NUCLEAR FUELS – PAST, PRESENT AND FUTURE

Gilda Bocock, Westinghouse

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Nuclear Fuel Primer

- Uranium oxide ceramic pellets less than ½ inch in diameter and about ½ inch tall
- Pellets are loaded into long, metal tubes made of Zirconium alloys
- Fuel rods are loaded into skeletons/cages to form a fuel assembly.
  - PWR: 8.5 inches square
  - BWR: 6 inches square

Nuclear Fuel Primer

- Skeletons / cages provide structural support and means to handle fuel rods
- BWR assemblies use an outer channel or sheath
- Fuel assemblies are typically 12 feet tall but could range from 8 – 14 feet tall
- Control rods (PWR) or control blades (BWR) pass into or between fuel assemblies to control reactivity

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PWR Fuel Assembly

The PWR 17x17 assembly is approximately 160 inches long (13.3 feet), 8 inches across, and weighs 1,500 lbs.

Ceramic Fuel Pellet

Sealed Fuel Rod

End Fitting

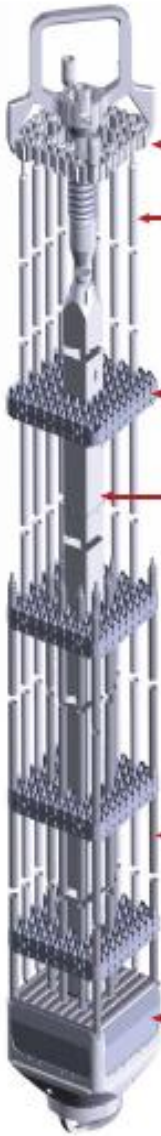
Spacer Grid

Structural Guide Tube

End Fitting

BWR Fuel Assembly

The BWR 10x10 assembly is approximately 174 inches long (14.5 feet), 5 inches across, and weighs about 500 lbs.



