



Workshop on Small- and Medium-Sized Nuclear Reactors (SMRs)

October 8 & 9, 2009

Workshop on Small- and Medium-Sized Nuclear Reactors (SMRs)

Agenda (Thursday)

- Opening Remarks Michael Johnson, Director
NRC/Office of New Reactors
- Opening Remarks (9:00) The Honorable Gregory B. Jaczko
Chairman, NRC
- 9:30 DOE Perspectives
Richard Black, DOE/NE
- 10:00 Break
- 10:15 NEI Perspectives
Paul Genoa, Nuclear Energy Institute

Workshop on Small- and Medium-Sized Nuclear Reactors (SMRs)

Agenda (Thursday)

- 10:45 -12:00 NRC Advanced Reactor Activities
- 12:00 – 1:00 Lunch
- 1:00 – 1:30 Overview of Generic Issues
- 1:30 - 2:30 Licensing Issues
- 2:30 – 3:00 Design Basis Issues
- 3:00 Break
- 3:15 – 4:15 Staffing, Human Factors, & Operational Issues
- 4:15- 4:45 Process Heat Applications
- 4:45 – 5:00 Meeting Wrap-up

Workshop on Small- and Medium-Sized Nuclear Reactors (SMRs)

Agenda (Friday)

- 8:30 – 9:00 Security Requirements and SGI Protection
- 9:00 – 9:30 Aircraft Impact Assessments
- 9:30 – 10:15 Financial Issues
- 10:15 Break
- 10:30 – 11:00 Offsite Emergency Preparedness
- 11:00- 11:30 International Activities
- 11:30 – 12:00 General Discussions & Future Activities



Workshop on Small- and Medium- Sized Nuclear Reactors (SMRs)

Opening Remarks

**Michael R. Johnson, Director
Office of New Reactors**



Workshop on Small- and Medium- Sized Nuclear Reactors (SMRs)

Opening Remarks

The Honorable Gregory B. Jaczko
Chairman
U.S. Nuclear Regulatory Commission



U.S. DEPARTMENT OF
ENERGY

Nuclear Energy

DOE Perspectives

Richard Black

**Associate Deputy Assistant Secretary,
Office of Nuclear Energy
US Department of Energy**



Workshop on Small- and Medium-Sized Nuclear Reactors (SMRs)

Break





Nuclear Energy Institute (NEI) Perspectives

Paul H. Genoa
Director, Policy Development
Nuclear Energy Institute



NRC Activities and Organization

**Michael E. Mayfield, Director
Advanced Reactor Program
Office of New Reactors**

NRC Organization

- Office of New Reactors (NRO)
 - ⊕ New Reactor Licensing Program
 - ⊕ Construction Inspection Program
 - ⊕ Advanced Reactor Program
- Office of Nuclear Regulatory Research (RES)
- Office of Nuclear Security and Incident Response (NSIR)
- Office of Nuclear Material Safety and Safeguards (NMSS)

NRC Activities

- Office of New Reactors
 - ⊕ Priority to new reactor licensing and construction inspection for facilities to be constructed around 2016-2017
 - ⊕ Advanced Reactor Program
 - Priorities:
 - building organization (staffing, resources)
 - developing regulatory infrastructure and addressing generic policy issues for SMRs
 - Preparations for Next Generation Nuclear Plant (NGNP) applications
 - Preparations for other near-term SMR applications (e.g., integral PWR designs)

NRC Activities

- Office of Nuclear Regulatory Research
 - ⊕ Current RES focus is related to high temperature gas-cooled reactor technology (NGNP)
 - Coordination of research activities with DOE
 - Development of analytical models and tools
 - Materials and high temperature environments
 - ⊕ Limited activities in computer code development/assessments for integral PWRs and SFRs

Next Generation Nuclear Plant (NGNP)

**William Reckley, Branch Chief
Advanced Reactors Branch 1
Advanced Reactor Program
Office of New Reactors**

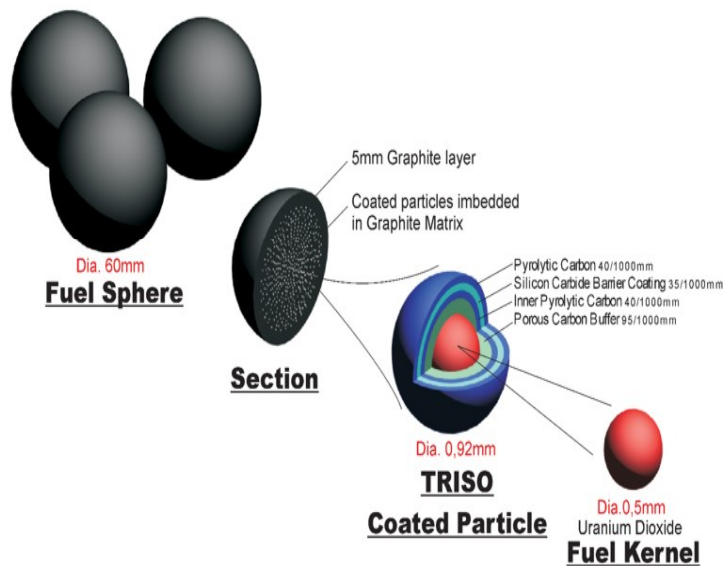
Next Generation Nuclear Plant (NGNP)

- Energy Policy Act of 2005
 - ⊕ The NRC shall have licensing and regulatory authority....
 - ⊕ The DOE and NRC shall jointly submit ...a licensing strategy for the prototype nuclear reactor...
 - August 2008 report states success depends on:
 - productive use of pre-application period (now to 2013)
 - meeting major milestones, including supporting research and code development
 - developing supporting regulatory infrastructure
 - ⊕ No later than September 2021, complete construction and begin operation...

