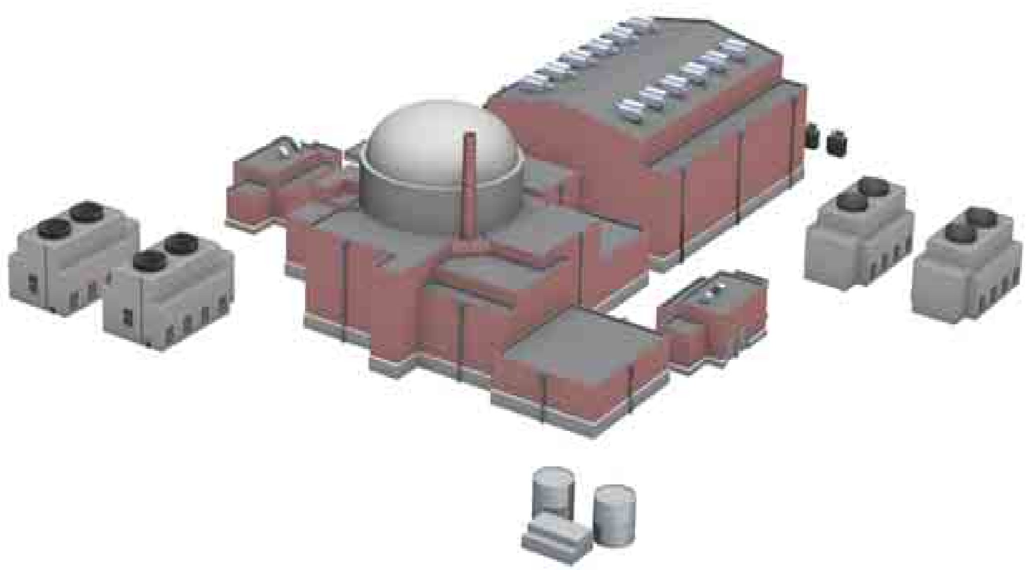
AREVA

PURE ENERGY

U.S. EPR Design Overview



Brian A. McIntyre

U.S. EPR Design Certification Project Manager

WM2009 Conference

March 4, 2009

The EPR Story

1989: Agreement between Framatome and Siemens on development of common next generation PWR

1989-1991: Development Common Product

1991-1994: Involvement of EDF and German utilities
Definition of EPR plant concept

1995-1997: Basic design studies

1998-2003: Post-basic design studies

2003: Order Placed For OL3

2004: Decision to construct an EPR in France

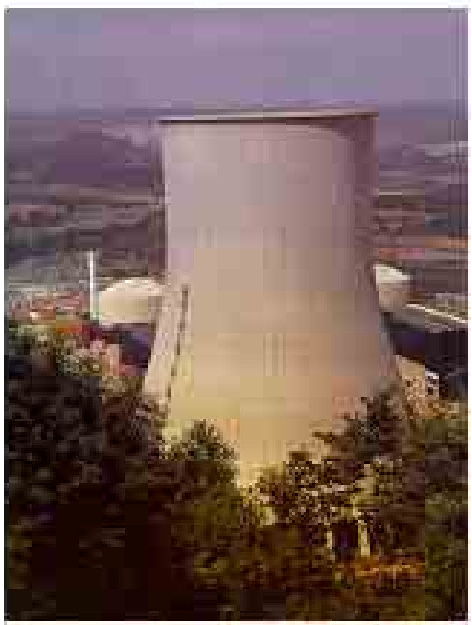
2005: New Plants Deployment BU Formed in US
Constellation/AREVA announce Joint Venture

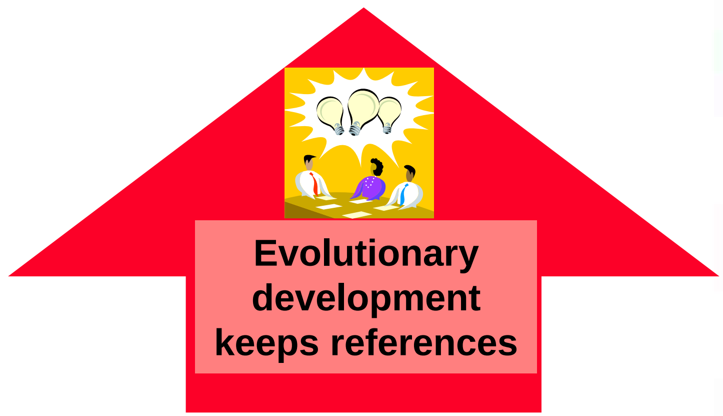
2007: AREVA submits design certification application in US
EdF begins construction of FA3
AREVA signs contract for 2 EPRs in Taishan, China

The EPR is Built on Experience of 77 plants operated in France & Germany

EPR

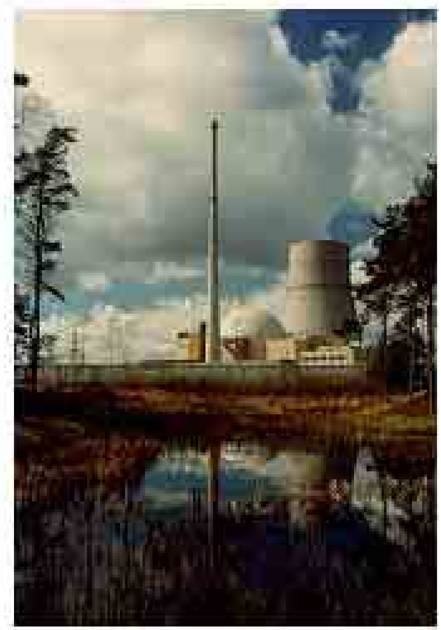
N4





Solid Basis of Experience with Outstanding Performance

KONVOI



N4 & KONVOI : Two Different Designs

N4

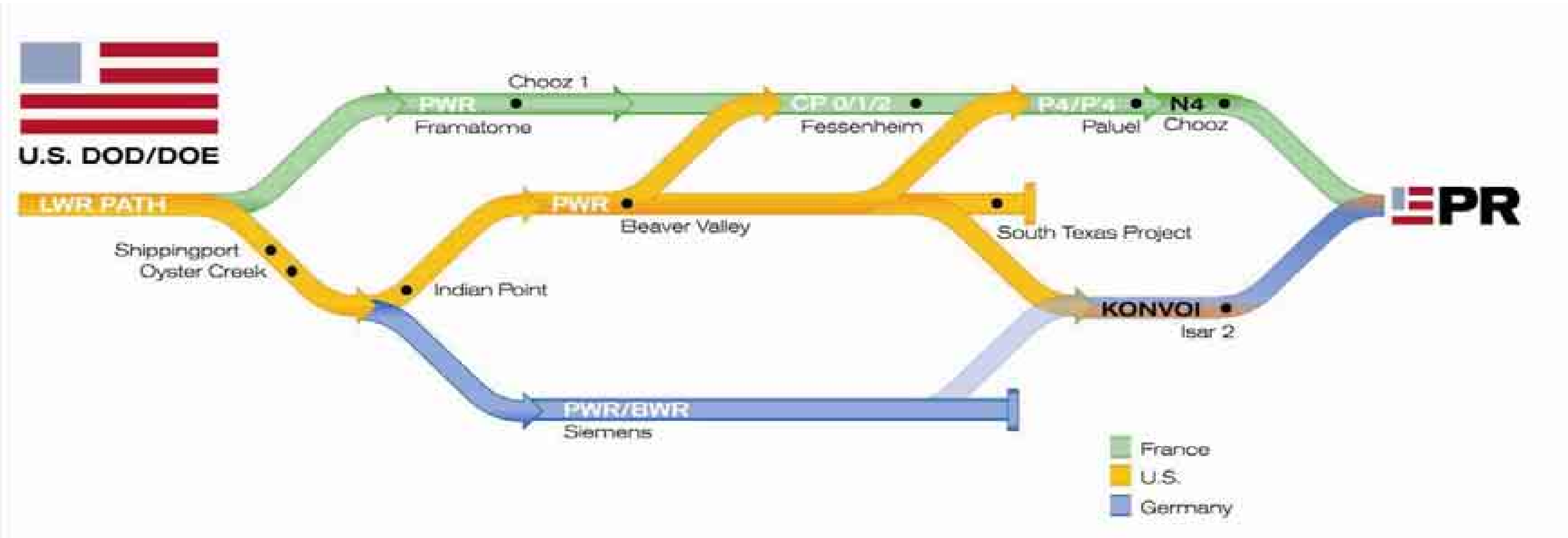
• concrete cylindrical containment
prestressed inner wall
• Cessna, Lear jet
• fuel building
• safety systems:
- 2 100% trains w connections
- spray system
- RHR inside the containment
• bottom in-core instr.
• computerized MCR
• core: 205 FAs 17x17

