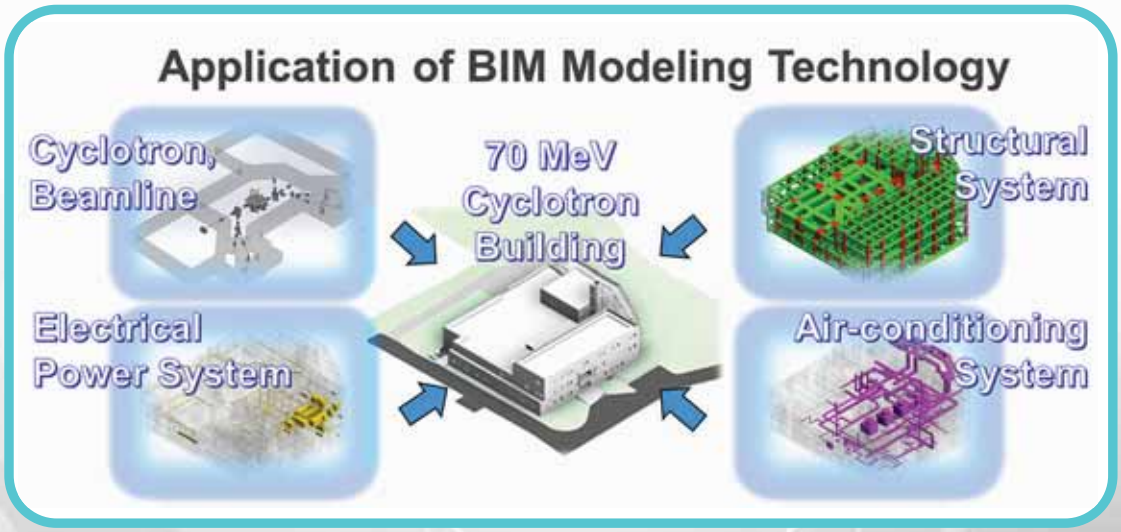
Application of results

NARI developed a soft error rate testing system, supporting industry in satellite electronic component verification. Using this system, four technical service projects were completed in 2023.

Application of BIM Technology in the Construction of a 70 MeV Cyclotron Building

To achieve the six core strategic industries regarding precision health, national defense and strategic stockpile; in alignment with the annual administrative policies and strategies of Executive Yuan and the Nuclear Safety Commission-the development of precision diagnostic medicine to stabilize the domestic supply and demand of nuclear medicine, promoting innovation in atomic energy technology, nurturing interdisciplinary talents, gradually establishing crucial nuclear technologies, and enhancing industrial value. To meet the government policy, it is necessary to establish a medium-sized cyclotron that combines functions for nuclear medicine pharmaceuticals and applications in atomic energy science. Therefore, NARI has proposed the "National Neutron and Proton Science Applications Research: 70 MeV Medium-sized Cyclotron Construction Project," which was approved by the Executive Yuan on October 21, 2021. This project focuses on the development of essential radiopharmaceuticals for domestic medical use, as well as conducting researches on neutron and proton science applications to promote their utilizations in industries, such as semiconductor and aerospace. Therefore, this project can enhance the infrastructure of space technology research and industrial development, and improves the international competitiveness of crucial technologies and industrial techniques in our country.

Considering the complexity of the new construction project for the 70 MeV medium-sized cyclotron building, involving cyclotron systems, related equipment and utility systems (including structures, electrical, air conditioning, plumbing, and fire fighting), as well as the requirements for radiation protection safety, NARI has introduced Building Information Modeling (BIM). BIM technology is a computer-based technology used to simulate actual engineering projects in a virtual space, applied to assist in the management of various stages of the building lifecycle, including planning, design, construction, operation, and maintenance. NARI utilizes BIM technology, combining research needs with the technical expertise of professional design consultants. Through parametric 3D drawing techniques, BIM technology assists in the integration of building structures with the cyclotron systems and related equipment. It also reviews design conflicts in various systems such as structure, electrical, air conditioning, and fire fighting to ensure the feasibility of structure design. Finally, advanced computer technology and 3D visualization will be utilized during the construction phase to guarantee on-time and high-quality completion. This work enhances the development capacity of domestic radiopharmaceutical and atomic science in Taiwan.



