The Westinghouse Advanced Passive Pressurized Water Reactor, **AP1000**™

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Background

- Late '80: USA Utilities under direction of EPRI and endorsed by NRC : *Advanced Light Water Reactor Utility Requirements Document (URD)* with policy and design requirements for next generation
- In Europe similar document *European Utility Requirements (EUR)*
- **Passive** is also *simpler, smaller and much improved*
- **Passive** has much higher expectations (ex. maintain safe shutdown for 72 hrs. after design base event w/o operator action vs. 30' for evolutionary)

Simplification and Standardization are Key to Future Nuclear Plant Construction

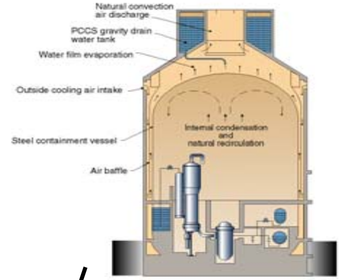
- Simplicity and standardization in **Design** through reduced number of components and bulk commodities
- Simplicity in **Safety** through use of passive safety systems
- Simplicity in **Construction** through modularization
- Simplicity in **Procurement** through standardization of components and plant design
- Simplicity in **Operation and Maintenance** through use of proven systems and components, and man-machine interface advancements

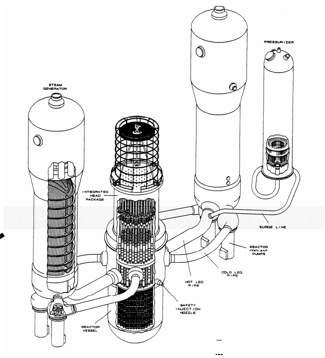
Improved Safety, Competitive Economics and Good Performance

AP1000 Investment in Technology

Extensive Testing of Passive Safety Systems

Simplified Passive Safety Systems

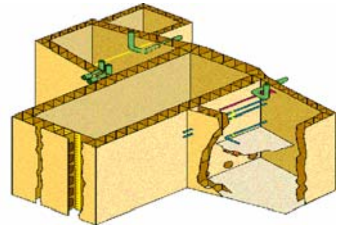




Proven Advanced Design Features

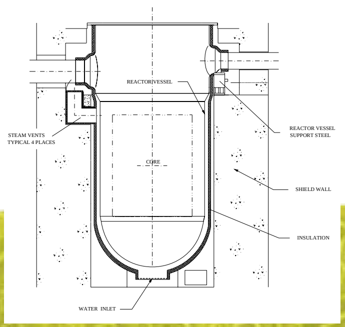

The United States Nuclear Regulatory Commission hereby certifies the
AP600 Standard Plant Design
as set forth in Appendix C of 10 CFR Part 52
Dated the 16th day of December, 1999

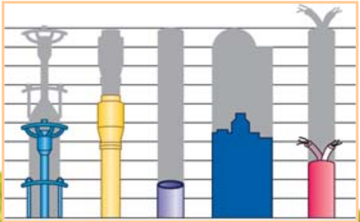
US NRC Certified



Modular Construction

PRA and Severe Accident Mitigation Features





Reduced Components and Commodities

Short Construction Schedule

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AP1000 Design Certification Received From NRC 12/30/05

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THE PLANT

- Our Design Certification includes:
  - Containment
  - Auxiliary Building
  - Annex Building
  - Turbine Building
  - Radwaste Building
  - Diesel Generator Building
  - Everything in Buildings

- It is based upon:
  - Passive Core Cooling
  - Passive Control Room Habitability
  - Passive Containment Cooling
  - Passive Fire Protection
  - Passive Security Features

AP1000 Addresses Security Needs

- Passive plants are less vulnerable to aircraft impact –
  - Smaller footprint
  - Fewer safety-related components
  - Fewer safety systems outside containment
- NEI/EPRI study shows containment integrity maintained after aircraft impact
- Westinghouse interacting closely with US NRC regarding security
- Westinghouse working with EPP utility group on hardening building for airplane crash resistance capability

