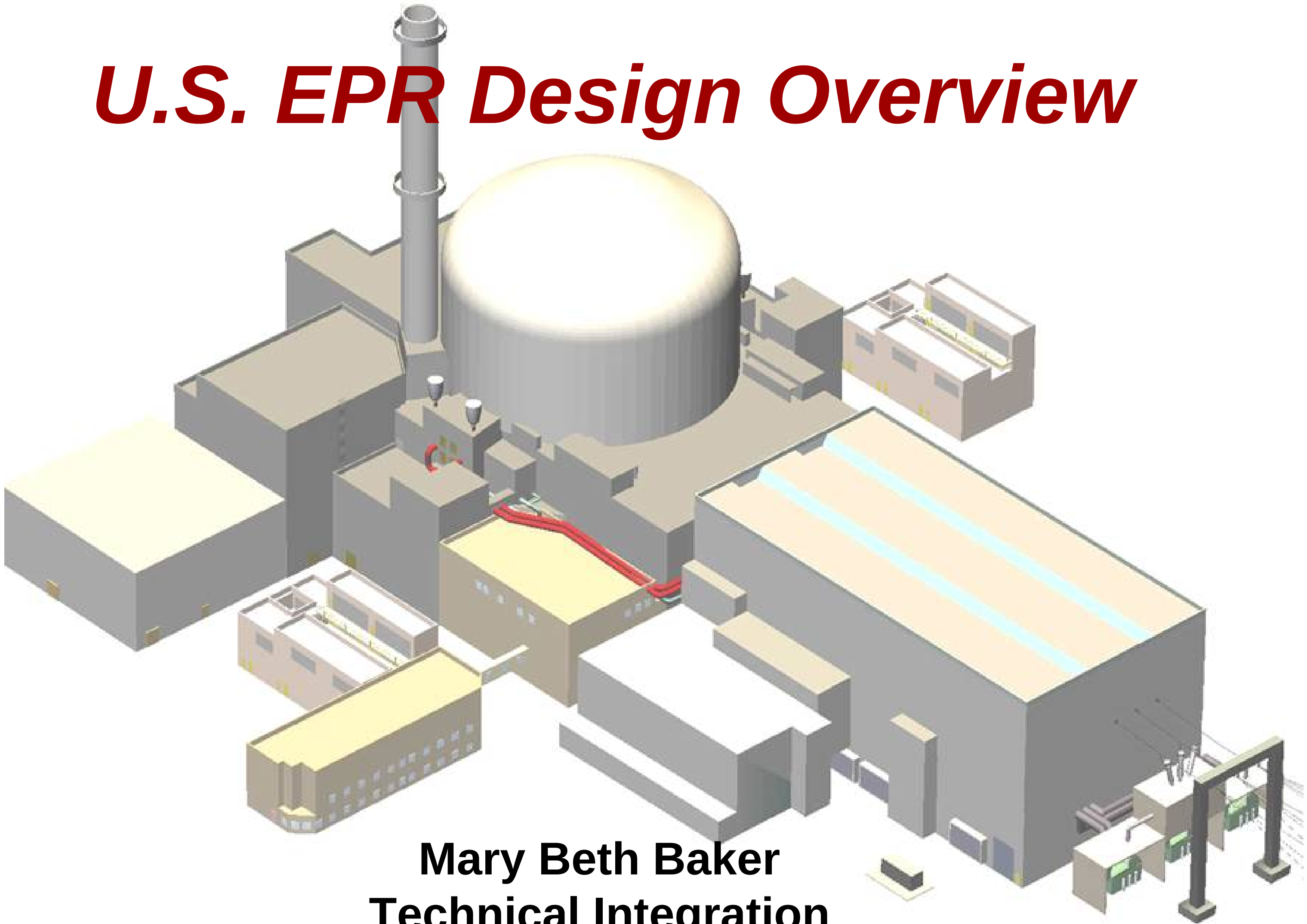
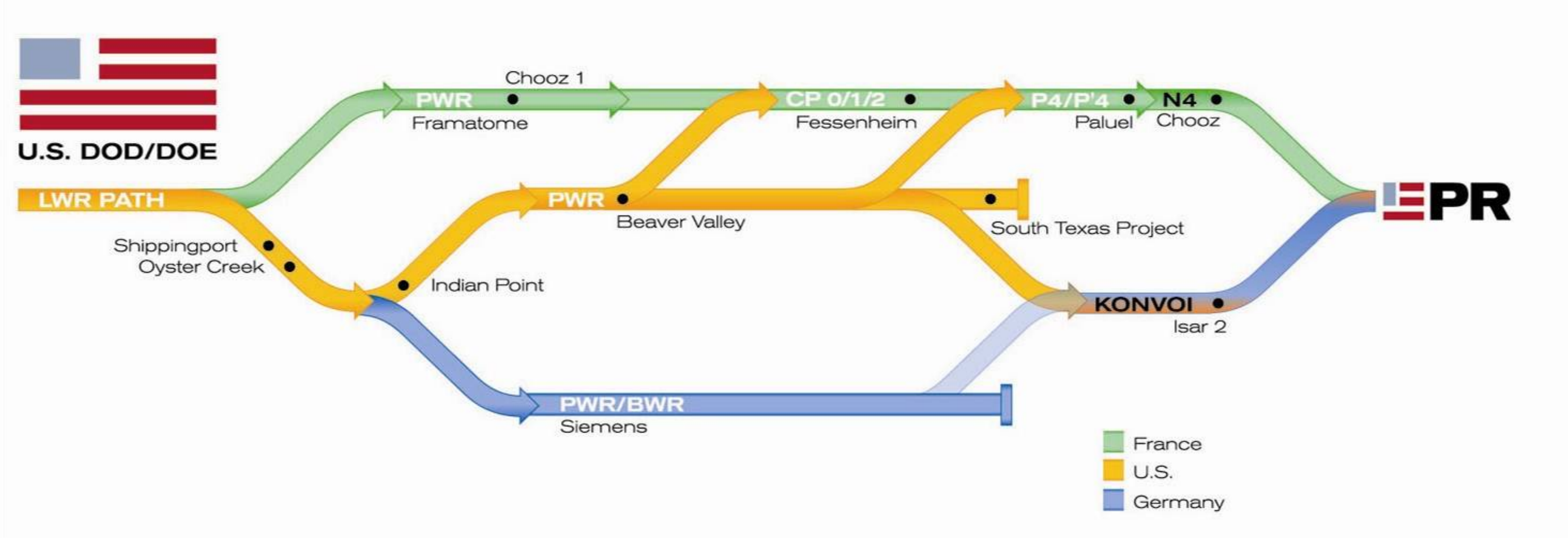
U.S. EPR Design Overview



Mary Beth Baker
Technical Integration
AREVA NP, Inc.

