Westinghouse Input to NRC Workshop on Regulatory Structure for New Plant Licensing, ANPR and Technology-Neutral Framework

Chuck Kling

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OVERVIEW

- **Westinghouse supports the ANPR for "Approaches to Risk-Informed and Performance-Based Requirements for Nuclear Power Reactors" and technology neutral regulations for advanced reactors**
- **Westinghouse is working with and supports NEI and PBMR on the technology neutral aspects of the ANPR**
- **IRIS' specific interest is for performance based modifications to emergency preparedness requirements:**
  - **Licensing approach**
  - **Improved margins by implementing Safety-by-Design™**
  - **Approach to reduction in size of EPZ**
- **International cooperation**

IRIS Licensing Approach

- Build on extensive AP600/AP1000 experience
- Employ data on tested passive systems/features
- Use RG 1.203 (i.e., EMDAP, PIRT, etc.) as systematic approach to complete EM V&V
- Perform required/adequate tests (e.g., major integral testing program started this year)
- Meet all current NRC licensing requirements
- Initial licensing under 10CFR52 (submit DC documentation ~2010)
- Subsequent licensing under 10CFR53 (without or reduced requirements for off-site emergency response plan)

IRIS LICENSING BASIS

- IRIS is based on proven LWR technology, newly engineered
- IRIS safety is keyed on Safety-by-Design™ plus simplified AP1000 type passive systems
- Safety-by-Design™ provides tremendous improvement of Defense in Depth
- IRIS will use its significantly enhanced safety to aim for licensing without the requirement of an off-site emergency response plan

IRIS APPROACH TENETS

- **Combine deterministic and probabilistic assessment**
- **“Trade-off” of barriers in Defense in Depth**
- **Consider all credible events**
- **Do not postulate a priori accidents**
- **Evaluate consequences and their probability of occurring**

IRIS Three Tier Safety

1. SAFETY-BY-DESIGN™
   Aims at eliminating by design possibility for accidents to occur
   Eliminates systems/components that were needed to deal with those accidents

2. PASSIVE SAFETY SYSTEMS
   Protect against still remaining accidents and mitigate their consequences
   Fewer and simpler than in passive LWRs

3. ACTIVE SYSTEMS
   No active safety-grade systems are required
   But, active non-safety-grade systems contribute to reducing CDF (core damage frequency)

IMPROVED SAFETY WITH SIMPLIFYIED DESIGN

Safety-by-Design^{TM}

- Engineer the integral design to eliminate accident initiators or drastically reduce consequences/probability
- IRIS safety systems are simpler and less in number than those needed in other passive LWRs
- Safety-by-Design^{TM} combined with risk-informed approach should demonstrate no need for off-site emergency response

TYPICAL PWR CLASS IV ACCIDENTS AND THEIR RESOLUTION IN IRIS DESIGN

Condition IV Design Basis Events		IRIS Design Characteristic	Results of IRIS Safety-by-Design™
1	Large Break LOCA	Integral RV Layout – No loop piping	Eliminated by design
2	Steam Generator Tube Rupture	High design pressure once-through SGs, piping, and isolation valves	Reduced consequences, simplified mitigation
3	Steam System Piping Failure	High design pressure SGs, piping, and isolation valves. SGs have small water inventory	Reduced probability, reduced (limited containment effect, limited cooldown) or eliminated (no potential for return to critical power) consequences
4	Feedwater System Pipe Break	High design pressure SGs, piping, and isolation valves. Integral RV has large primary water heat capacity.	Reduced probability, reduced consequences (no high pressure relief from reactor coolant system)
5	Reactor Coolant Pump Shaft Break	Spool pumps have no shaft	Eliminated by design
6	Reactor Coolant Pump Seizure	No DNB for failure of 1 out of 8 RCPs	Reduced consequences
7	Spectrum of RCCA ejection accidents	With internal CRDMs there is no ejection driving force	Eliminated by design
8	Design Basis Fuel Handling Accidents	No IRIS specific design feature	No impact

IRIS SAFETY-BY-DESIGN™: THE BOTTOM LINE

Criterion	Proposed Advanced LWRs	IRIS
Defense-in-Depth (DID)	Passive systems; active systems	Additional safety layer BEFORE traditional DID layers eliminates accidents' initiators
Class IV Design Basis Events	8 typically considered	Only 1 remains Class IV (fuel handling accident)
Core Damage Frequency (CDF)	$\sim 10^{-6}$—10^{-7}	$\sim 10^{-8}$
Large Early Release Frequency (LERF)	$\sim 10^{-6}$—10^{-8}	$\sim 10^{-9}$