NGNP - Technology

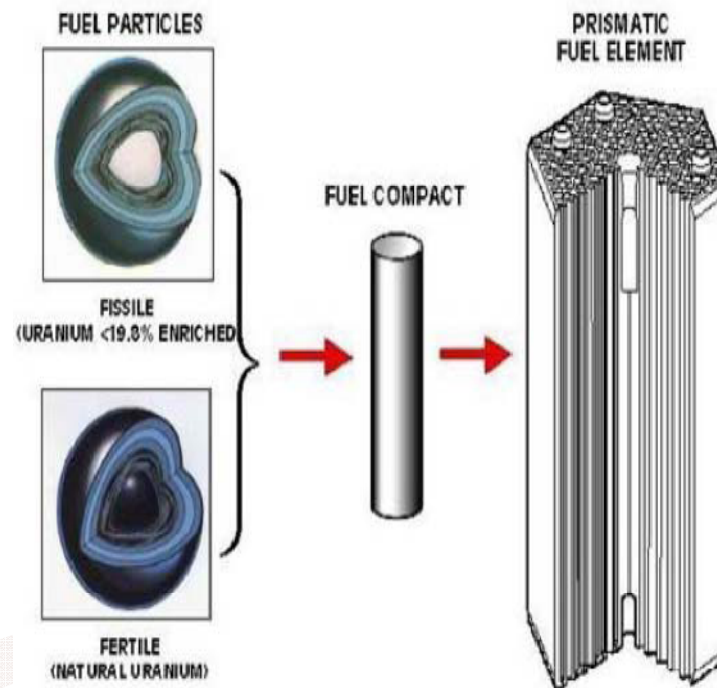
- High temperature gas-cooled reactors

FUEL ELEMENT DESIGN FOR PBMR



Pebble
(e.g., Pebble Bed Modular Reactor (PBMR))

Prismatic
(e.g., Areva Antares & General Atomics Modular Helium Reactor (MHR))



NGNP – Current Activities

- Evaluating existing requirements and guidance to identify needed changes (gaps)
- Identifying significant policy and key technical issues
- Developing overall licensing plan that coordinates:
 - ⊕ DOE/vendor research and development
 - ⊕ NRC confirmatory research & development of evaluation tools
 - ⊕ Required changes to regulations, policies, and guidance
 - ⊕ Development of infrastructure and technical expertise for new technology

Integral Pressurized Water Reactors

**Stewart Magruder, Branch Chief
Advanced Reactors Branch 2
Advanced Reactor Program
Office of New Reactors**

Integral Pressurized Water Reactors

- Technology
 - ⊕ Pressurized Water Reactors with nuclear steam supply components (e.g., steam generator, control rods, reactor coolant pumps) within the reactor vessel
- Current pre-application discussions regarding:
 - ⊕ Westinghouse IRIS
 - ⊕ NuScale
 - ⊕ B&W mPower

Integral PWRs – current activities

- Evaluating existing requirements and guidance to identify needed changes (gaps)
- Identifying significant policy and key technical issues
- Developing overall licensing plan that coordinates:
 - ⊕ NRC confirmatory research & development of evaluation tools
 - ⊕ Required changes to regulations, policies and guidance
 - ⊕ Development of infrastructure and technical expertise for new technology

Other Technologies

**William Reckley, Branch Chief
Advanced Reactors Branch 1
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Office of New Reactors**

Sodium-Cooled Fast Reactors (SFRs)

- Some pre-application interactions regarding:
 - ⊕ Toshiba 4S
 - ⊕ General Electric PRISM
- Distinction between SMR for remote locations and SFR as part of nuclear fuel cycle
- Evaluating potential research and licensing programs for future activities

Other Technology Groups

- Staff aware of some other efforts related to various other designs:
- Generation IV
 - ⊕ **Gas-Cooled Fast Reactor (GFR)**
 - ⊕ **Very High Temp Reactor (VHTR)**
 - ⊕ **Supercritical-Water Cooled Reactor (SCWR)**
 - ⊕ **Sodium-Cooled Fast Reactor (SFR)**
 - ⊕ **Lead-Cooled Fast Reactor (LFR)**
 - ⊕ **Molten Salt Reactor (MSR)**
- Hyperion Power Module
- Accelerator-Driven System (ADS)
- Fusion & Fission-Fusion Hybrids

Infrastructure & Generic Issues

- Infrastructure
 - ⊕ Organization & Staffing
 - ⊕ Contracting Strategy
 - ⊕ Training, Tools, & Guidance
- Generic Issues
 - ⊕ Address generic issues introduced or proposed by various SMR vendors

