NRC Research to Support Regulatory Decisions Related to Subsequent License Renewal Periods

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"I never think of the future, it comes soon enough."

Albert Einstein

Global Age of NPPs

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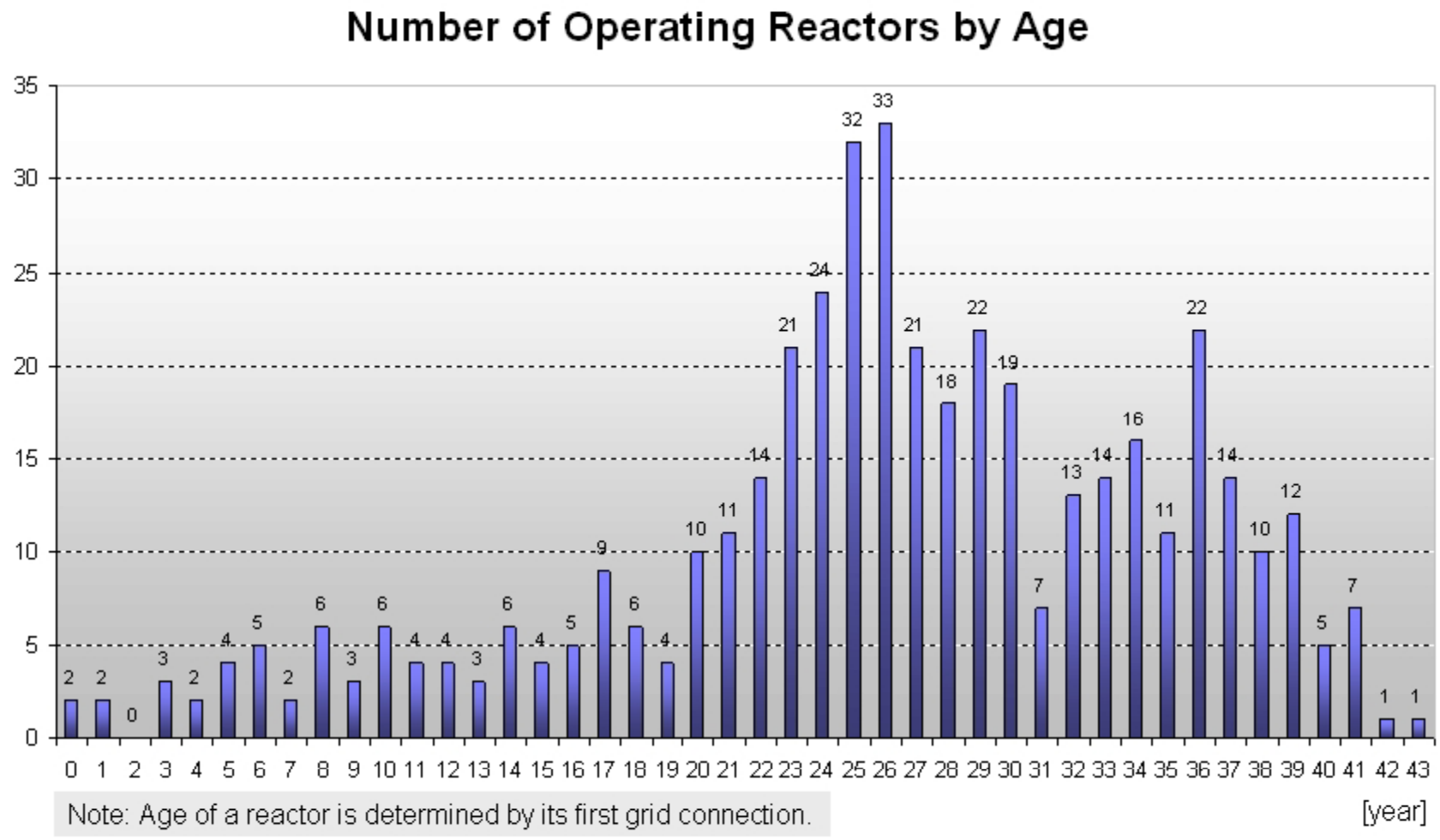

Source: International Atomic Energy Agency; http://www.iaea.or.at/programmes/a2/

Why Long-Term Operation

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- Steep fall-off in generating capacity if current nuclear operations not sustained
- 5% total U.S. generating capacity lost by 2035; 15% by 2045