IMPLICATIONS:

Both advanced LWRs and IRIS are extremely safe plants

HOWEVER:

IRIS has the technical basis to attain REDUCED OR ELIMINATED REQUIREMENT FOR EMERGENCY RESPONSE PLANNING

IRIS Approach to Risk-Informed Regulation

- Because safety-by-design adds DID, IRIS is expected to meet current licensing requirements with significant margin
- IRIS intends to use this margin to relax licensing requirements (i.e., no need for off-site emergency response)
- PRA is being used to improve design and justify relaxation of licensing requirements

TRADE-OFF OF BARRIERS IN DEFENSE IN DEPTH

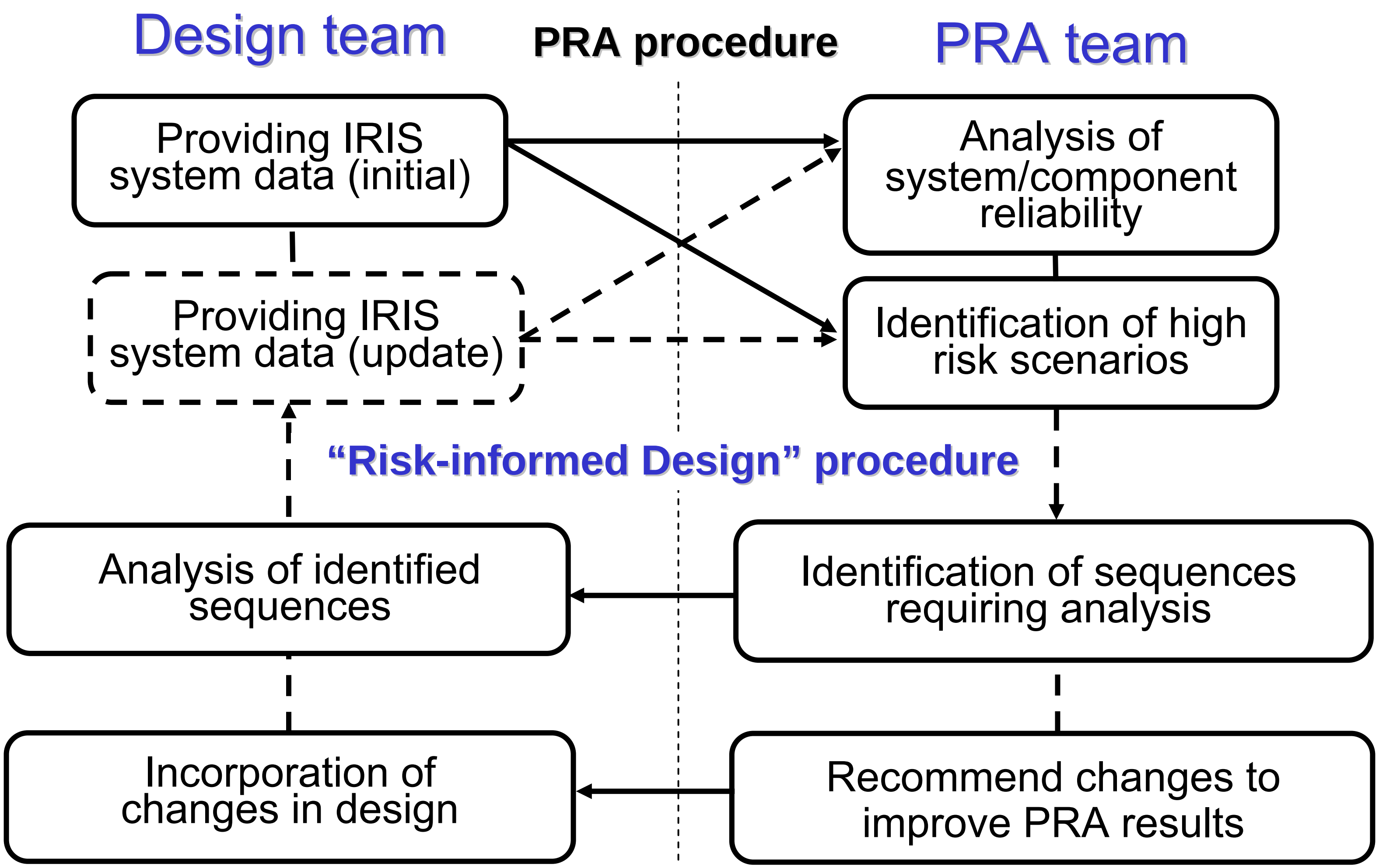
CURRENT REACTORS

- **Material barriers**
  - Fuel
  - Cladding
  - Vessel and piping
  - Containment
- **Legislative barrier**
  - Off site emergency response

