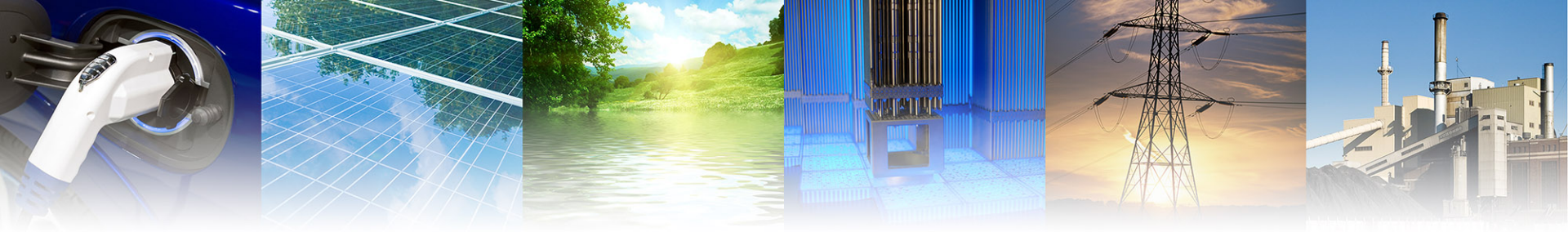

ELECTRIC POWER RESEARCH INSTITUTE

EPRI Perspective

Gregg Swindlehurst

NEKVaC Meeting
January 15&16, 2015

The Needs of the Operating Fleet

Any R&D initiative in the context of the operating LWR fleet must focus on the following questions and related considerations

- Is it important to the industry and/or to the regulator?
  - Maintain or enhance public health and safety
  - Address legacy, emerging, and future regulatory issues
  - Sustain operation of fleet
  - Improve design and operating margins
  - Improve fuel cycle economics
  - Facilitate power uprates
  - Facilitate life extension
  - Improve fuel reliability
- Is it technically achievable and has uncertainty been addressed?
- Can it be implemented by the industry within an acceptable schedule?
- Is it cost-effective?

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Use of Existing Studies to Identify Data Gaps

Note that many of the existing studies are old and need to be updated with more recent data

1) Separate effects tests
   - CSNI(1993)14 – SET Matrix for T/H Code Validation
   - CSNI(1996)16 - Evaluation of the SET Validation Matrix
   - NUREG/IA-0126 – 2D/3D Program Work Summary Report (1993)
   - NUREG/IA-0127 – Reactor Safety Issues Resolved by the 2D/3D Program (1993)
2) Integral effects tests
   - CSNI(1987)132 – CSNI Code Validation Matrix of T/H Codes for LWR LOCA and Transients
3) Containment
   - NEA/CSNI(2014)3 – Containment Code Validation Matrix
4) CFD
   - CSNI(2007)13 – Assessment of CFD for Nuclear Reactor Safety Problems (2014 rev)
   - CSNI(2010)2 – Extension of CFD Codes to Two-Phase Flow Safety Problem (2014 rev)
5) Fuel, fuel rod, and fuel assembly/bundles
   - CSNI(2009)15 – Nuclear Fuel Behaviour in LOCA Conditions
   - CSNI(2010)1 – Nuclear Fuel Behaviour Under RIA Conditions
   - CSNI(2001)21 – In-Vessel Core Degradation Code Validation Matrix
6) Transient test reactor
   - LOFT - LOCA and transients (1976-1985)
   - SPERT – RIA (1969)
7) U. S. system T/H analysis code assessment compilation (EPRI 2014 Report 3002003110)

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Industry Survey Feedback on Data Needs

1. Critical heat flux
    a) Low-flow, flow stagnation, and reverse-flow conditions for a range of pressures
    b) Need transient CHF correlations or first-principles approach (use of steady-state correlations during transients loses margin)
    c) Surface effects currently are not included
    d) Chemical effects currently are not included
    e) Post-CHF heat transfer (cladding failure is assumed rather than modeled)
2. Effects of exposure on fuel performance (major NRC decisions based on too few data)
    a) During LOCA
    b) During RIA
3. Two-phase flow
    a) Subcooled boiling data in PWR rod bundles that quantifies the heat fluxes that result in sensible heating and in boiling (needed for both clean and crudded cladding surfaces)
    b) Void drift interior to and between fuel assemblies
    c) Multi-dimensional two-phase flow
    d) Tests in large vertical pipes, large angled pipes, and large tees
    e) Critical flow data for a range of break sizes and conditions
4. LOCA
    a) Vessel downcomer boiling during refill and reflood
    b) Boron transport (dilution and precipitation)
    c) Gravity-driven reflood
    d) High pressure radiation emissivities for steam
5. Miscellaneous
    a) Natural circulation stability
    b) CFD-grade flow patterns in reactor vessel downcomer and lower plenum (LOCA and SLI
    c) CFD-grade tests for containment effects (refer to CSNI(2014)3)
    d) Pin-resolved neutronics transient experimental data
    e) Fuel assembly distortion during irradiation and related neutronic and T/H effects

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Additional EPRI / Industry Comments

- Need to ensure international experimental test data is captured
- Obtaining release of proprietary data may be the best approach to addressing data gaps
- Any testing program needs code analysis to be performed in parallel
- High cost of testing requires using M&S instead, so focus on assessment of fundamental physics of M&S codes (e.g. CFD, fuel rod thermal-mechanical, pin-resolved neutronics)

INDUSTRY CHALLENGE: How to work with regulators to obtain a cost-effective mix of simulation and data that can be used in regulatory decision making

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