Integration of Cyclotron and Building Systems Interfaces Using BIM Technology

New Energy and System Integration

Diversified value-added application technology of forest waste Establishing an innovative business model for the forest carbon sinks

The natural carbon sink is recognized as a promising strategic tool to realize the vision of zero carbon emission in response to the global warming trend. Carbon sinks are the natural carriers able to fix and absorb CO_2, with oceans, soils, and forests as the primary reservoirs. The forest carbon sink refers to forests sequestering carbon by capturing carbon dioxide from the atmosphere and transforming it into trees, shrubs, roots, etc, with advantages over ocean and soil carbon sinks regarding technology maturity and cost-effectiveness currently. However, the benefits of natural carbon sinks heavily depend on technological breakthroughs and applications. The goal of net-zero carbon emission is difficult to achieve with economic benefits based on the current business model.

New Zealand, rich in forest resources, has a flourishing wood processing industry. However, considerable forest waste is generated during the process and mainly ends up in landfills and incineration, not only negatively affecting the environment and ecology but also showing low economic benefits. New Zealand actively seeks feasible solutions to valorize forest waste, aiming to achieve waste reduction, carbon sequestration, and value-added benefits simultaneously.

Based on the full-wood utilization strategy, the NARI has fostered multi-party collaboration with Inspira Applied Bio Solutions and NZ Bio-forestry, using Pinus radiata as the feedstock to develop diversified value-added technologies for forest waste valorization. This further establishes the innovative business model for the forest carbon sinks, mitigating carbon emissions with maximized benefits.

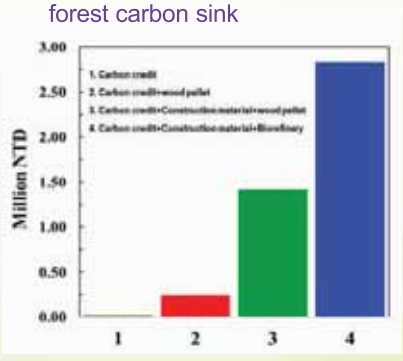
The R&D from the mentioned international multi-party collaboration is expected to demonstrate the following benefits:

1. Establish an energy and resources production technology with low carbon footprint: NARI's biorefinery technologies, including biomass pretreatment, enzyme hydrolysis, and lactic acid fermentation, successfully converted plywood-derived low-value wood waste into high-value biodegradable material. The pretreatment product also serves as a promising precursor for wood pellets. This reduces the impact of international carbon pricing developments on industry.
2. Strengthen international connection/Gear NARI's technology to international standards: Build collaborative partnerships with New Zealand, establish international exchanges, and facilitate global connections, assisting domestic industries to establish imported alternatives for energy and resources with low carbon footprint, thereby enhancing the operational resilience of the industry.
3. Seek for an innovative business model for forest carbon sink: Added values from plywood processing and biorefinery products, along with forest carbon sinks, significantly elevated the economic benefits from the unit area of forestland. The innovative business model serves as a paragon for the domestic industry to learn from and creates an emerging biorefinery industry.

Pinus radiata

Innovative solutions for valorizing forest waste

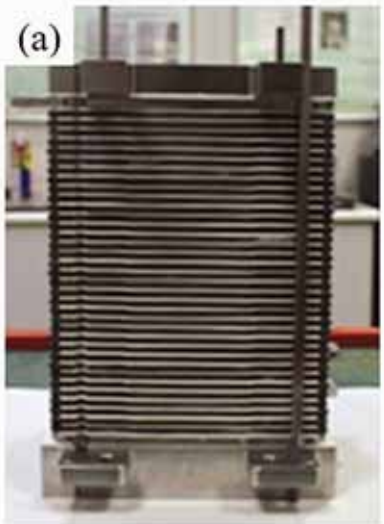
Economic profits evaluation for different business models of forest carbon sink