IRIS

- **Safety-by-Design™ barrier**
  Accidents are eliminated, consequences downgraded, probabilities reduced by design configuration
- **Material barriers**
  - Fuel
  - Cladding
  - Large coolant inventory
  - Vessel
  - Containment

Importance of PRA in Design



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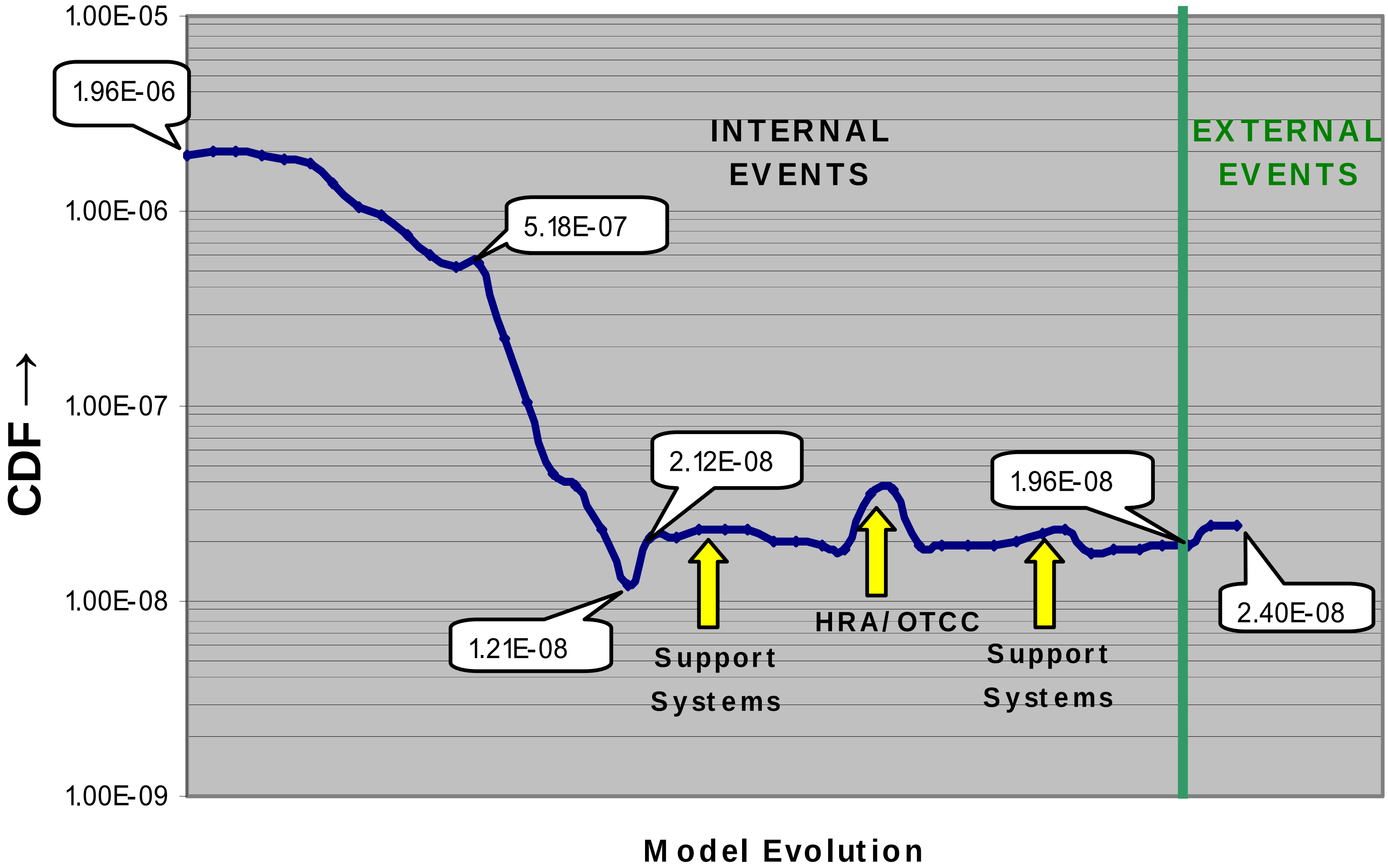
Design Improvements through PRA



