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Kansas State University

*Energy, Environmental Impacts and Sustainability Intersession
Course Workshop*

Nuclear Energy

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ENERGY WATER INFORMATION GOVERNMENT

January 4, 2005



Agenda

- Nuclear Energy's Current Status
- What's Pushing Nuclear Power's Resurgence?
- New Advanced and Passive Designs
- Department of Energy (DOE) 2010 Initiative
- Summary



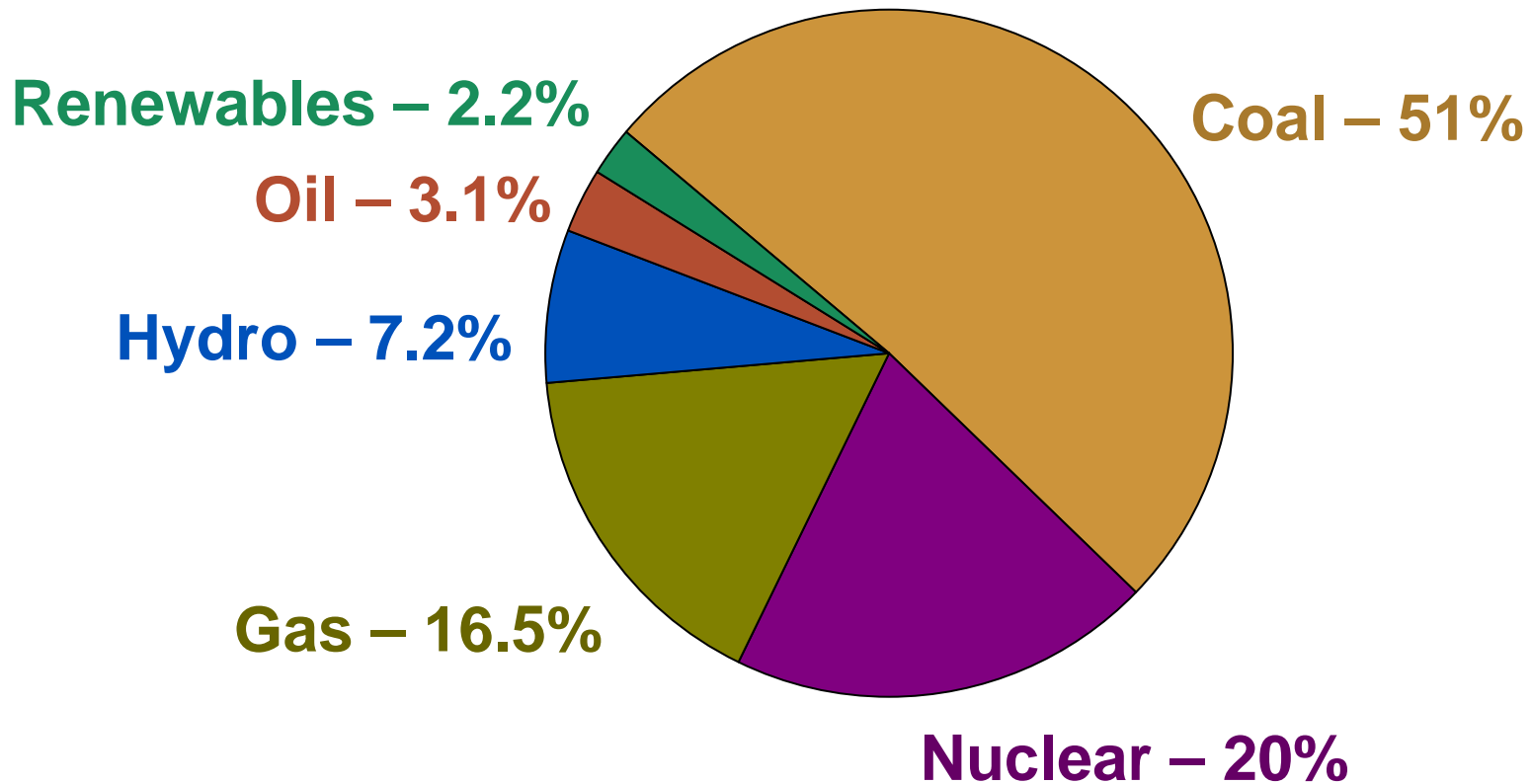


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Nuclear Energy's Current Status



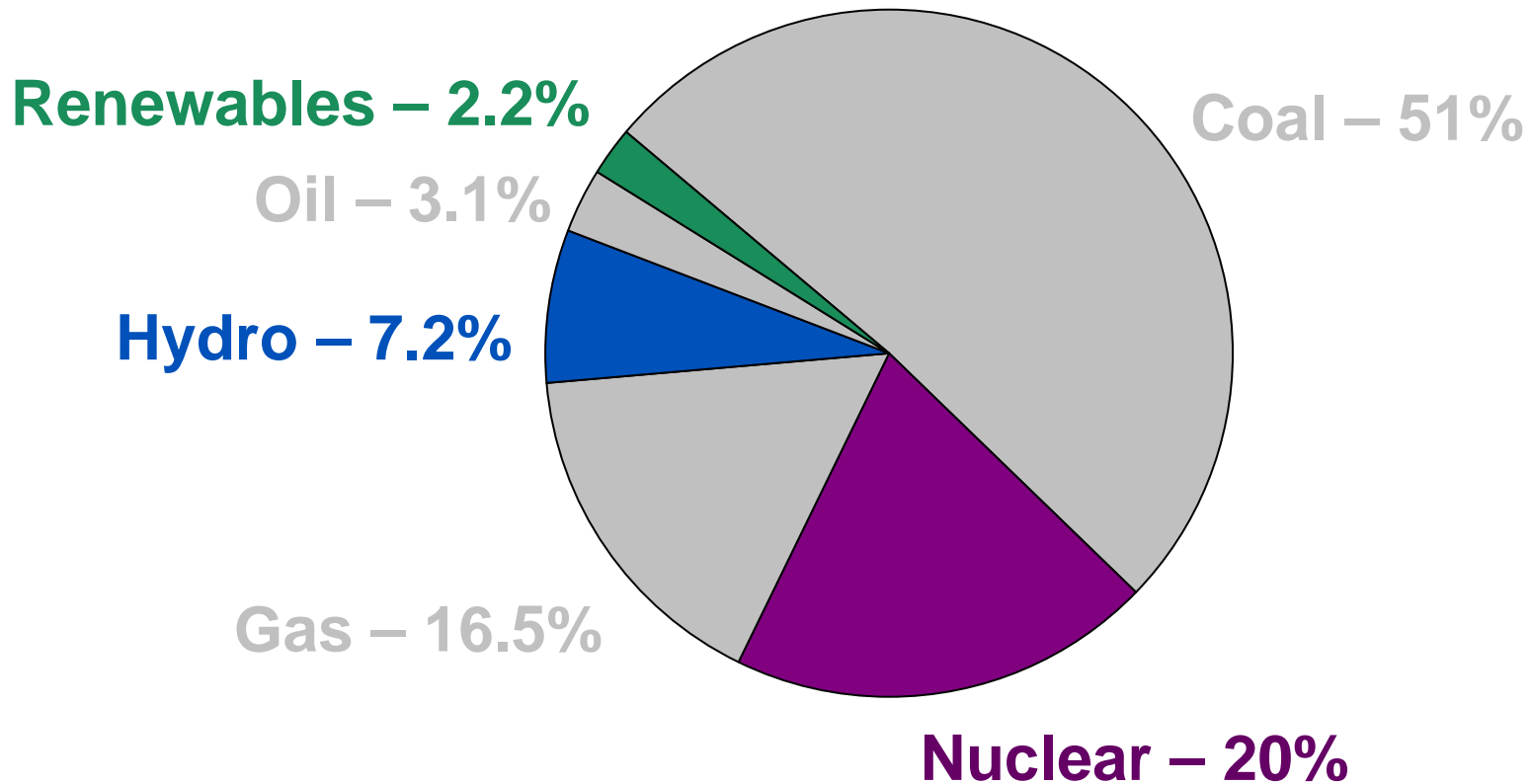
United States Fuels for Electricity Generation (2003)



Source: NEI



United States Fuels for Electricity Generation (2003)