NRC Activities, Technology Groups and Design Centers

- General Discussion



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Lunch

Generic Issues

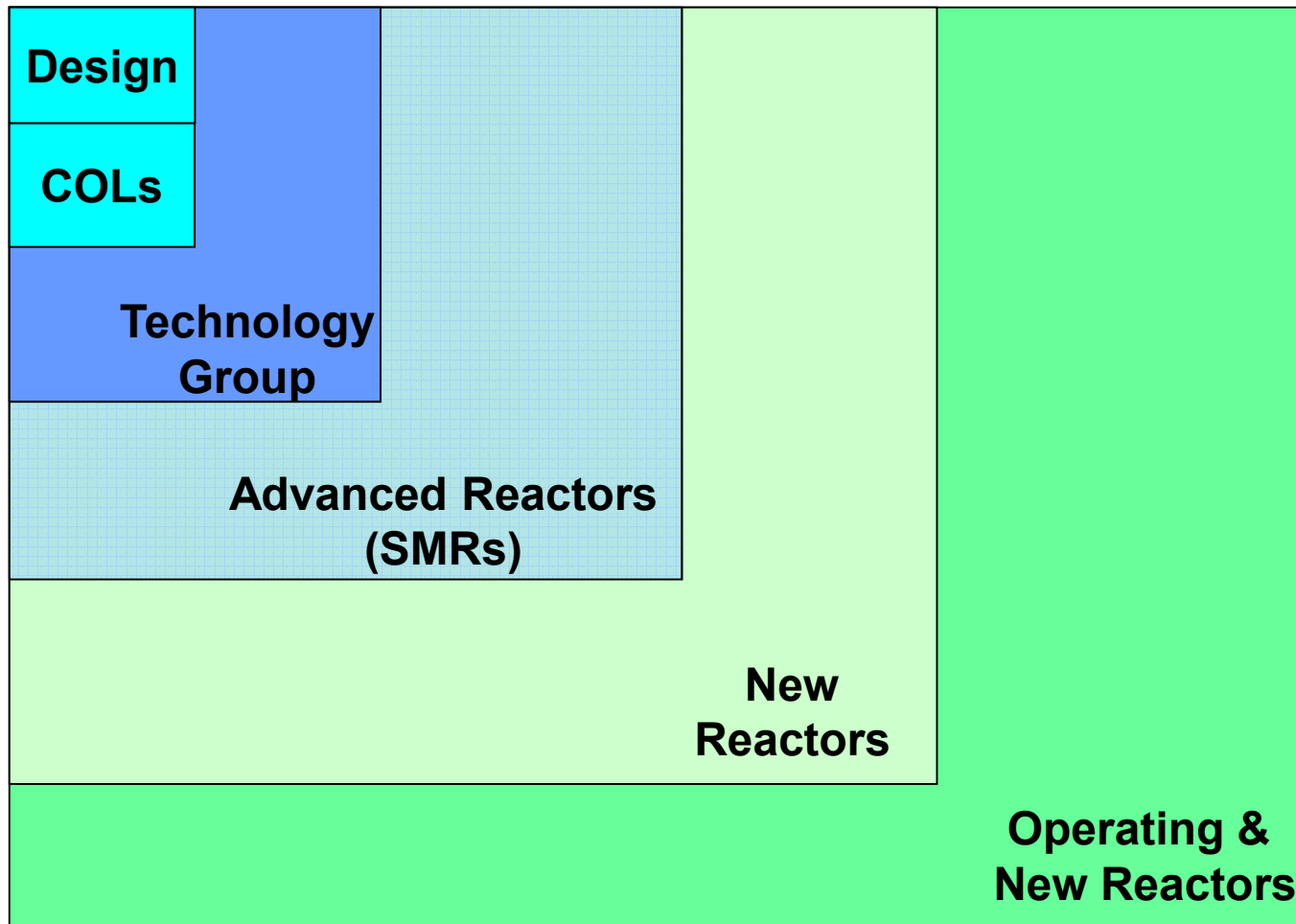
William Reckley
Advanced Reactor Program
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Generic Issues

- Many types of generic issues
 - ⊕ Generic to all nuclear reactors (including current generation facilities)
 - ⊕ Generic to new reactors (e.g., Part 52 issues)
 - ⊕ Generic to small- & medium-sized reactors (SMRs)
 - ⊕ Generic to technology groups (HTGRs, SFRs, iPWRs)

Overview of Generic Issues

Design Center



Generic Issues

- Need to address issues generically where possible
 - ⊕ Defines issues and stakeholders
 - ⊕ Yields common resolution
 - ⊕ Conserves resources
- Note that many of the generic issues relate to topics that are more traditionally associated with facility licensing versus design reviews

Generic Issues

- Resolution of generic issues could include:
 - ⊕ Legislation
 - ⊕ Rulemaking
 - ⊕ Commission Policy Statements
 - ⊕ Staff technical positions
(regulatory guides, interim staff guidance, standard review plans, safety evaluations, etc.)
 - ⊕ Industry codes and standards, NEI guidance, technology group reports, etc.

Generic Issues

- Examples:
 - ⊕ Price Anderson Act
 - ⊕ NRC fee rule
 - ⊕ Regulatory design and safety requirements for HTGRs, SFRs, etc.
 - ⊕ Emergency preparedness requirements
 - ⊕ Process heat applications