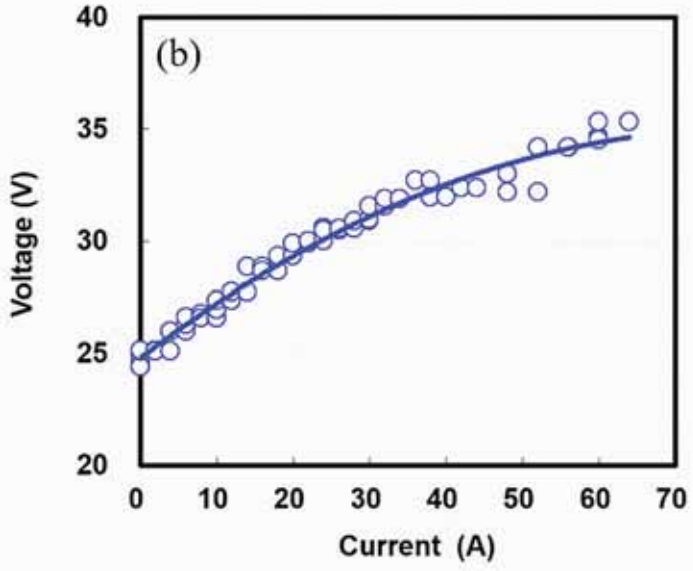
Assembling of kW-scale Solid Oxide Electrolysis Cell Stacks and High-Efficiency Hydrogen Production

Solid oxide electrolysis cells (SOECs) are power-to-gas devices that can convert electricity generated from renewable energy into fuel gas with a higher conversion efficiency than that of other electrolysis technologies. NARI has been committed to developing the assembling technique for kW-scale SOEC stacks to produce hydrogen through high-temperature water electrolysis, and to improving the conversion rate. It is aimed to evaluate the performance of the stacks with operating parameter optimization. Research results are applied to the conversion technology from the renewable power (solar, wind power, etc.) generating system to the energy storage device, and to future large-scale hydrogen production systems.

A 30-cell stack assembled with commercial anode-supported cells is tested at 750°C (Fig.(a)). Stack performance (I-V curve) is shown in Fig. (b). As the current load reaches 64 A (529 mA/cm^2), the voltage is about 35.3 V. The hydrogen production rate is around 14.61 LPM (0.88 m^3/h), and the hydrogen production efficiency is estimated at 71.2 %. The production efficiency will be elevated progressively. The associated patents, "Apparatus of integrating grid with parallel power-generating solid oxide fuel cell" and "Composition and preparation method of a metal protective film" have been awarded bronze medals in 2023 Taiwan Innotech Expo. Projects in cooperation with the industrial sector have also been executed, including the contract research project "SOEC co-electrolysis technology development", the technology transfer project "High temperature electrical ASR measurement technology", and the technical service project "Analysis of the current status on the technology development in solid oxide electrolysis cell and testing."



Outlook of a SOEC stack



SOEC stack operating current-voltage curve

The Development and Field Testing of the New 30 kW Wind Turbine

In Taiwan, many dispersed areas with favorable wind conditions suitable for installing small wind turbines are yet to be fully developed. Additionally, the feed-in tariff for small wind turbines below 30 kW suffices to provide domestic niche market for further development. The National Atomic Research Institute has assisted domestic manufacturers in developing a new 30 kW wind turbine to further improve system efficiency and conduct field testing.

This project brings together the wind turbine technical department of NARI, wind turbine development companies, wind farm operation and maintenance companies, and wind power lifting and transportation companies as collaborative partners. We aim to create a fully localized technical team, developing domestically commercial small wind turbines. In the future, we will drive the establishment and operation of decentralized power plants, achieve industry localization, and further promote the application of international energy markets.