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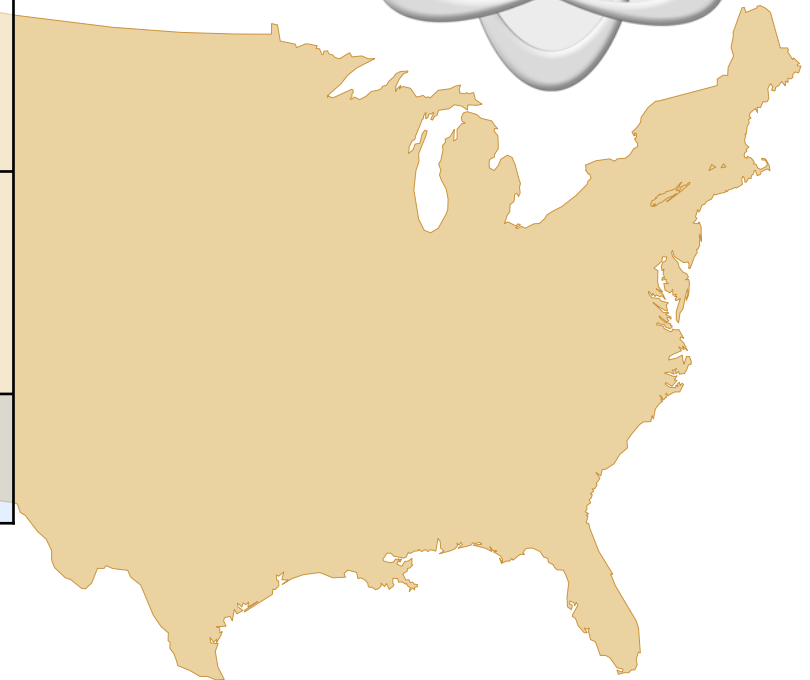
State's Percentage of Total Electricity Generation (2002)

	Nuclear	Coal	Gas	Other
Arkansas	31.32	52.48	5.74	10.46
Connecticut	50.60	12.25	13.41	23.74
Iowa	9.48	85.26	1.46	3.80
Illinois	51.53	44.38	2.57	1.52
Kansas	23.12	70.99	4.36	1.53
Missouri	10.54	82.66	4.87	1.93
Nebraska	28.62	66.39	1.14	3.85
New Hampshire	57.66	24.59	0.79	17.67
New Jersey	51.28	15.68	28.12	4.92
South Carolina	55.93	41.16	1.32	1.59
Vermont	76.11	0.0	0.20	23.69



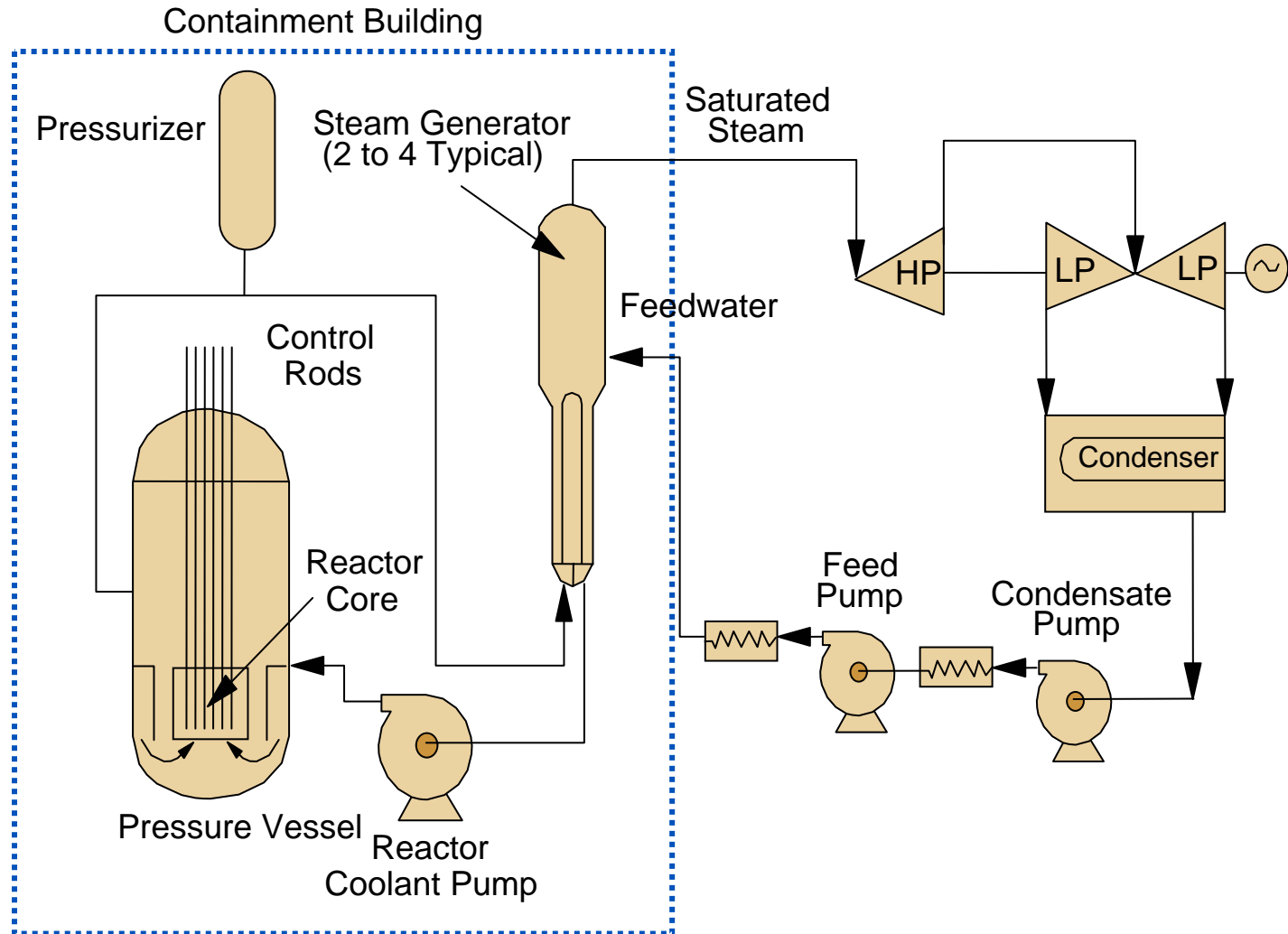
United States Nuclear Power Plants (2003)

Type	Operating Plants
Boiling Water Reactors (BWR)	35
Pressurized Water Reactors (PWR)	69
Total	104