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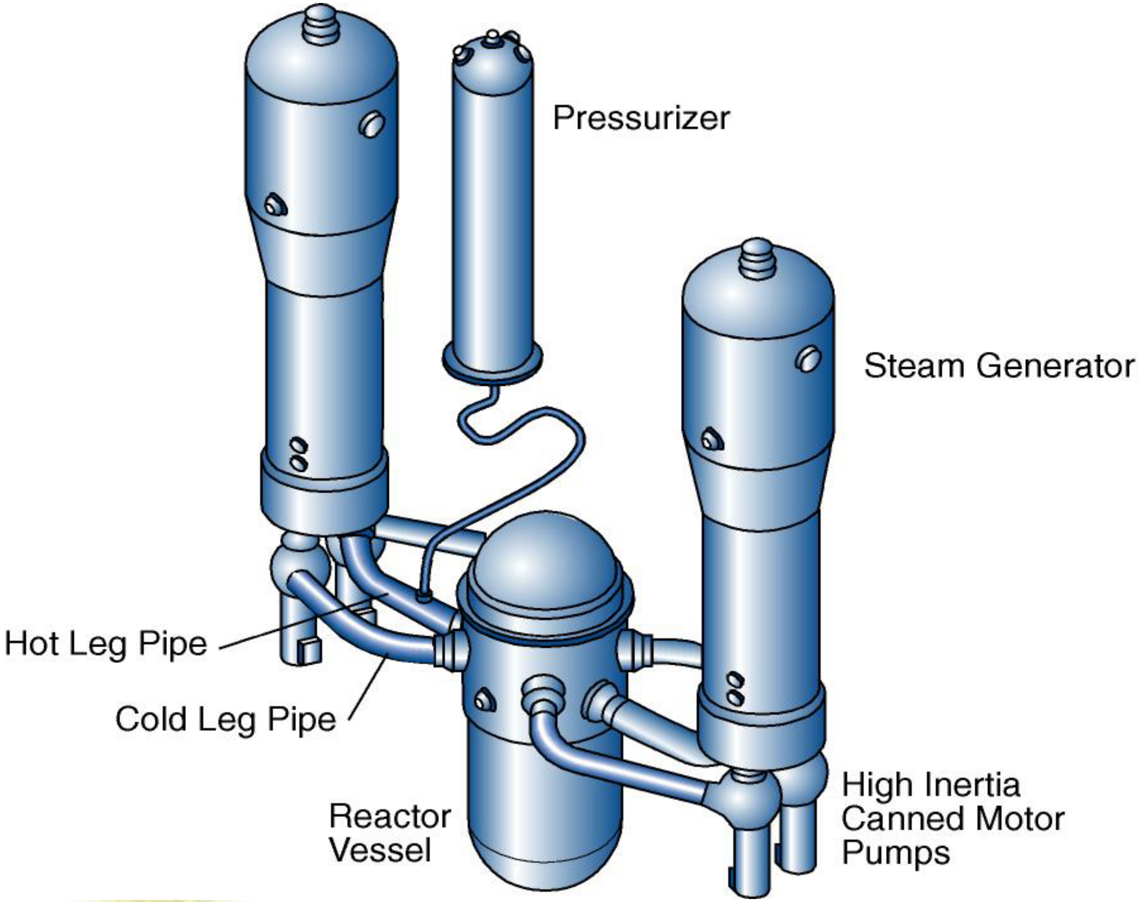
AP1000 Reactor Coolant System*