Design Heritage

- **EPR is a global product based on U.S. technology and experience that have been advanced to the next level.**



A mature design based on familiar technology

Experience from 77 operating PWRs in France & Germany

N4

KONVOI

Evolutionary design builds upon existing PWR experience

EPR

Solid Basis of Experience with Outstanding Performance

European Utility Participants

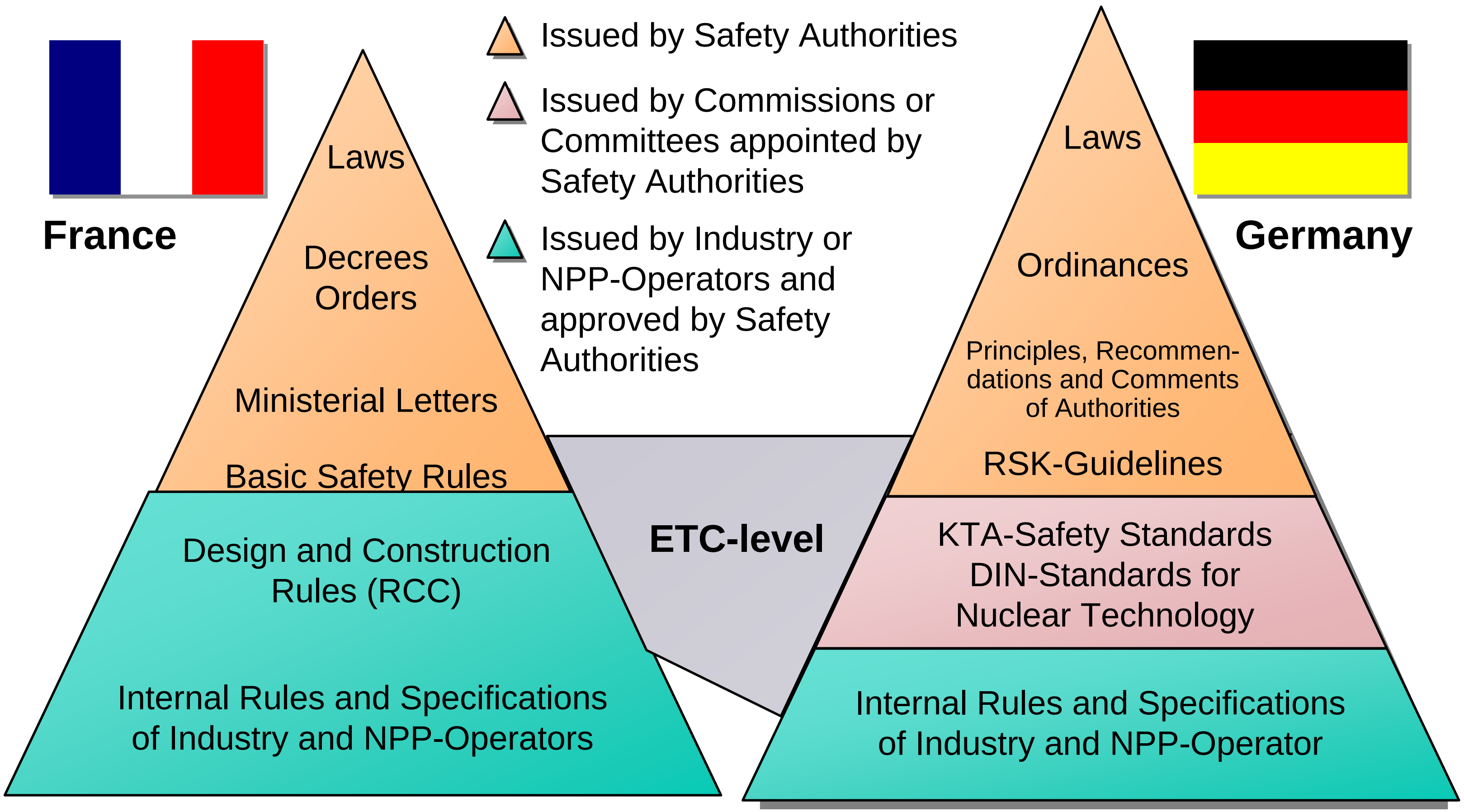
Full members

- French utility - *EDF*
- German producer federation - *VDEW*
- Finnish producers - *Fortum & TVO*
- Spanish nuclear utilities - *DTN*
- Belgian utilities - *Tractebel*
- Italian nuclear facilities - *SOGIN*
- Dutch utilities - *NRG*
- UK nuclear producer - *British Energy/Nuclear Electric*
- Swedish producers - *Vattenfall/FKA*
- Swiss producer federation - *UAK*

associated member

- Russian nuclear utility *REA*

The Harmonization of Codes and Standards



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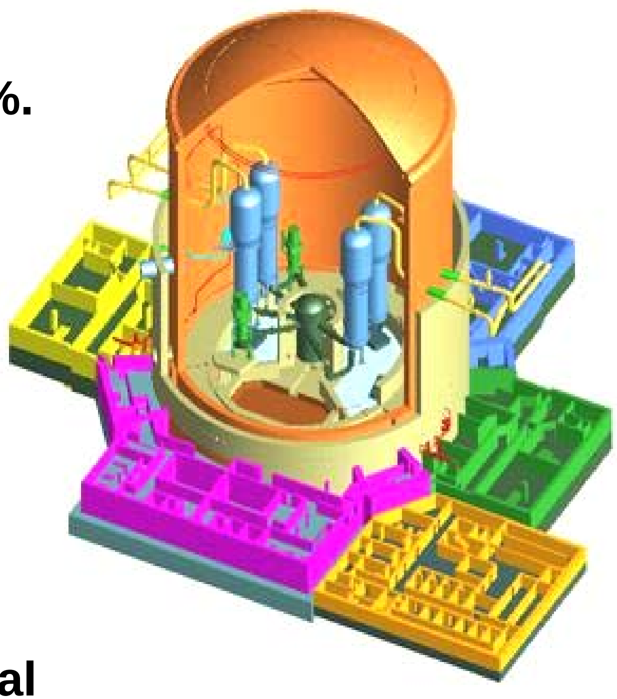
EPR Development Objectives

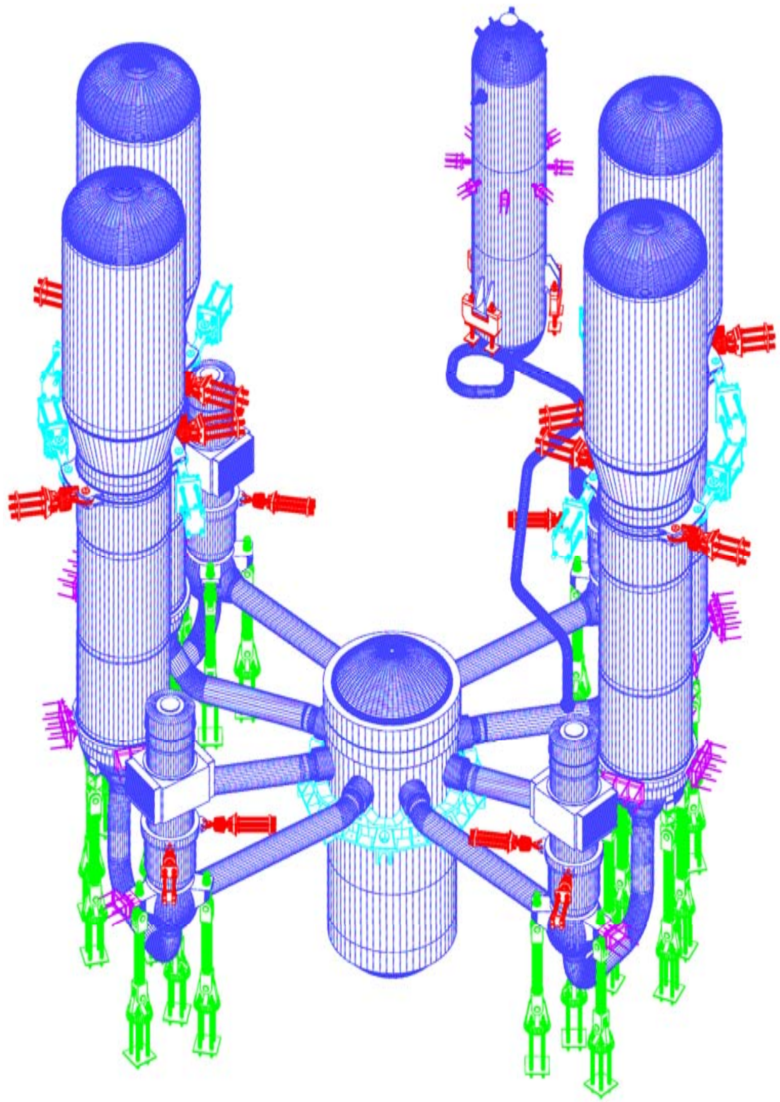
- **Evolutionary** design based on existing PWR construction experience, R&D, operating experience and “lessons learned”.
- **Improved economics**
  - **Reduce generation cost by at least 10%.**
  - **Simplify operations and maintenance.**
- **Safer**
  - **Reduce occupational exposure and LLW.**
  - **Increase design margins.**
  - **Reduce core damage frequency (CDF).**
  - **Accommodate severe accidents and external hazards with no long-term local population effect**