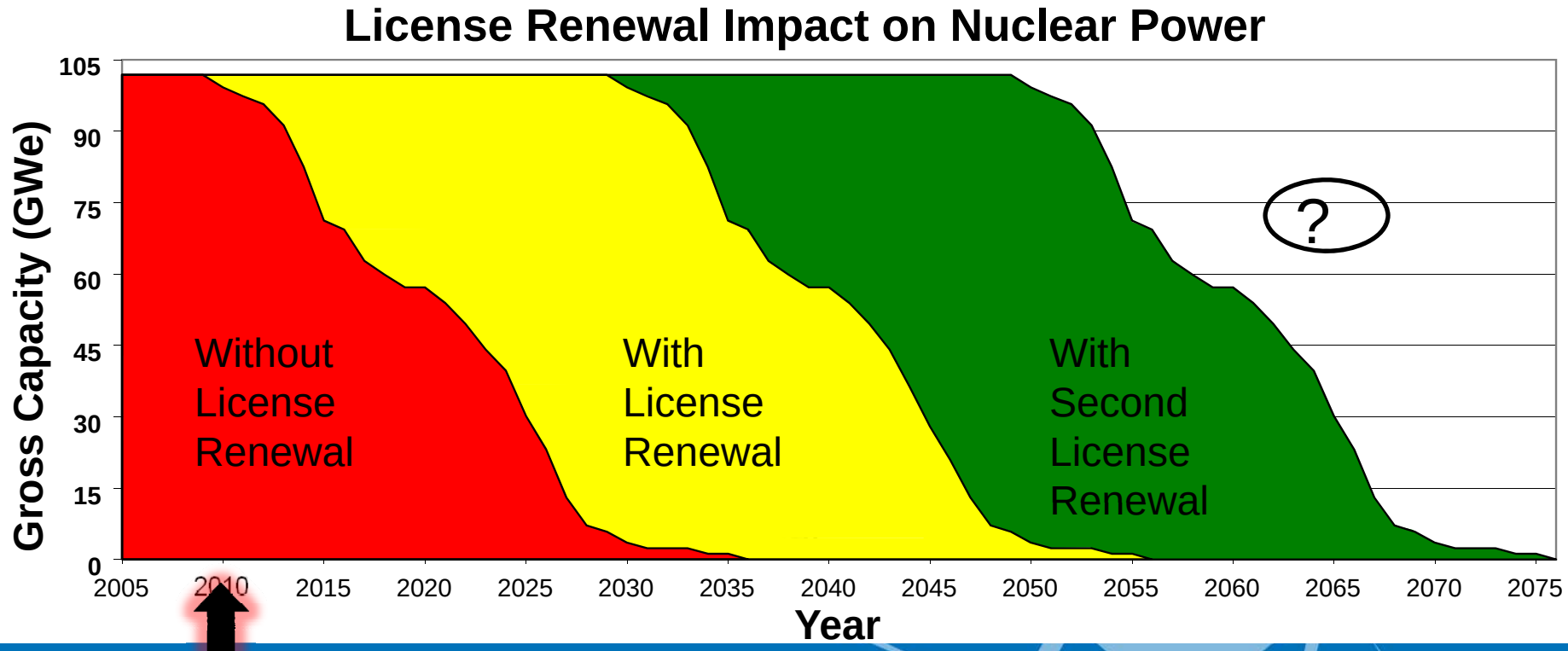

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Figure 29. U.S. nuclear power plants that will reach 60 years of operation by 2035

- EIA's *Annual Energy Outlook 2010 with Projections to 2035* assumes:
  - 30.8 GW retired at 60 years
  - 2.0 GW replaced by new NPPs
  - Remaining capacity replaced by coal or natural gas

EIA AEO 2010 (http://www.eia.doe.gov/oiaf/aeo/nuclear_power.html)

