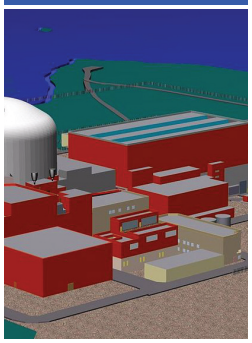

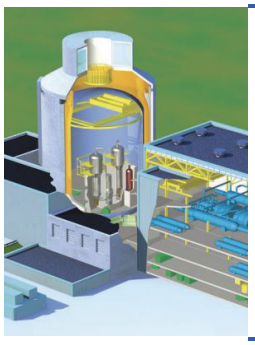

Forty-Fifth
Annual Meeting Program

Future of Nuclear Power Worldwide: Safety, Health and Environment

March 2–3, 2009

Hyatt Regency Bethesda
One Bethesda Metro Center
7400 Wisconsin Avenue
Bethesda, MD 20814

NCRP 1929 2009

On the cover:

- *top*: Evolutionary power reactor now being built in Finland.
- *center*: Advanced pressurized water reactor now being built in China.
- *bottom:* Advanced boiling water reactor built in Japan.

Introduction

Future of Nuclear Power Worldwide: Safety, Health and Environment

Forty-Fifth Annual Meeting of the National Council on Radiation Protection and Measurements

The role of nuclear power as a major resource in meeting the projected growth of electric power requirements in the United States and worldwide during the 21st century is a subject of great contemporary interest. The goal of the 2009 National Council on Radiation Protection and Measurements (NCRP) Annual Meeting will be to provide a forum for an in-depth discussion of issues related to the safety, health and environmental protection aspects of new nuclear power reactor systems and fuel production and processing strategies. The meeting will be an international conference with participation by representatives of many nations, scientific organizations, nuclear industries, and governmental agencies engaged in the development and regulatory control of advanced reactor systems and fuel concepts.

Topics of major interest in the context of the expected expansion in worldwide use of nuclear power that will be discussed include the following: (1) primary safety, health and environmental issues associated with the growth of nuclear power as an energy resource; (2) infrastructure needs for future nuclear power reactor systems and the associated radiation protection requirements, including nuclear plant operational practices, environmental issues associated with the growth of nuclear fuel-cycle and waste-management issues, and fuel nonproliferation safeguards; (3) key challenges to be addressed for nuclear power in the 21st century, including regulatory practices and controls, expansion of trained human resources and expanded educational capabilities in nuclear power technology, radiation protection requirements, and effective communication of the risks and benefits of nuclear power resources; and (4) perspectives on how to meet the major challenges in projected growth of nuclear power energy sources. The 2009 Annual Meeting will mark the 80th anniversary since the founding of NCRP and its predecessor organizations, and will be the 45th Annual Meeting held by NCRP following the 1964 Congressional Charter under Public Law 88-376 to provide guidance on matters related to radiation protection and measurements.

Future of Nuclear Power Worldwide: Safety, Health and Environment

Monday, March 2, 2009

Opening Session

8:15 am **Welcome**
Thomas S. Tenforde
President
National Council on Radiation Protection and Measurements

Sixth Annual Warren K. Sinclair Keynote Address

8:30 am **The Role of a Strong Regulator in Safe and Secure Nuclear Energy**
Peter B. Lyons
U.S. Nuclear Regulatory Commission

9:30 am **Panel on Safety, Health and the Environment: Implications of Nuclear Power Growth**
Sama Bilbao y Leon, *Moderator*
International Atomic Energy Agency

Panelists:

Challenges to New Nuclear Plant Development
Charles Pardee
Exelon Corporation

Impact of the Renewed Growth in Nuclear Power on State Radiation Control Programs
John P. Winston
Conference of Radiation Control Program Directors, Inc.

Other Side of the Waste Confidence Consideration
Robert M. Bernero
U.S. Nuclear Regulatory Commission (retired)

Next Generation Safeguards for Future Nuclear Power
Michael C. Miller
Los Alamos National Laboratory

10:30 am **Break**

Trends in Worldwide Use of Nuclear Power

Angelina Howard, *Session Chair*
Nuclear Energy Institute

10:45 am **NEA Nuclear Energy Outlook 2008**
Uichiro Yoshimura
OECD Nuclear Energy Agency

11:10 am **U.S. Evolutionary Power Reactor: Certainty in Safety**
Thomas A. Christopher
AREVA

11:35 am **Advanced Reactors and Associated Fuel-Cycle Facilities: Safety and Environmental Impacts**
Robert N. Hill
W. Mark Nutt
James J. Laidler
Argonne National Laboratory

12:00 pm **Lunch**

1:10 pm **Panel on International Perspectives on Future of Nuclear Power**
Joseph C. Perkowski, *Moderator*
Idaho National Laboratory

Panelists:

Expanded Development and Use of Nuclear Energy: Important Way to Solve Environmental Pollution in China
Liu Senlin
China Institute of Atomic Energy
Ziqiang Pan
Chinese Radiation Protection Association

New Nuclear Power Stations in the United Kingdom
David Bennett
Environment Agency, United Kingdom

Program Summary

International Perspectives on Nuclear Fuel Cycle
Alan Hanson
AREVA

Experience Feedback on Radiation Protection in Nuclear Power Generation: Japanese Perspective
Shojiro Matsuura
Japan Nuclear Safety Research Association
Shizuyo Kusumi
Nuclear Safety Commission, Japan

Nuclear Energy in the United States
Alexander Marion
Nuclear Energy Institute

2:40 pm **Break**

Infrastructure Needs for Future Nuclear Power

Patrice M. Bubar, *Session Chair*
U.S. Nuclear Regulatory Commission

3:00 pm **Radiation Protection at U.S. Nuclear Power Plants: Today and Tomorrow**
Michael Blevins
Luminant Power

3:25 pm **World Nuclear Association's Worldwide Overview on Front-End Fuel-Cycle Growth and Health, Safety and Environmental Issues**
Sylvain Saint-Pierre
Steve Kidd
World Nuclear Association

3:50 pm **Reactor Based Management of Used Nuclear Fuel: Assessment of Major Options**
Phillip Finck
Idaho National Laboratory
Robert Hill
Argonne National Laboratory
John Kelly
Sandia National Laboratory
Roald Wigeland
Idaho National Laboratory

4:15 pm **International Safeguards and the Global Expansion of Nuclear Power**
Thomas E. Shea
Pacific Northwest National Laboratory

4:40 pm **Break**

Thirty-Third Lauriston S. Taylor Lecture on Radiation Protection and Measurements

5:00 pm **Introduction of the Lecturer**
Robert L. Brent
Alfred I. duPont Institute

Radiation Epidemiology: The Golden Age and Remaining Challenges
John D. Boice, Jr.
Vanderbilt University School of Medicine
International Epidemiology Institute

6:00 pm **Reception in Honor of the Lecturer**

Future of Nuclear Power Worldwide: Safety, Health and Environment

Tuesday, March 3

8:20 am **NCRP Annual Business Meeting**

9:20 am **Break**

Key Challenges to be Addressed for Nuclear Power in the 21st Century

Audeen W. Fentiman, *Session Chair*
Purdue University

9:40 am **Essential Infrastructure: National Nuclear Regulation**
Carl J. Paperiello
U.S. Nuclear Regulatory Commission (retired)

10:05 am **Maintaining a Highly-Qualified Nuclear Industry Workforce**
Carol L. Berrigan
Nuclear Energy Institute

10:30 am **Break**

10:45 am **U.S. Department of Energy Facilities Needed to Advance Nuclear Power**
John F. Ahearne
Sigma Xi

11:10 am **New Nuclear Build and Evolving Radiation Protection Challenges**
Edward Lazo
OECD Nuclear Energy Agency

11:35 am **Communicating with Stakeholders about Nuclear Power Plant Radiation**
Ann Stouffer Bisconti
Bisconti Research

12:20 pm **Lunch**

1:30 pm **Role of the International Radiation Protection Association**
Kenneth R. Kase
Philip Metcalf
International Radiation Protection Association

1:50 pm **Panel on How to Meet the Challenges for Nuclear Power**
Mary E. Clark, *Moderator*
U.S. Environmental Protection Agency

Panelists:

Nuclear Power Expansion: Challenges and Opportunities
Paul W. Lisowski
U.S. Department of Energy

Three Most Important Actions For the Growth of Nuclear Power
Wayne L. Johnson
Pacific Northwest Laboratory

How to Meet the Challenges Reinvigorating the Research and Development Community and Infrastructure
Mark T. Peters
Argonne National Laboratory

Outlook for Nuclear Energy in a Shifting Political Climate
Annie Caputo
House Committee on Energy and Commerce

Low-Level Radioactive Waste Management: Status, Challenges and Solutions
Michael T. Ryan
Michael T. Ryan and Associates, LLC

Challenges and Opportunities of a Global Nuclear Energy Future
Thomas Isaacs
Stanford University
Lawrence Livermore National Laboratory

Program Summary

3:15 pm **Break**

3:35 pm **Rapporteur Summary**
Michael L. Corradini
University of Wisconsin-Madison

4:15 pm **Questions and Comments from the Audience**

4:50 pm **Closing Remarks**
Thomas S. Tenforde
President, NCRP

5:00 pm **Adjourn**

Monday, March 2, 2009

Opening Session

8:15 am

Welcome
Thomas S. Tenforde
President, National Council on Radiation Protection and Measurements

8:30 am

Sixth Annual Warren K. Sinclair Keynote Address

The Role of a Strong Regulator in Safe and Secure Nuclear Energy
Peter B. Lyons
U.S. Nuclear Regulatory Commission

A strong independent regulatory authority is not only necessary but valuable for any country that utilizes nuclear energy in its quest for energy diversity and security. Specific areas of elaboration will be: the value of the independent role played by the U.S. Nuclear Regulatory Commission (NRC), NRC's licensing process for new reactors, the current status of new reactor licensing work, some of the current challenges, and what the future may hold.