KONVOI

• steel spherical containment
• military aircraft Phantom
• spent fuel pit inside the reactor building
• safety systems:
- 4 independent 50%trains
- no spray system
• top mounted in-core instrumentation
• main control room with dedicated panels
• core: 193 FAs 18x18

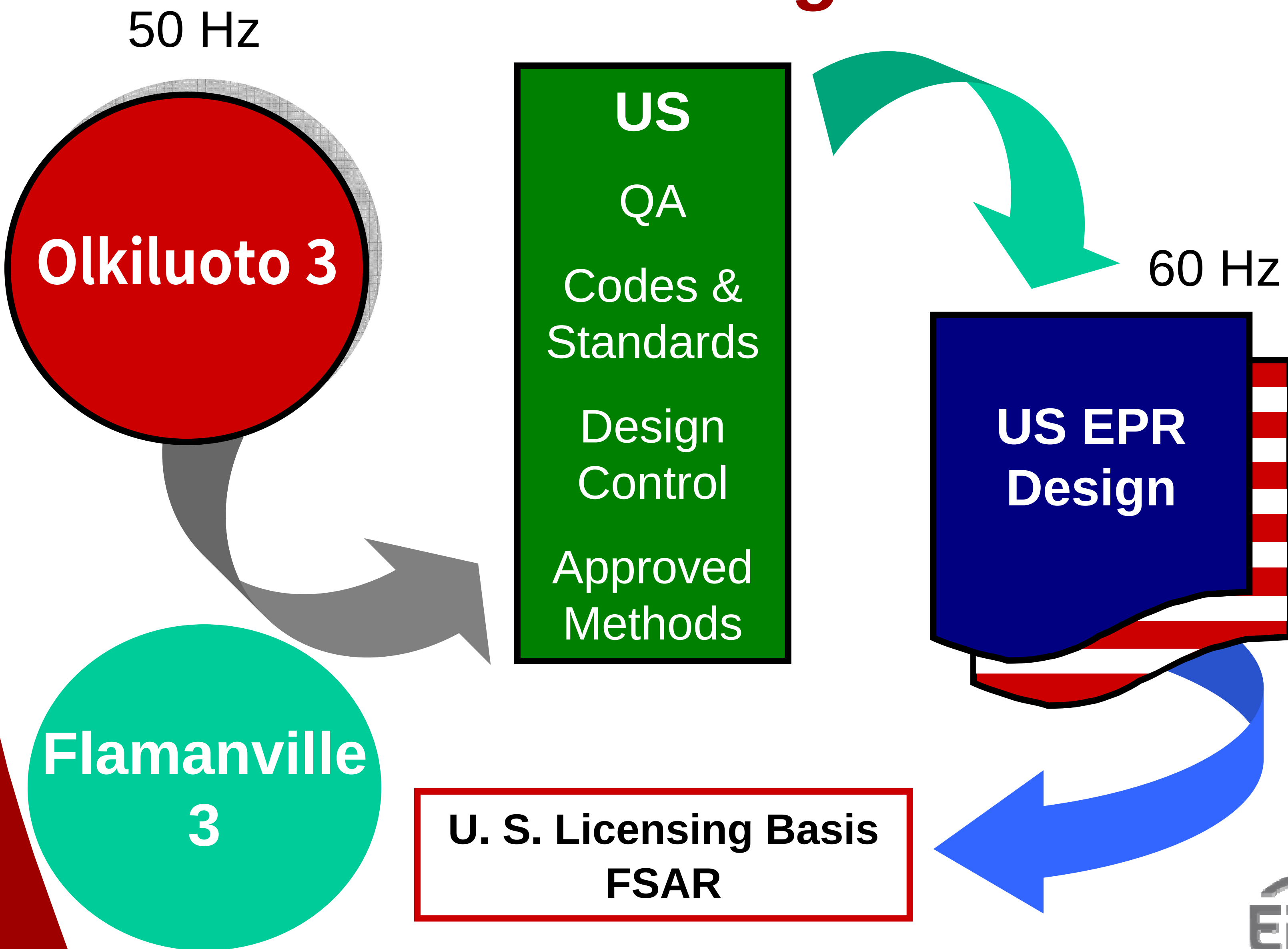
Design Heritage

- **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

EPR Design Conversion



EPR Fleet

- Finland – Olkiluoto 3
- France – Flamanville 3
- China – Tiashan 1 & 2
- United States
  - Design Certification
  - Combined License Applications
    - Calvert Cliffs
    - Nine Mile Point
    - Callaway
    - Bell Bend

EPR in Finland
Olkiluoto 3

OL3 Nuclear Island – February 2009

EPR in France
Flamanville 3

EPR in China
Taishan Project

- **Excavation Ceremony - August 2008**
- **The China EPRs will be the third and fourth projects being built in the global EPR fleet.**

U.S. EPR Design Certification

- **Objective**
  - **Obtain design certification for the U.S. EPR**
- **Two phases**
  - **Develop and submit FSAR to NRC for review**
    - **Project initiated January 2005**
    - **Submitted to NRC December 11, 2007**
  - **Obtain design certification**
    - **Application accepted for review - March 26, 2008**
    - **Final Safety Evaluation Report - June 2011**
    - **Rulemaking complete - June 2012**