Upper Tie Plate

Fuel Rod

ULTRAFLOW Spacer

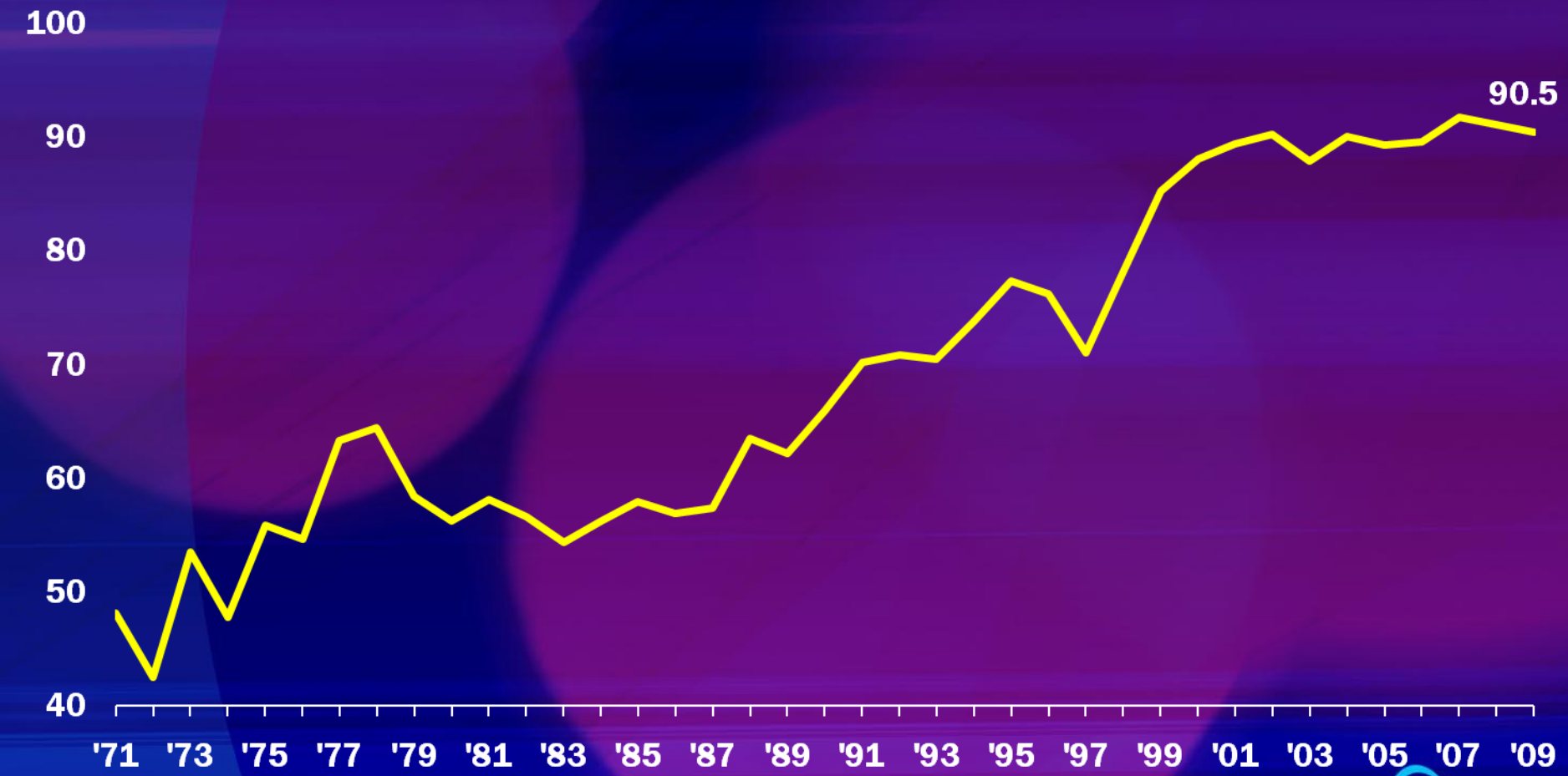
Water Channel

Part-length Fuel Rod

Lower Tie Plate

U.S. Nuclear Industry Capacity Factors

1971 – 2009, Percent