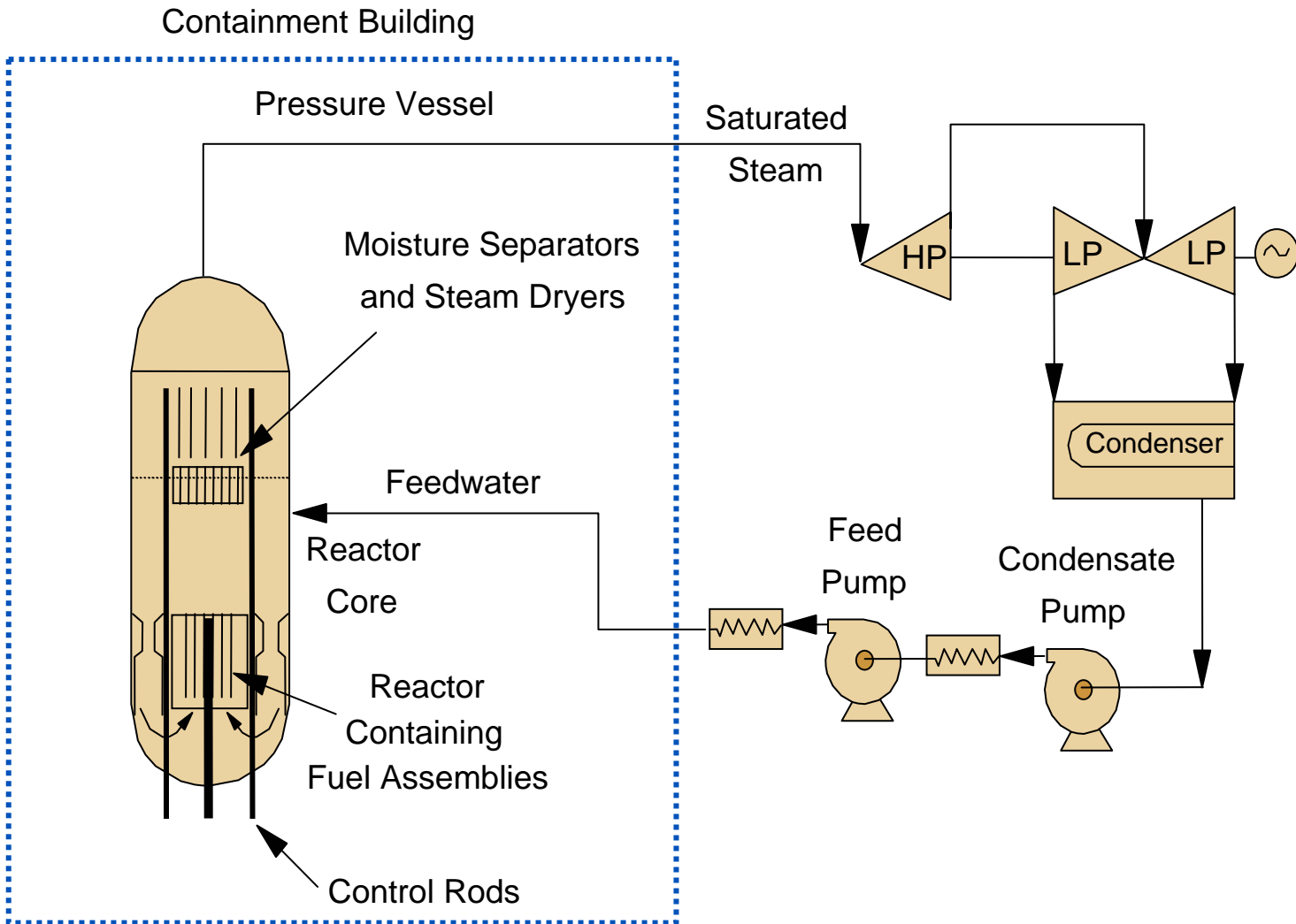


Schematic for a Pressurized Water Reactor





Schematic for a Boiling Water Reactor





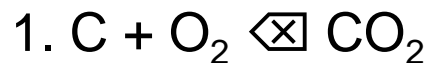
Fissioning Process – Uranium 235

U-235 + Neutron (n) \rightarrow Fission Products (FP) + Xn

$$\Delta M = \text{Mass (U-235)} + \text{Mass (n)} - \text{Mass (FP)} - \text{Mass (Xn)} \neq 0$$

$$\text{Energy Released} = \Delta MC^2 \cong 200 \text{ Mev} / \text{Fission}$$

Energy Released From Combustion Process^{1.} $\cong 2 \text{ ev} / \text{Reaction}$



Note: $1 \text{ ev} = 1.52 \times 10^{-22} \text{ Btu}$



Annual Fuel Requirements for 1000 MWe Plant

- 2,000,000 mTons of Coal
- 1,960,000,000 Gallons of Oil
- 30 mTons of Uranium
- 0.6 mTons of Tritium and Hydrogen
(Fusion)



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What's Pushing Nuclear Power's Resurgence?

Nuclear Power Growth Projections

- Anticipated Growth in Demand for Baseload Capacity
- High and Rising Cost of Natural Gas
- Global Warming Concerns
- Energy Consumption From Nuclear to Increase 50% by 2025 Just to Maintain Status Quo
- Equates to 50,000 MWe of New Nuclear Generation
- 30-35 New Nuclear Units (1,500 MWe Each)

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Building Momentum for Additional Nuclear Plants

- Non Emitting Source of NO_x, SO₂ and CO₂ (Global Warming)
- Well Suited for Hydrogen Production
- Proven Performance and Safety
- Improved Regulatory Oversight and Licensing (One-Step Process)
- Growing Support From Utilities, Wall Street, Media and Policy Makers
- Supportive Administration
- Passage of Energy Policy Act of 2005 Provides for Loan Guarantees, Production Tax Credits and Risk Insurance





Momentum “Deflators” for New Nuclear Additions



- Spent Fuel Disposal / DOE License Application for Yucca Mountain Repository (Nevada) Pushed Into 2006
- Economics / Demonstrate a 48-Month or Better Construction Schedule
- Transportation of Spent Fuel
- Change in Political Landscape



New Licensing Process (10 CFR Part 52)

- Design Certification of Standard Plant Designs by NRC
- Early Site Approval Prior to Build Decision
- Combined License for Construction and Operation (COL) Prior to Major Construction





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New Advanced and Passive Designs



Advanced Reactor Designs

- Evolutionary
 - Additional Active Safety Divisions
 - Lower Probability of Accident
 - GE's Advanced Boiling Water Reactor (ABWR)
 - Areva's European Pressurized Reactor
 - Westinghouse 80+
- Passive
 - No Active Cooling System for Reactor Isolation or Accident Mediation
 - Passive Systems (Natural Circulation, Gravity) Replace Active Systems
 - Westinghouse AP 600, AP 1000
 - GE's Economic Simplified Boiling Water Reactor (ESBWR)



Advanced Boiling Water Reactor (ABWR)

- 1350 MWe Reactor
- 3-50% Capacity Safety Divisions Each With a Dedicated Diesel Generator
- 60-Year Operating Life
- 87% Plant Availability
- Certified Standard Design by NRC