Commercial nuclear power in the United States began under the oversight of the U.S. Atomic Energy Commission (AEC). At that time, AEC's regulatory programs sought to ensure public health and safety without imposing excessive regulation that would inhibit the growth of the industry. As a result of this difficult balance, in 1974 Congress divided these roles, assigning the regulatory function to NRC. Not only did NRC become the regulator for nuclear power reactors, but also the regulator of all civilian use of radioactive materials, including fuel enrichment facilities, industrial and medical applications, and waste disposal facilities. Today, senior executives of the nuclear power industry understand and appreciate the value that an independent and technically strong regulator brings to assuring the public that nuclear plants are being operated safely and securely. The level of public assurance depends on NRC being a tough regulator—the job of NRC is to ask the tough questions and make the tough calls. The nuclear industry recognizes that any possibility of construction of new nuclear power plants in the United States depends directly on continued public assurance of safe and secure operations of existing power reactors in operation today.

NRC's 10 CFR Part 52 licensing process, which is now being used for the first time, was initially developed almost 20 y ago. The licensing process provides a regulatory framework addressing design certifications, early site permits, and combined licenses. The design certification process allows a reactor vendor to submit a design to NRC for review and certification that is independent of a site. Safety reviews must be based on an essentially complete

design. Similarly, the early site permit process allows an applicant to apply for a site permit independent of any particular design. In reviewing an early site permit application, NRC staff address site safety issues, environmental protection issues, and plans for coping with emergencies. A combined license authorizes both construction and conditional operation of a nuclear power reactor. All of these licensing actions allow for public and other stakeholder participation through public meetings and hearings. As of October 2008, NRC had 17 combined license applications under review, representing 26 reactors using five designs.

Many important challenges face NRC and the industry, such as ensuring that applications submitted to NRC for design certifications and licenses for new plants are fully complete and of high quality and implementing modular construction.

Other challenges that will impact both new and operating reactors include: the globalization of the nuclear supply chain, procurement of off-the-shelf commercial grade components for use in safety-related applications, new designs such as security enhancements and digital systems, and maintaining a quality workforce with an appropriate safety culture. Over the past 3 y, NRC alone has hired over 400 engineers and scientists per year to keep up with the attrition of an aging workforce in concert with our expanding workloads. Likewise, industry is hiring engineers and health physicists to support activities ranging from new reactors to site decommissioning and cleanup. The challenge to support educational programs in these areas must be shared by NRC, industry, and academia.

Management of both high- and low-level waste may challenge industry, NRC, and the Agreement States. NRC faces a monumental task in the review of the license application for a potential Yucca Mountain high-level waste repository. Low-level waste issues may also present special challenges, especially since the Barnwell Site closed to out-of-compact wastes earlier this year. A final challenge, specifically relevant to NCRP, is the refinement of understanding and communications associated with low doses of radiation. In a time when scientific information is significantly increasing, it is critical that we carefully and continually evaluate the scientific basis for radiological protection recommendations.

Provided that continued safety is demonstrated by the nations that operate reactors, the future may be promising, as reactor technology can be expected to progress toward new generations of designs with demonstrably greater safety and potentially greater utility, especially for small modular types. Increasing concern for carbon-free electrical power and process heat sources may drive further interests in both new plants and in extending the operation of existing units. The requirement of the Energy Policy Act of 2005 for the U.S. Department of Energy to develop a Next Generation Nuclear Plant is one example of an initiative that will further advance nuclear technologies. Future challenges will include developing the expertise necessary for reviews of these advanced technologies and ongoing challenges such as spent-fuel and waste management.

[*The remarks above are the personal views of Commissioner Lyons, and may not represent the collective view of the Commission.*]

Future of Nuclear Power Worldwide: Safety, Health and Environment

9:30 am

Panel on Safety, Health and the Environment: Implications of Nuclear Power Growth
Sama Bilbao y Leon, *Moderator*
International Atomic Energy Agency

Panelists:

Challenges to New Nuclear Plant Development
Charles Pardee
Exelon Corporation

The recent presidential election brought to light that no matter what the solution is for our future energy needs, the answer involves a more diverse mix of energy resources, one of which is nuclear. Many factors are driving the debate over new nuclear plant development. The challenges to new plant development include operating nuclear plant performance, environmental considerations, public sentiment, used-fuel management, and cost uncertainties. The threshold condition before any other considerations can be given credence is our current industry performance. First and foremost, if nuclear operators fail to maintain high levels of safety and performance, the rest of the challenges will become a moot point. It is imperative that current nuclear plants safely operate at high-capacity factors, maintaining competitive fuel costs, and experience no significant events for new nuclear plant development to remain attractive to the energy mix. Compared to its competition such as coal, gas or petroleum, nuclear power's production costs, fuel costs, and greenhouse gas generation are among the lowest in the electric utility sector. These attributes combine to set the stage for future nuclear plant development.

The increase of carbon dioxide levels in the atmosphere, coupled with concern about their possible climate effect, is now a very significant factor in the comparison of coal and nuclear power for producing electricity. A major selling point for new nuclear plant construction is the fact that it produces less carbon dioxide than even wind energy per kilowatt hour, when calculated as a total life-cycle carbon footprint.

However, production of electricity from any form of primary energy has some environmental impact. Nuclear plants are no exception because they have infrastructures that require significant landscape to accommodate heat sinks, water consumption needs and requirements to support transmission line access. They generate thermal, gaseous and liquid discharges that must be managed appropriately to ensure minimal environmental impact and to demonstrate their ability to be positive environmental stewards to local communities.

One of the key influences surrounding nuclear power for generation purposes is public sentiment. Today, nuclear power is benefiting from increased public acceptance of electricity generated from sources that are greenhouse gas compliant, which is helping to create a resurging interest in nuclear power as part of our energy mix.

Current public concerns regarding nuclear power generation are centered on emission-free energy, economic benefits, the environmental footprint, vulnerabilities to terrorism, weapons proliferation, and the perceptions left by the legacy events such as Three Mile Island and Chernobyl. With the complex nature of the physics behind the design, we are often challenged and measured on our ability to

communicate to the public that nuclear power is a safe, clean and reliable source of energy for the future.

Used-fuel management has been a utility concern for years and plants are now forced to develop costly temporary onsite storage solutions because of delays encountered with the development of a government-owned central repository (Yucca Mountain). New plant construction and operation will accelerate the necessity for a resolution (both interim and the long term) to the used-fuel storage issue.

A nuclear renaissance is refreshing, but brings with it challenges to an industry that had been somewhat stagnant or dormant for years. Cost uncertainties associated with construction, component availabilities, an aging workforce, attracting new talent, and new regulatory processes are challenges the industry must face to successfully build in the future. The need is there and made more attractive with the incentives offered by the Energy Policy Act of 2005.

The question now is who will be first?

Impact of the Renewed Growth in Nuclear Power on State Radiation Control Programs

John P. Winston
Conference of Radiation Control Program Directors, Inc.

The renewed interest in nuclear power in the United States will impact state radiation control programs in many ways. The time lapsed since the last siting and construction process has left state programs with a generation of employees having no experience in evaluating environmental impact studies associated with the siting and construction of new plants. State programs will be involved in the coordination and attendance of public meetings, hearings, and the dissemination of information. A stack and perimeter environmental monitoring program will need to be designed, implemented and maintained.

In states with existing nuclear power generation, new plants at new locations will require additional personnel and resources to develop and perform both environmental monitoring and emergency response plans. If the plant involves a new design, training will be required for the individuals in an existing nuclear safety and radiation control program.

States with their first plant within or near their state line will be tasked with developing the infrastructure necessary for a new off-site emergency response program. A mechanism of funding or fee collection to support the additional staff and resources associated with implementing the new program will be required.