Source: Energy Information Administration

Updated: 5/10

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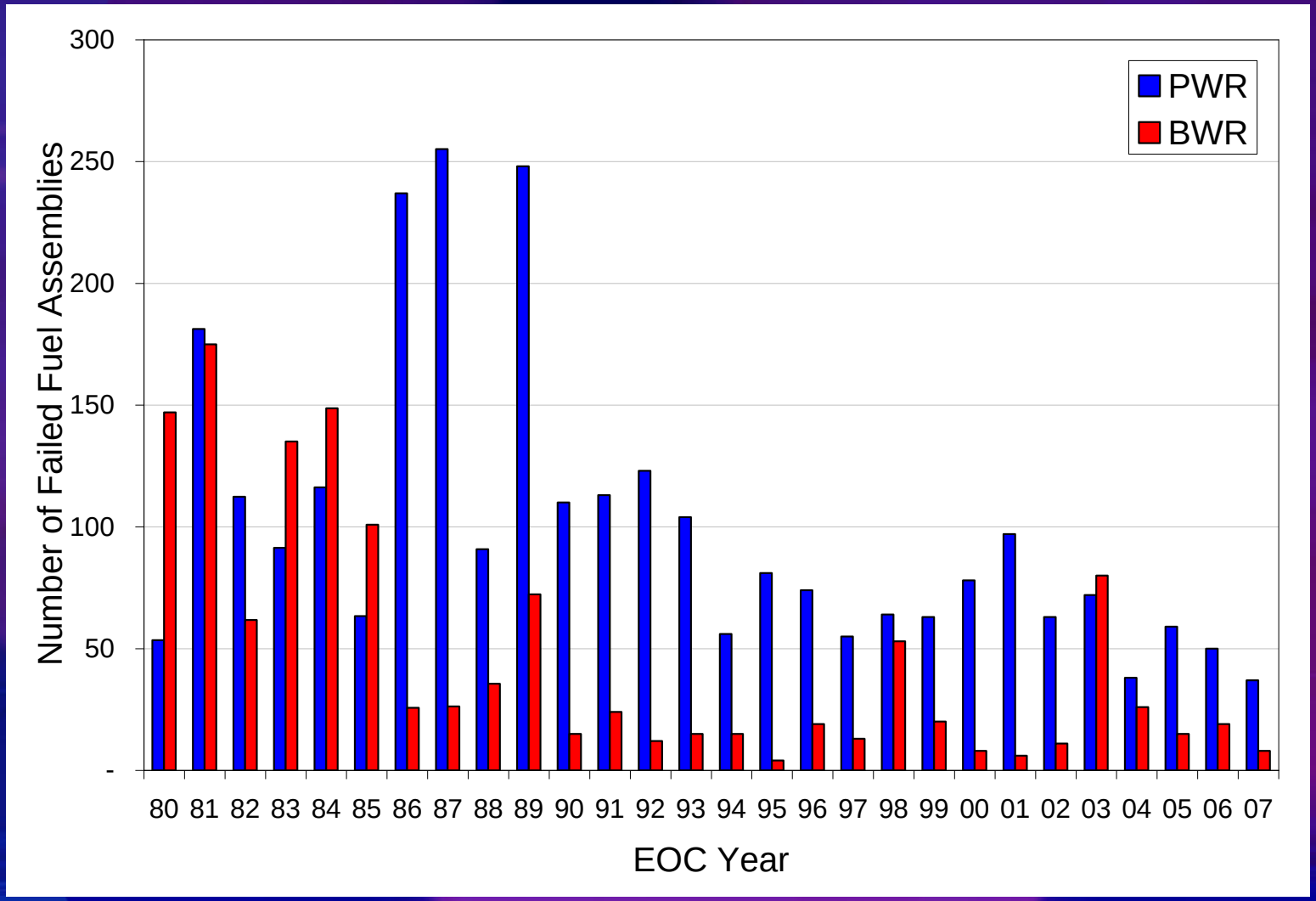
What has changed over time?