Design → PRA → Improved Design → PRA …

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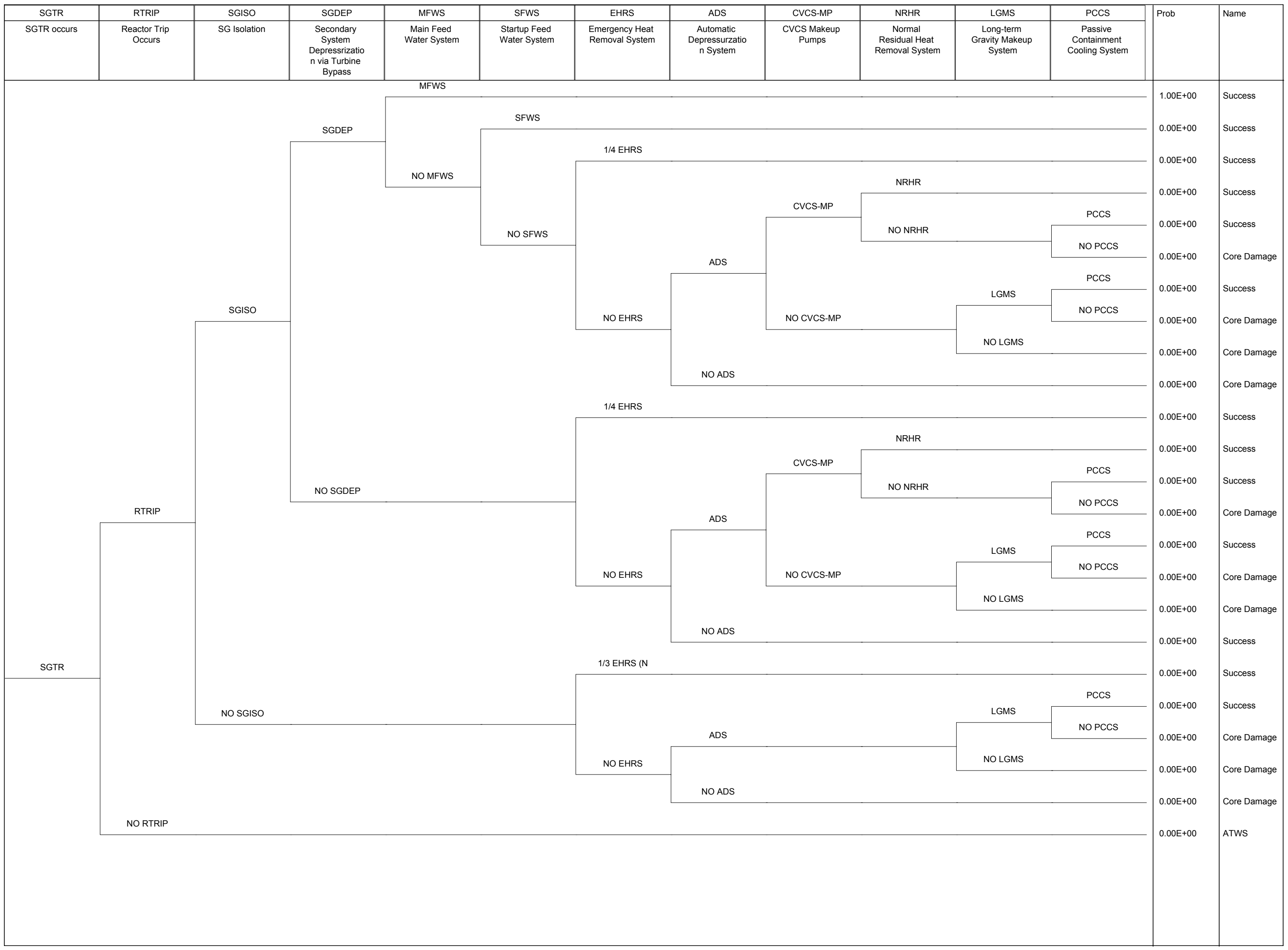
Importance of PRA in Licensing

- A key to meeting risk informed licensing requirements is a robust, complete and acceptable PRA
- PRA methods are straightforward
- Concerns are:
  - Identifying the probability/uncertainty of all credible initiating events (i.e., FMEAs, etc.)
  - Quantifying the probability/uncertainty of subsequent failures (e.g., single, multiple, common mode, etc.)
  - Quantifying the results and uncertainty of the sequence of events (e.g., EMDAP qualified EMs)
- Goal: Use PRA to show licensing requirements are met with DiD, single failure, mechanistic analyses providing guidance.