The projected growth of nuclear power will mean additional opportunities for development and training of state personnel. State radiation control programs will benefit from an expanded emphasis on emergency response capabilities, which also enhances the program's ability to respond to other radiological emergencies. The success of the necessary expansion and training will hinge on the level of financial resources.

Other Side of the Waste Confidence Consideration

Robert M. Bernero
U.S. Nuclear Regulatory Commission (retired)

In the aftermath of the Three Mile Island accident, a lawsuit challenged the right of the U.S. Nuclear Regulatory Commission (NRC) to continue issuing new reactor

licenses, or amending existing licenses, given that there was no solution evident for the disposal of the high-level radioactive waste (HLRW) generated by these reactors. Not long after this challenge, Congress enacted the Nuclear Waste Policy Act of 1982; the Act that began the process of site selection and licensing of a HLRW repository that has reached the stage of license application now under review by NRC. An initial policy statement of "waste confidence," was issued by NRC, that is, confidence that the national activity would lead to the establishment of HLRW disposal capability on an acceptable time scale. NRC issued another waste confidence finding about 1990, recognizing the contention about the selection of the Yucca Mountain Site for development. The 1990 statement even considered that the Yucca Mountain Site might be finally rejected, putting the search for another site on a generation-long development of an alternate site. This length of time is considered tolerable because long-term surface storage of HLRW can be safe for at least a 100 y. NRC remains conscious of the need for waste confidence and continues to consider new and amended licenses for reactors.

There is another side of the waste confidence issue, consideration of the disposal of low-level radioactive waste (LLRW). Disposal sites were operating in several places across the United States at the time of the waste confidence challenge. In 1980, Congress enacted the Low-Level Radioactive Waste Policy Act, and in 1985 enacted the Low-Level Radioactive Waste Policy Amendments Act. These Acts established a wholly new system of LLRW sites, to be developed by groups of states, called Compacts. Under the terms of these Acts, each state's governor did make what amounts to a statement of waste confidence to NRC in 1990. In the years after the Acts the Compacts were formed and site work proceeded in varying degrees. Before long the site development process stalled in most Compacts. The Northwest Compact chose the Hanford Washington Site, already operating, for their LLRW and agreed to accept LLRW from the Rocky Mountain Compact. The operating LLRW site in Barnwell, South Carolina continued to accept LLRW from all other states. These operating sites were accepting all classes of LLRW, Classes A, B and C for varying disposal fees. In addition, sites such as the one in Clive, Utah opened to receive Class A waste from any state. The Barnwell Site began to restrict its LLRW receipts and recently closed to all states outside its Compact. Under current restrictions LLRW generators in 36 states are storing Class B and C LLRW for lack of access to an acceptable disposal site.

Only a few of the early generation power reactors have been or are being decommissioned. Those that do not have access to disposal for Class B and C LLRW must continue to store it. Most of these decommissioning projects go to "green field" state, that is, complete removal of the radioactive waste. NRC and the U.S. Environmental Protection Agency have not established a national standard for "clearance," a standard for the low level at which radioactive waste may be disposed of without regard to its level of activity. For many of the reactors decommissioned, concrete rubble that could be technically justified as being within a clearance standard is shipped for disposal to other states at significant cost. Most of the earlier generation power reactors have been granted life extensions, extending their end-of-useful life by at least 20 y. They face substantial difficulties and costs for decommissioning and disposal of LLRW as well as for HLRW. New reactors, even if designed for decommissioning ease, will face this same disabled LLRW disposal system. The other side of waste confidence, for LLRW, should be considered.

Next Generation Safeguards for Future Nuclear Power
Michael C. Miller
Los Alamos National Laboratory

An essential component in the expansion of nuclear energy is full confidence in nonproliferation and safeguards. In addition to expansion of the existing light-water reactor fleet, advanced fuel-cycle concepts are increasingly being developed and deployed. New technologies will be needed to achieve this confidence in a way that enables efficiency as well as efficacy. In this talk I will outline the needed research and technology development to support the nuclear renaissance: including incorporation of safeguards into facility design, advancing instrumentation for tracking and accounting for nuclear material, and fully integrating all available data so that near real-time knowledge of facility operations is possible.

10:30 am **Break**

Trends in Worldwide Use of Nuclear Power

Angelina Howard, *Session Chair*
Nuclear Energy Institute

10:45 am **NEA Nuclear Energy Outlook 2008**
Uichiro Yoshimura
OECD Nuclear Energy Agency

This presentation refers to Nuclear Energy Outlook, which is the first of its kind and responds to the renewed interest in nuclear energy by many Organization for Economic Cooperation and Development (OECD) member countries. World energy demand continues to grow unabated and is leading to very serious concerns about security of supply, soaring energy prices, and climate change stemming from fossil-fuel consumption. Nuclear energy is increasingly seen as having a role to play in addressing these concerns.

This Outlook uses the most current data and statistics available and provides projections up to 2050 to consider growth scenarios and potential implications on the future use of nuclear energy. It also offers unique analyses and recommendations on the possible challenges that lie ahead.

Topics covered by the Nuclear Energy Outlook include nuclear power's current status and projected trends; environmental impacts; uranium resources and security of supply, costs, safety and regulation; radioactive waste management and decommissioning; nonproliferation and security; legal frameworks; infrastructure, stakeholder engagement; advanced reactors; and advanced fuel cycles.

11:10 am **U.S. Evolutionary Power Reactor: Certainty in Safety**
Thomas A. Christopher
AREVA

The original design goal of the Evolutionary Power Reactor (EPR) was increased to have margins of safety in all aspects of the plant, the use of proven technology, and

more efficient operation for higher capacity factors. Based upon the extensive experience of the U.S., German, and French nuclear industries, this evolutionary design is tailored to the safety and environmental issues that we anticipate in the next 60 y. Reactor safety was raised to a new global level in the design of EPR. Not only have we improved the reactor core margins, the design thoroughly addresses the possibility of severe accidents, including airplane crashes.

Additionally, the containment shielding and layout allows for access to significant areas of the containment for maintenance at power.

EPR provides a geographical footprint for a 1,600 MWe power plant that is 40 % less than that required today. Also, there is a substantial reduction in thermal discharge to the environment for that power level.

11:35 am

Advanced Reactors and Associated Fuel-Cycle Facilities: Safety and Environmental Impacts

Robert N. Hill
W. Mark Nutt
James J. Laidler
Argonne National Laboratory

Advanced nuclear fuel-cycle technology is being developed worldwide to improve waste management and resource utilization. The safety and environmental impacts of these new technology and fuel-cycle approaches will be contrasted to conventional technology options in this presentation. The evaluation will address three fuel-cycle phases: power reactor operation, fuel recycle, and waste management. This presentation will focus on technology options being investigated in current U.S. nuclear research programs.

Two advanced reactor technologies, the sodium-cooled fast reactor and the very high temperature gas-cooled reactor are being developed. Modern designs emphasize inherent features to prevent accidents. The safety approach and resulting performance for each reactor type will be explained. In addition, the potential impact on environmental assessment for siting and accident response will also be explored.

Both advanced aqueous and electrochemical technologies are being considered for used-fuel processing; the used fuel is separated into product streams and valuable materials are recovered for recycle as new nuclear fuel. Treatment of both existing spent light-water reactor fuel and advanced reactor fuels must be considered. In this presentation, the safety performance and regulatory limits of existing fuel-cycle facilities will be reviewed. The impact of technology options to improve recycle efficiency, restrict emissions, and improve safety will be identified.

A closed fuel cycle implies a vastly different strategy for spent-fuel handling and storage, compared to the current once-through fuel cycle. Furthermore, the spent-fuel processing system can be designed to provide optimized waste management strategies. In this presentation, key technology alternatives will be identified and safety and environmental impacts will be compared.

12:00 pm

Lunch

Abstracts: Monday, March 2

1:10 pm

Panel on International Perspectives on Future of Nuclear Power
Joseph C. Perkowski, *Moderator*
Idaho National Laboratory

Panelists:

Expanded Development and Use of Nuclear Energy: Important Way to Solve Environmental Pollution in China
Liu Senlin
China Institute of Atomic Energy

Ziqiang Pan
Chinese Radiation Protection Association

Coal-fired power is the main source of air pollution and greenhouse gas in China. To solve this issue, it is necessary to adjust the structure of power sources and reduce the percentage using coal-fired power. Developing a nuclear power station is the best way to resolve this issue.

Because of the large amount of discharged sulfur dioxide by the coal-fired chain, it has developed an acid rain zone in southern China including part of Zhe Jiang Province, most of Jiang Xi Province, central and north of Hu Nan Province, west of Guang Xi Province, east of Gui Zhou Province, and west of Chong Qing. The greenhouse gas rate of the coal-fired chain is about 1,300 g CO_2/KWh. The nuclear-power chain emission rate is about 13.7 g CO_2/KWh, 100 times less than for the coal-fired chain.