Major Design Features

- Nuclear Island
  - *Proven Four-Loop RCS Design*
  - *Four-Train Safety Systems*
  - *Double Containment*
  - *In-Containment Borated Water Storage*
  - *Severe Accident Mitigation*
  - *Separate Safety Buildings*
  - *Advanced 'Cockpit' Control Room*
- Electrical
  - *Shed Power to House Load*
  - *Four Emergency D/Gs*
  - *Two Smaller, Diverse SBO D/Gs*
- Site Characteristics
  - *Airplane Crash Protection (military and commercial)*
  - *Explosion Pressure Wave*

Reflects full benefit of operating experience and 21st century requirements.



- Conventional 4-loop PWR design, proven by decades of design, licensing & operating experience.
- NSSS component volumes increased compared to existing PWRs, increasing operator grace period for many transients and accidents

A solid foundation of operating experience.

Key Plant Parameters

Parameter	Typical 4-Loop (Uprated)	U.S. EPR
Design Life	40	60
Thermal Power, MW	3587	4590
Electrical Power (Net), MW	1220	1600
Plant Efficiency, Percent	34	35
Hot Leg Temperature, F	619	624
Cold Leg Temperature, F	559	563
Reactor Coolant Flow Per Loop, gpm	100,500	125,000
Primary System Operating Pressure, psia	2250	2250
Steam Pressure, psia	1000	1109
Steam Flow Per Loop, Mlb/hr	4.1	5.17
Total RCS Volume, cu.ft.	12,265	16,245
Pressurizer Volume, cu.ft.	1800	2649
SG Secondary Inventory at Full Power, lbm	101,000	182,000

Increased power and thermal efficiency

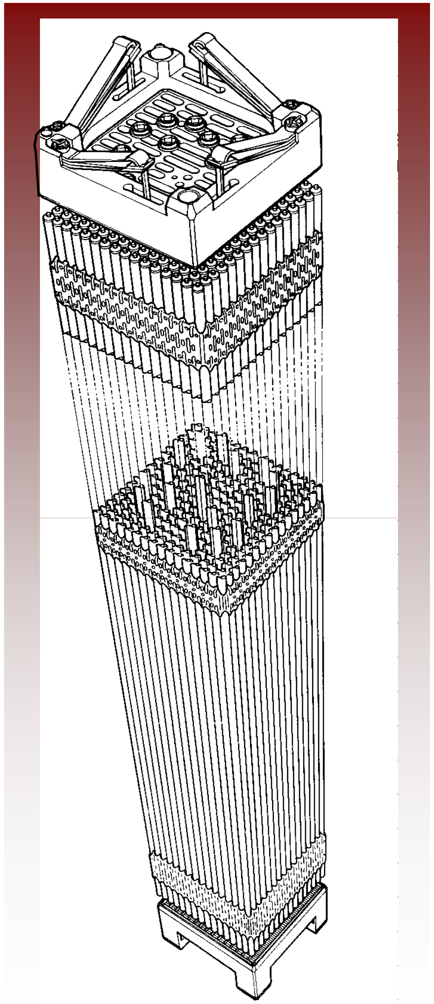
Core Characteristics

- Increased Uranium utilization (~7% reduction in uranium consumption)
- Designed for use of MOX fuel
- Designed for 12 to 24 month fuel cycle
- Up to 5% enrichment
- > 60 GWd/t burn-up

Designed for increased flexibility & performance

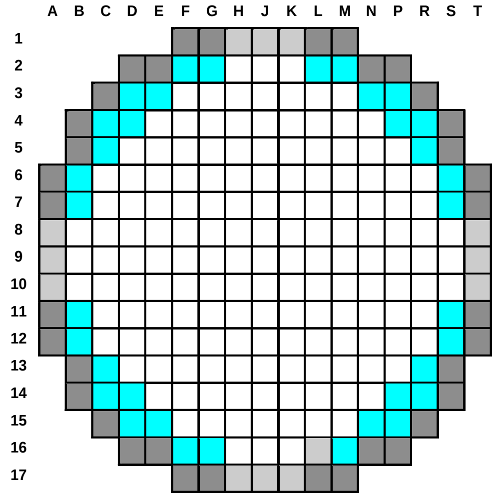
Fuel Design Proven By Operation

- 17x17
- Typical Pitch-to-Diameter Ratio
- M5 Cladding
- Heated Length Similar to N4
- M5 HTP Mixing Vane Grids
- Anti-Debris Lower End Fitting
- Significant Design Margins
- MOX Compatible