- Longer cycles
- Shorter outages
- Power uprates
- Chemistry
- Uranium prices have increased

» The operating environment for the fuel has become more challenging.

» The impact from fuel failures has increased.



» Zero Fuel Failure goal initiated in 2005.

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Greg Kessler, AREVA

Economic Impact

PWR

- Dose & Contamination
- Uranium utilization
- Core Re-design
- Fuel inspection
- Root Cause
- RCS Cleanup
- Monitor RCS Chemistry
- INPO ratings
- Dry Storage characterization

$1.5M = Cost of a Fuel Leak

BWR

All PWR Cost Plus …

- Lost Generation
- Mid-Cycle Outage
- Suppression Tests
- Regulatory involvement, employee compensation, vendor costs….

$15M Cost Potential

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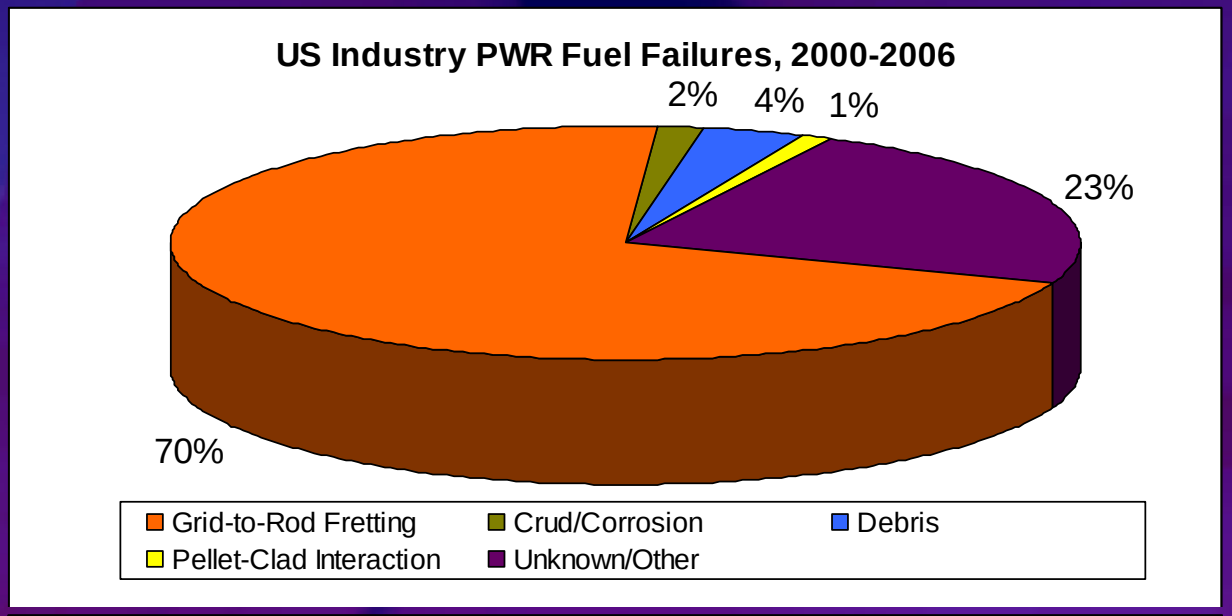
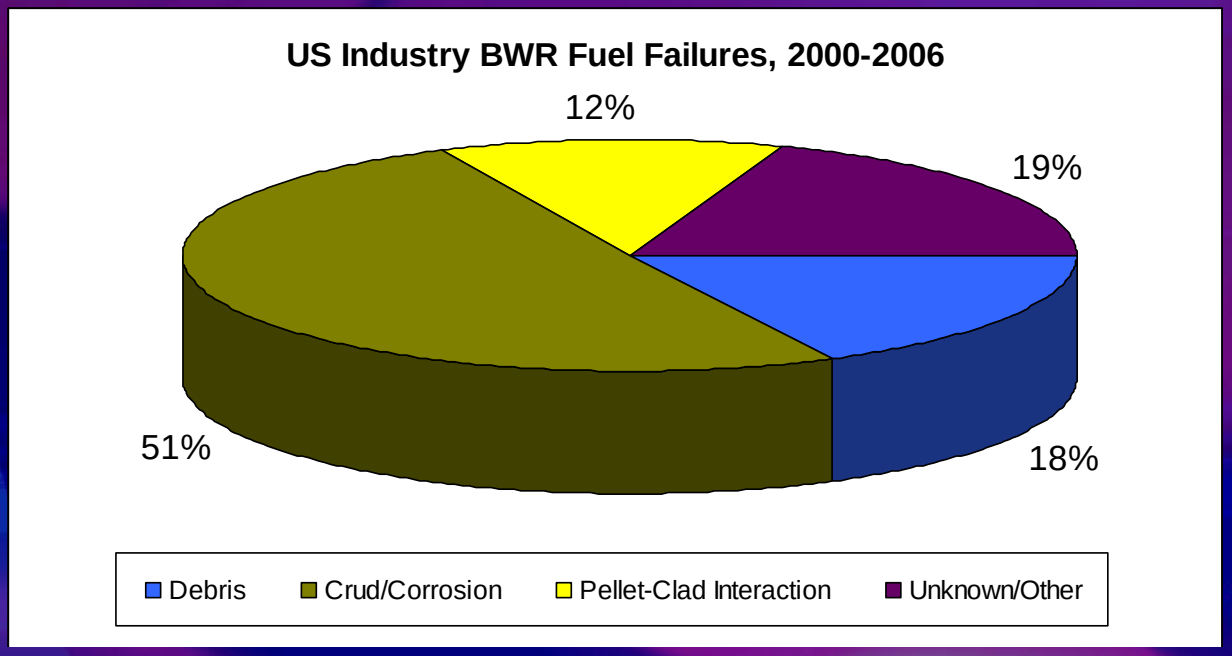

US Industry PWR Fuel Failures, 2000-2006
2%
4%
1%
23%
70%
Grid-to-Rod Fretting
Crud/Corrosion
Debris
Pellet-Clad Interaction
Unknown/Other


US Industry BWR Fuel Failures, 2000-2006
12%
19%
51%
18%
Debris
Crud/Corrosion
Pellet-Clad Interaction
Unknown/Other

Industry Fuel Integrity Initiative

INPO:

- Develop Guidance Documents
- Promote Information Sharing
- Evaluate Performance During Plant Evaluations and Review Visits

Stations:

- Adopt Robust Designs
- Recognize and Mitigate Adverse Operating Conditions
- Improve FME Controls
- Oversee Suppliers
- Better Analyze Failure Causes