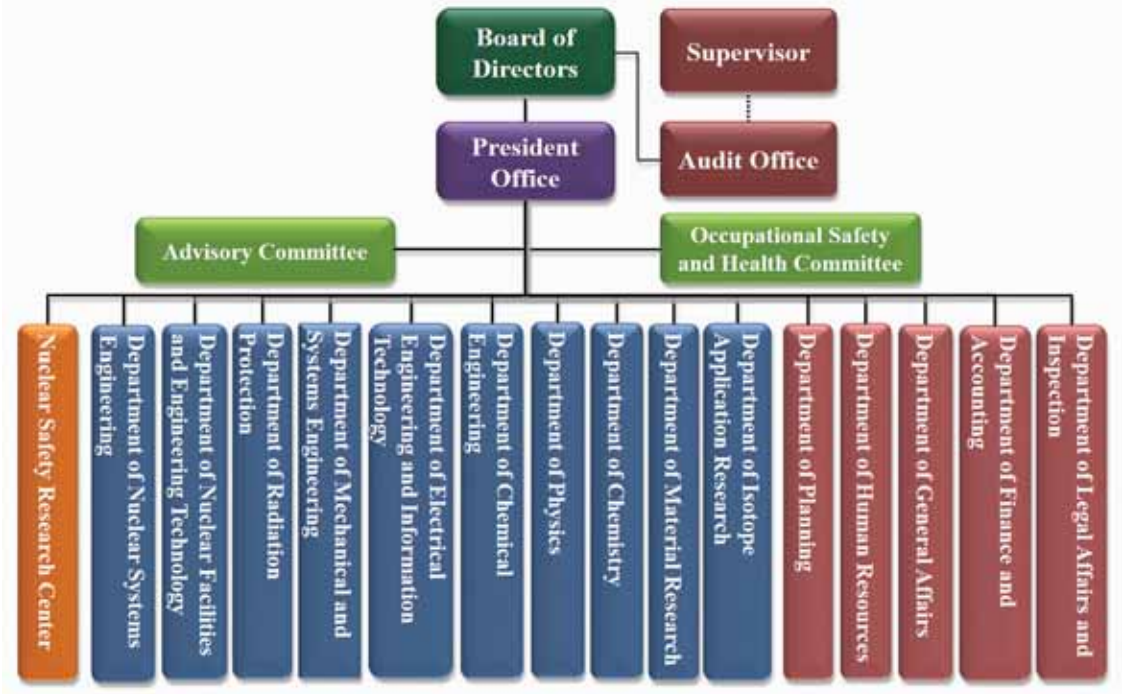
Current Operations and Management

Board of Directors and Supervisors

(Data Date: June 1, 2024)

Board Chair	Shin Chang
Director	Zhen-Wei You、Zhi-Peng Li、You-Min Huang、Xiu-Mei Wu、Qiu-Ying Qiu、Yan-Ru Liu、Ming-Zhen Chen、Shu-Fen Kao、Zong-Xin Wu、Fa-Zheng Lin
Executive Supervisor	Jia-Hang Li
Supervisor	Yun-Ying He、Hong-Yu Zhuang

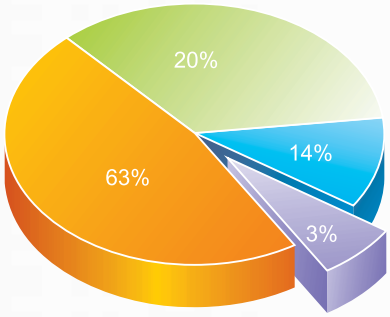
Organizational Chart



Human Resources

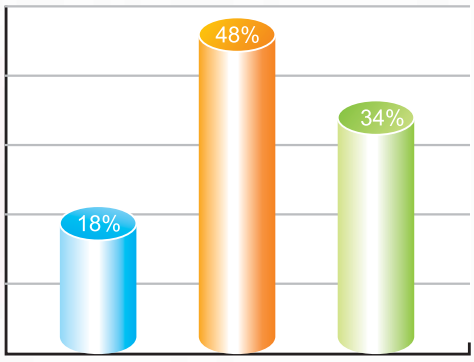
（May 2024）

Number of Employees: 786 ／ Average Age: 46 years



Research Staffs	495 Persons	(63%)
Technicians	159 Persons	(20%)
Administrative Staffs	110 Persons	(14%)
Other Staffs	22 Persons	(3%)

Statistics of Educational Background



Ph.D.	143 Persons	(18%)
Master	377 Persons	(48%)
Bachelor's degree or below	266 Persons	(34%)

Financial Statements

Income and Operating Statement (Unit: NT)

Item	2023
Income	
Business Revenue	783,834,868
Non-operating Income	475,384
Total Revenue	784,310,252
Expenses	
Business Costs and Expenses	734,465,062
Non-operating Expenses	225,411
Total Expenses	734,690,473
Net Income (Loss) before Taxes	49,619,779
Income Tax Expense (Benefit)	9,923,956
Net Income (Loss) for the Period	39,695,823

Balance Sheet (Unit: NT)

Item	2023
Assets	
Current Assets	866,453,235
Property, Plant, and Equipment (PP&E)	1,076,284,089
Intangible Assets	165,435,208
Other Assets	1,760,979,645
Total Assets	3,869,152,177
Liabilities	
Current Liabilities	595,619,927
Other Liabilities	3,227,194,084
Total Liabilities	3,822,814,011
Net Worth	
Reserves	6,642,343
Accumulated Surplus	39,695,823
Total Net Worth	46,338,166
Total Liabilities and Equity	3,869,152,177

2023 highlighted events

(INER 1.1-9.26、NARI 9.27-12.31)

2023.1.6 Former Vice President Annette Lu was invited to give a speech on "Taiwan's Challenges and Future Prospects." After her speech, Vice President Lu visited the Radionuclides in Food Radioactivity Testing Laboratory and the Biological Tritium Testing Laboratory at INER.