Timing is Critical

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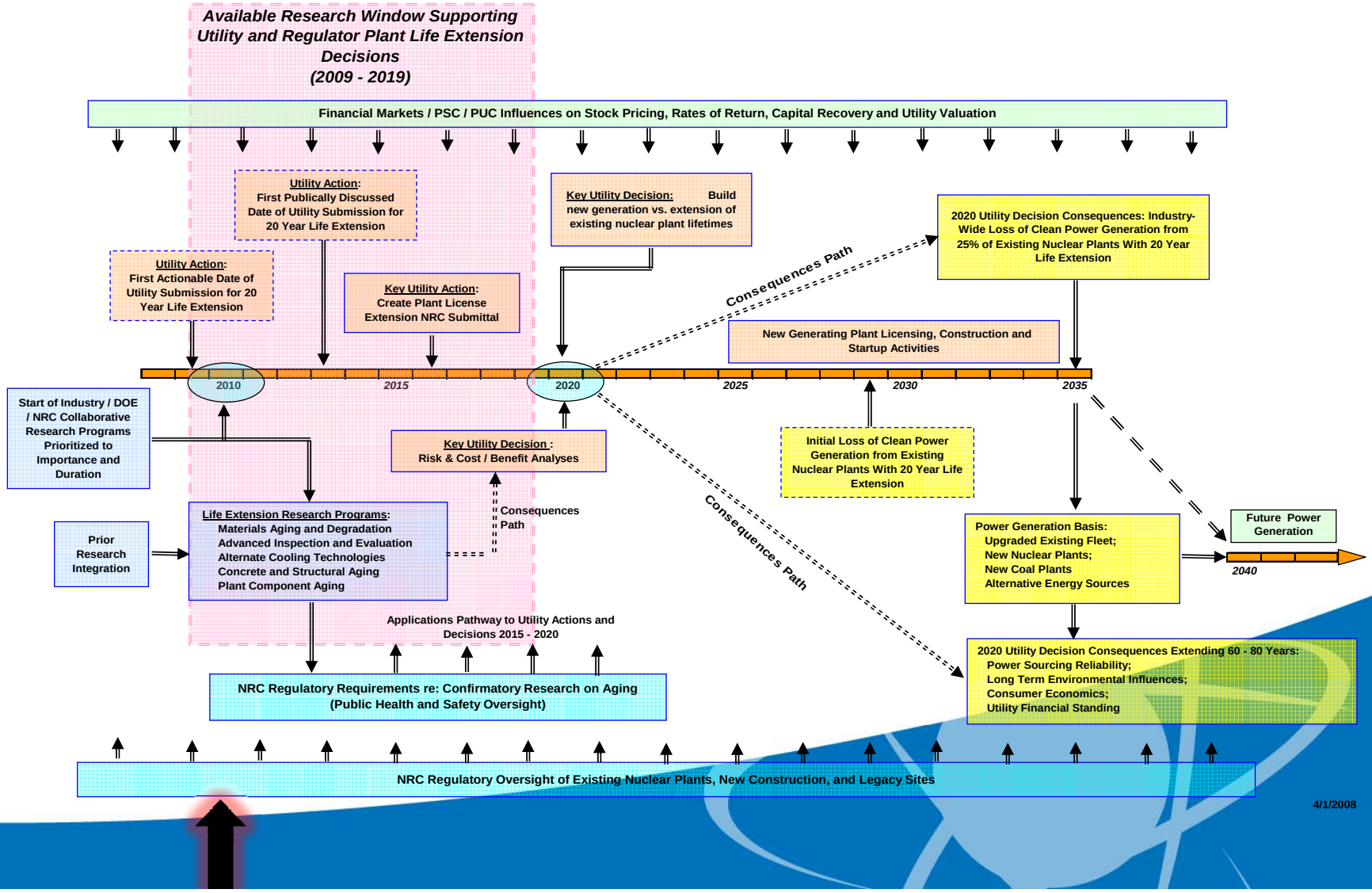
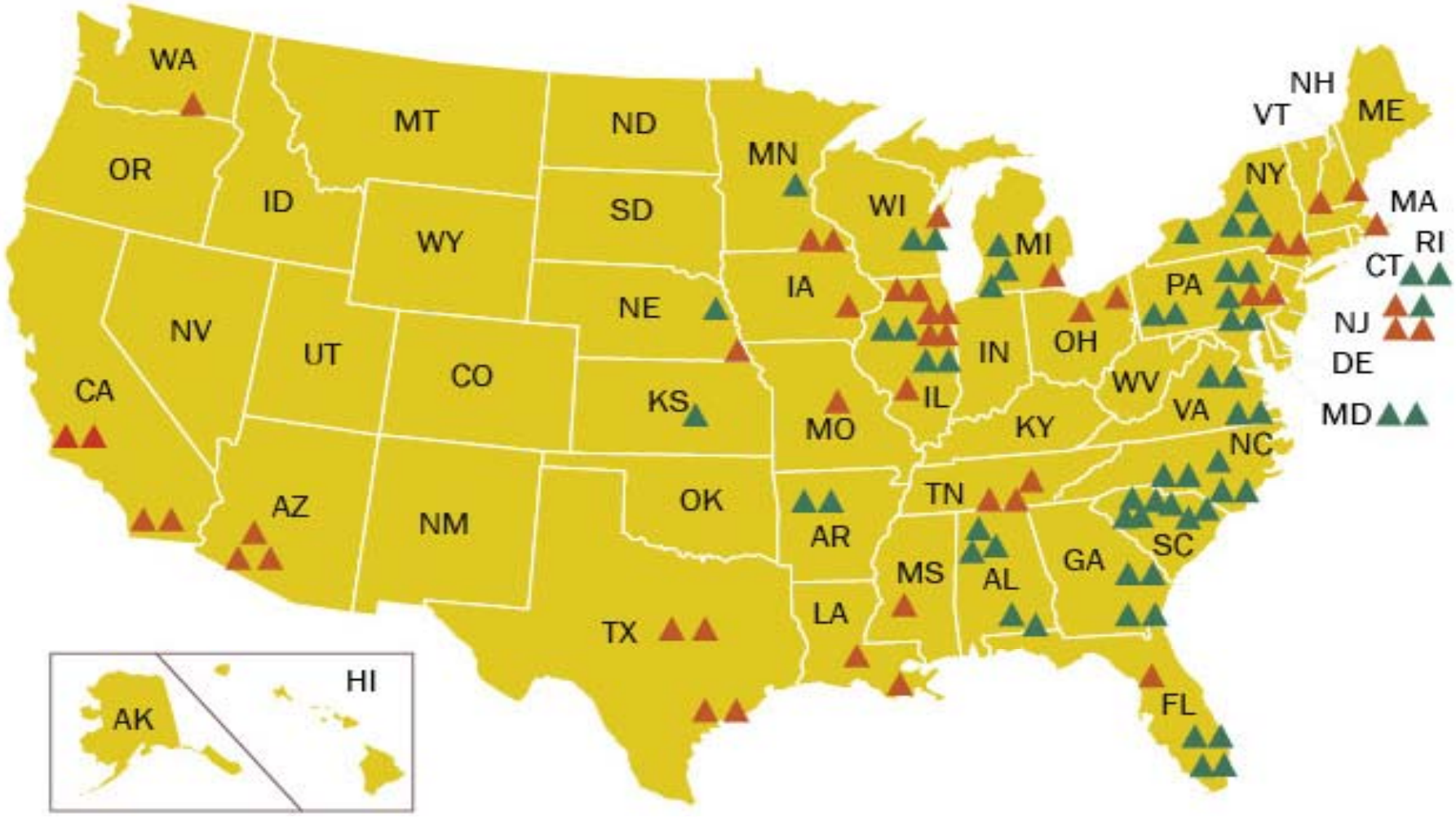