In the beginning of the 21st century, China has decided to actively develop nuclear power. In 2006, the State Council of China announced a 2020 nuclear power development program. The program states that by the year of 2020, we will achieve 40 GW_e with 18 GW_e more in development. By the end of 2008, we have 9.1 GW_e operating in China and 11.3 GW_e being constructed, with an approved-to-be-built reactor output of 23.9 GW_e. The total amount is 44.3 GW_e. It has exceeded our original 2020 plan. According to the current developing situation, we will achieve 70 GW_e before 2020 and 30 GW_e to-be-built. The estimation of some scholars indicates we may achieve 200 GW_e in China's nuclear power capability by 2030.

New Nuclear Power Stations in the United Kingdom
David Bennett
Environment Agency, United Kingdom

In May 2007 the U.K. government published a policy document, *Meeting the Energy Challenge*. It provided a framework for addressing U.K. future energy needs. As part of this it invited vendors of nuclear power plants to submit requests for Generic Design Assessment (GDA) to the nuclear regulators. Health and Safety Executive and the Environment Agency are the regulators for safety, security and environmental performance of any new nuclear power stations.

In June 2007 the government announced that four designs had met their criteria for being accepted for design assessment. The regulators formally started the assessment process for the four designs in August 2007.

The GDA process allows the nuclear regulators to assess new designs before an application to build and operate at a particular site is made. The early interaction allows regulators a better opportunity to influence vendors' designs. For vendors it provides an opportunity to reduce project risk by obtaining early regulatory approval and reducing overall time scales.

GDA is a structured, multi-step process spread over several years and is being carried out in an open and transparent manner. It is designed to be a rigorous and thorough process by which the regulators are carrying out their role in connection with new nuclear power station designs. The first stage of assessment has been completed. The regulators have concluded that there are no fundamental design aspects or shortfalls at this stage (in terms of safety, security or the environment) that would prevent any of the designs from ultimately being constructed in the United Kingdom.

The GDA process is setting high standards of openness and transparency with the creation of a public involvement process, which allows the public to view detailed design information on the web and comment, and by the decision to publish HSE and the Environment Agency's internal assessment reports. At the end of the GDA process, designs will not be issued with statements of acceptability unless the regulators' assessment criteria are met and appropriate safety, security, environmental and waste management standards can be assured.

There are a number of challenges associated with the GDA process. Much of the vendor documentation for the designs have been developed to meet regulatory systems in other countries. Inevitably these differ from those in the United Kingdom, which means that some of the documentation provided does not provide all the information needed by U.K. regulators. To maximize the benefit from other assessment work and ensure that missing information is provided, U.K. regulators are developing links with overseas regulators and also developing the vendors' understanding of U.K. regulatory needs.

International Perspectives on Nuclear Fuel Cycle

Alan Hanson
AREVA

It appears that the world is at the leading edge of resurgence in nuclear power as a source of electricity. In order to fuel the dozens of new reactors expected to be built, there will need to be new facilities for the mining, conversion, enrichment and fabrication of nuclear fuel. Following fuel irradiation, new facilities will also be needed to store, recycle and dispose of nuclear waste. Efforts are already underway to put in place the needed fuel-cycle facilities, but more will be needed.

Experience Feedback on Radiation Protection in Nuclear Power Generation: Japanese Perspective

Shojiro Matsuura
Japan Nuclear Safety Research Association

Shizuyo Kusumi
Nuclear Safety Commission, Japan

Nuclear power plants (NPPs) have been constructed continuously in Japan since the1960s and currently 55 commercial NPPs are in operation. Simultaneously,

efforts are made to establish fuel-cycle related installations based on the nation's policy on spent-fuel recycling and there exist 12 such installations including one under construction. Furthermore, an experimental sodium-cooled fast reactor (SFR) named "Joyo" and a prototype SFR, "Monjyu" were built, as well as a high temperature gas-cooled engineering test reactor.

Meanwhile, evolutionary advanced light-water reactors (LWRs)—advanced boiling water reactor (ABWR) and advanced pressurized water reactor (APWR)—were developed in the country. In a national project called "LWR Improvement and Standardization Program," the Japanese government assisted the development of the evolutionary reactors through such activities as establishing the development targets, conducting various verification tests for the new or improved systems and components, and evaluating the LWRs. The evolutionary LWRs have been in operation or in preparation for construction already. In April 2008, Japan launched the Next Generation LWR Development Program as a national project for further advancement in LWRs. Furthermore, public and private sectors are actively developing innovative reactors such as SFR and very high temperature reactor (VHTR) which are also selected as Generation IV reactors in the Generation IV International Forum.

In the above mentioned "LWR Improvement and Standardization Program," which began in 1975, "reduction of radiation exposure of NPP workers" was one of the main objectives. Various improvements have been realized in Phase 1 and Phase 2 of the program. Making many fundamental improvements from the design stage of the evolutionary LWRs in Phase 3 (started in 1981), it was shown that yearly NPP workers collective dose can be as low as 0.5 person-Sv in ABWR and APWR.

For operating reactors, including those constructed in the 1960s and 1970s, collective dose data of NPP workers are evaluated. The exposure reduction measures for operating reactors are discussed in terms of reactor water chemistry.

For future advanced reactors, general and specific considerations needed for exposure reduction at the design stage are summarized. Based on the operating experience of Jyoyo, Monju and the High Temperature Test Reactor, general radiation protection characteristics of SFR and VHTR are summarized. Finally, based on the Japanese experience, selected topics and issues relevant to radiation protection of future nuclear power generation are briefly presented.

Nuclear Energy in the United States

Alexander Marion
Nuclear Energy Institute

Today in the United States, 104 nuclear power plants in 36 states generate nearly 20 % of the nation's electricity with a high level of safety and reliability at a low cost. The focus on safety remains first and foremost, with continued excellence and positive trends as measured by industry and regulatory performance indicators related to nuclear, radiation and industrial safety.

In 2007, the plants continued to perform well, turning in new records for output and capacity factors. Production costs continue to be the lowest of any source of electricity.

In March 2000, the U.S. Nuclear Regulatory Commission (NRC) began to approve 20 y renewals of nuclear power plants' 40 y operating licenses. This allows those

plants that have compiled detailed applications and undergone rigorous review to operate for a total of 60 y. Since then, NRC has approved license renewals for 49 nuclear reactors. To date, the owners of 99 nuclear units have decided to pursue license renewal, and more are expected to follow suit.

Nuclear energy is the only major source of base-load electricity generation that does not emit criteria air pollutants or greenhouse gases. As discussions of both tighter emissions controls and greenhouse gas reductions continue at the national, state and regional levels, nuclear energy's environmental benefits take on more significance. In 2007 alone, operating nuclear power plants prevented the emission of three million tons of sulfur dioxide and one million ton of nitrous oxide. Nuclear energy is perhaps even more important when considering carbon dioxide emissions, with nuclear plants preventing emission of 693 million metric tons in 2007.

The U.S. nuclear power industry continues to make progress toward the construction of new nuclear power plants in the United States. To date, companies have submitted 17 license applications to NRC for 26 new reactors. The U.S. Department of Energy has received 19 applications for federal loan guarantees, representing 21 new reactors and loan guarantees of 122 billion dollars.

Given the current business environment, a reasoned perspective on the "renaissance" of nuclear power suggests that it will unfold slowly over time. A successful nuclear renaissance will see, at best, four to eight new plants in commercial operation by 2016 or so. The exact number will, of course, depend on many factors—electricity market conditions, capital costs of nuclear and other base-load technologies, commodity costs, environmental compliance costs for fossil-fueled generating capacity, natural gas prices, customer growth, customer usage patterns (which would be heavily influenced by lower economic growth), availability of federal and state support for financing and investment recovery, and more.

If those first plants are completed on schedule, within budget estimates, and without licensing difficulties, a second wave could be under construction as the first wave reaches commercial operation. The confidence gained by completing the first projects on time and within budget estimates will support the decision-making process for the follow-on projects, and provide incentive for companies to invest in the expansion of the U.S. nuclear component manufacturing sector.

2:40 pm **Break**

Infrastructure Needs for Future Nuclear Power

Patrice M. Bubar, *Session Chair*
U.S. Nuclear Regulatory Commission

3:00 pm **Radiation Protection at U.S. Nuclear Power Plants: Today and Tomorrow**
Michael Blevins
Luminant Power

The nuclear power industry work ethic and culture is founded on learning from experience and continuously finding ways to improve performance; especially in regard

to radiation safety. Over the past 25 y, this process of continuous improvement has yielded dramatic results in regard to radiation protection of workers, the public, and the environment. In light of the resurgence of nuclear energy in the United States, the nuclear power industry is developing strategies to achieve step change improvements to performance and address emerging challenges in the area of radiation protection.