2023.3.28 Director-General Chen attended the signing ceremony of the new contract for the "Taiwan Space Radiation Environment Testing Alliance," led by the Taiwan Space Agency. INER is responsible for conducting radiation dose accumulation effect tests using a cyclotron, assisting in enhancing Taiwan's capabilities in radiation testing for space electronic components.

2023.4.13 The delegation of 14 members from Foreign Affairs and National Defense Committee of Canadian Federal House of Representatives along with officials from Canadian Ministry of Fireign Affairs, visited INER. A technical tour was arranged in visiting HLW laboratories, plasma research facilities, and engaged in panel discussions.

2023.4.19-21 The "2023 AEC-IRSN Meeting in the field of Radiation Protection and Nuclear Safety" was held in Taiwan, with INER Deputy Director-General Shian-Shing Shyu serving as the host for the two-day event. On April 21st, the French Institute for Radiological Protection and Nuclear Safety (IRSN) visited multiple laboratory facilities at INER and engaged in discussions.

2023.5.10 Tina Wilson, Business Representative of the New Zealand Commerce and Industry Office (NZCIO), along with representatives from New Zealand BioForestry, Tupu Angitu, New Zealand Forest Managers, and the Chairman of Johnson Company's forestry division, 14 people in total, visited INER. The main focus of the visit was on INER's FixCarbon technology.

2023.5.24 INER hosted Project Results Seminars for the "2022 Research Projects commissioned by the Atomic Energy Council, Executive Yuan." This event featured a total of 49 projects presented over 6 sessions, with 273 participants invited from industry, academia, and research institutions.

2023.5.29 At the 13rd meeting during the 7th session of the 10th Legislative Yuan, the Organic Act of Nuclear Safety Commission (NSC) and the Establishment Act of National Atomic Research Institute (NARI) were passed the 3rd Reading.

2023.6.5 Deputy Director Ming-Chi Lu of the Taoyuan City Environmental Protection Bureau, together with 5 councilors from the City Council including Mr. Chih-Wen Chen, Ms. Hsien-Lien Wang, Mr. Ching-Ping Huang, Mr. Pei-ChenYu, Mr. Tao Ling, and secretaries from their offices in a total of 30 people visited INER for discussions regarding the current status of LLW storage. A technical tour in INER was arranged.

2023.6.29 The Public Construction Commission of Executive Yuan approved the basic design report for the construction project of the "70 MeV Medium-Sized Cyclotron Building" at INER.

2023.7.22 INER hosted the "2023 Symposium on Development and Applications of Nuclear Medicine and Molecular Imaging" at National Taipei University of Technology. This event included 8 keynote speeches, with a total attendance of 220 participants (100 attended in person and 120 attended virtually).

2023.8.21 Minister without Portfolio of Executive Yuan Mr. Ching-Sen Chang led officials from the Office of Energy and Carbon Reduction, the Ministry of Agriculture, the Ministry of Economic Affairs, the National Science Council, the Ocean Affairs Council, and the Environmental Protection Administration visiting 9 key research and development facilities at INER.

2023.8.24 INER's "FixCarbon Technology: Carbon-Negative Bioplastics from Afforestation" has been honored with the 2023 R&D 100 Awards, marking its third consecutive year of winning this global contest.

2023.8.25 Academician Dr. Chi-Huey Wong of Academia Sinica was invited to give a lecture on "Glycoscience in Development of Precision Medicine." After the lecture, Dr. Wong visited four facilities at INER, including the Nuclear Medicine Pharmaceutical Center.

2023.8.31 Premier Chen of Executive Yuan listened to the Director-General Chen's briefing entitled "Positioning and Future Development of the National Atomic Research Institute (NARI)." Premier Chen highlighted main supportive directions for the future of NARI, including urging relevant ministries to propose suitable R&D projects for NARI to leverage its resources and system integration capabilities, so as to propose forward-projected national key research topics.