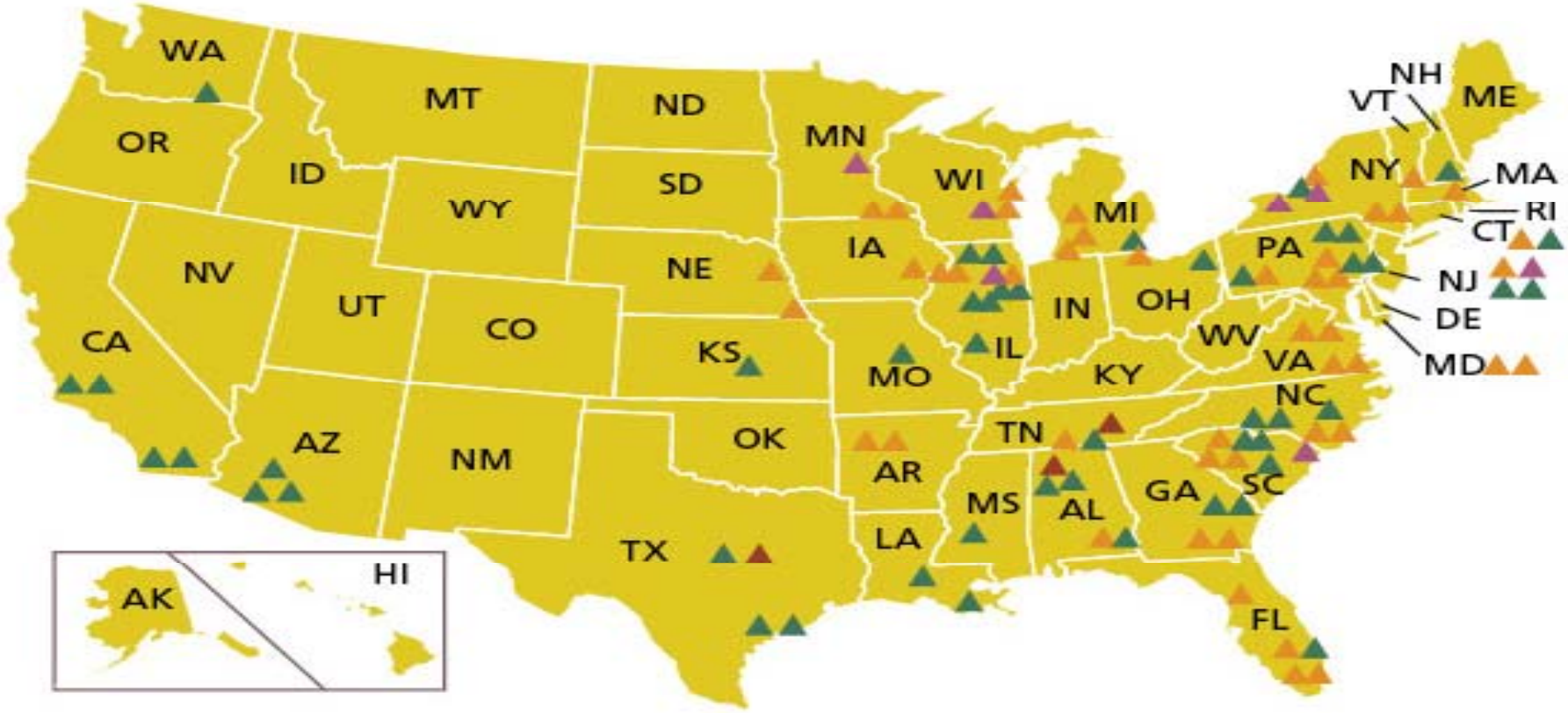
License Renewal Granted for Operating Nuclear Power Reactors