U.S. EPR Projects

Calvert Cliffs Unit-3, Maryland
COLA submitted March 2008

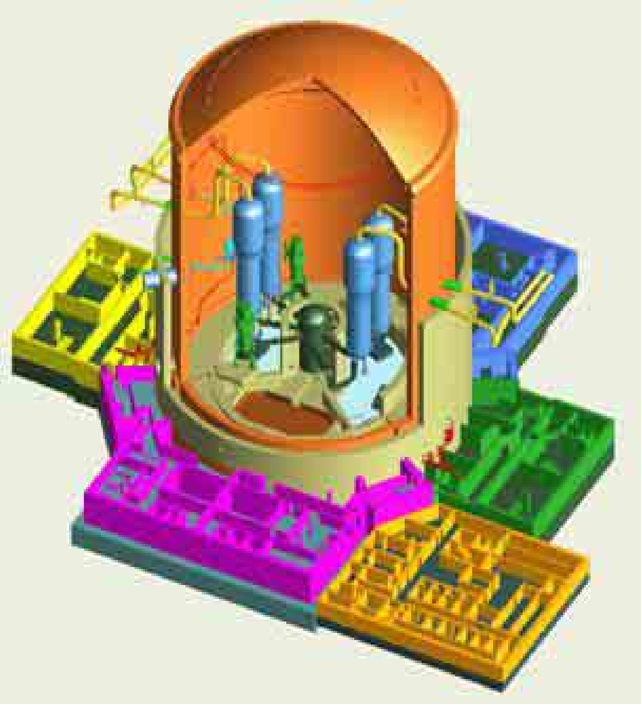
Ameren Callaway Unit-2, Missouri
COLA submitted July 2008

Nine Mile Point Unit-3, New York
COLA submitted September 2008

PPL Bell Bend, Pennsylvania
COLA submitted October 2008

EPR Development Objectives

- **Evolutionary design** based on existing PWR construction experience, R&D, operating experience and "lessons learned"
- **Safer**
  - Reduce occupational exposure and LLW
  - Increase design margins
  - Increased redundancy & physical separation of safety trains
  - Reduce core damage frequency (CDF)
  - Accommodate severe accidents and external hazards with no long-term local population effect
- **Improved Operations**
  - Reduce generation cost by at least 10%
  - Simplify operations and maintenance
  - 60-year design life



Major Design Features

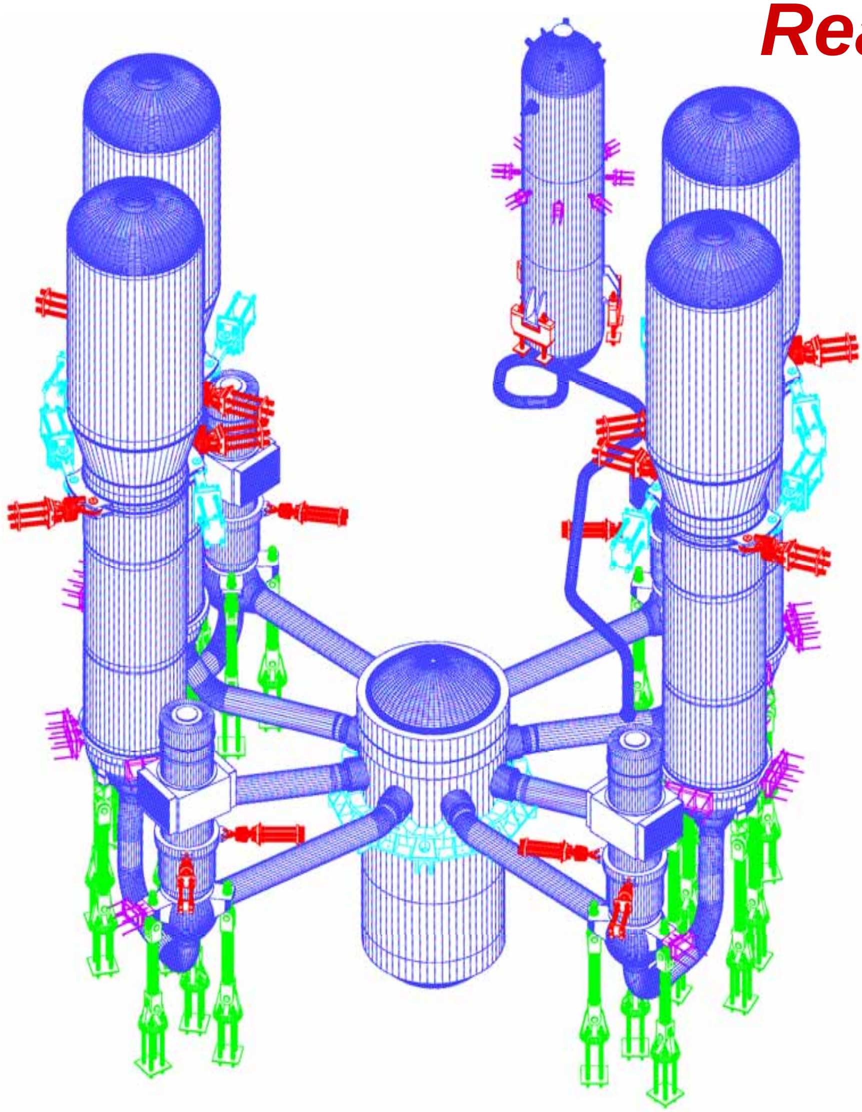
- Nuclear Island
  - *Proven Four-Loop RCS Design*
  - *Four-Train Safety Systems*
  - *Containment & Shield Bldg*
  - *In-Containment Borated Water Storage*
  - *Severe Accident Mitigation*
  - *Separate Safety Buildings*
  - *Advanced 'Cockpit' Control Room*

- 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.