In the area of occupational radiation safety, every plant has a well-developed program for maintaining radiation exposures as low as reasonably achievable (ALARA) that involves all levels of plant workers, radiation protection staff, site management, and company senior management and executives. Work to be performed in a radiologically-significant area is planned, staged and carried out in a manner that will ensure a high degree of radiation and industrial safety and minimize radiation exposures. Following completion of the work, post-job reviews are conducted with the workers to identify lessons learned and plan further improvements for the next time the work is scheduled.

The dose reduction results that have been achieved through this process of continuous improvement have been dramatic. In the past 25 y, the average annual collective dose per reactor was reduced from 7.74 to 1.06 mSv, a sevenfold decrease. At the same time, average annual measurable dose per worker was reduced from 6.6 to 1.4 mSv, more than a fourfold decrease. In the area of industrial safety, the results have been equally dramatic, with a threefold decrease achieved in the industrial safety accident incidence rate over the 10 y period from 1997 to 2006, from 0.38 per 200,000 worker-hours to 0.12. For perspective, the incidence rate for office workers in 2006 (1.7 per 200,000 worker hours) was more than 10 times that for nuclear power plant workers.

Similar results have been achieved and sustained in regard to minimizing public dose from radiological effluents from nuclear power plants. Conservatively estimated doses are a small fraction of regulatory radiation dose limits and are well below regulatory criteria that define ALARA. In addition, nuclear power plants have established programs for ecological stewardship that are reflective of the fundamental compatibility of nuclear power as an energy source with the goals of conservation and protection of the environment.

In consideration of the extended operating period of the current fleet of nuclear power plants and in anticipation of building and operating new plants, the nuclear power industry has formed a working group of utility company executives and nuclear power plant radiation protection program managers to develop industry strategies to prepare for the future and address emerging challenges in radiation protection. The name given to the effort is “RP 2020,” to characterize a planning time frame through the year 2020 that will encompass the period in which the first wave of new nuclear power plants are expected to commence operation.

The working group concluded that simply improving the existing programs and processes would ultimately fall short of what is needed to address emerging challenges, so the mission of RP 2020 has been aimed at “reshaping” radiological protection at nuclear power plants.

The initial focus of RP 2020 (in 2008 to 2009) is on developing and implementing strategies in the area of occupational radiation safety. Examples of strategies that are being pursued include the following:

- reform radiation protection regulations to become more focused on results, rather than process;

- significantly reduce radiation fields that are accessed by workers in the plant;
- improve technologies utilization to facilitate remote monitoring and worker self-protection;
- redefine the roles, skills and qualifications for radiation protection staff;
- improve worker and public access to radiation protection information; and
- standardize radiation protection practices.

In 2009 to 2010, the nuclear power industry will focus on the development of strategies that address public radiation safety and protection of the environment.

3:25 pm

World Nuclear Association's Worldwide Overview on Front-End Fuel-Cycle Growth and Health, Safety and Environmental Issues

Sylvain Saint-Pierre
Steve Kidd
World Nuclear Association

This presentation first presents the World Nuclear Association (WNA) worldwide nuclear industry overview on the anticipated growth of the front-end fuel cycle from uranium mining to conversion and enrichment, and on the related key health, safety and environmental (HSE) issues. This presentation subsequently puts an emphasis on uranium mining in new producing countries with insufficiently developed regulatory regimes that pose greater HSE concerns. It introduces and describes the new WNA policy on uranium mining: sustaining global best practices in uranium mining and processing, principles for managing radiation, HSE, which is an outgrowth of an International Atomic Energy Agency cooperation project that closely involved industry and governmental experts in uranium mining from around the world.

Given the expected expansion of nuclear power over the coming decades, world uranium production must grow quickly in order to meet increasing demand. Production in the existing major uranium producing countries, such as Canada and Australia, will be expanded, but the most significant increases are likely to come from Kazakhstan. *In situ* leaching (a recovery technique led by the Kazakh operations and used elsewhere) is expected to represent a greater share of uranium production. That said, conventional mining (open-pit and underground mines) is expected to remain dominant. Uranium production is also likely to start in some new countries, mainly in Africa. Conversion facilities will be expanded to cope with rising demand, with complete replacement of the present plant in France (AREVA). The most significant feature in enrichment will be the gradual replacement of the older gas diffusion facilities in France (AREVA) and the United States (Usec) by heavy investment in gas centrifuge facilities. Elsewhere, both Urenco and the Russians will likely expand their existing centrifuge capacities. General Electric has invested in the SILEX laser enrichment technology and will try to commercialize it within the next 5 y.

Concerning HSE issues, no key issues are foreseen in connection to the global expansion of conversion and enrichment. In fact, the upgrades of existing and new plants are expected to deliver greater HSE performance. Beyond this, one of the most notable improvements no doubt arises from the change of enrichment technology from older hugely energy hungry gas diffusion enrichment plants to low energy consumption centrifugation enrichment plants. Concerning uranium mining, current HSE performance is expected to continue improving in current uranium

producing countries which benefit from well-established regulatory regimes. Real HSE challenges point rather at new uranium producing countries with insufficiently developed regulatory regimes. Recognizing that managing radiation, health and safety, waste, and the environment is paramount, the worldwide community of uranium mining and processing recently issued the above stated new WNA policy on uranium mining which reflects the global industry commitment by setting out common, internationally-shared principles in these fields that are applicable to sites throughout the world. This new policy serves as a key worldwide reference to establish suitable policies and infrastructures at the world, region and national levels.

3:50 pm

Reactor Based Management of Used Nuclear Fuel: Assessment of Major Options

Phillip Finck
Idaho National Laboratory
Robert Hill
Argonne National Laboratory
John Kelly
Sandia National Laboratory
Roald Wigeland
Idaho National Laboratory

In recent years and throughout the world, concerns about global warming and energy security have prompted a reassessment of the benefits of the nuclear option, with significant plans to deploy new reactors. Simultaneously, pathways for disposing of used nuclear fuel have not yet been deployed. Partitioning of used fuel and transmutation of certain fission products and actinides has been assessed to provide a more sustainable approach to used-fuel management.

We have assessed conventional management schemes, such as the use of mixed-oxide fuel in light-water reactors, and advanced schemes, such as the transmutation of minor actinides in fast reactors. More advanced schemes, such as the use of deep-burn options in advanced thermal reactors have also been assessed.

These options are being compared on several key criteria, including better utilization of repository space, reduction of radiotoxicity, potential consequences on the public, investment and deployment strategies, and long-term energy sustainability issues, including concerns about proliferation of nuclear materials.

This comparison indicates that several technologies, or combination of technologies in advanced systems offer potential for improving all measures simultaneously. Nevertheless, few of these technologies have reached sufficient technical maturity to be deployed today; furthermore, recent progresses in basic sciences and advanced modeling and simulation offer the opportunity to develop novel approaches that will leapfrog current technologies and provide significant improvements for the key criteria described earlier.

This presentation will review these comparisons and propose pathways for a systematic development of the technologies.

The data suggesting this conclusion will be presented.

Future of Nuclear Power Worldwide: Safety, Health and Environment

4:15 pm

International Safeguards and the Global Expansion of Nuclear Power
Thomas E. Shea
Pacific Northwest National Laboratory

Nuclear power is in the minds of many national energy planners today, so many that the Director General of the International Atomic Energy Agency, Mohammed El Baradei, has lost count. For the nuclear renaissance to reach to the far corners of the world, new reactors and new deployment arrangements will help to realize these ambitions. This presentation will address the interest, the means through which that interest might be realized, and the challenges that expansion poses. It will focus on how to manage the proliferation risks, how international safeguards might address the verification requirements, and in particular, how assurances of supply of critical goods and services (especially addressing fuel supply and spent-fuel disposition) may reinforce international efforts to prevent proliferation and nuclear terrorism.

4:40 pm

Break

Thirty-Third Lauriston S. Taylor Lecture on Radiation Protection and Measurements

5:00 pm

Introduction of the Lecturer
Robert L. Brent
Alfred I. duPont Institute

Radiation Epidemiology: The Golden Age and Remaining Challenges
John D. Boice, Jr.
Vanderbilt University, School of Medicine, International Epidemiology Institute

Although the history of radiation epidemiology spans nearly 100 y, it was not until about the mid-1950s that radiation doses were estimated and organ-specific risks quantified in cohort studies. The major studies during the golden age of radiation epidemiology include the atomic-bomb survivors, radium dial painters, underground miners, ankylosing spondylitis patients, cervical cancer patients, children x rayed prenatally, children irradiated for benign conditions, women with tuberculosis fluoroscopically monitored, women with mastitis, patients given Thorotrast®, and patients treated with radiation for a variety of malignant and nonmalignant conditions. These studies remain the foundation of our understanding organ-specific radiation risks and are considered by the various national and international committees when making recommendations for radiation protection of workers and the public. During the past 50 y, there was a shift in emphasis from the study of genetic or heritable effects to somatic effects in the individuals exposed—since no study had found convincing evidence for genetic effects in man. Radiogenic cancers were identified at lower and lower doses providing support for the linear-

nonthreshold model used in radiation protection. The increased radiation exposure to the world's populations has also reinforced the need for knowledgeable scientists to provide balanced evaluations of risks so that benefits are not unduly curtailed. The world continues to need nuclear power for electricity; and medical imaging (computed tomography and positron emission tomography scans) has catapulted medical radiation to the number one contributor to population exposures, surpassing natural background. Below are five studies that exemplify the golden age issues and future opportunities for radiation epidemiology.