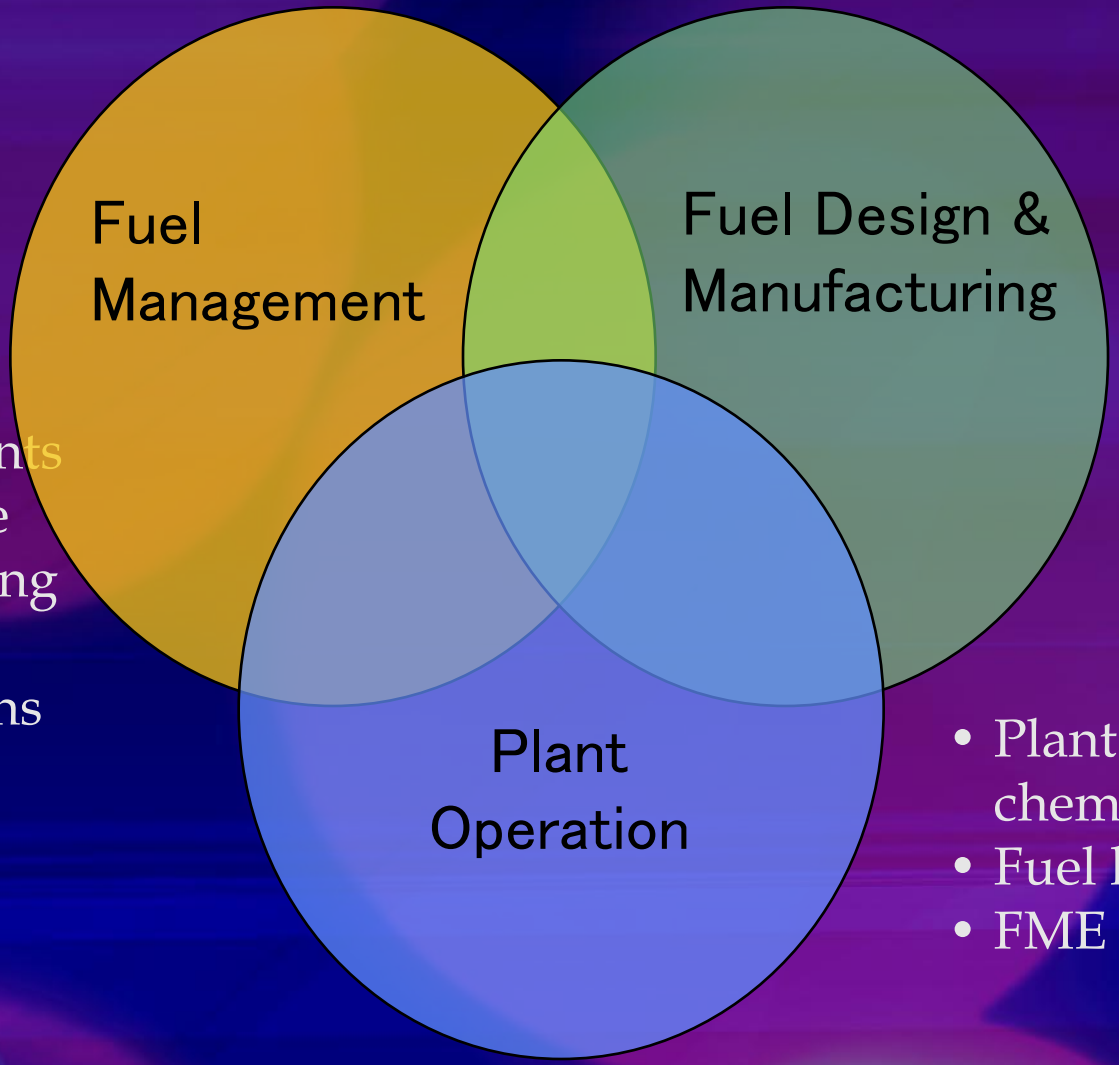
EPRI:

- R&D to Support Plan
- Provide Technical Information and Bases to Utilities

Fuel Suppliers:

- Analyze Failure Causes
- Improve Designs
- Improve Manufacturing
- Share OE
- Benchmark PIE Data

Excellence in All Areas Required for Success in Zero Fuel Failure Goal



- Risk assessments
- Error-free engineering
- Accurate predictions

- Robust design and materials
- Comprehensive testing
- Manufacturing quality and reliability