2023.8.31 INER's technology on "Design of Flexible Transparent Organic Solar Cell Modules and Low-Carbon Solution Printing Mass Production Process" won the National Science Council's "2023 Future Tech Award".

2023.9.5 INER held the "2023 Biomass Energy Clean Zero Carbon Emission Technology Application Seminar" at the IEAT International Conference Center in Taipei. The seminar included five keynote speeches, with a total of 53 participants.

2023.9.5-8 INER hosted the "2023 TWNSS International Consultation Meeting," inviting 5 renowned international experts in neutron facilities from the United States (NIST, ORNL), Japan (RIKEN), and the United Kingdom (ISIS), along with domestic experts and scholars from companies and institutions such as TSMC, CSC, NSRRC, NCU, and NTHU. There were 50 participants in this conference.

2023.9.27 INER was restructured into Taiwan's 11th administrative corporation from a government institution, and renamed the "National Atomic Research Institute (NARI)". Dr. Shin Chang, Deputy Chairperson of the Nuclear Safety Commission (NSC), had been appointed as its first Chair of the Board.

2023.10.12 The NARI hosted the "2023 Nuclear Backend Forum and Technical Symposium" inviting 102 experts and scholars from Taiwan Power Company, academia, and industry. The aim was to assemble a team capable of handling future decommissioning tasks for Taiwan's nuclear power plants.

2023.10.14 Winners of the "2023 Taiwan Innotech Expo" competition had been proclaimed. In this contest, NARI won two platinum awards, four gold medals, three silver medals, and six bronze medals for the outstanding innovated technologes.

2023.10.17 The New Zealand Commerce and Industry Office (NZCIO) and the Asia New Zealand Foundation, led by Tina Wilson (Director of NZCIO Trade Development Centre), with a delegation of 19 foreign guests, visited NARI for discussions on interested topics. A technical tour was followed..

2023.10.25 The Research Center for Biotechnology and Medicine Policy announced the winner list of the 20th National Innovation Award and the NARI won two Awards on "Research and Innovation".

2023.11.6 NARI held its first Board of Directors meeting, where decisions were made on 10 related regulations and operational documents. Dr. Tsu-Mu Kao was appointed as the President of NARI, and the decisions were submitted to the NSC for review.

2023.11.8 Dr. Tsu-Mu Kao assumes the office as the first President of NARI.

2023.11.19-24 The 34th Sino-Japanese Modern Engineering and Technology Symposium was held in Taiwan. NARI presented the topic "Oceanic dispersion modeling and the marine biota detection method of Tritium." Experts and scholars from Japan and Taiwan conducted academic discussions and visited NARI's laboratories on November 21st.

2023.11.21 The inauguration ceremony of NARI was held with the honorable participation of NSC Chairman Tung-Yang Chen, NCSIST President Chung-Cheng Chang, NARI's board members, representatives from NSC, SNM, and NTHU, and other distinguished guests.

2023.12.4-5 "The 2023 TECRO-AIT Joint Standing Committee Meeting on Civil Nuclear Cooperation" was held in Taiwan where NARI delivered a keynote presentation entitled "Overview of the Research Programs at NARI and Future Prospects," and joined group discussions throughout the meeting.

2023.12.13 NARI hosted the "40th Anniversary International Symposium on Introduction of PRA Technology in Taiwan - Pioneering the Era of Quantitative Risk Assessment." President Kao specially invited Prof. George Apostolakis, Emeritus Professor of MIT and former USNRC Commissioner; Dr. Der-Yu Hsia, former AEC Chairman; Prof. Enrico Zio of Politecnico di Milano in Italy, and Prof. Vincent Ho of PolyU in Hong Kong, along with other honorable guests from OHS, NSTC, OSHA, ODM, ITRI, TPC, NTHU, THSR, and Bechtel Energy, in Taiwan.

2023.12.26 NARI was recognized with nominations for one team award and one individual award for NSC's "12th Nuclear Safety Excellence Awards". Additionally, at the "2023 Excellence Awards for Radioactive Material Safety Operations and Outstanding Contributions to Research and Development," NARI secured three team awards and three individual awards. The awards ceremony for these accolades took place at the auditorium on the 3rd floor of NSC.

2023 Annual Report

National Atomic Research Institute

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