Licensed to Operate (104)

▲ License Renewal Granted (59)

U.S. Commercial Nuclear Power Reactors— Years of Operation by the End of 2010



Years of Commercial Operation	Number of Reactors
△ 0-9	0
▲ 10-19	6
▲ 20-29	48
▲ 30-39	48
▲ 40 plus	2

Note: Ages have been rounded up to the end of the year.

Source: U.S. Nuclear Regulatory Commission

Now 4 units over 40 years of age, and 2 more will go into the extended operating period this year

Integration of Domestic Nuclear Research Programs

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INDUSTRY	NRC	DOE
• **Profit motive / shareholder perspective**	• **Public health and safety protection perspective**	• **Long term national interest perspectives**
• **Short term research addressing known problems and managing costs / downtime**	• **Confirmatory research addressing known safety issues**	• **Long term research addressing predictive and improvement opportunities**
• **Ex: IASCC – Better, faster weld repairs needed for reliability and reduce field repair times**	• **Ex: Better testing and repair integrity assurance methods needed**	• **Ex: Crack precursors and irradiation damage need to be understood for better predictions and future material selection**
Long Term Operability Program	*Life Beyond 60 Program*	*LWR Sustainability Program*

Individually, each program addresses a specific perspective; collectively, they address the majority of issues that need to be answered for safe extended operations.