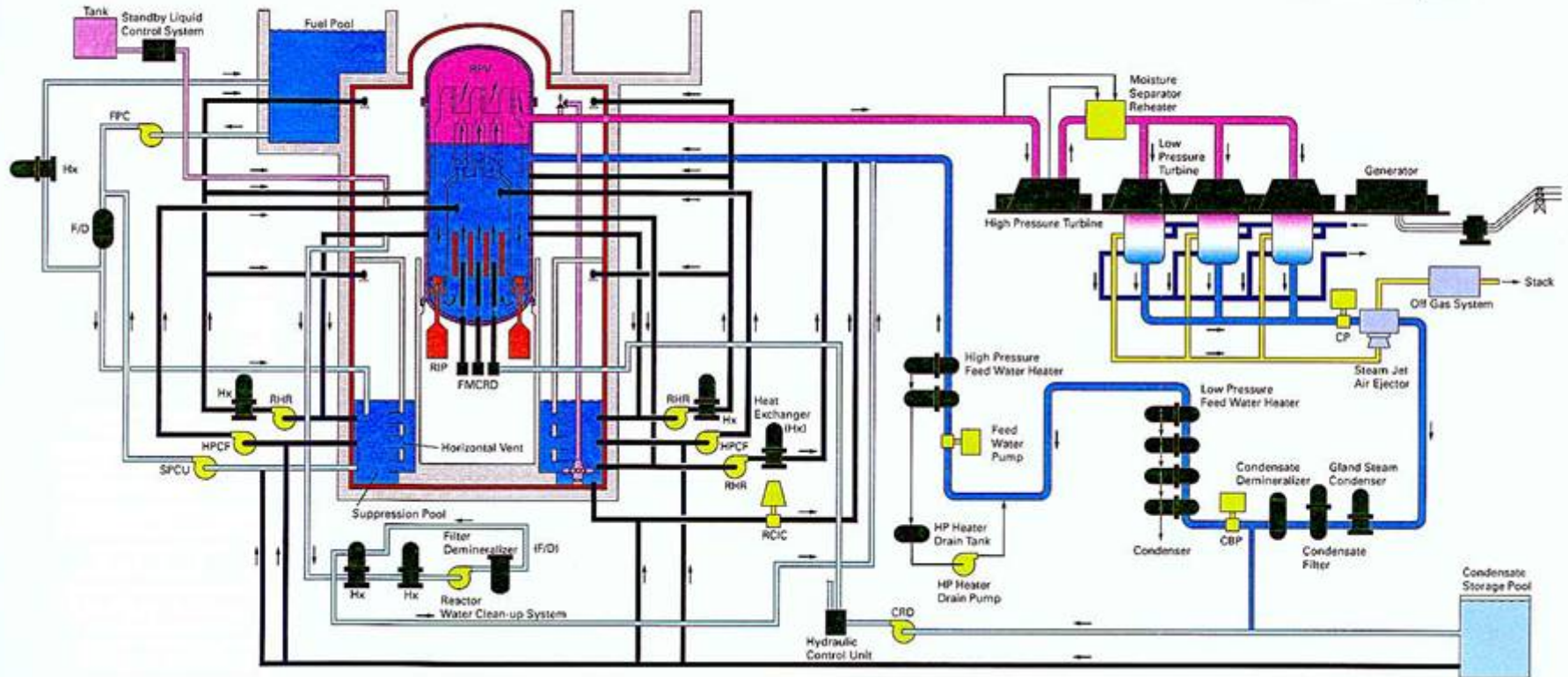


Advanced Boiling Water Reactor

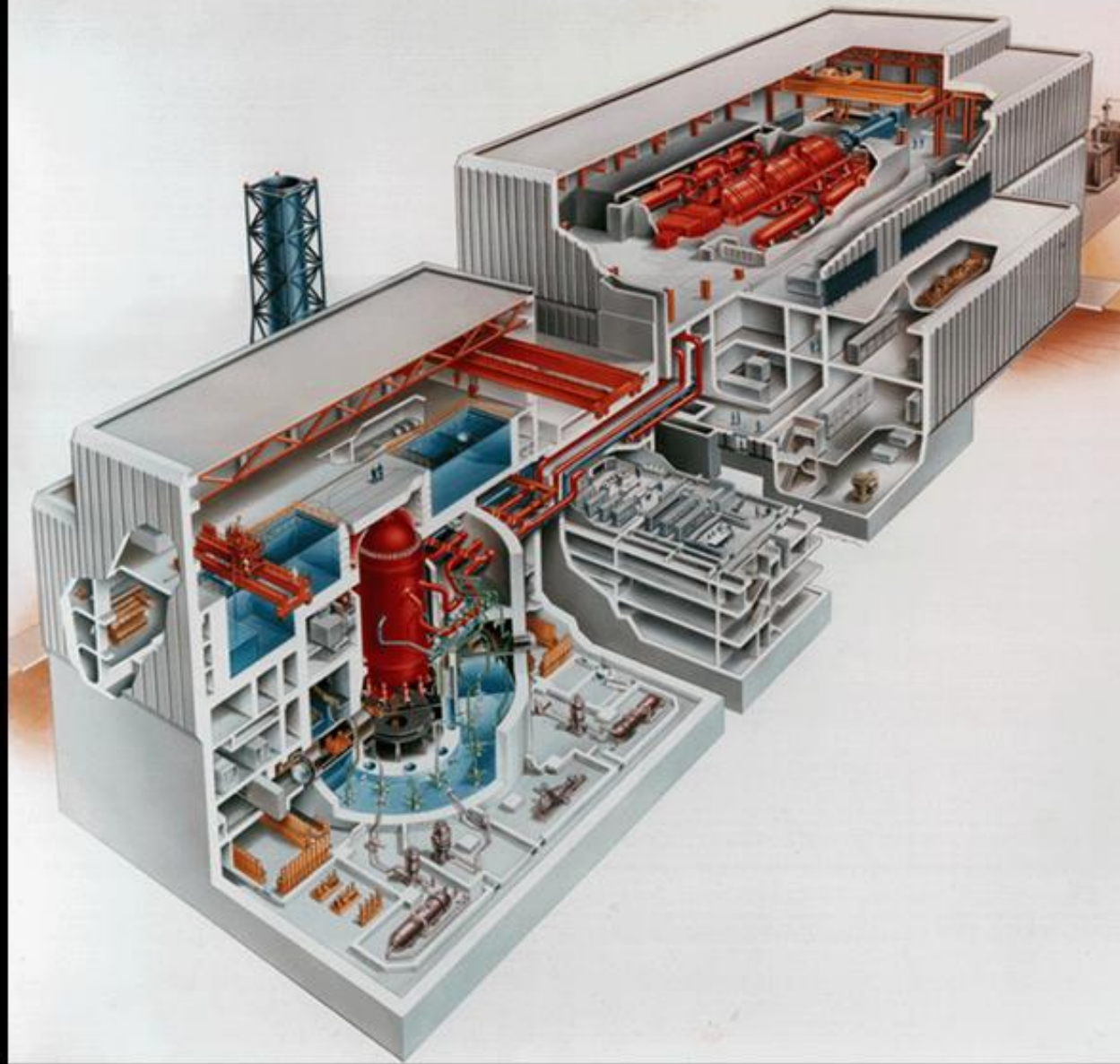
Active Safety...

Advanced Boiling Water Reactor

ABWR
General Description



Advanced Boiling Water Reactor



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Areva European Pressurized Reactor (EPR)

- 1600 MWe Reactor
- 4-100% Capacity Safety Divisions Each With a Dedicated Diesel Generator
- 60-Year Operating Life
- 36% Plant Efficiency
- Submitting Standard Design for NRC Certification



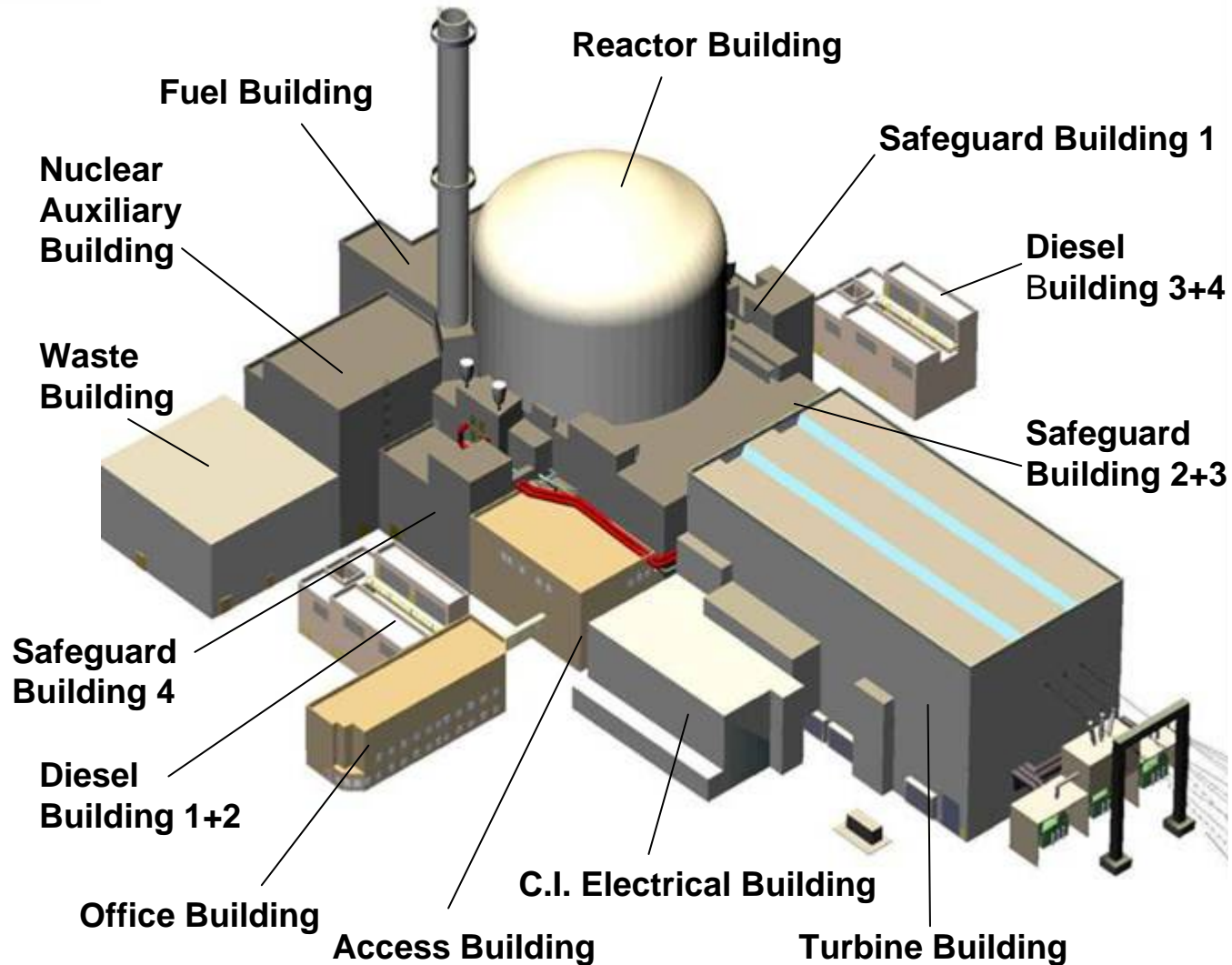
Four Independent Safety Trains in Separate Buildings