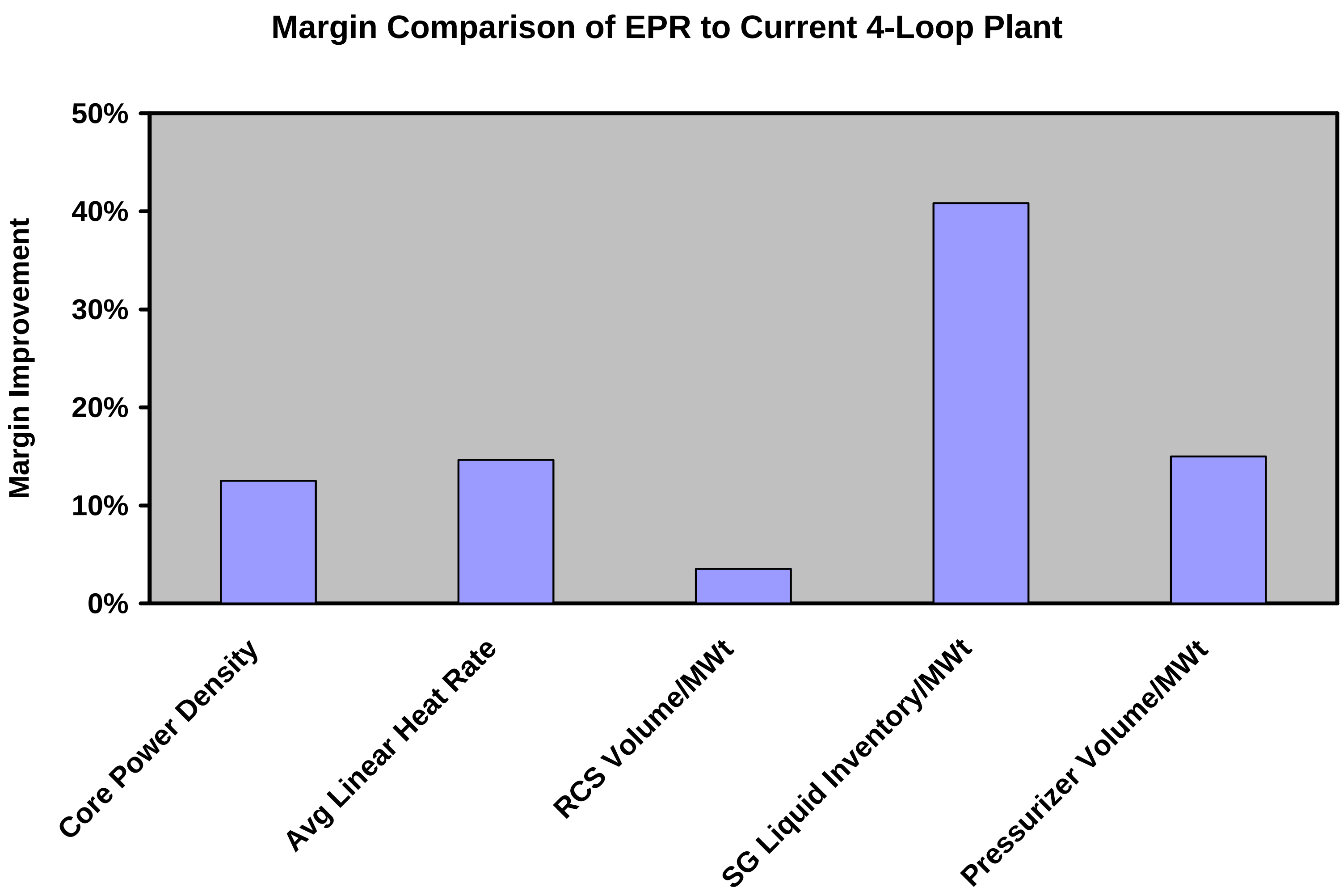
EPR Core Design Parameters

Parameter	Current 4-Loop (Uprated)	EPR
Core Thermal Power, MW	3587	4590
Number of Fuel Assemblies	193	241
Fuel Lattice	17x17	17x17
Active Fuel Length, ft	12	13.78
Rods Per Assembly	264	265
Average Linear Heat Rate, kw/ft	5.84	5.10
Peak Linear Heat Rate, kW/ft	14.6	14.0
Number of Control Rods	53	89



Type of Plant	No of Fuel Assy	
4-loop 1300 MWe	193	
4-loop N4	205	
U.S. EPR	241	

Improved Design Margin



Increased power with improved margins.

Selected Key Features of EPR

Double-Walled Containment

- Inner wall post-tensioned concrete with steel liner
- Outer wall reinforced concrete
- Protection against airplane crash
- Protection against external explosions
- Annulus sub-atmospheric and filtered to reduce radioisotope release

The Four Train Concept

Each safety train is independent and located within a physically separate building.

The Four Train Concept (cont'd)

4 Independent Safety Trains

Arranged into 4 divisions

- ⇨ Preventive maintenance during power operation
- ⇨ Shorter outage time
- ⇨ Simplified technical specifications

Higher Availability

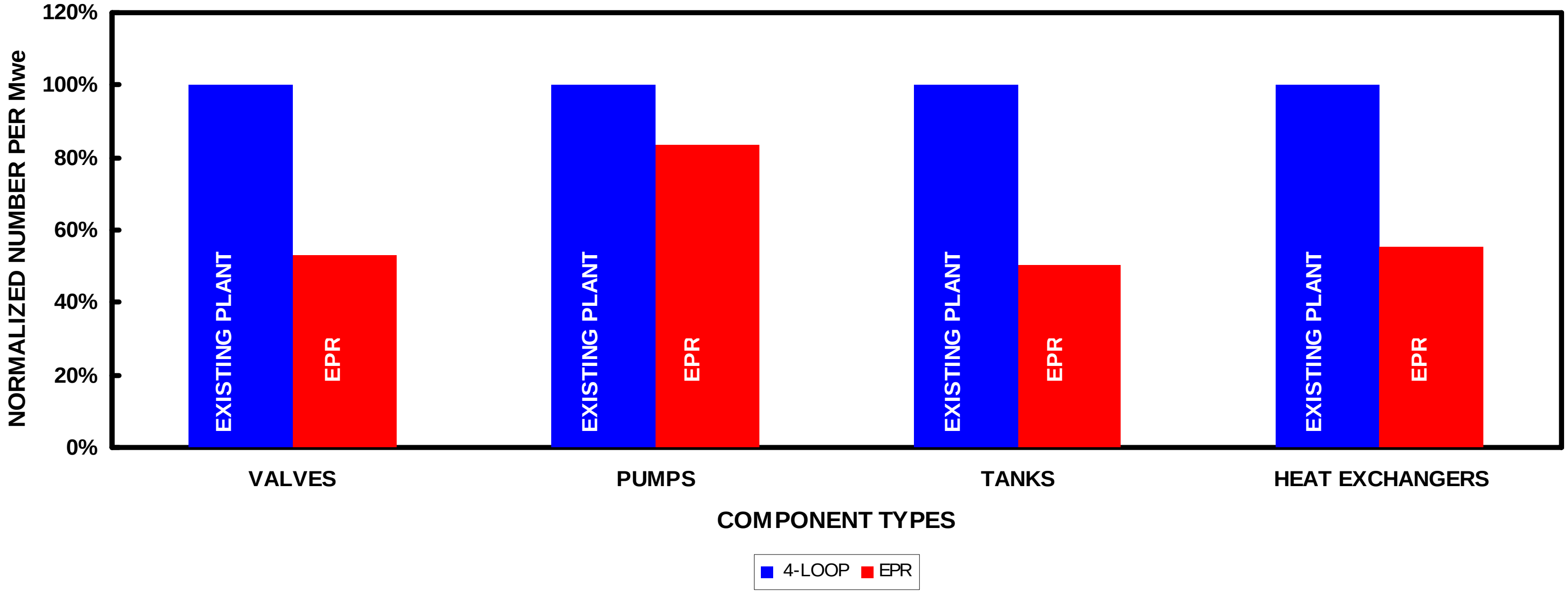
- ⇨ Smaller components
- ⇨ No header between trains
- ⇨ Fewer valves per train

Easier Maintainability

- ⇨ Efficient hazard protection
- ⇨ Reduced piping and components
- ⇨ Optimized plant layout