Reactor Coolant System

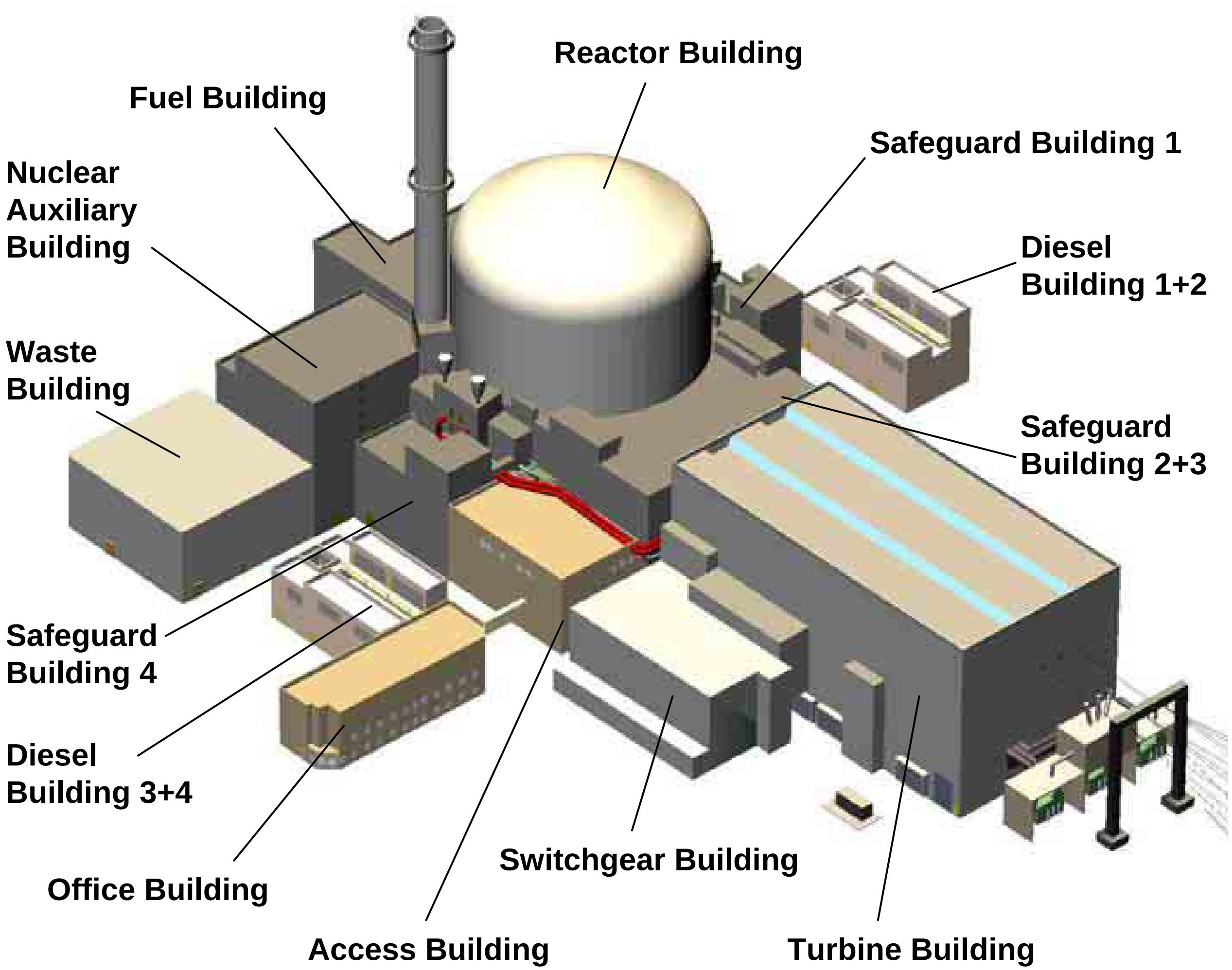


- **Conventional 4-loop PWR design, proven by decades of design, licensing & operating experience.**
- **NSSS component volumes increased compared to existing PWRs, increasing operator grace period for many transients and accidents**

A solid foundation of operating experience.

General Plant Layout

Standard EPR



Radial Design
N+2 Approach

The Four Train Concept

4 Independent Safety Trains

Arranged into 4 divisions

- ⇨ Preventive maintenance during power operation
- ⇨ Shorter outage time

Higher Availability

- ⇨ Smaller components
- ⇨ Fewer valves per train

Easier Maintainability

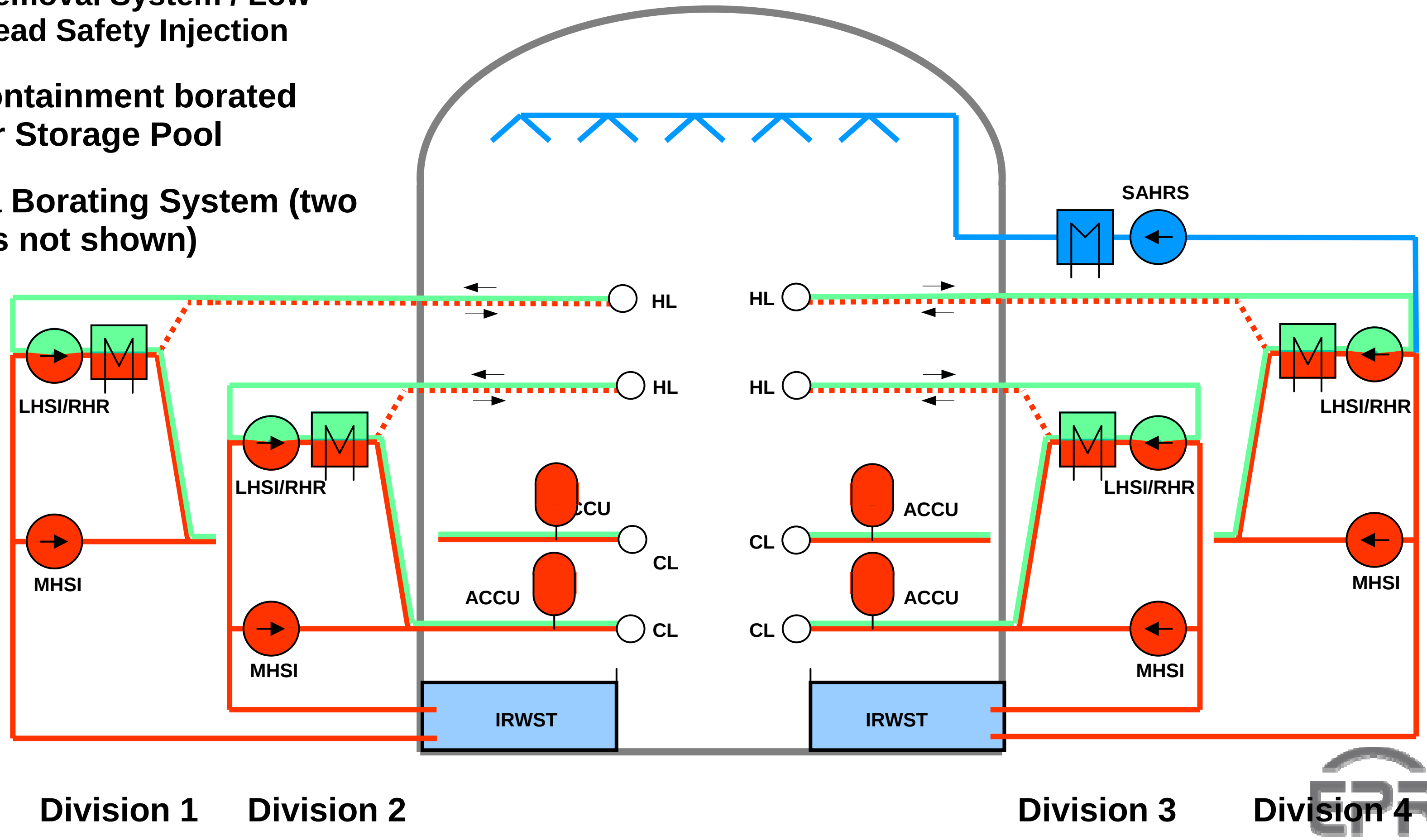
- ⇨ Efficient hazard protection
- ⇨ Reduced piping and components
- ⇨ Optimized plant layout