Aging R&D Areas

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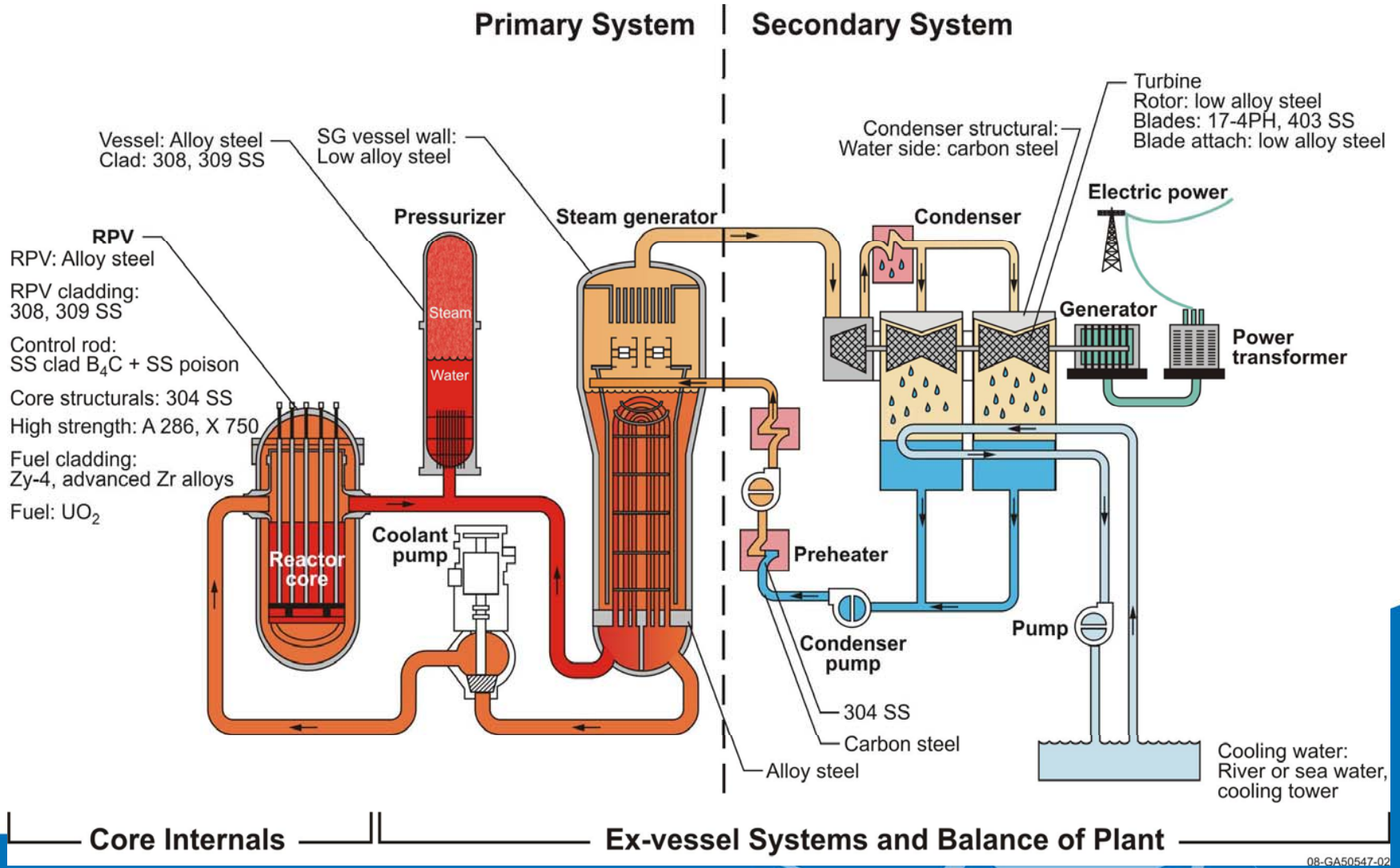

Materials Issues Key

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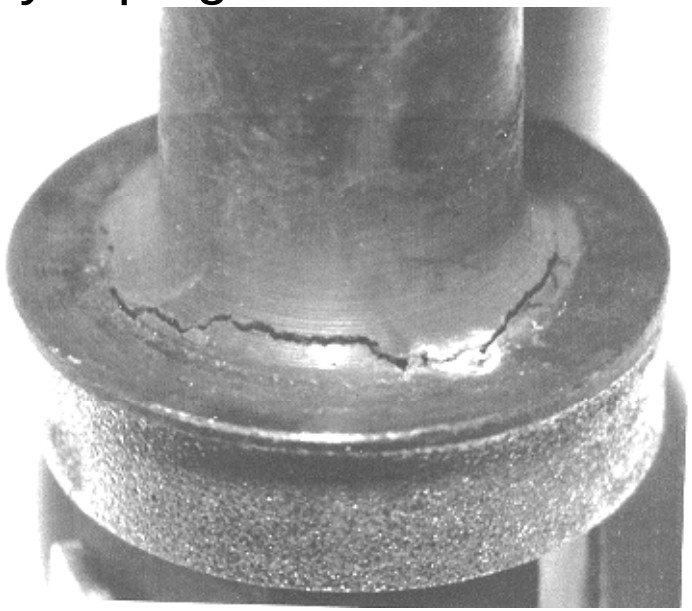
- Materials research key need for existing nuclear reactor fleet
- Materials degradation can lead to increased maintenance, increased downtime, and increased risk
- Materials issues must be resolved for:
  - Reactor Pressure Vessels and Primary Piping
  - Core Internals
  - Secondary System
  - Weldments
  - Concrete
  - Cabling
  - Buried Piping