Lower Unit Cost

Reduced Equipment Quantities

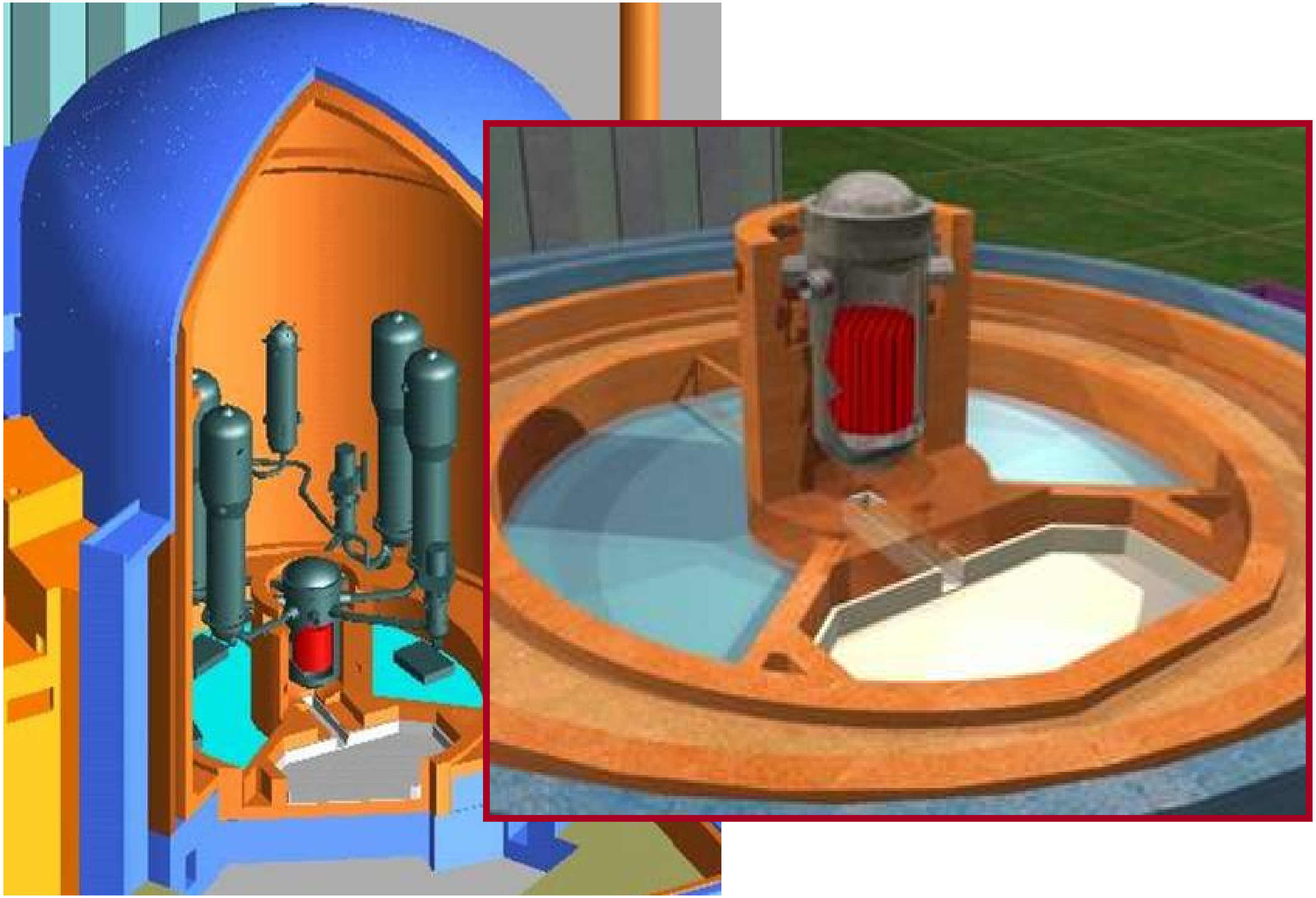


Study based on: RCS, Pzr. Spray, RCP seal and Leakoff, SI/RHR, CVCS incl. Boration and Demin/Seal Water, SFP Cooling, CCW, FW AFW/EFW, and MS

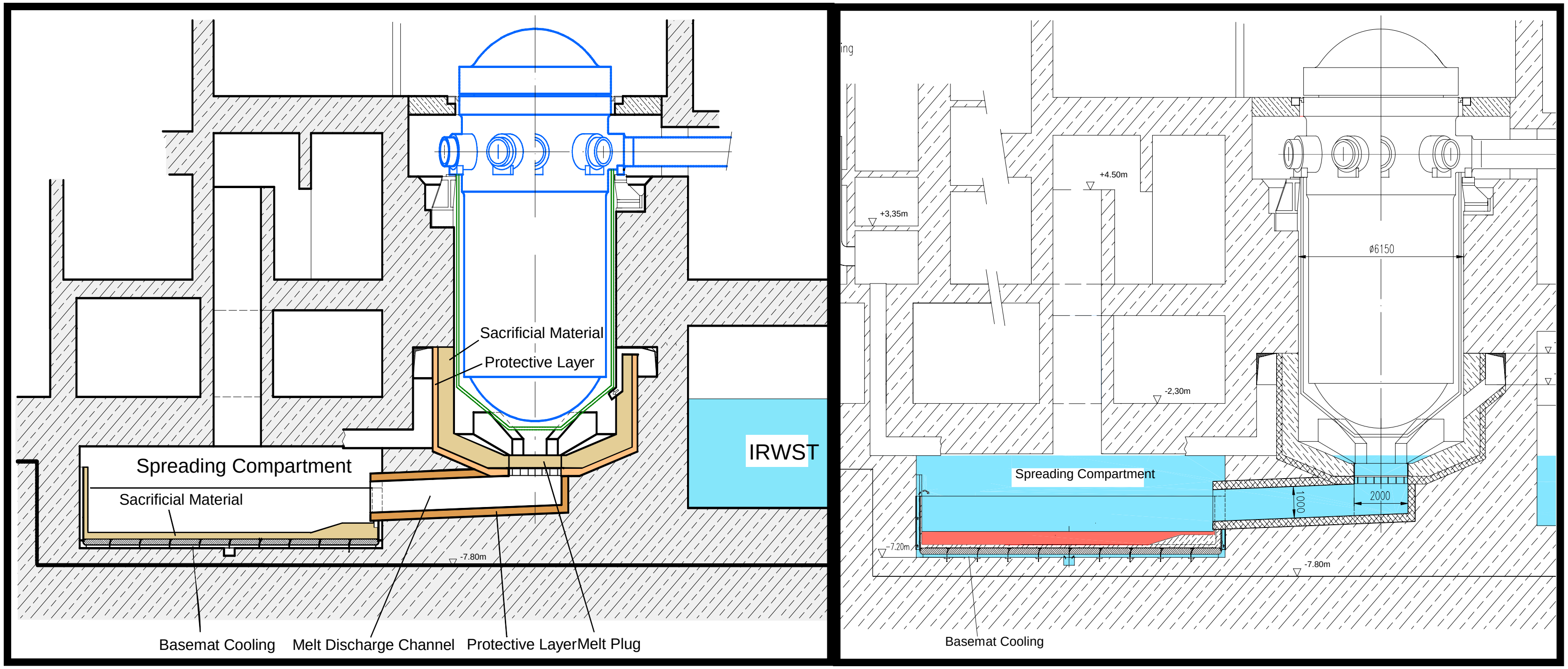
	EPR	4-Loop PWR	% Change (Absolute)	% Change (Count/MWe)
Pumps & Turbines	43	37	16	(16)
Heat Exchangers	34	44	(23)	(44)
Tanks	23	33	(30)	(50)
Valves	2,044	2,766	(26)	(47)

** Information based on AREVA study of Modern 4-Loop facility*

Severe Accident Mitigation:
Views of Corium Spreading Area & IRWST



Severe Accident Mitigation:
IRWST Provides Passive Cooling of Corium



Operator-Friendly Man-Machine Interface

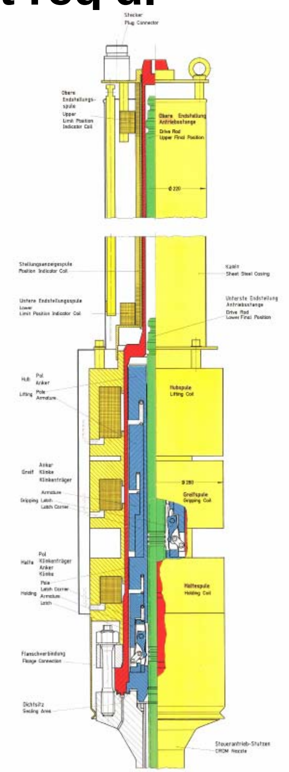
N4 Control Room

EPR Control Room

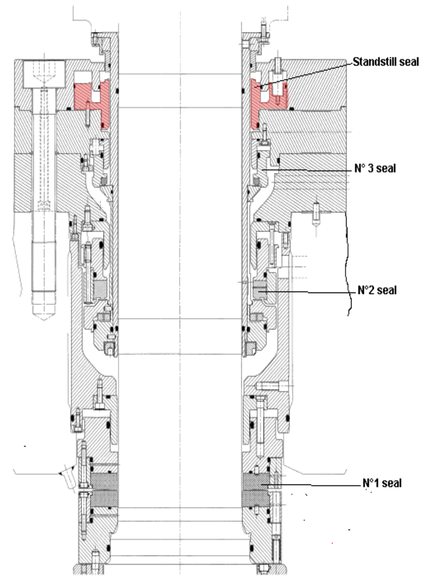
Capitalizing on nuclear digital I&C operating experience and feedback.