NRC Interactions with Industry on Generic Issues

- NRC Coordination
- NEI coordination
- Industry Groups
- Combinations of above

Generic Issues

- General Discussion

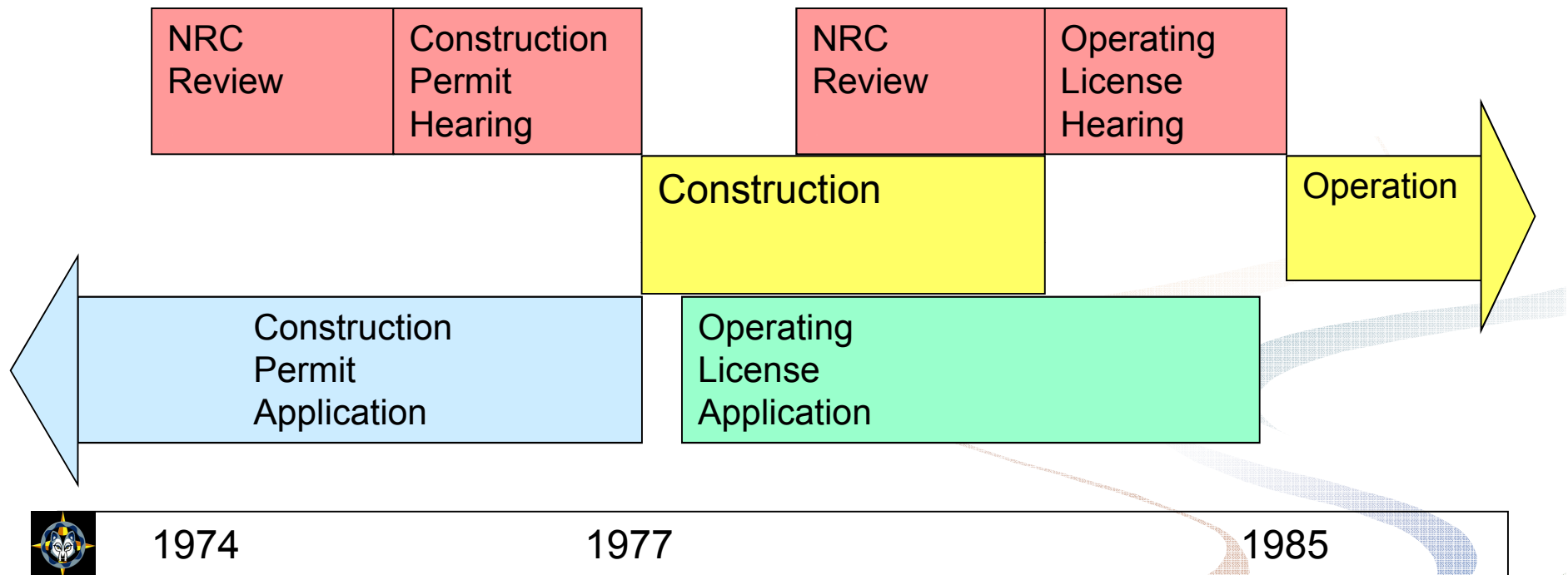


Licensing Issues

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Licensing Issues

- Part 50 Licensing Process



1974

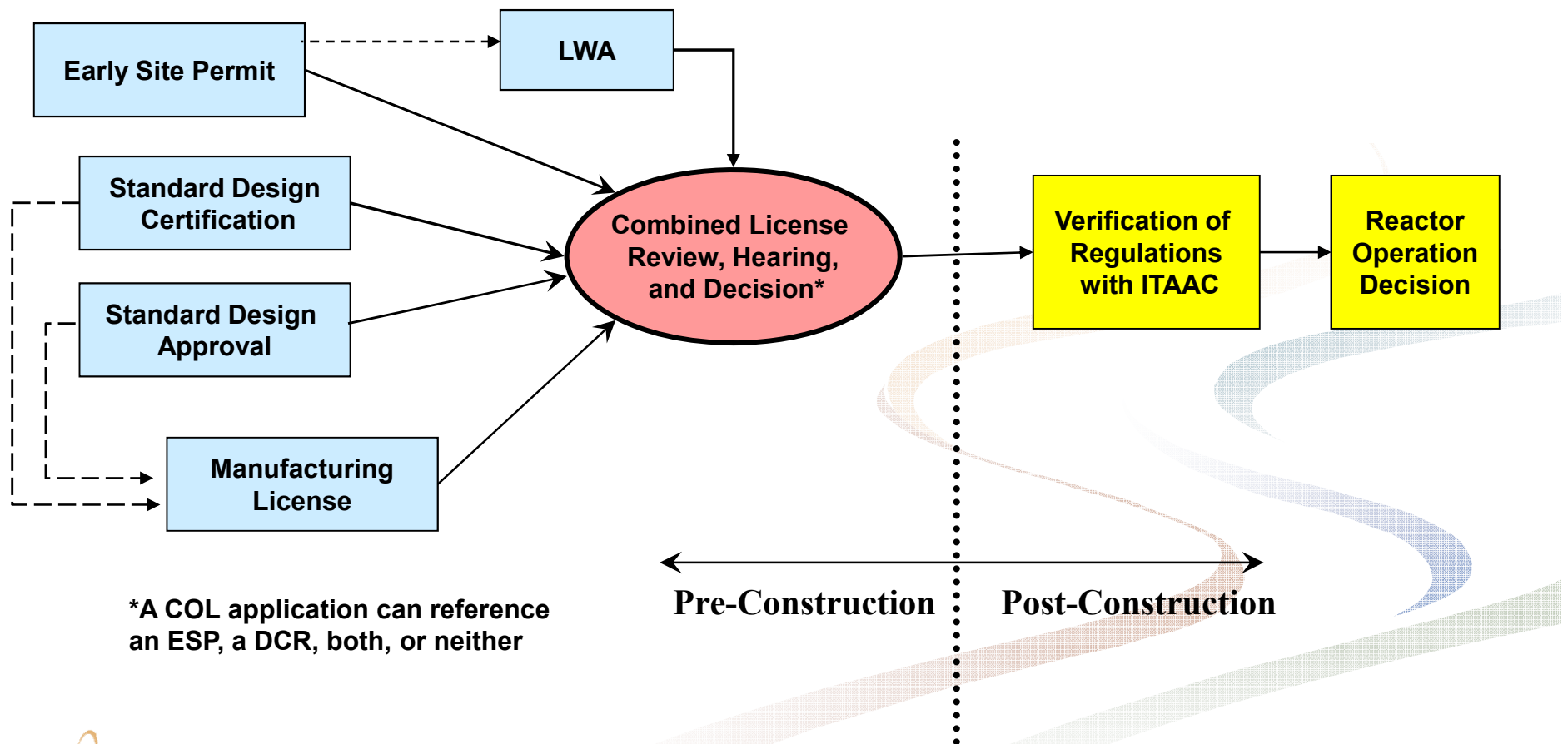
1977

1985

Timeline for Wolf Creek Nuclear Generating Station

Licensing Issues

- Part 52 Process



*A COL application can reference an ESP, a DCR, both, or neither

Licensing Issues

- Licensing issues identified include:
 - ⊕ Licensing for prototype reactors
 - ⊕ Application of international codes and standards
 - ⊕ Issues for multi-module facilities
 - ⊕ Manufacturing licenses
 - ⊕ Inspections, tests, analyses and acceptance criteria (ITAAC)