Lower Unit Cost

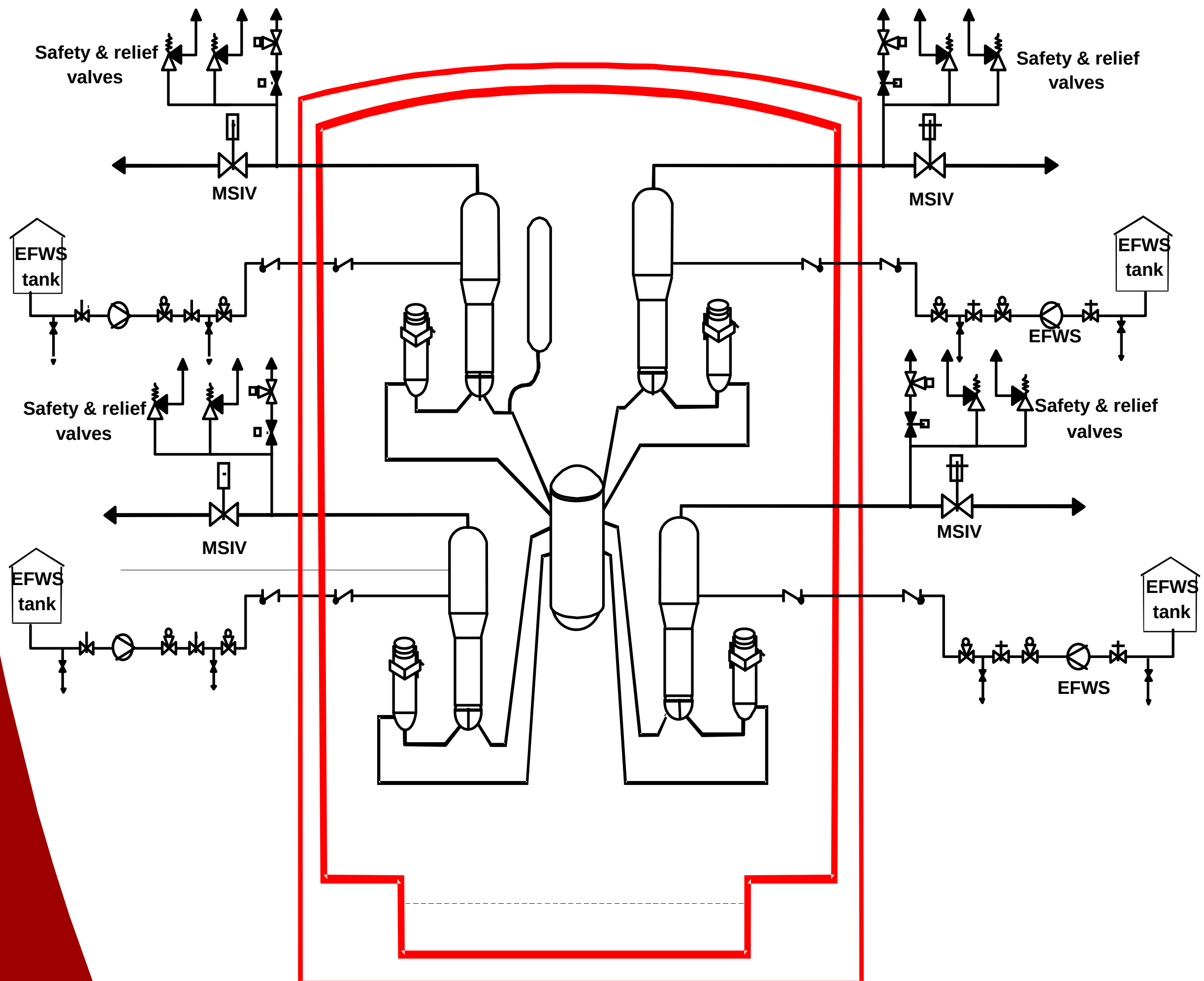
Primary Side Safety Systems

- Four train Safety Injection System (SIS)
  - Medium head SI pumps
  - Combined Residual Heat Removal System / Low Head Safety Injection
- In-Containment borated water Storage Pool
- Extra Borating System (two trains not shown)

- Non-safety containment spray for severe accident



Secondary Side Safety Systems

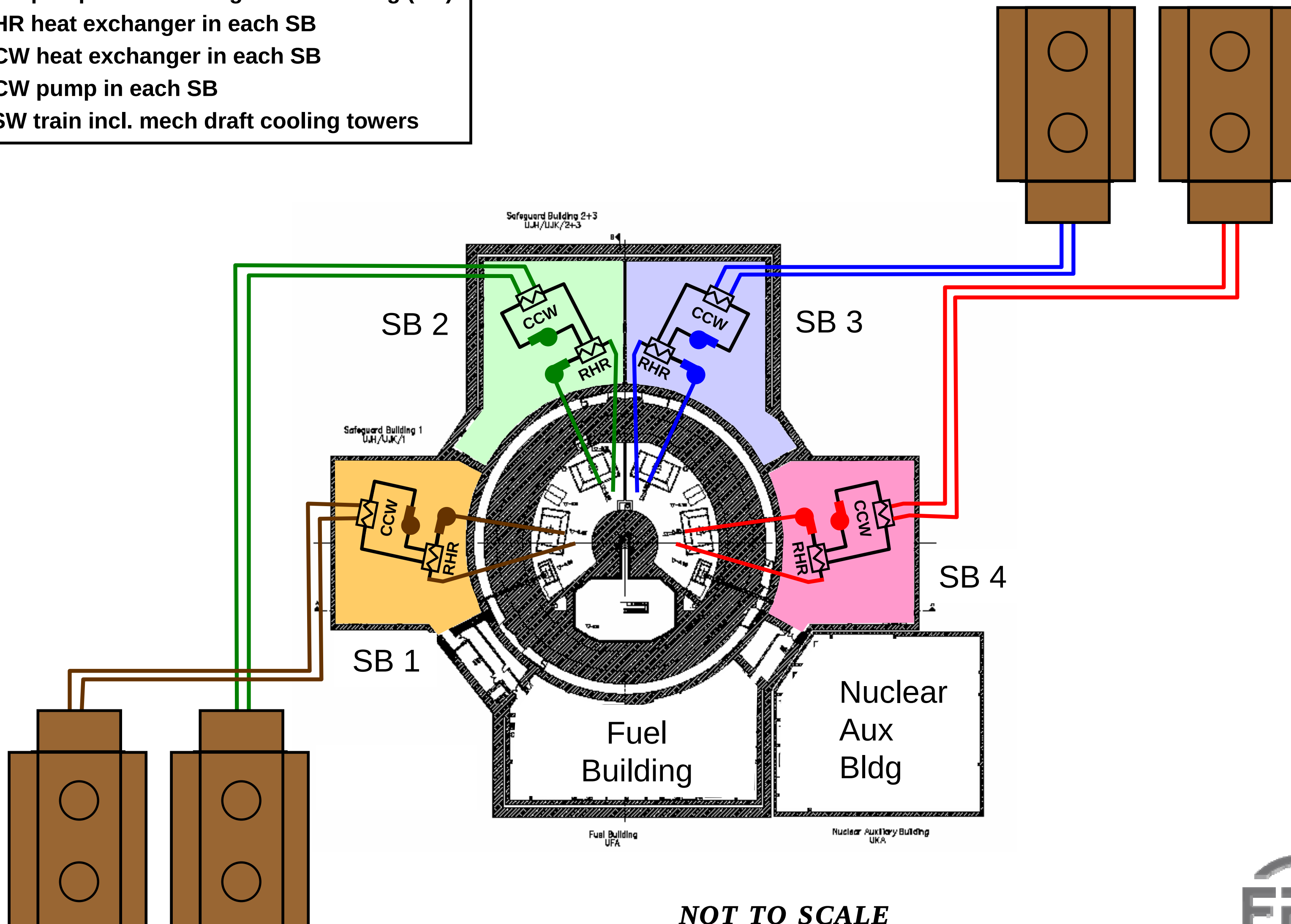


- Safety-related main steam relief train
- Four separate Emergency Feed Water Systems (EFWS)
- Separate power supply for each
- 2/4 EFWS also powered by Station Black Out (SBO) diesels
- Interconnecting headers at EFWS pump suction & discharge