NRC's Aging Management Research

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- NRC research into potential technical issues that may challenge long-term safe operation
- Challenges include:
  - Reactor vessel and internals
  - Electric cable insulation
  - Buried/submerged structures
  - Concrete exposed to high temperature and radiation

Proactive Management of Materials Degradation

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- Develop information
  - Materials behavior
  - Mitigation or repair
  - Inspection or monitoring
- Proactively address potential future degradation
  - Avoid failures
  - Maintain integrity and safety
- Increase cooperation
  - Prioritize PMMD research with industry
  - Pursue additional international collaborations
- Evaluate existing requirements
  - Integrity of susceptible components
  - Inspection and monitoring regulations

Avoid Surprises e.g. V.C. Summer And Davis Besse

NRC Aging Management Research

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- Information Tool Knowledge Capture & Utilization
- Identify Degradation Scenarios Not Addressed in NUREG-1801, “Current Generic Aging Lessons Learned (GALL) Report”
- Identify Inspection and Monitoring Programs and Associated Requirements for Highly Likely Degradation Scenarios

NRC Aging Management Research

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- Assess Results from Implementation of License Renewal Aging Management Programs and Recommend Improvements for Subsequent License Renewal Periods
- Hold Recurrent NRC/Industry Workshops on Status of Operating Experience from Initial Renewal Term and Industry Research Activities to Address Aging Management Technical Issues for Subsequent License Renewal Periods
- Develop Domestic and International Partnerships to Share Expertise, Capabilities and Resources Related To Aging Management Research

Materials Degradation

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- Extending the life of any reactor will require comparing the known modes of materials degradation with the expected service life to identify possible problems
- Materials are a common problem/concern in existing reactors/nuclear facilities
  - Materials degradation can lead to increased maintenance, increased downtime, and increased risk
- Understanding the long-term behavior of materials in a nuclear reactor is critical for safe, reliable, reactor operation

Expanded PMDA

- NRC Developed NUREG/CR-6923, “Expert Panel Report on Proactive Materials Degradation Assessment”
  - Published February 2007
  - Scope encompassed passive components in primary, secondary and some tertiary systems of BWRs and PWRs, the failure of which could lead to a release of radioactivity or affect functionality of safety systems
- NRC updating and expanding PMDA to capture operating period beyond 60 years and to expand scope
  - EMDA will ascertain gaps in present level of understanding of materials degradation during subsequent license renewal periods
    - EMDA will look at materials in passive, long-lived systems, structures and components (e.g., RPV steels, concrete, cables, underground piping, etc.)
  - NRC and DOE LWRSP collaborating on developing EMDA

Workshop on Embrittlement Models

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- Development of Predictive Models of Neutron Irradiation Embrittlement in Reactor Pressure Vessel Steels to Support Worldwide Efforts on Nuclear Power Plant Life Extension
- Safe operable lifetime of reactor pressure vessels is regulated by surveillance programs
  - Surveillance programs are, necessarily or by law, limited to
    - Materials of current construction
    - Fluences not much larger than those experienced at end of currently licensed lifetime
- Trend curves in current regulatory use (in US) do not extrapolate well to conditions outside of their calibrated range (e.g., high fluences, low copper)

Conclusions

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- Research is necessary to establish basis for long-term operation of existing nuclear plants beyond 60 years, and this research will:
  - Answer safety questions on aging, reliability, and long-term operability of systems, structures and components
- Industry has lead role to drive the process and identify issue resolutions
  - Ultimately, life extension is utility business decision
- NRC ensures that safety-significant issues are identified and resolved in a timely manner
  - It is **not** NRC's responsibility to resolve any potential aging issues that may impact continued safe operation of existing fleet
  - NRC seeking to collaborate with DOE, industry and international partners in an integrated, holistic program to ensure long-term safety