Prototype Reactors

- Regulatory provisions for prototype plants in 10 CFR 50.43(e)
- May require preventative or mitigative compensatory measures to address uncertainties
 - ⊕ Design features (supplemental robust systems)
 - ⊕ Limitations on operation
 - ⊕ Testing program (staged startup process)
 - ⊕ Limited duration of license

International Codes and Standards

- Regulatory compliance with U.S. codes & standards must be maintained for components fabricated outside U.S.
- Applicant/licensee must ensure U.S. standards are met
- NRC inspection program must be developed

Multi-Module Facilities

- Structure (including duration) of COL(s) issued for modular reactors that begin operation with intent to subsequently add modules
- Certification of design of facility that can employ a single reactor or can consist of multiple reactor modules
- Licensing, inspections, and Commission approval for operation (52.103g) for modular facilities
- Staffing requirements for passive modular facilities

Manufacturing Licenses

- Part 52 structured assuming that certified design (including nuclear steam supply system) is a subset of “nuclear reactor” addressed by manufacturing license
- Additional evaluation needed to determine if and/or how manufacturing licenses may be used for SMRs with site-specific safety features/structures

ITAAC

- Inspection, tests, analyses, and acceptance criteria (ITAAC)
 - ⊕ ITAAC for modular facilities (common structures, systems and components and for specific modules)
 - ⊕ ITAAC for integral LWRs will likely be similar to those for large LWRs
 - ⊕ Unique ITAAC will have to be developed for HTGRs & SFRs

Risk-Informed and Performance-Based Approaches

- Opportunity to better incorporate risk-informed and performance-based approaches into the designs and licensing of small and medium-sized reactors
- Performance-based approaches may help in the resolution of issues given limited operating experience for some reactor designs

Licensing Issues

- Group Discussion



Design Basis Issues

Stewart Magruder
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Licensing Approaches

- Deterministic
- Deterministic - complemented by probabilistic insights (NGNP)
- Proposed risk-informed regulatory framework (NUREG-1860)

Pre-application Objectives

- Approach must meet objectives of NRC Policy Statements
 - ⊕ Safety Goals
 - ⊕ Probabilistic Risk Assessment (PRA)
 - ⊕ Advanced Reactors
- Account for uncertainties in a conservative and bounding manner

Design Basis Issues

- Design development & review affected by:
 - ⊕ Defense-in-depth considerations
 - ⊕ Use of PRA
 - ⊕ Approach to accident selection
 - ⊕ Classification of systems, structures, and components

Component Design

- Containment
 - ⊕ Functional performance requirements
 - ⊕ Use of reduced- or non-pressure-retaining building
 - ⊕ Use of a non-traditional, small containment for each module
- Redundancy of safety-related components
 - ⊕ passive, safety-related residual heat removal systems

Source Term Issues

- Core composition and source term issues
 - ⊕ Source terms for new fuel types and new plant designs
 - ⊕ Multi-module dose calculations
 - ⊕ Multi-module severe accident analysis

Design Basis Issues

- General Discussion



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Break

Staffing, Human Factors and Operational Issues

John Smith
Advanced Reactor Program
Office of New Reactors

Staffing, Human Factors, and Operational Issues

- Operator staffing for small or multi-unit facilities
- Operator reliability and digital I&C for advanced multi-module control rooms
- Installation or removal of reactor modules during operation in multi-unit facilities
- Operational programs for small or multi-unit facilities

Staffing Requirements

- Number of operators on a per-module basis
- Training and simulator requirements
- Shift requirements, supervisory and reserve
- Shared staffing with other connected industrial facilities
- NRC Resident Inspector requirements

Operator Reliability and Digital I&C

- Can an operator reliably and safely control multiple reactor modules?
- How may smart indicators and computer procedures assist?
- Can an operator controlling active modules also be concurrently taxed with online refueling or the installation and maintenance of other modules?
- How many modules may be simultaneously operated at a single control station?
- How are cross-cutting responsibilities coordinated with other facilities to which reactor modules provide process heat?

Reactor Module Installation

- Addresses moving, adding, or removing reactor modules while other modules continue to operate.
- What difficulties arise with two or more modules tied to a common turbine or energy output?

Operational Programs

- Assess currently defined operational programs for new reactors (gap analyses).
- Example: In-service inspection (ISI) and in-service testing (IST) of systems and components
- New programs may be needed for coordinating and operating with adjacent chemical or process plants.

Staffing, Human Factors, and Operational Programs

- Group Discussion



Process Heat Applications

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Process Heat Applications

- Possible uses of process heat
 - ⊕ Hydrogen production facility
 - ⊕ Chemical plants
 - ⊕ Refineries
 - ⊕ De-salination plants
 - ⊕ Bitumen recovery from oil sands

Process Heat Applications

- **Issues**

- ⊕ Close coupling of nuclear and process plant (temperature transients, heat exchanger failures, etc.)
- ⊕ Hazards to nuclear plant and personnel from chemical facility
- ⊕ Reactor impacts on process facility (reactor trips, tritium migration)
- ⊕ Interface requirements and regulatory jurisdiction issues (nuclear and chemical facilities)

Process Heat Applications

- Group Discussion



Meeting Wrap-up & Adjourn

- Feedback, Suggestions ?
- Adjustments for tomorrow ?
- New Topics ?