Example: Residual Heat Removal Systems

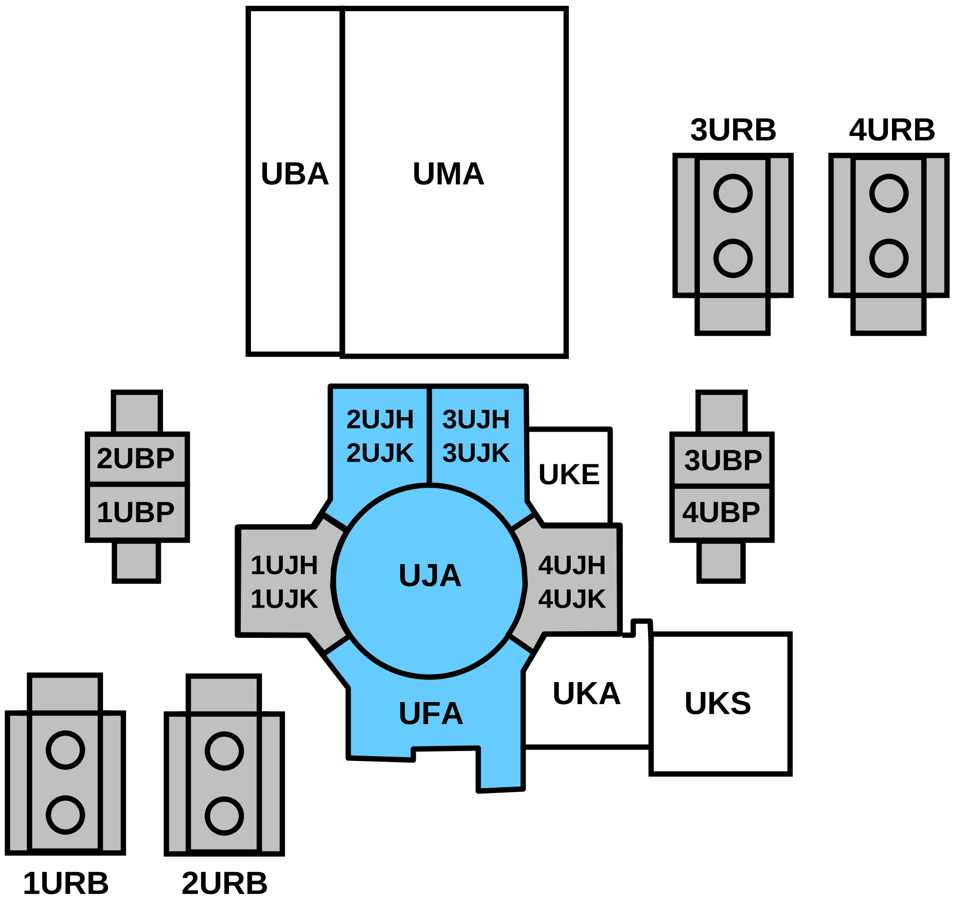
Each Train Connects to Different RCS Loop

- **1 RHR pump in each Safeguards Building (SB)**
- **1 RHR heat exchanger in each SB**
- **1 CCW heat exchanger in each SB**
- **1 CCW pump in each SB**
- **1 ESW train incl. mech draft cooling towers**



NOT TO SCALE

Protection From External Hazards



UBA	Switchgear Building
UBP	Emergency Power Generating Building
UFA	Fuel Building
UJA	Reactor Building
UJH	Safeguard Building Mechanical
UJK	Safeguard Building Electrical
UKA	Nuclear Auxiliary Building
UKE	Access Building
UKS	Radioactive Waste Processing Building
UMA	Turbine Building
URA	Cooling Tower Structure
URB	Essential Service Water Cooling Tower Structure

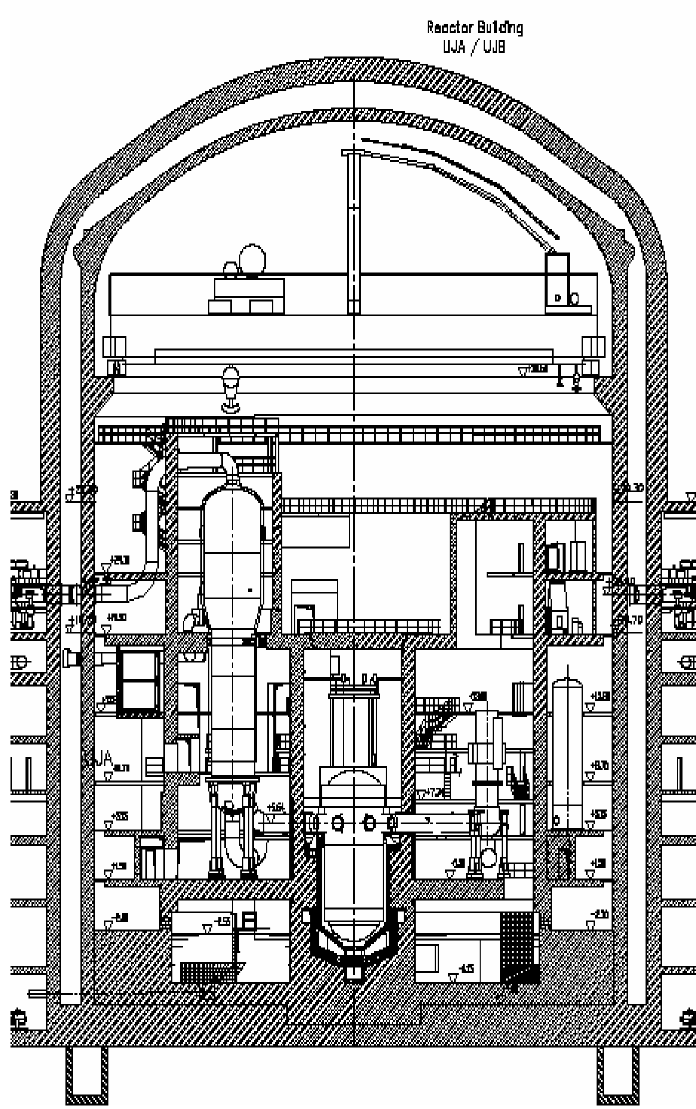
PROTECTED BY SHIELD BUILDING

PROTECTED BY PHYSICAL SEPARATION

NOT PROTECTED

EPR Reactor Building

- Containment wall post-tensioned concrete with steel liner
- Shield wall reinforced concrete
- Free volume = 2.8 Mft^3
- Design pressure = 62 psig
- Annulus filtered to reduce radioisotope release
- In-Containment Refueling Water Storage Tank (~500,000 gal)
- Severe accident mitigation features
- The design leak-rate at design pressure for a 24-hour period is less than 0.25 percent by volume



Aircraft Hazard Protection

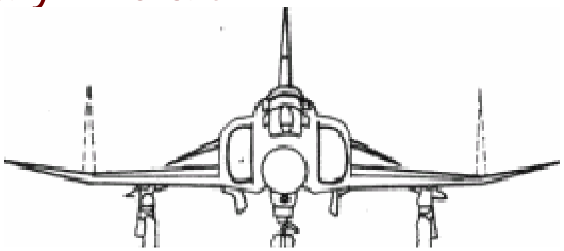
- **Inner wall: post-tensioned concrete with steel liner**
- **Outer wall: reinforced concrete**
- **Protection against airplane hazards**
- **Protection against external shock waves**
- **Annulus sub-atmospheric, filtered to minimize radioisotope releases**