1. Breast cancer was increased after repeated chest x-ray fluoroscopies to monitor lung collapse treatments of young women with tuberculosis. Fractionated, though high dose rate, exposures resulted in similar breast cancer risks as acute exposures and the dose response was linear. Lung cancer and leukemia and heart disease, however, were not increased.
2. Cervical cancer patients were at a much lower risk of leukemia than atomic-bomb survivors, indicating that cellular killing predominates over cell transformation when high radiotherapeutic doses are delivered to small volumes of tissue. Cancers of other organs, such as the rectum and bone, appear increased only after enormous radiotherapy exposures. Some organs, such as the stomach and pancreas, receive low dose scatter and provide evidence for and against radiation effects at nontherapeutic dose levels.
3. An association between prenatal x-ray exposures and childhood cancers has been repeatedly found in case-control studies. Despite the absence of individual dose reconstructions, these studies are put forward as demonstrating low dose radiation effects. Such claims, however, are not entirely well-founded. No cohort study has revealed an increase in childhood cancer following *in utero* exposure. The remarkable similarity (in case-control studies) in all the relative risk estimates for all the different childhood cancers (all ~1.5) suggests a bias, as does the unlikelihood that embryonic tumors such as Wilms would be induced following a pelvimetry x ray given just a week or so before birth. *En passant*, studies of populations living near nuclear installations in the United States and other countries have not confirmed a causal association between radiation exposures and childhood leukemia—any possible exposures are likely small.
4. Studies of underground miners around the world have clearly demonstrated that radon is a lung carcinogen; the linearity of the dose response in all cohort studies is noteworthy as is the absence of elevations in other cancers. Studies of indoor radon support an association at low doses, but risk estimates for protection purposes remain focused on the robust underground miner data at low radon concentrations.
5. Finally, radionuclide intakes by workers exposed in the 1950s and 1960s are being incorporated into epidemiologic studies following comprehensive dose reconstructions such as among Pratt and Whitney Rocketdyne® workers exposed primarily to uranium compounds. Organ-specific dose from internal radiation accrues over time and is the proper metric for risk analyses, and not effective dose (a radiation protection quantity).

So what are the challenges remaining for epidemiology? While we know that radiation causes cancer, there are a surprising

large number of cancers for which an association with radiation is not convincing. These include cancers of the cervix, uterus, testes, prostate, pancreas and kidney, and blood disorders such as chronic lymphocytic leukemia, Hodgkin and non-Hodgkin lymphoma, and multiple myeloma. The ameliorating effect of lowering the rate of exposure over time needs to be convincingly demonstrated for specific cancers. Lumping all cancers together for inferences may be useful for radiation protection but is of questionable biological validity; thus more pooled analyses of specific organs should be encouraged. Finally, more knowledge is needed on the effects of intakes of radionuclides and on possible noncancer effects.

6:00 pm **Reception in Honor of the Lecturer**

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Tuesday, March 3

8:20 am **NCRP Annual Business Meeting**

9:20 am **Break**

Key Challenges to be Addressed for Nuclear Power in the 21st Century

Audeen W. Fentiman, *Session Chair*
Purdue University

9:40 am **Essential Infrastructure: National Nuclear Regulation**
Carl J. Paperiello
U.S. Nuclear Regulatory Commission (retired)

In order for nuclear power to expand to many countries that do not currently have it, it will be essential for these countries to have laws, regulations, guidance and organizations that can license or permit nuclear power plants and support nuclear facilities, ensure compliance by inspection, and enforce nuclear regulations. These are necessary both because the viability of nuclear power worldwide depends on an extremely high level of safety, and compliance with a number of international treaties is required before nations will supply the material, hardware and software to build and operate nuclear power plants. While infrastructure support can be obtained from the International Atomic Energy Agency (IAEA) and other countries, an essential core must exist in the country seeking to establish domestic nuclear power generation. Further, while some reliance can be placed on the safety reviews of standard reactor designs by the nuclear regulators in

supplier nations, the certification of fuel design, the quality of instruments, and the matching of the reactor to a proposed site in the importing nation will require site-specific reviews. National arrangements are also needed for emergency preparedness, environmental protection, transportation and the storage of fuel, and transportation and disposal of radioactive waste. Furthermore, even if foreign contractors and consultants are engaged to perform much of the technical work for the regulatory body that has to be performed by the importing nation, that nation must have a core cadre of technically knowledgeable regulators and an organization to provide management and oversight of the contractors and consultants. These technical skills encompass a broad range of engineering disciplines, not just nuclear engineering, earth sciences, environmental sciences, radiation protection, physical security and material control, and accountability to identify a few. IAEA has a number of programs to support the development of national nuclear regulatory infrastructures. These programs address: nuclear safety standards, nuclear installation safety, radiation safety, the safety of radioactive waste management, decommissioning, safety and security of radioactive sources, incident response and emergency preparedness, and training and education relative to these areas. Consistency in national nuclear regulations and requirements, the deployment of standardized nuclear power plant designs, and standardized supporting material infrastructure can promote the safe and secure worldwide growth in nuclear power.

10:05 am

Maintaining a Highly-Qualified Nuclear Industry Workforce

Carol L. Berrigan
Nuclear Energy Institute

Despite nuclear power's vital role in the U.S. economy, the nuclear utility industry faces the same staffing challenges as the rest of the utility workforce and the American workforce at large. Aging demographics play a role in human resource concerns. However, the commonalities of the fields that are hiring reveal that the labor market is tightening. Companies must prepare for increased competition for qualified and experienced workers and craftspeople.

Overall, the nuclear industry is responding to this challenge. The 2007 Nuclear Energy Institute Workforce Survey indicates that industry efforts are translating into an increasing number of young employees at nuclear vendors and within the nuclear utilities in the engineering and operations fields. There is an increased focus across the industry on developing maintenance staff, radiation protection technicians, and other specialized personnel as new educational programs and partnerships are developed.

With expanded staffing requirements to support new nuclear plants, growing competition from other sectors, and increasing attrition rates of current employees due to retirement and other attrition, the nuclear industry must continue to expand its aggressive efforts to maintain its highly-qualified staff today and develop its future workforce.

The nuclear industry has responded to workforce trends. It has engaged organized labor, government, educational institutions, and nonprofit organizations. These collaborations have had many positive results from development of national demand projections for technicians, power plant operators, and engineers to increasing awareness of nuclear careers among teachers, students and workforce development professionals.

Recruitment efforts across the industry have been enhanced, increasing the number of new hires in several disciplines and targeting untapped labor pools like veterans and minorities. Industry-based curricula and new educational programs have been created and deployed to develop local talent pools. Policy makers have also been engaged at the national, regional and local levels to increase career awareness and allow the industry to leverage its workforce development investments with the public sector funds. In addition, industry has begun a systematic engagement with the public workforce and education systems to ensure that the energy and construction sectors are viewed as a priority in state-based workforce development and education programs.

In addressing the workforce issue, the nuclear power industry is pursuing these key goals:

- systematically assess industry staffing requirements;
- develop and promote programs to increase the quality and quantity of the available workforce;
- develop and deploy programs, tools and techniques to retain and recruit employees; and
- develop and deploy programs to provide additional resources to educate and train employees.

Across industry, government and nonprofits, nuclear industry activities are succeeding and continue to evolve. The examples and good practices outlined in this presentation demonstrate how collaboration helps to align investments, build career awareness and image, and lay the foundation to recruit and train workers within the nuclear field and across the broader energy industry.

10:30 am **Break**

10:45 am **U.S. Department of Energy Facilities Needed to Advance Nuclear Power**
John F. Ahearne
Sigma Xi

Based on several reviews of existing U.S. Department of Energy (DOE) facilities, many high-priority facilities require moderate to significant investment before they can provide the capabilities needed by the DOE Office of Nuclear Energy. The studies show the importance of emphasizing international collaboration, especially with respect to longer-term, high-cost research and development goals, such as in developing recycling and fast-reactor capabilities. A depressing story was revealed of decayed or decaying facilities that in most cases are not suited for their intended uses without significant and often expensive refurbishments. However, even if aggressive new power plants and advanced programs do not proceed, the United States needs a robust set of nuclear research facilities. International collaborations should be increased, especially in the current climate of stringent budgets.