Friday, October 9, 2009



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Security Requirements and Safeguards Information

Wes Held
Advanced Reactor Program
Office of New Reactors

Security Requirements & Safeguards Information (SGI)

Advanced Reactor Policy Statement

- ⊕ Updated October 2008 to include security in design considerations. Examples include:
 - Designs that include considerations for safety and security requirements together in the design process such that security issues (e.g., newly identified threats of terrorist attacks) can be effectively resolved through facility design and engineered security features, and formulation of mitigation measures, with reduced reliance on human actions
 - Designs with features to eliminate or reduce the potential theft of nuclear materials.

Security Requirements & Safeguards Information (SGI)

Can modifications to security requirements be justified?

⊕ SMR design features

- Small size
- Reduced number of vital areas
- Safety systems underground

⊕ Issues

- Size of security staff
- Size of protected area

Security Requirements & Safeguards Information (SGI)

Safeguards Information Protection programs

- ⊕ Need for a program
- ⊕ Setting up a program
 - Regulations/Order
 - Program approval
 - Storage location inspection
- ⊕ Aircraft Impact Characteristics

Security and Safeguards Information

- Group Discussion



Aircraft Impact Assessments

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Advanced Reactor Program
Office of New Reactors

Aircraft Impact Assessments

- Requirements for aircraft impact assessments added as 10 CFR 50.150 and references with Part 52
- Aircraft impact assessment requirements considered complementary to 10 CFR 50.54(hh)(2), which requires licensees to develop and implement guidance and strategies intended to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities under the circumstances associated with loss of large areas of the plant due to explosions or fire

Aircraft Impact Assessment

- Applicant shall identify and incorporate those design features and functional capabilities to show that, with reduced operator actions,:
 - ⊕ The reactor core remains cooled, or the containment remains intact; and
 - ⊕ spent fuel pool cooling or spent fuel pool integrity is maintained

Aircraft Impact Assessments

- Aircraft impact characteristics based on the beyond-design-basis impact of a large commercial aircraft
- Detailed parameters set forth in guidance that is designated as Safeguards Information (SGI)

Aircraft Impact Assessments

- Supplementary Information for rulemaking (74 FR 28131; June 12, 2009) acknowledges that specific requirements may need to be evaluated for non-LWR designs
- Aircraft impact assessments will, however, be needed for all future nuclear power plants
- Additional issues may arise related to nearby industrial facilities

Aircraft Impact Assessment

- Group Discussion



Financial Requirements

Jack Donohew
Advanced Reactor Program
Office of New Reactors

Financial Issues

- **NRC Fees** (10 CFR Part 170 and Part 171)
- **Insurance and Liability**
 - ⊕ Price-Anderson Act for public liability (10 CFR Part 140)
 - ⊕ On-site property damage (10 CFR 50.54(w))
- **Financial Qualifications** (10 CFR 50.33(f))
- **Decommissioning Funding Required** (10 CFR 50.75)

Annual NRC Fee

- Should NRC fees for an operating nuclear power reactor be based on the licensed thermal power of the reactor?
- Should annual fees be assessed per reactor module or per the COL for a multi-reactor module facility?
- Advanced Notice of Proposed Rulemaking regarding a possible variable annual fee structure for power reactors based on licensed power limit and assess fee per COL for multi-reactor module facility, published in the Federal Register on March 25, 2009 (74 FR 12735). Comment period expired June 8, 2009.

Insurance and Liability

- Price-Anderson Act for public liability in 10 CFR Part 140 and on-site property damage in 10 CFR 50.54(w).
 - ⊕ Current financial protection requirements in 10 CFR 140.11(a)(4) are based on a minimum rated electrical capacity of 100,000 electrical kilowatts (100 MWe) that does not address process heat and small nuclear plants (i.e., plants with a capacity less than 100 MWe).
 - ⊕ For small nuclear plants less than 100 MWe, there is 10 CFR 140.12 with reduced financial protection amounts specified.
 - ⊕ Do current financial protection requirements in 10 CFR 140.11(a)(4) and 140.11(b) that apply to modular plant "facilities" at a single site reasonably address proposed small- and medium-sized reactors?
 - ⊕ Is the on-site property damage required by 10 CFR 50.54(w) reasonable for the small- and medium-sized reactors?