Enhanced, Predictable Licensability

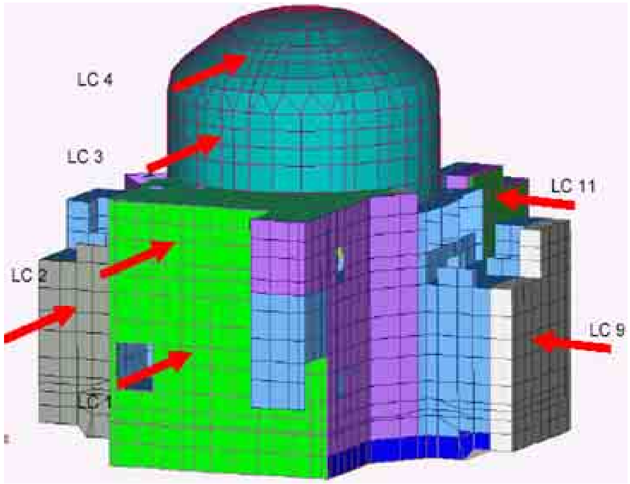
EPR Aircraft Hazard Protection

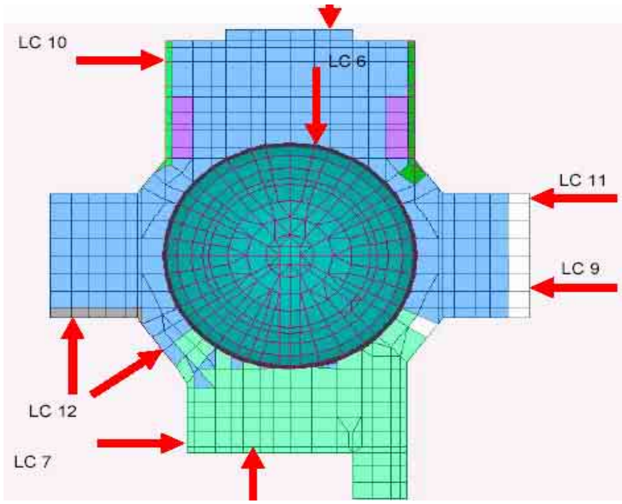
EPR Designed to Withstand Impact of:

Large Commercial Airplane & Military Aircraft



At various Elevations & From different Sides





Operator-Friendly Man-Machine Interface

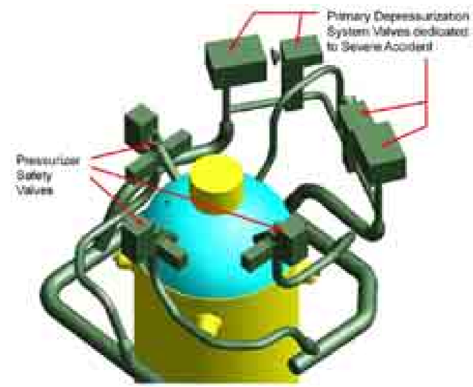
N4 Control Room

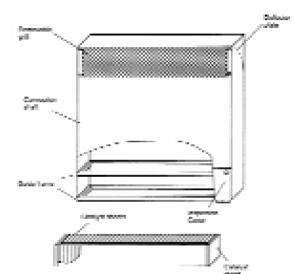
EPR Control Room

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

Severe Accident Mitigation

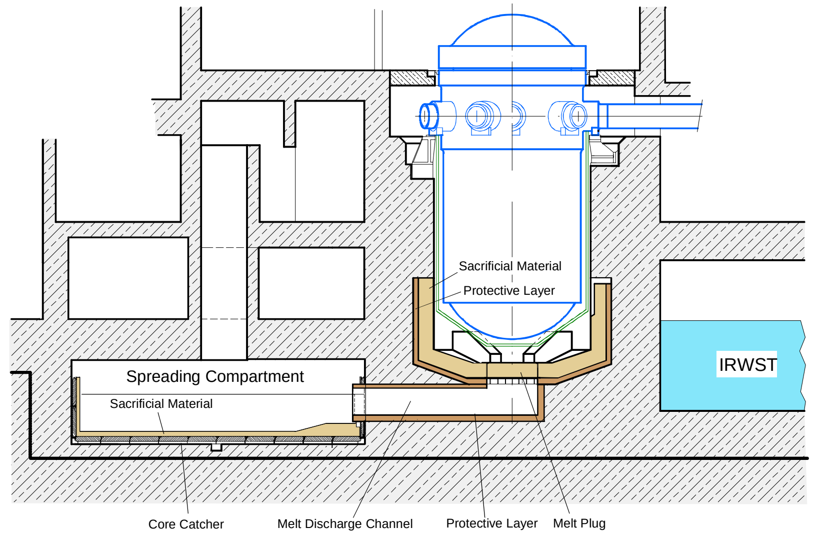
- **Prevention of high-pressure melt-through using Primary Depressurization System**
- **Passive ex-vessel melt stabilization, conditioning and cooling**
- **Long-term melt cooling and containment protection using active cooling system**
- **Control of H_2 concentration using passive autocatalytic recombiners**

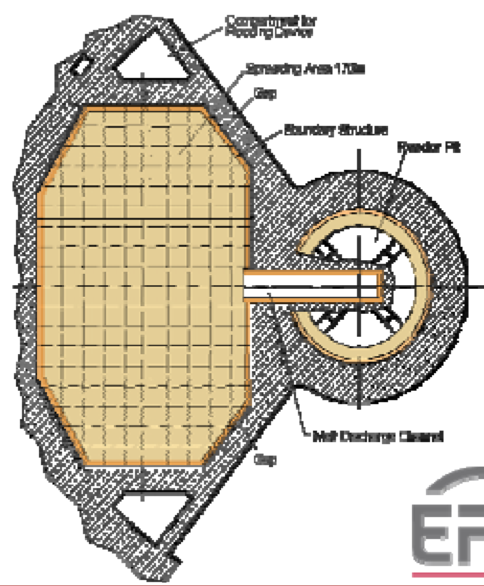




Melt Conditioning and Stabilization

- **Reactor cavity temporarily retains molten core debris prior to spreading and stabilization processes**
  - Limits uncertainties associated with RPV release states
  - Corium/concrete interaction within reactor cavity lowers melting temperature of corium and promotes spreading
- **Melt spreading and relocation**
  - After melt plug failure, conditioned melt will relocate into spreading area (shallow crucible)
  - Large spreading area promotes cooling
  - Spreading area is dry at time of melt relocation to preclude ex-vessel steam explosion
- **Stablization**
  - Water from IRWST passively cools melt for up to 12 hours
  - Thereafter, severe accident heat removal system actively cools the melt and depressurizes containment