- Four Trains, Each 100%, Provide Redundancy for Maintenance or Single-Failure Criterion
- Physical Separation Against Internal Hazards (e.g. Fire)
- Shield Building Extends Airplane Crash and External Explosion Protection to Two Safeguard Buildings and Fuel Building





EPR – Plot Plan





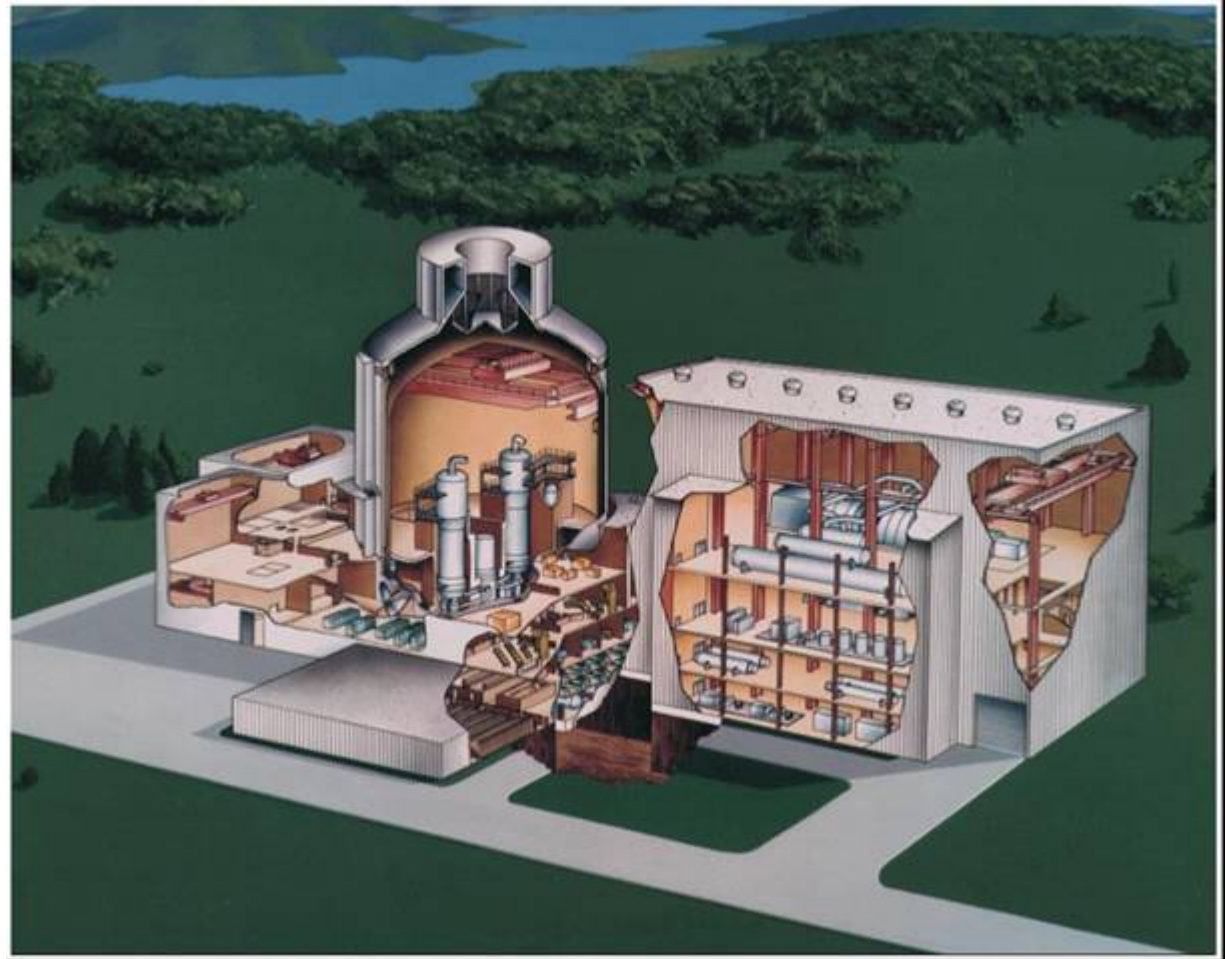
Westinghouse Advanced Passive (AP) 1000 MWe System

- 1000 MWe Reactor
- Passive Reactor Core Cooling System
- Passive Containment Cooling System
- Major Reduction in Safety Related Pumps, Valves, Piping and Electrical Components
- 60-Year Operating Life
- Expect Standardized Plant Certification From NRC Soon



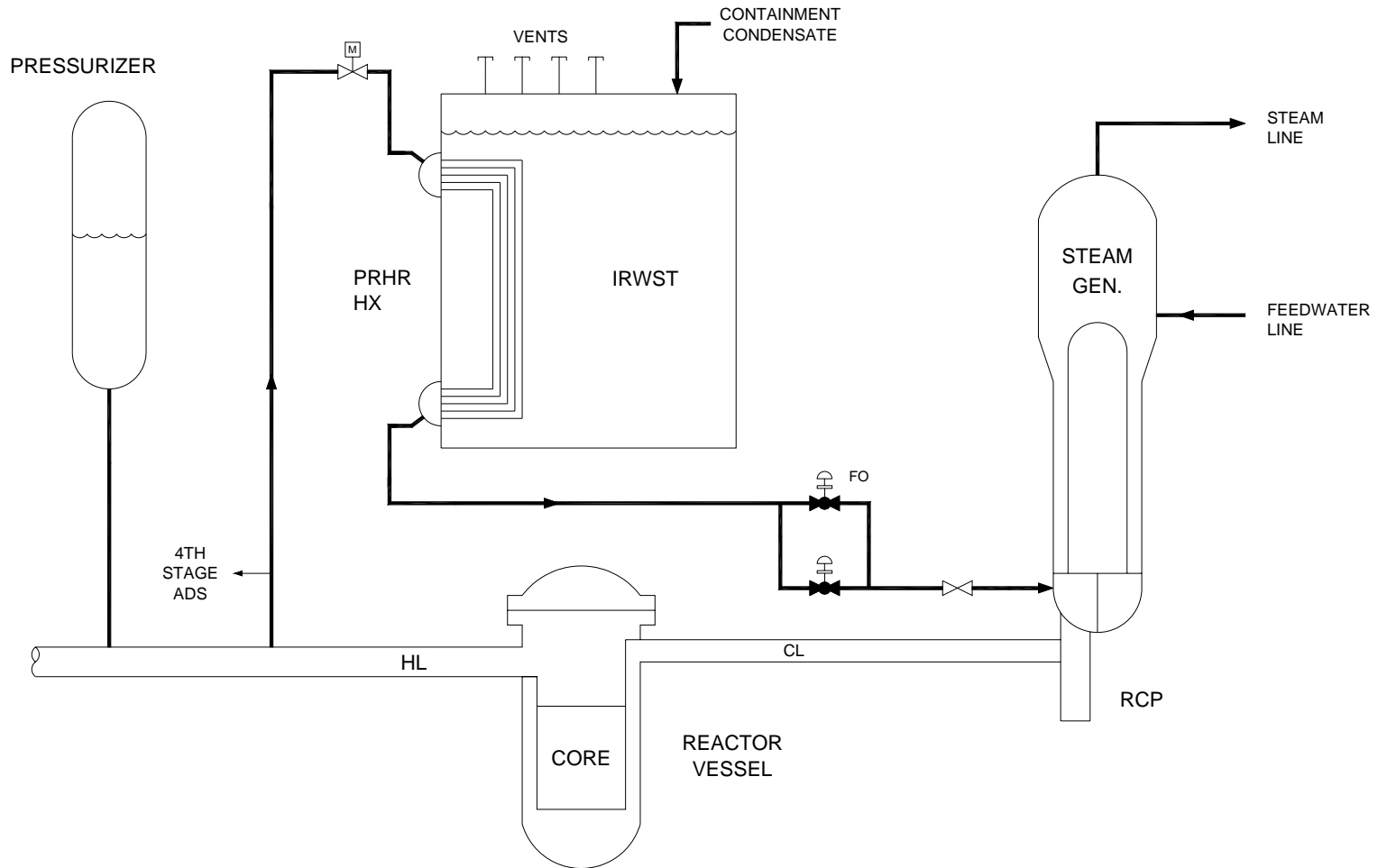
AP1000...Westinghouse New Standardized Passive Plants