Financial Qualifications

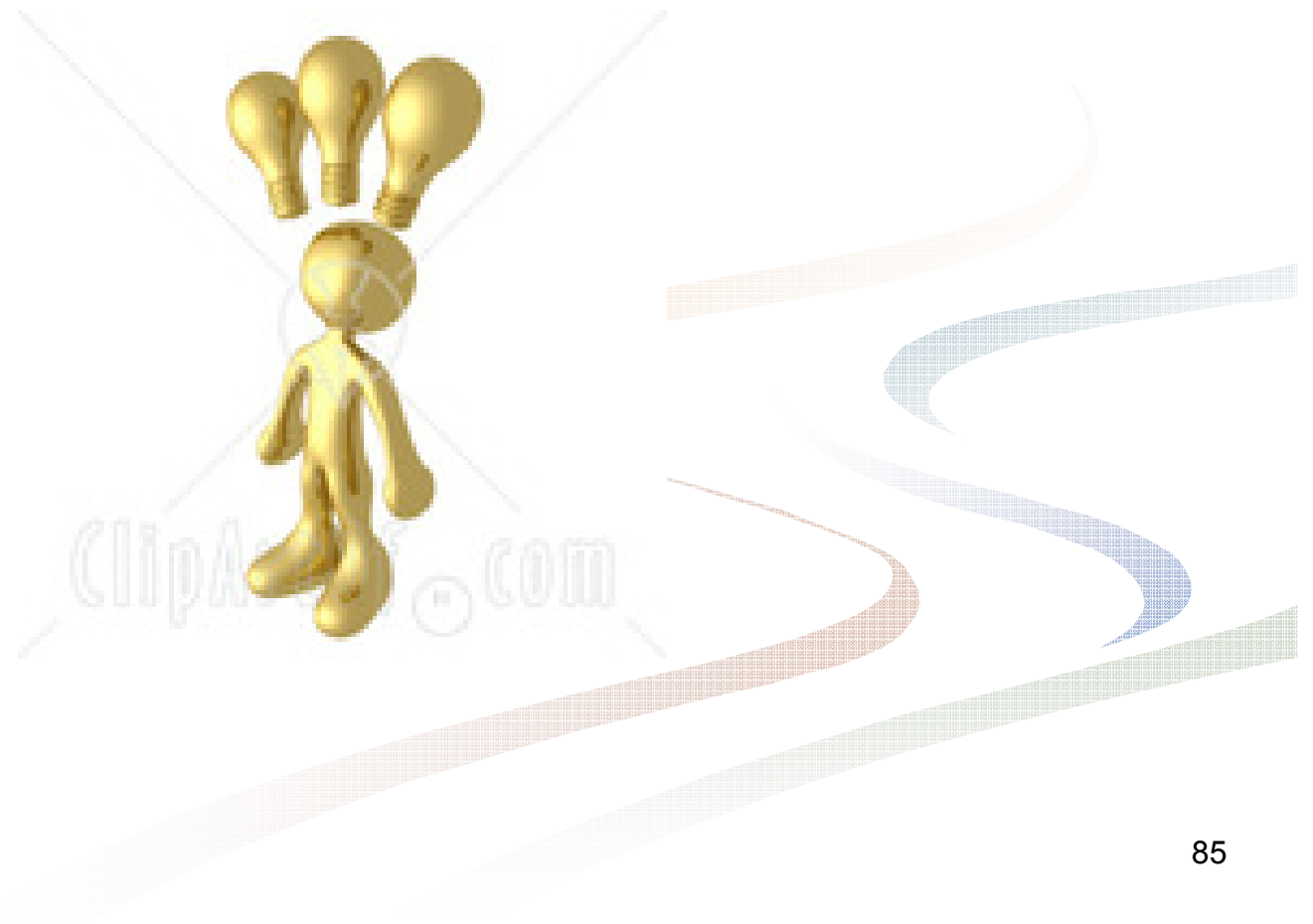
- Financial qualification requirements are in 10 CFR 50.33(f).
- Electric utilities, as defined in 10 CFR 50.2, are exempted from this requirement.
- Do the current requirements adequately address the possible business arrangements being discussed for small- and medium-sized reactors?

Decommissioning Funding Requirements

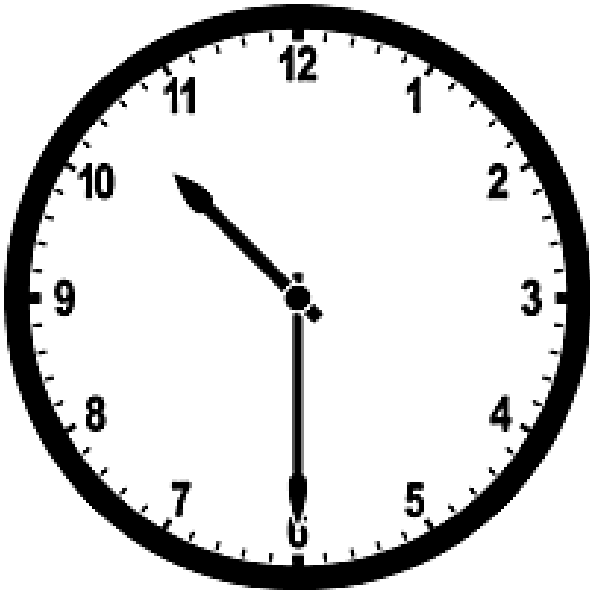
- Required decommissioning funding, in 10 CFR 50.75, is for large LWRs.
 - ⊕ 50.75(b)(4) the amount may be a cost estimate for decommissioning
 - ⊕ 50.75(c)(1) addresses PWRs and BWRs with a licensed power level ≥ 1200 MWt
 - ⊕ 50.75(c)(2) provides the annual adjustment factor
 - ⊕ 50.75(e) specifies the methods for providing the funding
- Should the regulations and/or guidance be revised to address small- and medium-sized reactors?

Financial Requirements

- Group Discussion



Workshop on Small- and Medium-Sized Nuclear Reactors (SMRs)



Break

Emergency Preparedness

Wes Held
Advanced Reactor Program
Office of New Reactors

Offsite Emergency Preparedness

Can modifications to offsite emergency preparedness be justified?