Some research and development programs would be the same whether there are no new builds, a few builds, or many builds. Research and development is needed:

- to keep current plants running well and avoid any surprises, including aging phenomena;
- to encourage a new cadre of engineers and scientists to become involved in nuclear energy;
- on waste management; and
- to maintain the United States as a major participant in international nuclear power discussions.

Abstracts: Tuesday, March 3

11:10 am

New Nuclear Build and Evolving Radiation Protection Challenges

Edward Lazo
OECD Nuclear Energy Agency

Radiological protection has continued to evolve in order to meet emerging challenges and will continue to do so. This presentation will discuss the scientific and social challenges that will or may be faced by the radiological protection community in the coming 10 to 20 y, and will discuss how these challenges may affect what is expected to be a renewed interest in building and operating nuclear power plants for electricity generation.

11:35 am

Communicating with Stakeholders about Nuclear Power Plant Radiation

Ann Stouffer Bisconti
Bisconti Research

A national public opinion survey taken on September 18–21, 2008 for the Nuclear Energy Institute added new insights about perceptions of radiation and radiation from nuclear power plants, as well as effective strategies for communicating with stakeholders. Bisconti Research conducted the survey with the GfK Group, based on telephone interviews with a nationally representative sample of 1,000 U.S. adults, margin of error of plus or minus three percentage points.

Perceptions of Radiation

The survey found that misperceptions about radiation persist and have changed little over the past 18 y. Most Americans understand that we receive radiation from nature, but almost half of them still believe that radiation from nuclear power plants is more harmful than the same amount of radiation from the sun. Almost half also believe that any amount of radiation is harmful. One-third of Americans do not know that radiation is easily detected and measured.

Perceptions of Radiation from Nuclear Power Plants

The survey repeated a question from 1991 about which of six activities would expose a person to the most radiation, including "living next to a nuclear power plant for a year." The largest number chose chest x ray (38 %). Those ranking the nuclear power plant first dropped from 58 to 30 % (a 28 percentage-point drop). Also, 41 % said it is likely that people living next to a nuclear power plant are exposed to harmful levels of radiation, compared with 58 % in 2001. These improvements may be due to increased public support for nuclear energy resulting from growing awareness of the need for nuclear energy and its benefits. As of September 2008, 74 % favored the use of nuclear energy. Need trumps fear.

Messages about Radiation from Nuclear Power Plants

The survey tested messages about radiation from nuclear power plants in three ways: emotional appeal, rational appeal, and analogies to put the amount of radiation in perspective. Best points communicate how radiation is controlled and about the many beneficial uses of nuclear technologies. Talking about beneficial uses makes the nuclear technologies more familiar and communicates the ability to control radiation. As in past research, analogies are more effective with men than with women. The messages altogether had a 10-point impact on attitudes. Credibility of the spokesperson may be essential to gain more extensive shifts away from ingrained beliefs about nuclear power plant radiation.

12:20 pm **Lunch**

1:30 pm **Role of the International Radiation Protection Association**

Kenneth R. Kase
Philip Metcalf
International Radiation Protection Association

Global concerns over energy supply and climate change have given rise to a noticeable increase in uranium prospecting, mining and extraction in a number of countries. Many countries are contemplating the introduction of nuclear energy and the changing world economy is spreading the use of advanced nuclear and radiation-related technologies to many parts of the world. International concerns over nuclear proliferation have given rise to global initiatives on nuclear energy and operation of nuclear fuel-cycle facilities. The emerging global nuclear safety regime, with binding international conventions continues to promote and encourage high standards of radiation safety worldwide. All these developments call for increasing capacity and capabilities in radiation protection expertise. These developments have and continue to present both challenges and opportunities to the International Radiation Protection Association (IRPA).

An association of 48 radiation protection societies representing 61 countries with an individual membership of approximately 17,000, IRPA is engaged in fostering the development of competent radiation protection programs in developing countries and mentoring the formation of new radiation protection societies. IRPA also fosters the exchange of scientific and technical information and provides a venue for interaction and communication among radiation protection professionals through its International Congresses on Radiation Protection, most recently in Buenos Aires in October 2008. Future congresses are planned for Glasgow in 2012 and Cape Town in 2016. Midway between these congresses, IRPA sponsors and assists member societies in holding regional congresses. In 2010, congresses will be held in Tokyo in May, Helsinki in June, Nairobi in September, and Medellin in October.

IRPA also promotes the scientific and professional recognition of the radiation protection expert. One significant step forward in this area has been the success of a petition by IRPA to the International Labor Organization to recognize and include radiation protection in the listing of recognized occupations. Linked to this initiative IRPA adopted a definition of the "radiation protection expert" and has proposed its inclusion in the revision of the International Atomic Energy Agency (IAEA) Basic Safety Standards that is currently underway. Related to this activity IRPA continues to engage with regional and international initiatives to harmonize approaches to qualifications and recognition by combinations of training, experience, examination and evaluation by peers. Continuing education and professional enhancement programs are a significant part of each IRPA congress. Close collaboration with the IAEA generally results in IAEA training events being scheduled in conjunction with IRPA congresses.

A number of other activities are designed to enhance the effectiveness of radiation protection practitioners in the implementation of nuclear technologies. Recognizing the ethical dimensions of the role played by radiation protection practitioners in the health and safety of persons working with radiation and of the public living near nuclear installations and

facilities using radioactive materials or radiation generating devices, the IRPA Code of Ethics was developed and has been adopted or used by many associate societies. IRPA has embarked on the development of guidelines for the conduct of stakeholder engagement to address the importance of engaging stakeholders (people or organizations interested or affected by activities involving occupational or public exposure to radiation) and discussing radiation effects and risks as part of a decision-making process. IRPA recently began work on an initiative proposed by the French Society for Radiation Protection designed to maintain and improve current levels of radiation protection and transfer this culture to the new generation of radiation protection professionals. This is a multi-year project to develop guidance for maintaining and improving the radiation protection culture as part of an overall safety culture. The guidance would include standards for teaching, offer the basic tools needed, establish qualifications for radiation protection experts, and assist in forming radiation protection societies. These IRPA projects are discussed and refined through the Associate Society Forum discussions that are held at each IRPA international and regional congress.

1:50 pm

Panel on How to Meet the Challenges for Nuclear Power
Mary E. Clark, *Moderator*
U.S. Environmental Protection Agency

Panelists:

Nuclear Power Expansion: Challenges and Opportunities
Paul W. Lisowski
U.S. Department of Energy

Increases in demand for energy and growing concerns about climate change have started a substantial worldwide expansion of nuclear electric power. Nations with mature nuclear installations are working to maintain the existing high standards of safety and reliability and to address the challenges of maximizing plant lifetime and managing used nuclear fuel. Increased use of nuclear energy for unconventional applications such as desalinization and production of hydrocarbon liquid fuel from coal without concomitant carbon emissions are under consideration. Those efforts require increased infrastructure investment and, in some cases, research and development to successfully move ahead. Geologic repositories must be made available for used fuel and for the residual high-level radioactive waste from recycling. Nations moving towards initial nuclear power deployment must develop the intellectual, regulatory and technical foundations before construction and operation. For international security reasons, the expansion of nuclear power to new nations must avoid the need for indigenous enrichment or reprocessing facilities. For that reason essential elements of the expansion need to include reliable fresh fuel supply and used-fuel recovery together with enhanced material accountability and safeguards. In light of this, the United States launched the highly successful Global Nuclear Energy Partnership. The Partnership has developed a statement of principles to accomplish the above goals and has put in place a management framework used by 25 nations working to achieve safe, secure nuclear power expansion.

Future of Nuclear Power Worldwide: Safety, Health and Environment

Within the United States, the Advanced Fuel Cycle Initiative is successfully developing fuel-recycling technologies that increase utilization of reactor fuel, diversify our fuel supply, simplify management of used nuclear fuel, and reduce the long-lived waste radiotoxicity. Successfully completing the research and development necessary to initiate recycling in those areas will be vital to sustaining the U.S. long-term use of nuclear energy.

Three Most Important Actions for the Growth of Nuclear Power

Wayne L. Johnson
Pacific Northwest National Laboratory

There is broad and increasing recognition that nuclear energy must play a role domestically and internationally in meeting energy needs in the 21st century. Nuclear energy's growing acceptance is most often attributed to the fact that it is a base-load source of electricity which has virtually no carbon emissions and can help reverse the adverse impacts of global warming; however, it is also due to the greatly improved operational performance of reactors worldwide.

Despite the favorable conditions for the growth of nuclear energy, there is little agreement on the specifics of fuels, reactor types, fuel cycles, and waste disposal practices. Furthermore, the support for nuclear energy is fragile and could be hampered or derailed by even a minor accident, terrorist threat (real or hoax), cost or schedule overruns, or a number of other events. While it is absolutely necessary to do all we possibly can to prevent these events, or limit their direct impact, some negative events will invariably occur.