- Mature
- Safe
- Simple
- Affordable



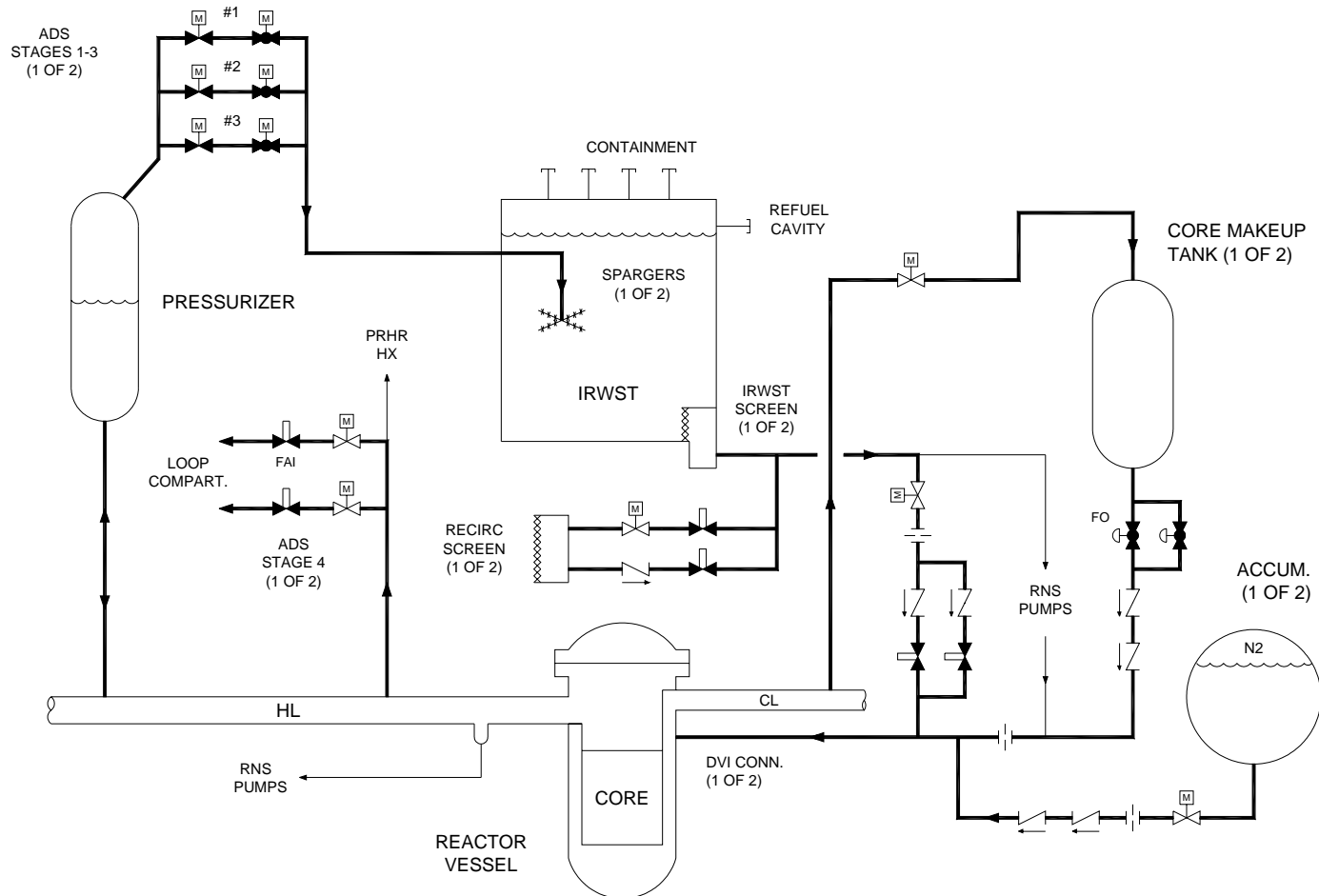


Passive Decay Heat Removal



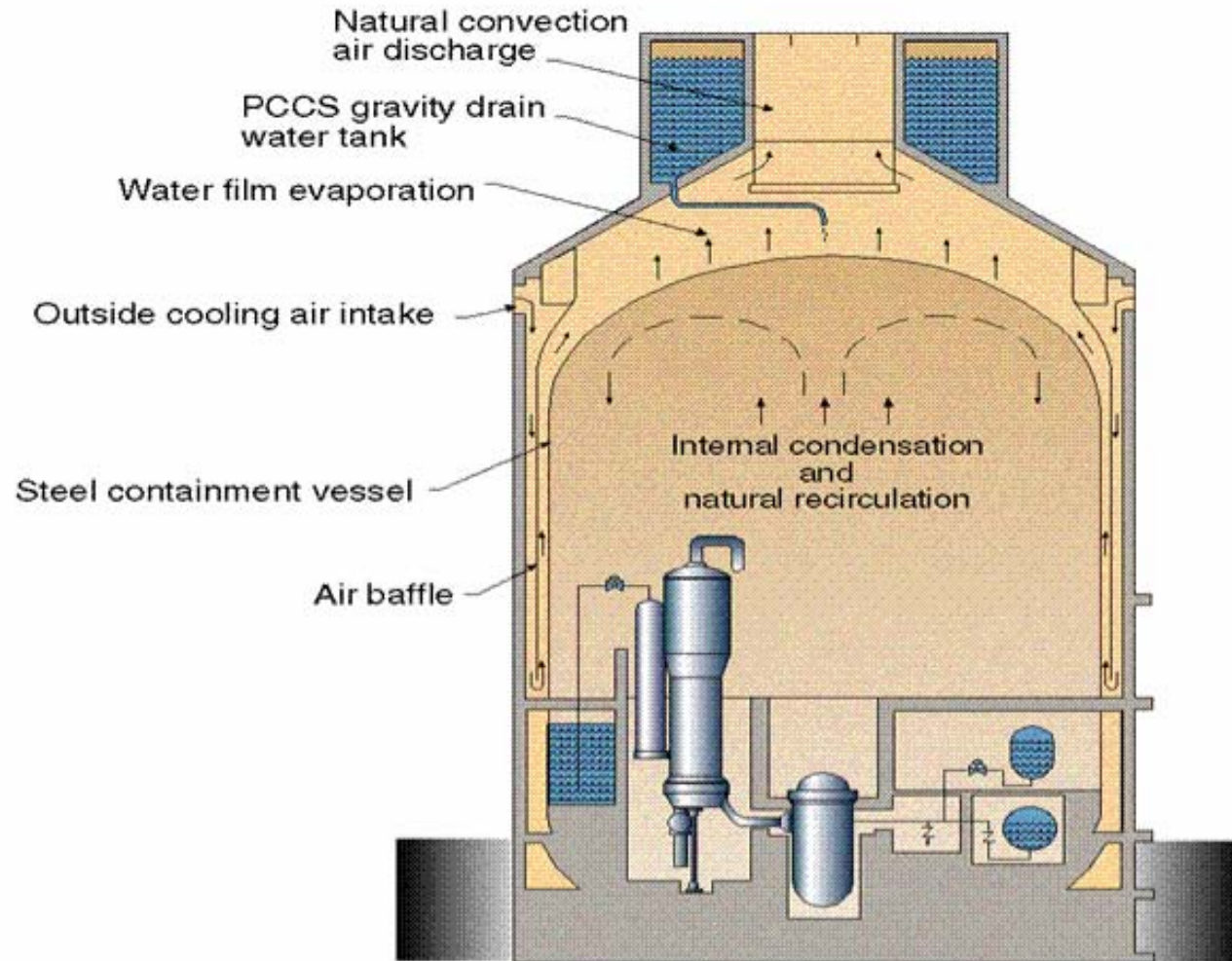


AP1000 Passive Safety Injection





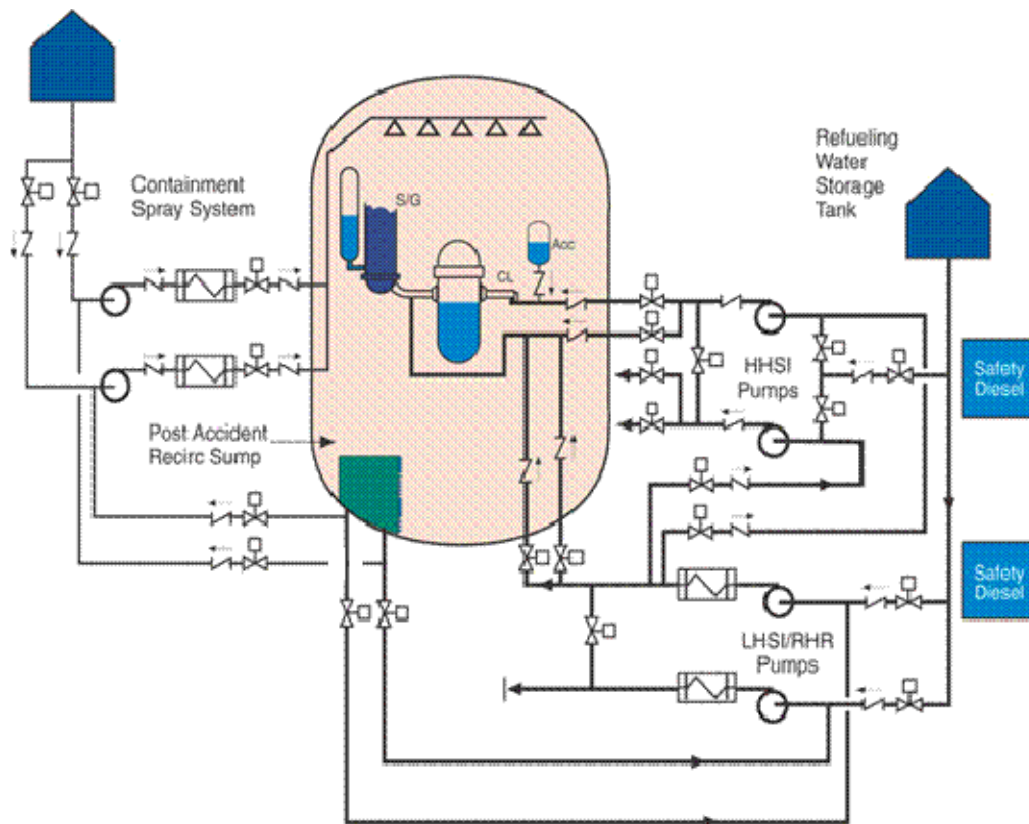
Passive Containment Cooling System



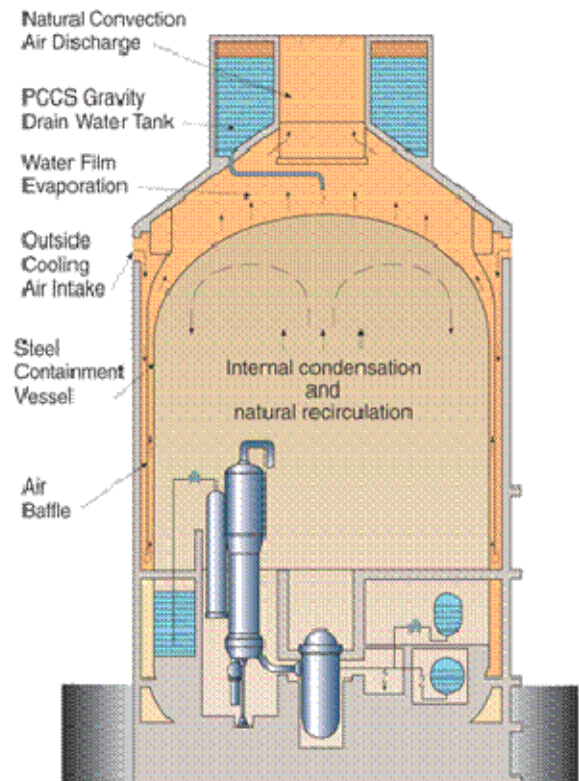


Simplification of Safety Systems Dramatically Reduces Building Volumes