⊕ SMR characteristics

- Lower probability of severe accidents
- Smaller offsite consequences per module
- Slower accident progression

⊕ Possible modifications

- Smaller emergency planning zone (EPZ)
- Revised siren requirements
- Need for potassium iodide distribution

Offsite Emergency Preparedness

Use of probabilistic and deterministic methods for determining EPZ

Previous work on reviewing EPZs

Onsite Emergency Response Staffing

Offsite Emergency Response Staffing

Emergency Preparedness

- Group Discussion



International Activities

Joe Williams
Advanced Reactor Program
Office of New Reactors

Purpose

- Describe current NRC activities
- Describe challenges and opportunities from NRC perspective
- Gain understanding of issues from stakeholders

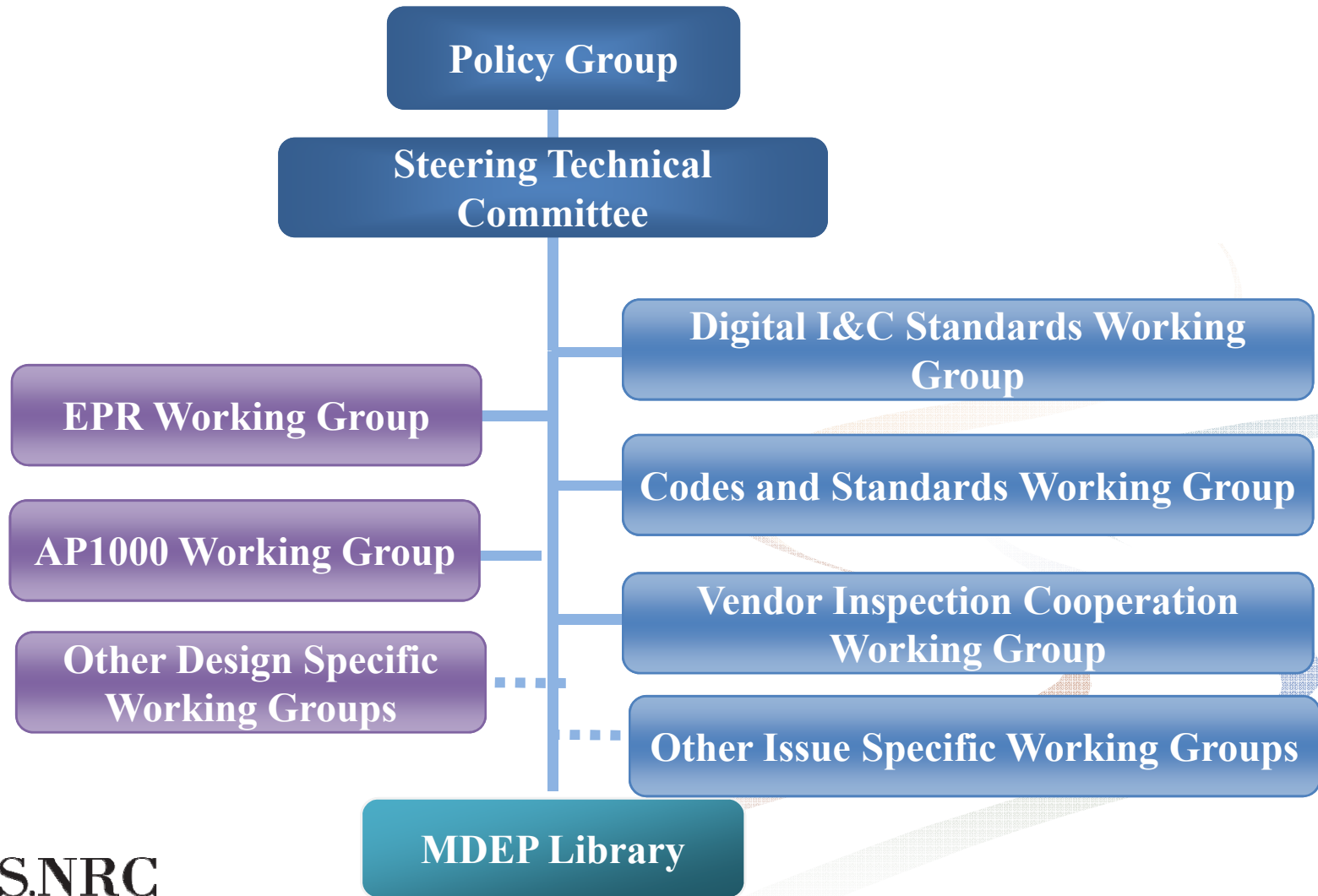
Multinational Design Evaluation Program

- Initiative to develop innovative approaches to leverage resources and knowledge of experienced regulators for new reactor design reviews
 - ⊕ Enhance cooperation within existing framework
 - ⊕ Increased convergence of codes, standards, and safety goals
 - ⊕ Facilitate licensing reviews

MDEP Membership

- Canada, China, Finland, France, Japan, Korea, Russian Federation, South Africa, the United Kingdom, and the United States
- IAEA/NEA participation

MDEP Structure



Industry Interactions

- Vendors participated in Digital I&C working group meetings
- Digital I&C WG will work with IEEE and IEC on potential convergence
- Codes & Standards Working Group working with Standards Development Organizations to identify similarities and differences with the objective of convergence
- Areva presented differences in EPR designs to the EPR Working Group

Other Activities

- Bilateral agreements with NRC counterparts
- Assistance to countries for implementation of effective regulatory programs
- IAEA has identified interest in power reactors in several dozen countries, but only a few are thought capable of supporting or interested in large reactors
 - ⊕ Expense
 - ⊕ Grid restrictions
- Per IAEA, viable small designs could find market in 30-40 countries

Challenges

- Multinational component fabrication
- Codes and standards
- Design differences

International Activities

- Group Discussion



General Discussion & Future Activities

- Feedback, Suggestions
 - ⊕ Future Meetings ?
 - ⊕ Part 52 workshop/webinar ?
- Industry Working Group(s)
- Additional Issues or Concerns

Workshop on Small- and Medium-Sized Nuclear Reactors (SMRs)

- Adjourned ...