Equipment Improvements

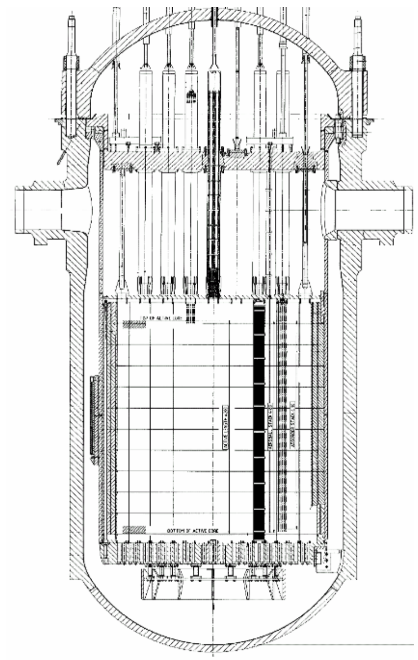
Martinsitic CRDM housing. Forced convection cooling of coils not req'd.



RCP stand-still seal eliminates leakage during SBO.



No penetrations in RV lower head.

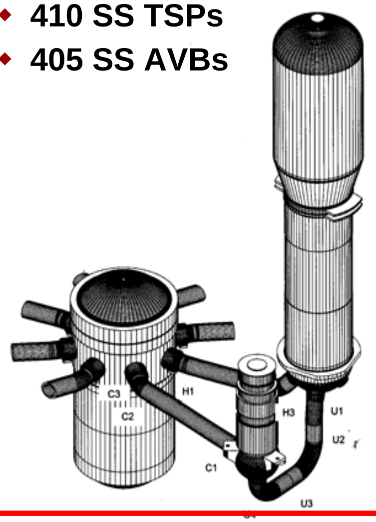


Equipment Improvements

Extensive use of forgings with integral nozzles.

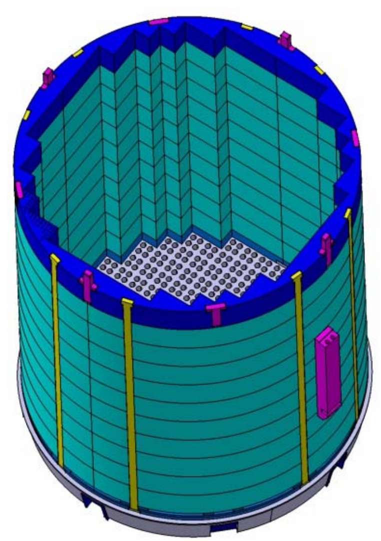
Materials resistant to corrosion and cracking

- 304L SS hot/cold legs
- 316L SS surge line
- 304L/316L RV internals
- 308/309 SS cladding
- Alloy 690 SG tubes
- 410 SS TSPs
- 405 SS AVBs

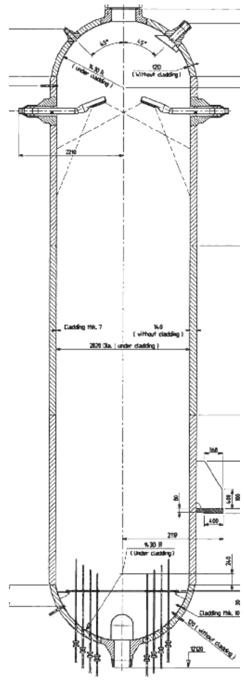


Conventional core baffle replaced by heavy reflector.

- Eliminates bolting
- Improves neutron economy
- Reduces vessel fluence

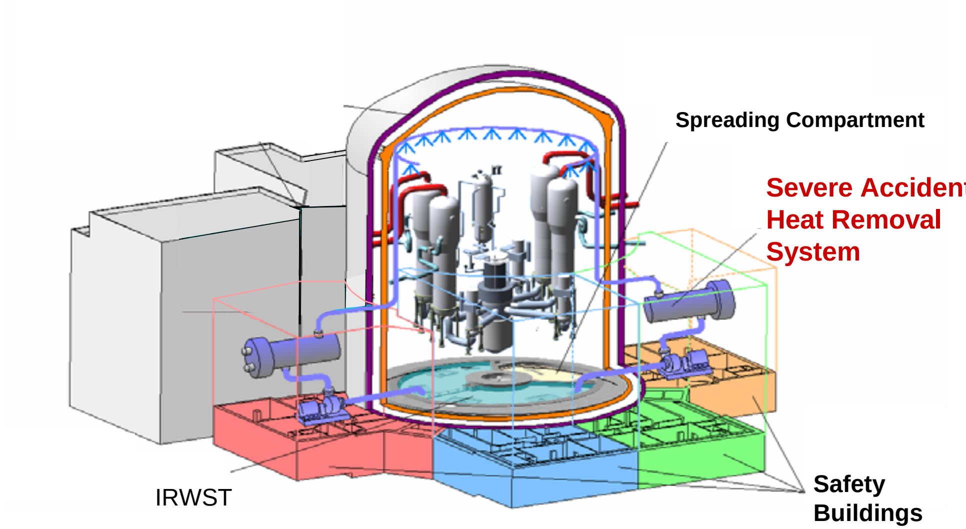


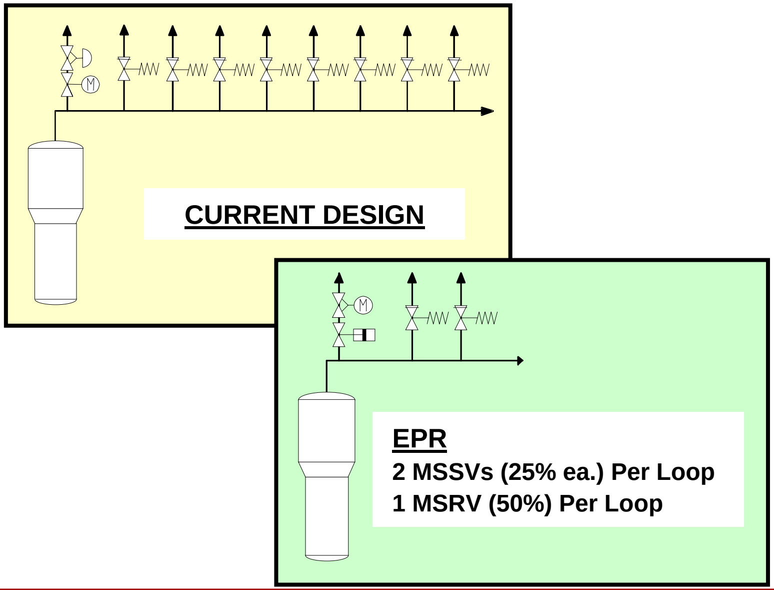
Two normal pzr spray (ea. from different CL) plus one aux spray



Reduced Maintenance & Surveillance Testing

- No containment fan coolers
- Containment spray is non-safety (for severe accident)
- No turbine-driven MFW or AFW pumps (all electric)
- Main steam relief & safety valves reduced from 8 - 10 to 3 per loop