Standard PWR



AP1000



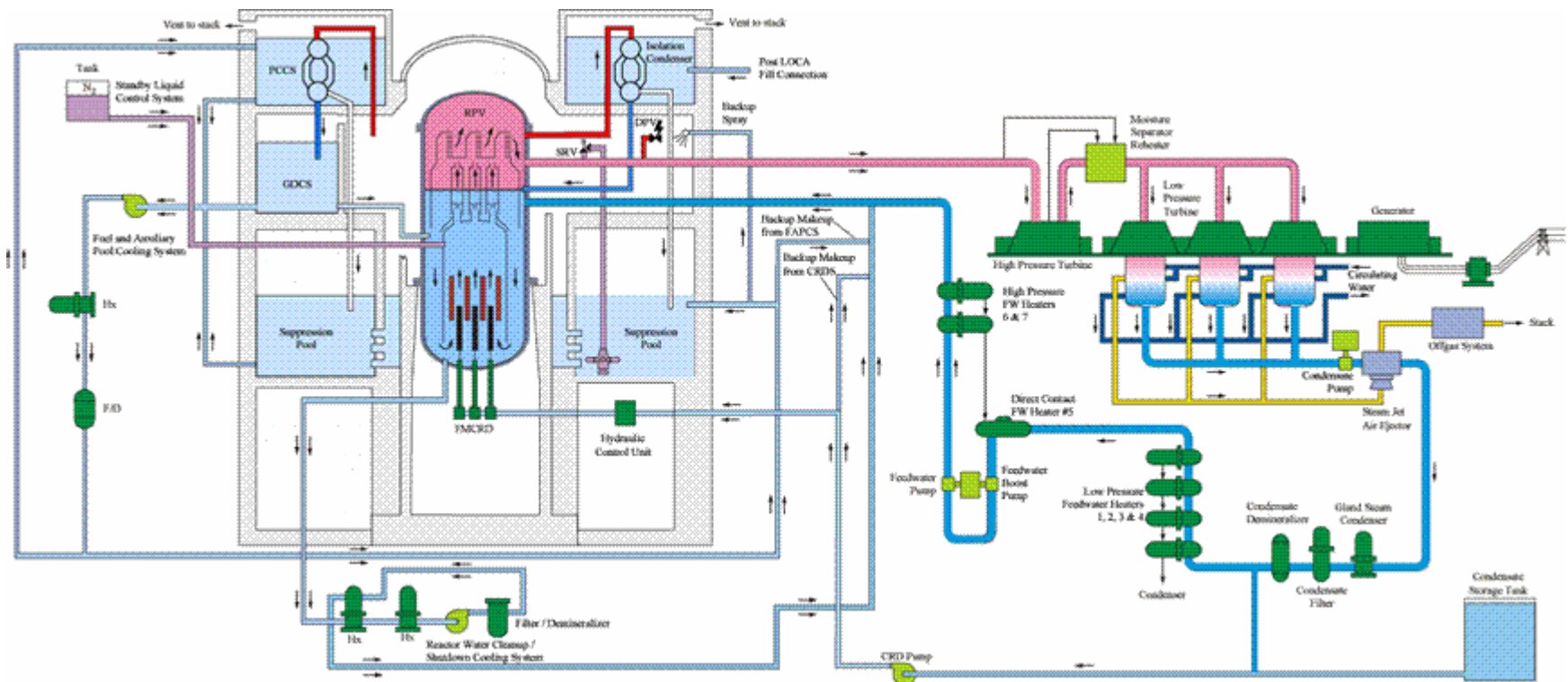


GE Economic Simplified Boiling Water Reactor (ESBWR)

- 1500 MWe Reactor
- Natural Circulation (No Recirculation Pump)
- Passive Safety Systems
- Major Reduction in Safety Related Pumps, Valves, Piping and Electrical Components
- 60-Year Operating Life
- Submitted Standard Design for NRC Certification