- Plant operations and chemistry control
- Fuel handling
- FME practices

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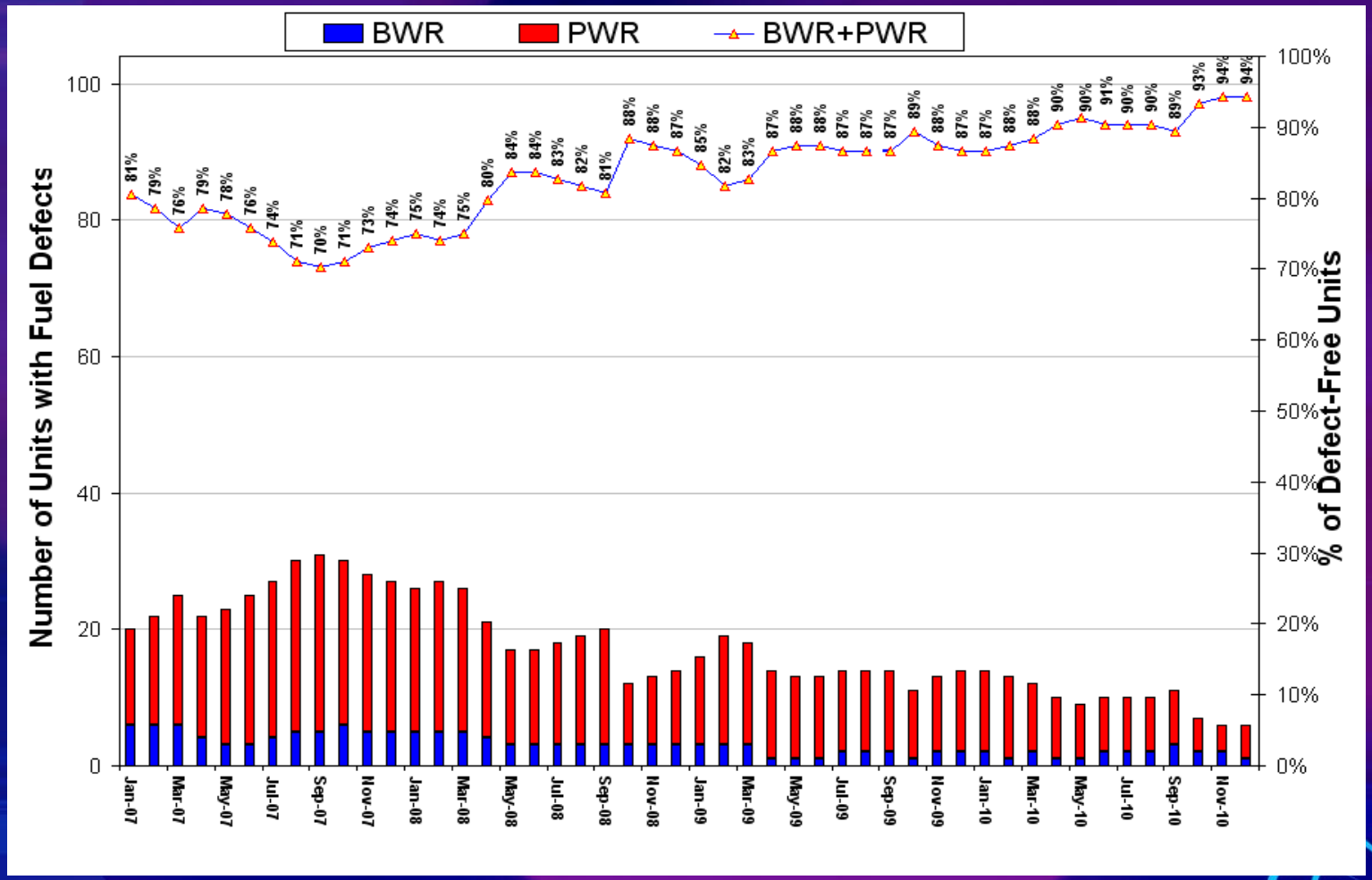
US Nuclear Industry Fuel Performance



Ongoing Efforts / Challenges

- Grid-to-Rod Fretting
  - Implement robust fuel designs
  - Manage transition cores
- Foreign Material Exclusion
  - During manufacturing
  - During handling
  - During plant maintenance

Ongoing Efforts / Challenges

- Reliability for the future
  - Utility focus on fuel performance
  - Change management & risk assessments
    - power uprates
    - Fuel design changes / transition cores
  - New reactor designs & operating strategies

The New Paradigm – Managing Margins to Failure

- Baseline fuel inspections
  - Quantify current margins (corrosion/GTRF)
  - Validate the impact of changes
- Cycle risk assessments
  - Effective change management
  - Crud, PCI, GTRF