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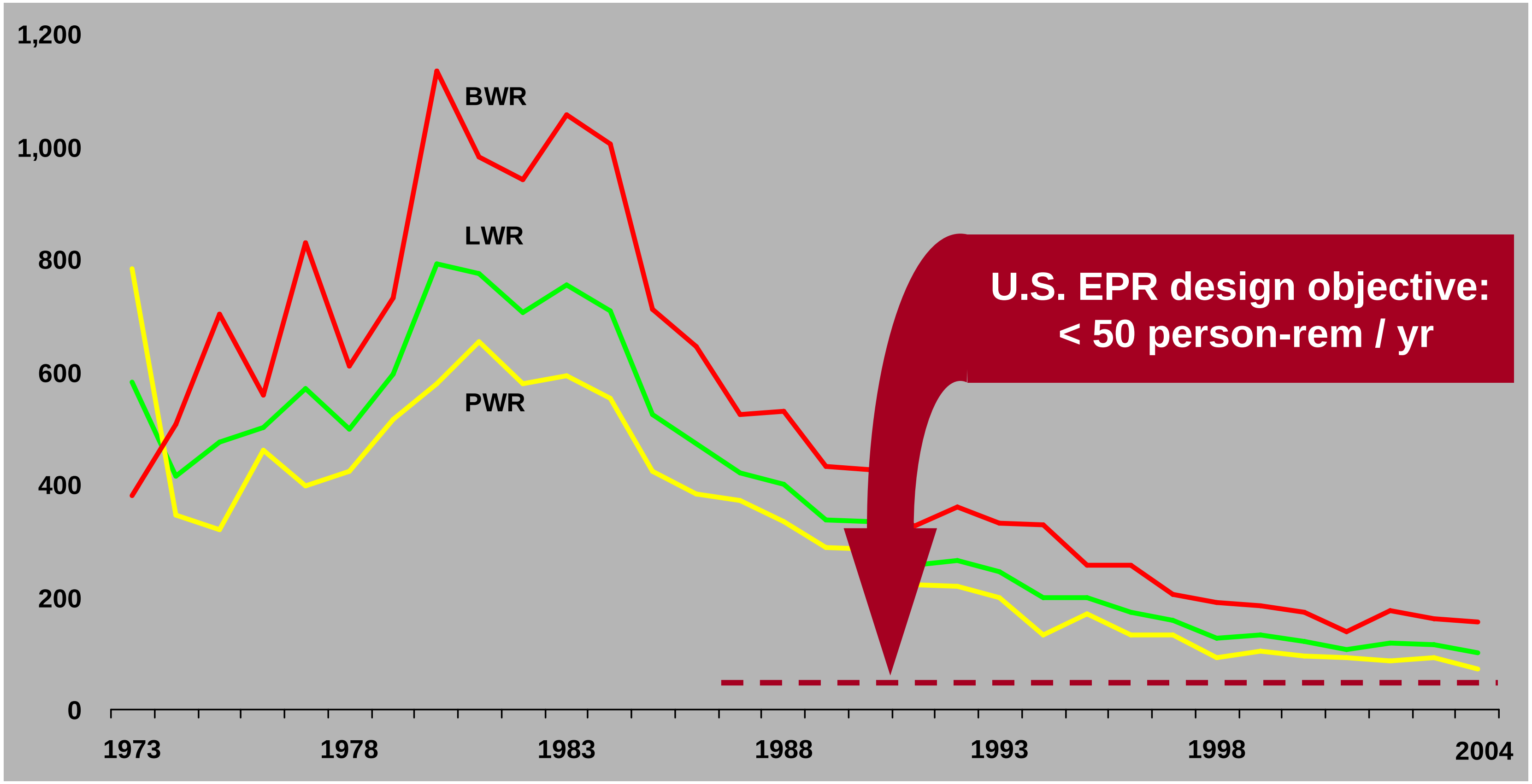
Additional OE Feedback

- **Elimination of Single-Point Vulnerabilities**
  - **Four, 33% Main Feedwater Pumps**
  - **Three, 50% Condensate Pumps**
  - **By-pass of components for maintenance w/no derate**
  - **Duplicates of key components (e.g., demins, Hx's) to allow isolation for maintenance**
- **Layout to Facilitate Maintenance**
  - **Room for access designed in**
  - **Most components can be removed and replaced via pre-designed pathways and equipment hatches**
- **ALARA**
  - **Minimize Cobalt in plant components**
  - **Vessels and Hx's designed to minimize deposits**
  - **Use of "Hot" and "Cold" zones**

U.S. Industry-Average Dose Per Reactor

1973-2004, (Person-rem)



Source: Nuclear Regulatory Commission Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities 2004

Updated: 4/06

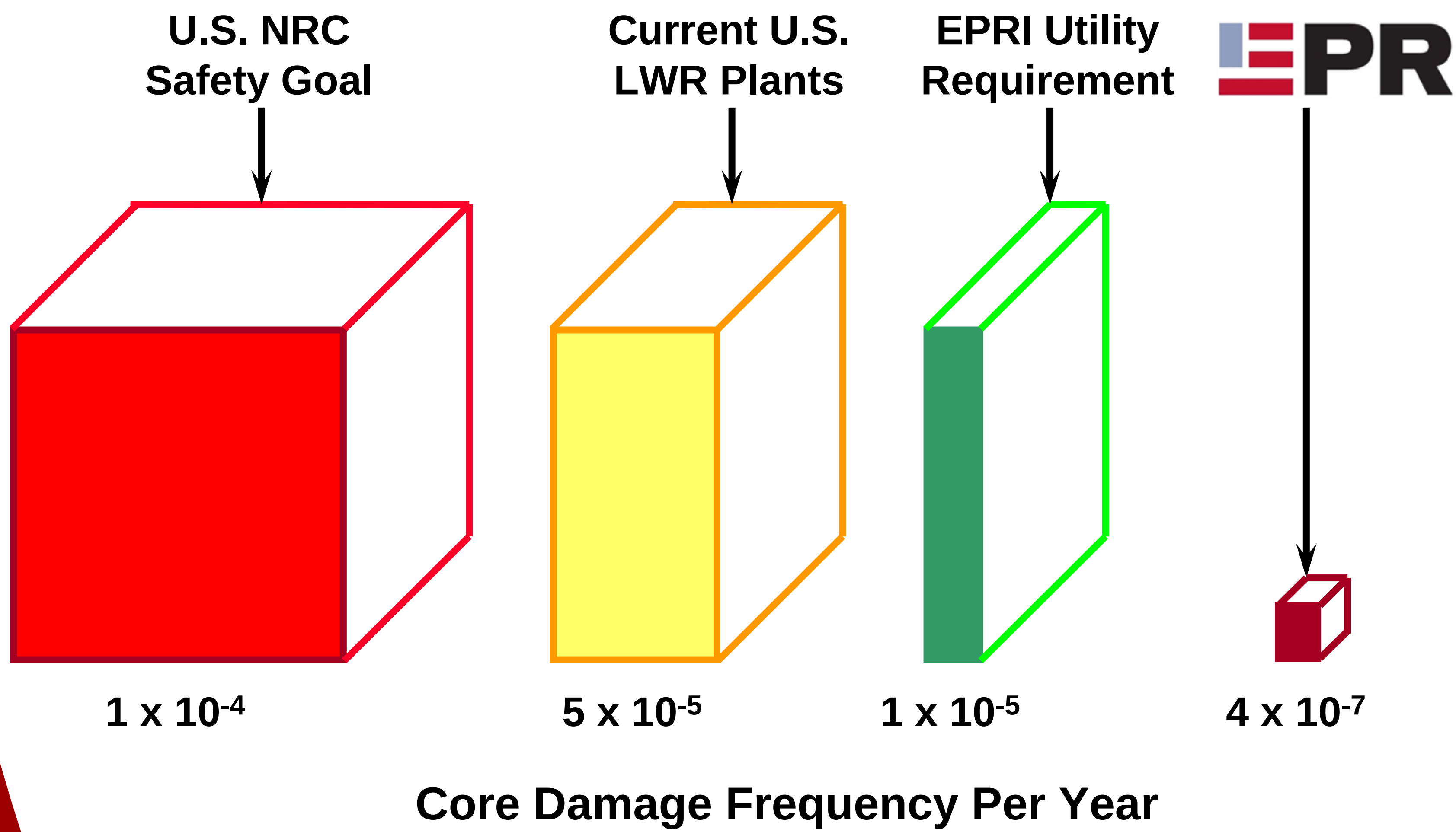
Probabilistic Objectives And Targets

- **Safety objective for integral core melt frequency (all plant states, all types of initiators): < 10^{-5} per year**