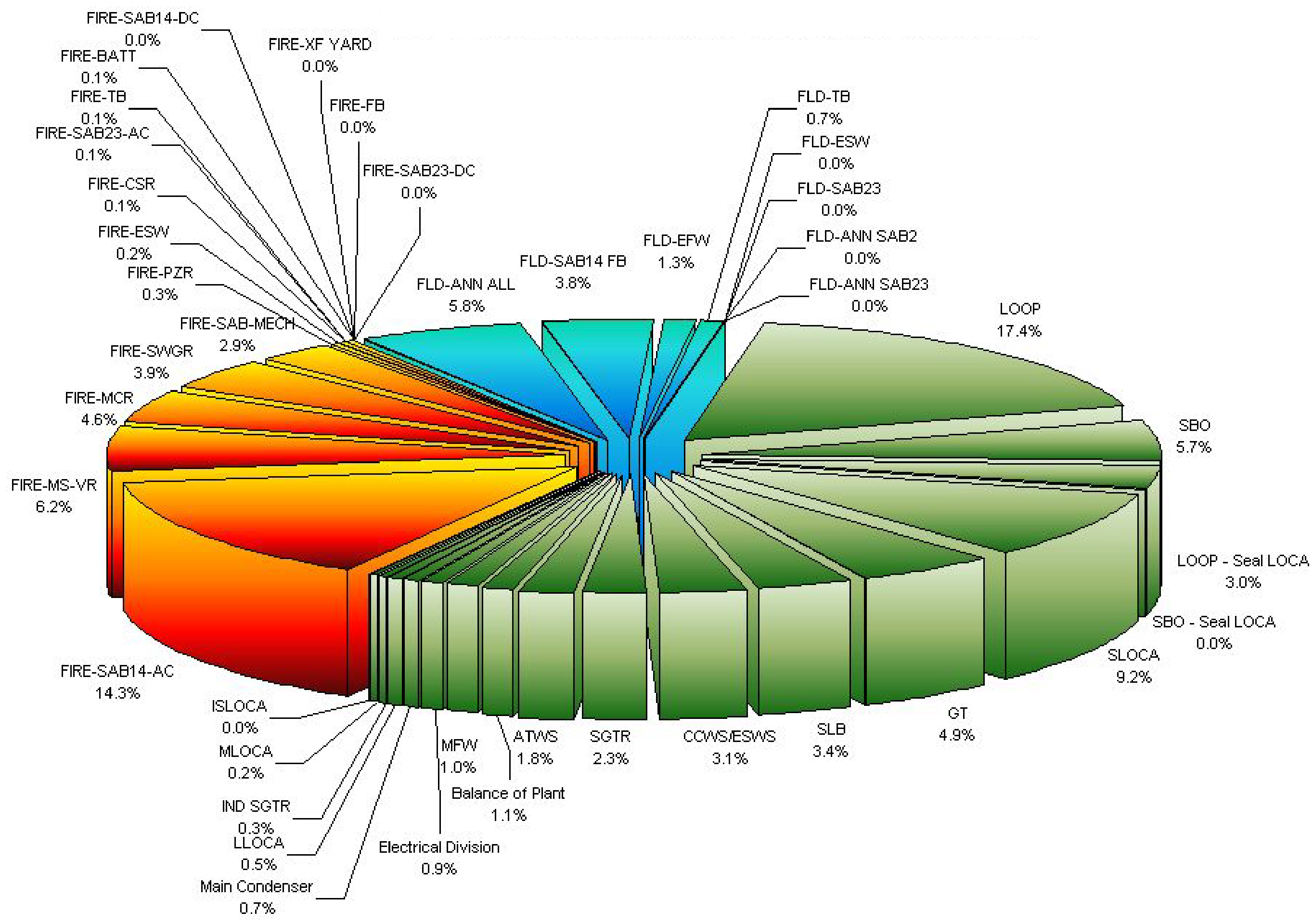
Probabilistic Objectives And Targets

- **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**

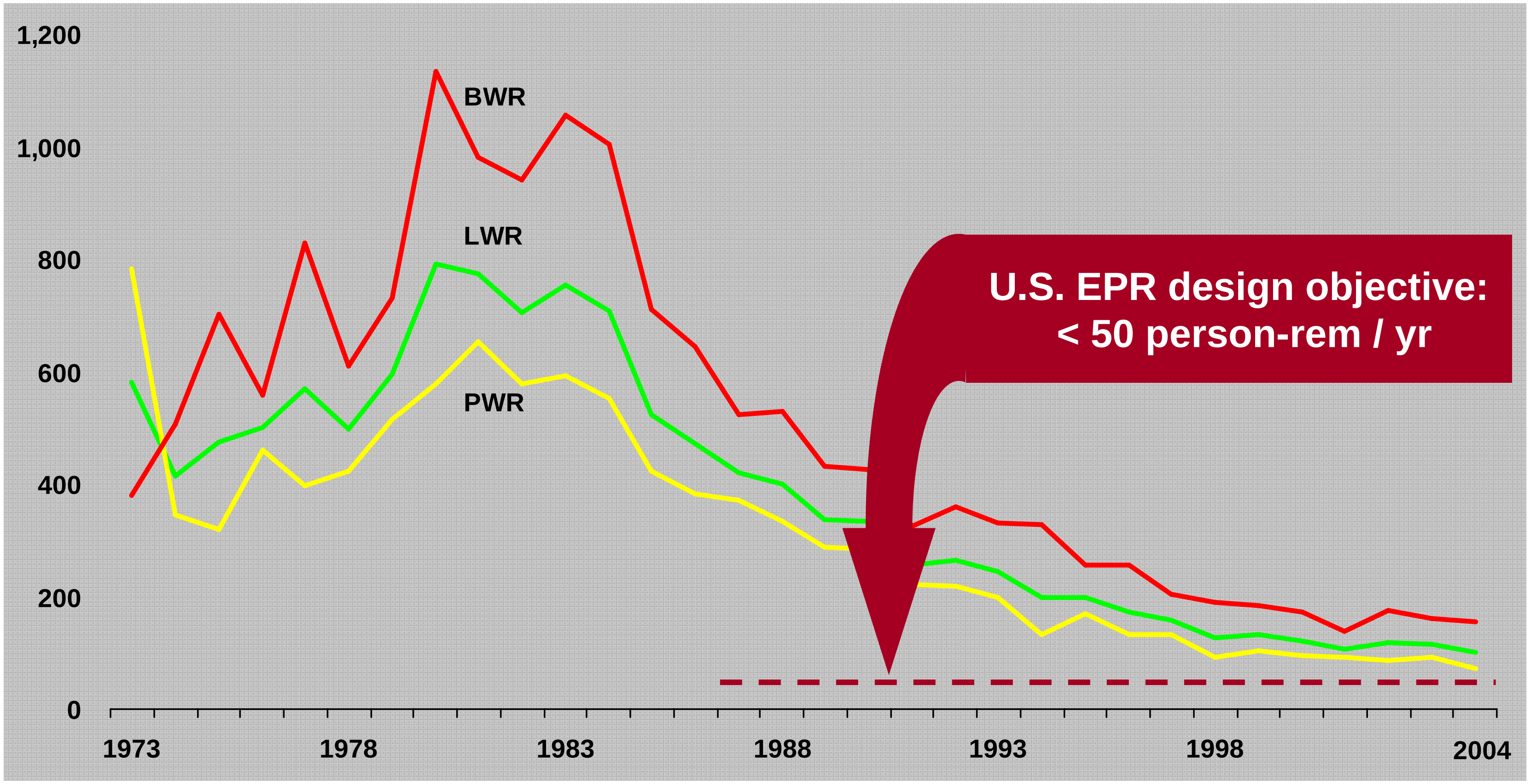
U.S. EPR CDF (At-Power Events)



Level 1 At-Power, Internal Events CDF = 5.3 x 10^{-7}/yr
CDF For All Events < 5.8 x 10^{-7}/yr

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

Design Summary

- **EPR is evolutionary**
- **Most features are typical of operating PWRs**
- **Features included to**
  - **Improve safety**
  - **Protect critical systems from external events**
  - **Improve human factors**
  - **Enhance reliability**