Typical Event Tree (SGTR)



GOAL: NO EMERGENCY RESPONSE

- <u>Generation IV</u>

Safety goal: No need for offsite response

“No credible scenario should exist for release of radioactivity requiring offsite response to ensure public safety”

“….This goal is not to be construed as zero probability of any accidental release….rather, the focus of this goal is to eliminate the need for formal emergency planning. ….A reasonable measure of this goal could be expressed as “no credible accident scenarios that could result in offsite release of radiation exceeding US protection action guidelines”. ….these guidelines may change as improved radiation dose-response models are developed**”**

ADVANTAGES OF LIMITED OFF-SITE EMERGENCY RESPONSE

- **Reduce EPZ to the exclusion area**
- **Reduce local government interaction**
- **Increased public acceptance**
- **Significant economic benefit to utilities**
- **Can site plant close to population centers**
- **Lower transmission and infrastructure costs**
- **Reduces licensing uncertainty**

GOAL: A nuclear plant is treated the same as a "normal" industrial facility with respect to emergency evacuation

EPZ Size Reduction for IRIS

- **Pursue probabilistic aspect (RG 1.183) including DBA and severe accidents influence on emergency planning.**

- **Complete dose assessment to calculate the doses assumed by the public and by the Control Room personnel**

Approach for Reduced EPZ

- While the current EPZ is defined as an area beyond that the PAG limits are not exceeded, even after an assumed severe accident (deterministic); the new EPZ should be defined as an area within which PAG limits are met with a probability lower than a specified value.

SECURITY

- Outstanding capabilities against malevolent threats
- Design Basis Treats must be defined in the context of risk
- As for Safety-by-Design™, they are based on intrinsic design characteristics

Examples

- Aircraft crash (as in 9/11)
  - More than half of IRIS containment is underground
  - Reinforced auxiliary building around containment, with cylindrical shape to minimize impact
  - Most importantly, IRIS building will be less than 25m high, offering basically no target (other plants are much higher)
- Inside sabotage (disabling of safety systems)
  - IRIS has very few safety systems because of its safety-by-design™
  - IRIS safety systems are passive, which are much more difficult to disable than active systems
  - IRIS is designed for redundancy (the only critical item, the Emergency Heat Removal System, is designed with four trains and multiple heat sinks)

MDAP
(Multinational Design Approval Program)

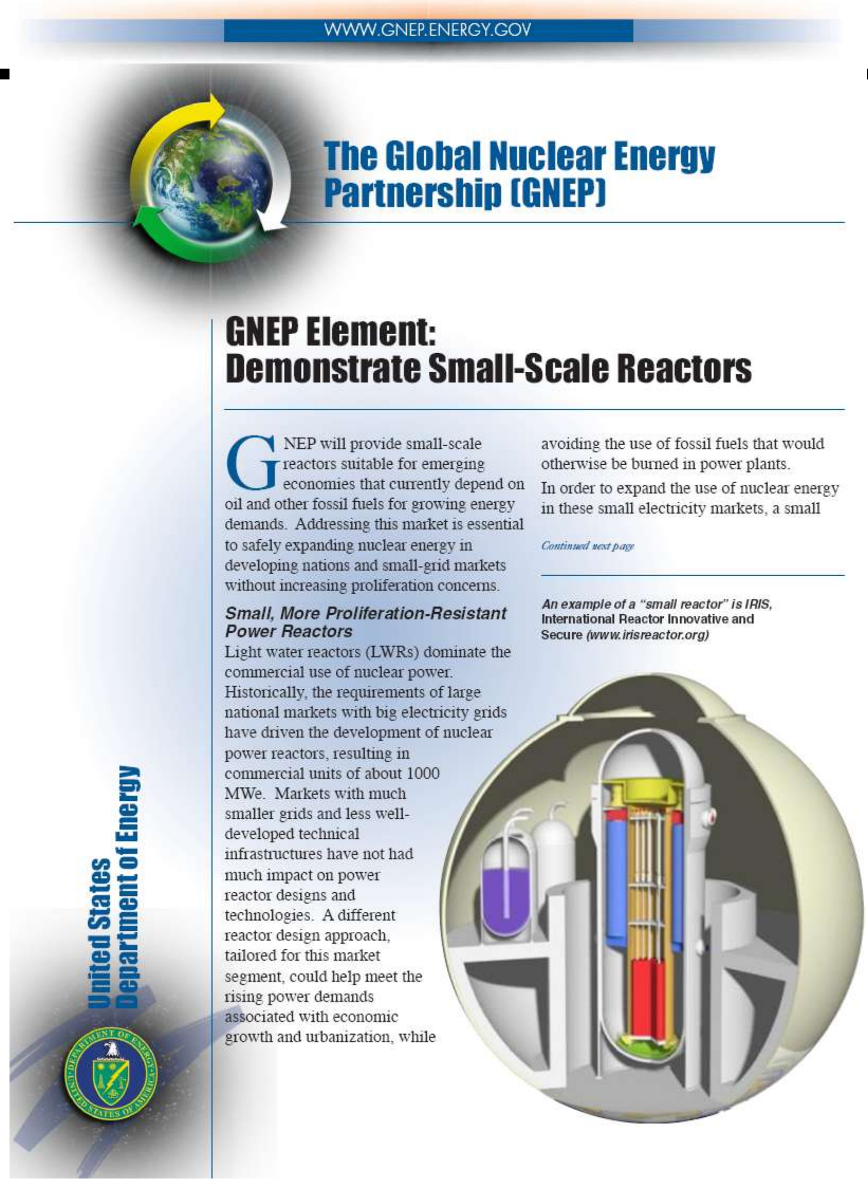
- Joint licensing by US NRC and other country(ies) licensing authority(ies)
- Promoted by NRC
- Excellent program for IRIS, we have notified NRC of our interest
- Westinghouse will lead NRC licensing, other countries will participate as desired and necessary
- Will speed up other countries licensing process, while enhancing regulatory review and public acceptance