Most major nuclear projects take up to 20 y from initial planning through design, licensing, construction and start up. What are the three most important actions which could be taken by government or industry in the next 4 y to provide a predictable and stable base for the global growth of nuclear power? Clearly there are a number of important actions to consider, including the timely licensing of future plants, capital cost reductions and the financing of new and advanced reactors, closing the fuel cycle with either light-water or fast reactors, the opening of a repository for radioactive waste disposal, prevention of nuclear proliferation, and of course, continued safe operation. National decisions will be important, but international institutions such as the International Atomic Energy Agency can also play an important role. This will identify a range of important actions for consideration, and then focus on the top three actions that are necessary, explain why, and elaborate on the impact each action will have.

How to Meet the Challenges Reinvigorating the Research and Development Community and Infrastructure

Mark T. Peters
Argonne National Laboratory

The world energy demand is increasing at a rapid pace. In order to satisfy the demand and protect the environment for future generations, future energy sources must evolve from the current dominance of fossil fuels to a more balanced, sustainable approach to energy production. The future approach must be based on abundant, clean and economical energy sources. Therefore, because of the growing worldwide demand for energy and need to minimize greenhouse gas emissions, there is a vital and urgent need to establish safe, clean and secure energy

sources for the future. Nuclear energy is already a reliable, abundant and carbon-free source of electricity for the United States and the world. In addition to future electricity production, nuclear energy could be a critical resource for "fueling" the transportation sector (*e.g.*, process heat for hydrogen and synthetic fuel production, electricity for plug-in hybrid and electric vehicles) and for desalinated water. Nuclear energy must experience significant growth to achieve the goals of our future energy system. To allow the necessary growth, many challenges must be met, including a concentrated effort to rebuild the necessary nuclear enterprise, including a broad-based research and development (R&D) effort.

To reduce cost, ensure sustainability, and improve efficiency, safety and security, investments in a sustained nuclear science and technology R&D program are needed. Such a program must effectively support and integrate both basic and applied research and use, to the extent possible, modeling and simulation capabilities to address both near-term, evolutionary activities (*e.g.*, life extensions of the current fleet) and long-term solutions (*e.g.*, advanced reactors and fuel-cycle facilities). Industry will pursue evolutionary R&D to further improve efficiencies along each step of the current fuel cycle. It is incumbent upon the government to implement long-term R&D programs for developing transformational technologies and options for advanced nuclear fuel cycles. Including regulators in the research and evaluation of results will facilitate the development of licensing and regulation of future nuclear facilities and technologies.

Finally, training the next generation of engineers and scientists must be an integral part of a robust nuclear program. To satisfy the need, government and industry must both play important roles to stimulate workforce development by providing an environment that is exciting and thriving. Industrial and federal government commitment will be required to reinvigorate university and national laboratory programs. In addition, R&D infrastructure must include modern capabilities, such as irradiation systems for testing new fuels and structural materials; chemical separations and characterization capabilities; and physics facilities for radiation transport, thermo-hydraulics, cross-sections, and criticality science. These and other capabilities require modern facilities, as our current R&D infrastructure has atrophied and is becoming obsolete. Modeling and simulation technologies have made tremendous advances since the design of existing facilities. The design of the next-generation facilities must incorporate state-of-the-art testing and diagnostics tools and be guided by the data requirements for advancing the realism and accuracy of high-performance simulation tools and approaches.

Outlook for Nuclear Energy in a Shifting Political Climate

Annie Caputo
House Committee on Energy and Commerce

Driven by several positive factors, U.S. utilities have shown strong interest in building new nuclear plants for the first time in 30 y. These positive factors include passage of incentives in the Energy Policy Act of 2005, the increasing likelihood that the federal government may pass legislation limiting the emission of greenhouse gases, and the growing demand for electricity. While several of these positive factors remain, there are also many challenges including waste management,

regulatory stability, and project financing. The new presidential administration, the economic crisis, and changing Congressional attitudes toward nuclear power will have a significant impact on the development of new plants. This presentation will attempt to give a snapshot of how new nuclear construction may fare in this shifting political climate.

Low-Level Radioactive Waste Management: Status, Challenges and Solutions

Michael T. Ryan
Michael T. Ryan and Associates, LLC

The historical foundations and future challenges for commercial low-level radioactive waste (LLRW) management in the United States will be presented. LLRW has been managed at government facilities since the beginning of the nuclear age and in the commercial sector since the early 1960s. Over the intervening years many technical, management and regulatory changes have occurred. Significant progress has been made in waste form, waste packaging, and in recognizing radionuclides important to performance of disposal technologies and disposal facilities. This presentation will examine approaches that can be used under existing regulations and risk-informed approaches to improve and clarify guidance used to develop and evaluate disposal facilities during the licensing process, operational phase, and ultimately during the closure of LLRW facilities. The management of LLRW has been successfully achieved in the commercial sector in the Unites States. Additional successes can be achieved by taking advantage of past operating experiences as well as continuing improvements in LLRW treatment, packaging and disposal technologies. Combining these successes and process improvements with risk-informed decision making can perhaps improve the management of these wastes while at the same time making the regulatory process more transparent for practitioners, stakeholders, and the public.

Challenges and Opportunities of a Global Nuclear Energy Future

Thomas Isaacs
Stanford University
Lawrence Livermore National Laboratory

Global warming, energy security, energy adequacy, and environmental protection are among the factors causing renewed attention to new nuclear power. Whether or not there will be what qualifies as a "nuclear renaissance" in the coming 20 y or so, it is quite likely that there will be a return to the construction of nuclear power plants. In some cases these programs will result in a growth of nuclear power within nations that already have operating plants. In other cases, it is likely that countries that currently do not have nuclear power plants or have very few will begin a program, resulting in the spread of facilities and expertise.

One of the concerns that arises, particularly with the envisioned spread of nuclear power is the potential impact on nuclear security. Will the potential for more opportunities for nuclear power raise more opportunities for nuclear proliferation, "latent" proliferation, regional instability, or acts of nuclear terrorism?

Much attention is being paid recently to the possible formulation of initiatives to provide assured fuel supplies to countries

starting or adding to their nuclear capabilities. The principal rationale is to provide sufficient assurances that countries will have access to the fuel they need to run these plants for the 40 to 60 y they will be in operation. It is hoped that they will then be willing and able to forgo the development of indigenous enrichment capabilities needed to supply reactor fuel, since enrichment plants can bring nations to the doorstep of a nuclear weapons capability.

Though many have discussed in passing the need to also consider the "back end" of the nuclear fuel cycle, spent fuel, waste management, interim storage, reprocessing, and ultimate disposal, it has received much less attention to date. Yet this is likely to be the element of the fuel cycle with which most nations, and new nuclear nations in particular, will need and appreciate the most assistance.

Is it possible that by addressing all challenges associated with the entire fuel cycle together and throughout time, we stand a better chance of simultaneously meeting energy security, national security, nonproliferation, and waste management objectives than if we address these as separate issues?

3:15 pm **Break**

3:35 pm **Rapporteur Summary**
Michael L. Corradini
University of Wisconsin-Madison

4:15 pm **Questions and Comments from the Audience**

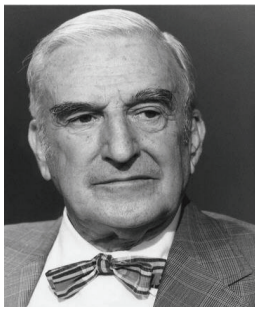
4:50 pm **Closing Remarks**
Thomas S. Tenforde
President, National Council on Radiation Protection and Measurements

5:00 pm **Adjourn**

Mission Statement

The National Council on Radiation Protection and Measurements (NCRP) seeks to formulate and widely disseminate information, guidance and recommendations on radiation protection and measurements which represent the consensus of leading scientific experts. The Council monitors areas in which the development and publication of NCRP materials can make an important contribution to the public interest.

The Council's mission also encompasses the responsibility to facilitate and stimulate cooperation among organizations concerned with the scientific and related aspects of radiation protection and measurements.



Lauriston S. Taylor
1929–1977

Warren K. Sinclair
1977–1991

Charles B. Meinhold
1991–2002

Thomas S. Tenforde
2002–

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Tuesday, March 3, 2009	7:00 am – 1:00 pm

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M.L. Miller [published in Health Physics **93** (2007) 596]

"The report [NCRP Report No. 138] is directed particularly to expert groups and public authorities who will be responsible for coping with actual, potential and rumored releases of radiation."

"With commendable foresight, the NCRP initiated the committee some years ago with support from the U.S. Department of Energy, and its work was concluded prior to the terrorist attacks of September 11, 2001."

N. Wald [published in Radiation Research **158** (2002) 812-813]

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