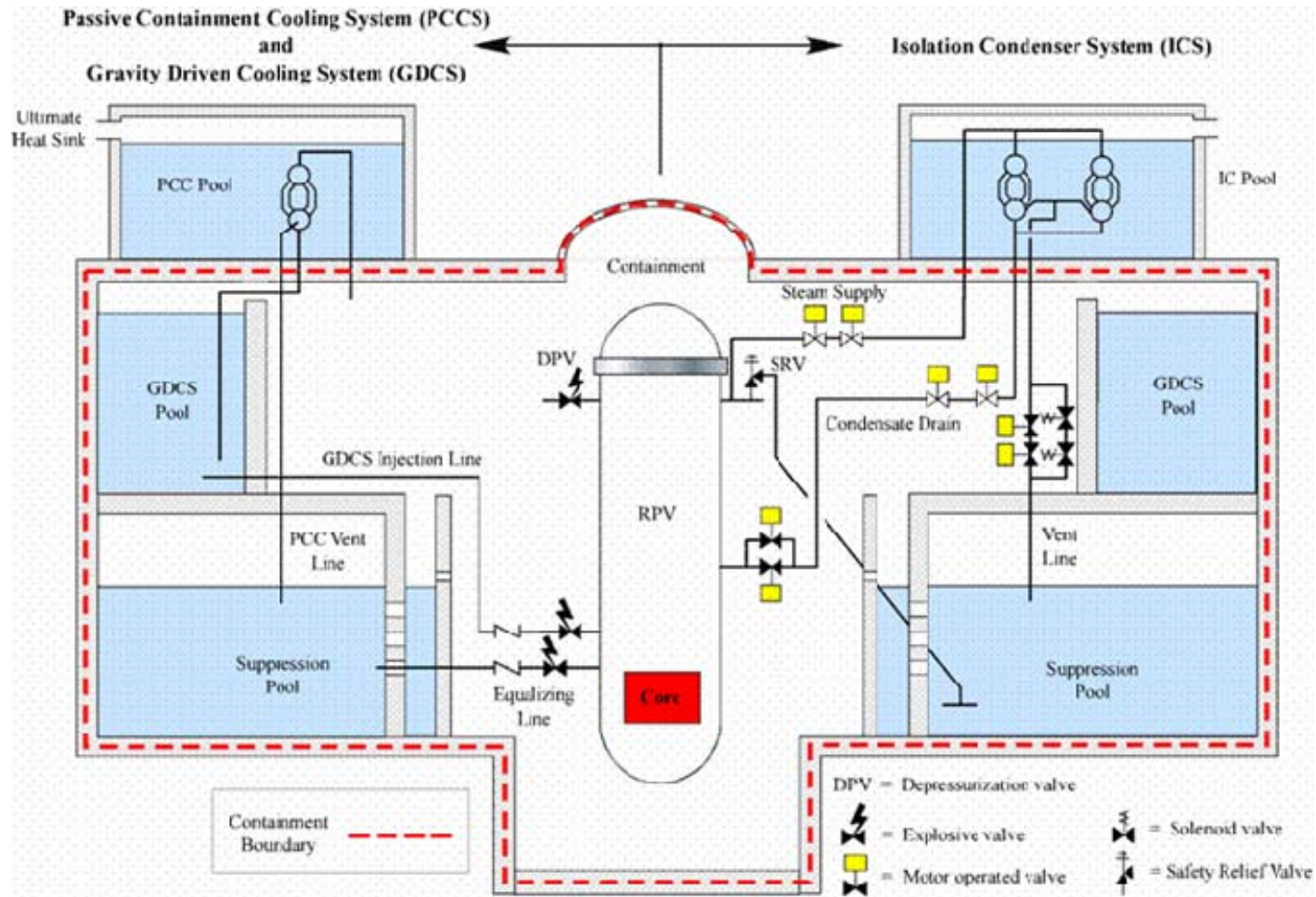
GE Economic Simplified Boiling Water Reactor (ESBWR)





GE Economic Simplified Boiling Water Reactor (ESBWR)

Passive Safety...





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Department of Energy (DOE) 2010 Initiative



DOE Nuclear Power 2010 Initiative



- Establishing Conditions Needed to Start Construction
- Demonstrating Early Site Permit Process
- Demonstrating NRC Combined Licensing (COL) Processes

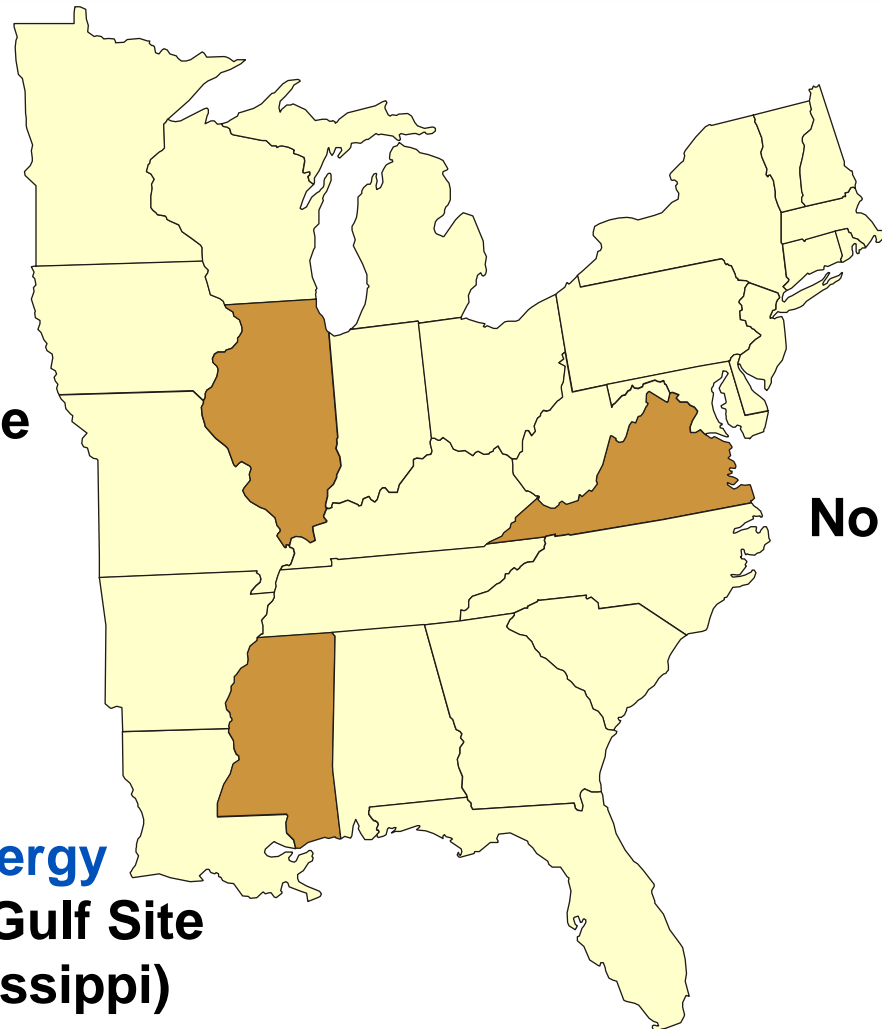


Early Site Permit Applications

Exelon
Clinton Site
(Illinois)

Dominion
North Anna Site
(Virginia)

Entergy
Grand Gulf Site
(Mississippi)





2010 Consortia to Test COL Process

Consortium Lead	Potential COL Application	Reactor Design	Site
Dominion	2006	ESBWR	North Anna
NuStart*	2006	AP1000	TVA / Bellefonte
	2007	ESBWR	Grand Gulf
TVA (Study)	--	ABWR	TVA / Bellefonte

** Entergy, Exelon, Southern, Constellation, Duke, Tennessee Valley Authority, Progress, Florida Power & Light, EDF, Westinghouse, GE (B&V), Bechtel.*



Other Potential COL Applications

Utility	Potential COL Application	Reactor Design	Site
Entergy	2007	ESBWR	River Bend
UniStar*	2008	EPR	Calvert Cliffs / NMP
Duke	2006	AP1000	Greenfield
Southern Nuclear	2008	AP1000 or ESBWR	Vogtle
Progress Energy	2 – 2008	TBD	Florida or Carolinas

* Constellation Energy and AREVA.



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Summary



Summary

- 20% of U.S. Electrical Generation Is Nuclear
- Nuclear Power Is Undergoing a Resurgence
- Nuclear Is a Non-Fossil Fuel Source (No NO_x, SO₂ or CO₂)
- Projections Show 30-35 New Plants by 2025
- New Plants Will Include the ABWR, EPR, AP1000 and ESBWR Designs
- Nuclear Engineers Will Be Needed
 - New Plant Design / Construction
 - Replace Retiring Engineers