DOE’s GNEP Initiative

Program announced Feb 6, 2006

Objective - seven main elements:

1. **Expand use of nuclear energy;**
2. **Demonstrate proliferation-resistant recycling;**
3. **Minimize nuclear waste;**
4. **Develop Advanced Burner Reactor (ABR);**
5. **Establish reliable fuel services;**
6. **Demonstrate small-scale reactors;**
7. **Develop enhanced nuclear safeguards.**



WWW.GNEP.ENERGY.GOV

The Global Nuclear Energy Partnership (GNEP)

GNEP Element: Demonstrate Small-Scale Reactors

GNEP will provide small-scale reactors suitable for emerging economies that currently depend on oil and other fossil fuels for growing energy demands. Addressing this market is essential to safely expanding nuclear energy in developing nations and small-grid markets without increasing proliferation concerns.

Small, More Proliferation-Resistant Power Reactors

Light water reactors (LWRs) dominate the commercial use of nuclear power. Historically, the requirements of large national markets with big electricity grids have driven the development of nuclear power reactors, resulting in commercial units of about 1000 MWe. Markets with much smaller grids and less well-developed technical infrastructures have not had much impact on power reactor designs and technologies. A different reactor design approach, tailored for this market segment, could help meet the rising power demands associated with economic growth and urbanization, while avoiding the use of fossil fuels that would otherwise be burned in power plants.

In order to expand the use of nuclear energy in these small electricity markets, a small

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An example of a "small reactor" is IRIS, International Reactor Innovative and Secure (www.irisreactor.org)

United States Department of Energy

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IAEA approach

- Similar to SECY-97-020 Task Force approach that increased safety in one level of the DID is used to justify reduced requirements in another level
- Therefore improvement in Level 1 (fuel), Level 2 (primary boundary), or Level 3 (containment) can reduce Level 4 (emergency preparedness) criteria
- Use DA to demonstrate consequences of severe accidents don't result in exceeding PAG limits outside the plant.
- Deterministic-Probabilistic Approach - Defines cut-off frequency of events to be considered.

IRIS COOPERATION WITH IAEA

- **IAEA Coordinated Research Project (CRP) for small reactors includes five projects with IRIS members investigating the revised licensing issues**

- **IRIS organizations:**
  - **Westinghouse**
  - **Polytechnic of Milan, Italy**
  - **University of Zagreb, Croatia**
  - **Lithuanian Energy Institute, Lithuania**
  - **Eletronuclear, Brazil**

First review of work performed

CONCLUSION

- IRIS on track for 2015-2017 deployment under 10CFR52
- Do not want to start over to implement 10CFR53
- Safety-by-Design^{TM} combined with risk-informed approach can demonstrate no need for off-site emergency response under 10CFR53