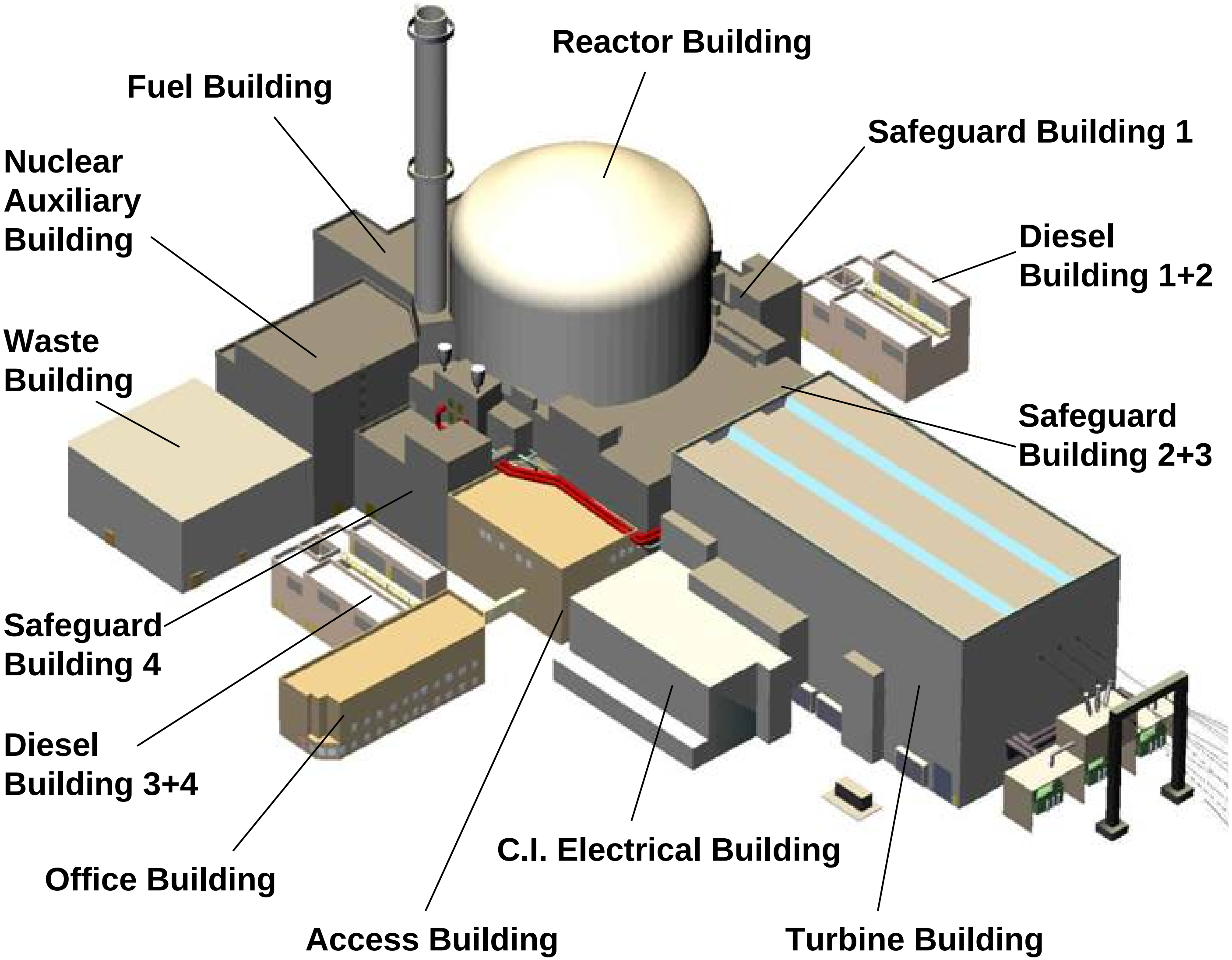
- **Design target for core melt frequency for internal events**
  - **from power states: < 10^{-6} per year**
  - **from shutdown states: less than power states**

- **Design target for core melt with large and early releases from containment: < 10^{-7} /year**

U.S. Nuclear Industry Safety Goals

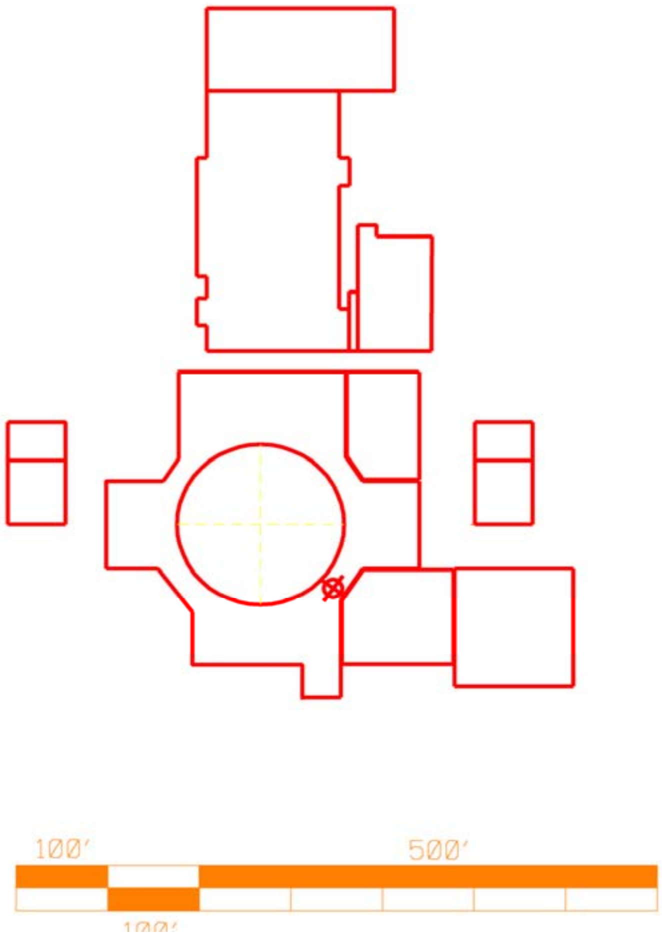


General Plant Layout

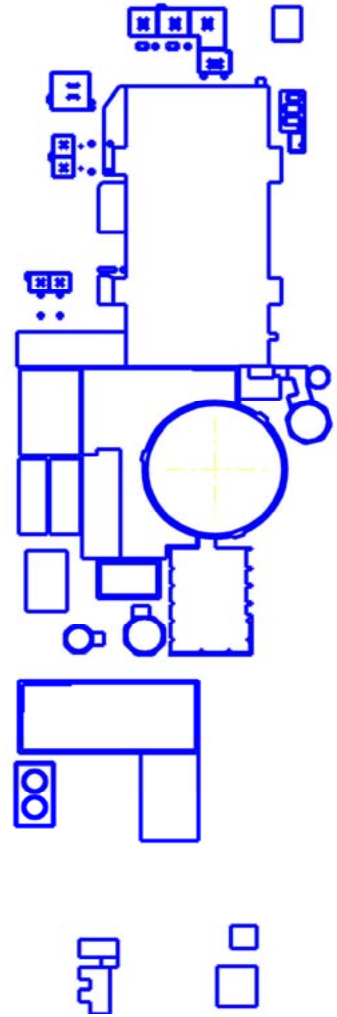


U.S. EPR vs. Current Unit

U.S. EPR
1600 MWe



4-Loop Unit
1235 MWe



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Conclusions

- EPR is evolutionary
- Most features are typical of operating PWRs
- Features included to
  - Improve Safety
    - Increase redundancy & separation
    - Reduce core damage frequency
    - Reduce large early release frequency
    - Mitigate severe accident scenarios
  - Protect critical systems from external events
    - Aircraft Hazard
    - External Explosion
    - Flood
  - Improve human factors
  - Lower O&M Costs
    - Simplified Systems
    - On-Line Maintenance
    - Use of latest, proven technology
    - Economy of Scale