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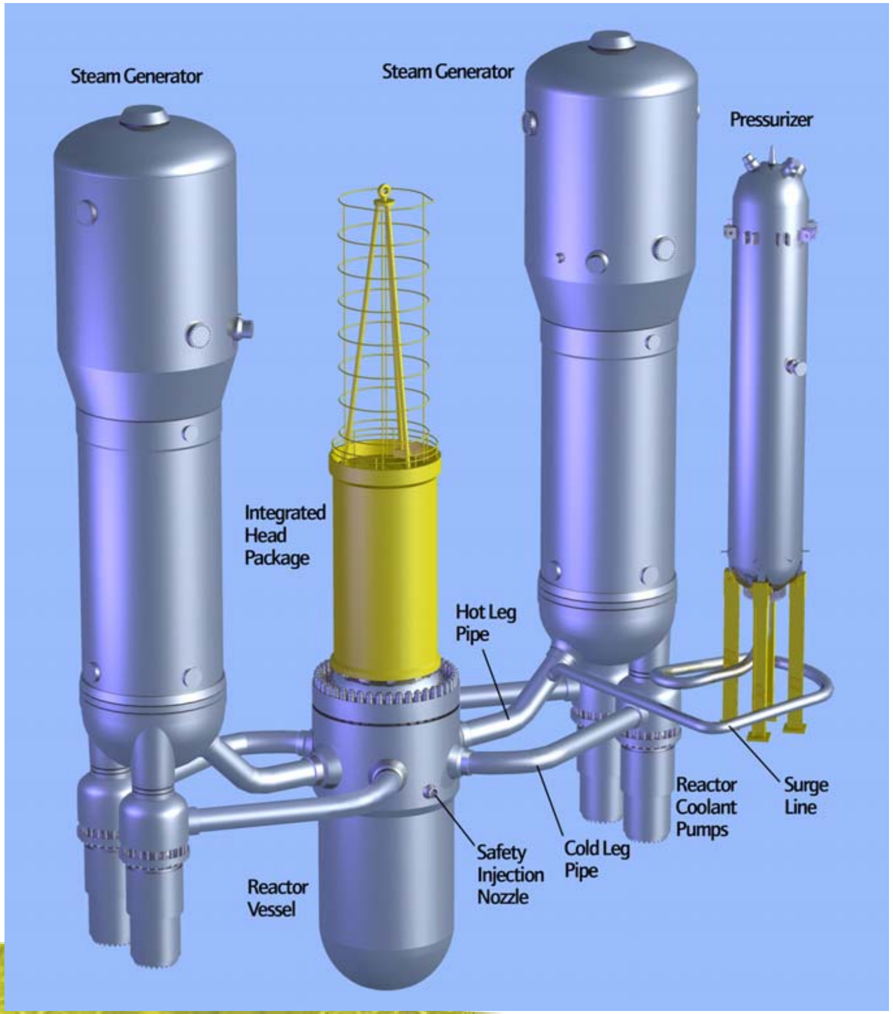
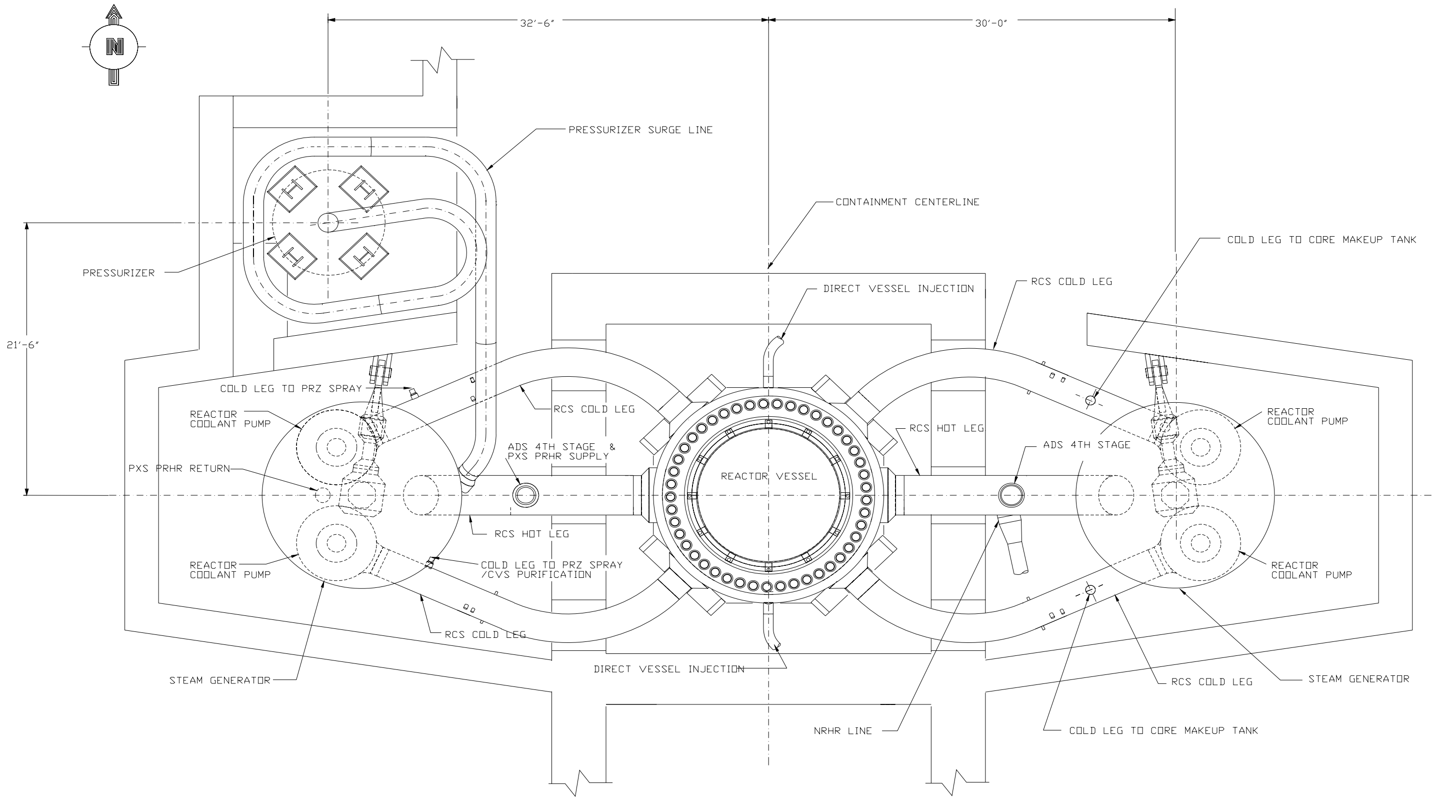
Familiar but Improved Reactor Coolant System

- Fuel, Internals, Reactor Vessel
  - Top-mounted fixed in-core instrumentation
  - Ring-forged reactor vessel (no longitudinal welds)
  - Improved materials - 60 yr life
  - All-welded core shroud (not bolted)
- Steam Generators
  - Similar to large Westinghouse SGs in operation



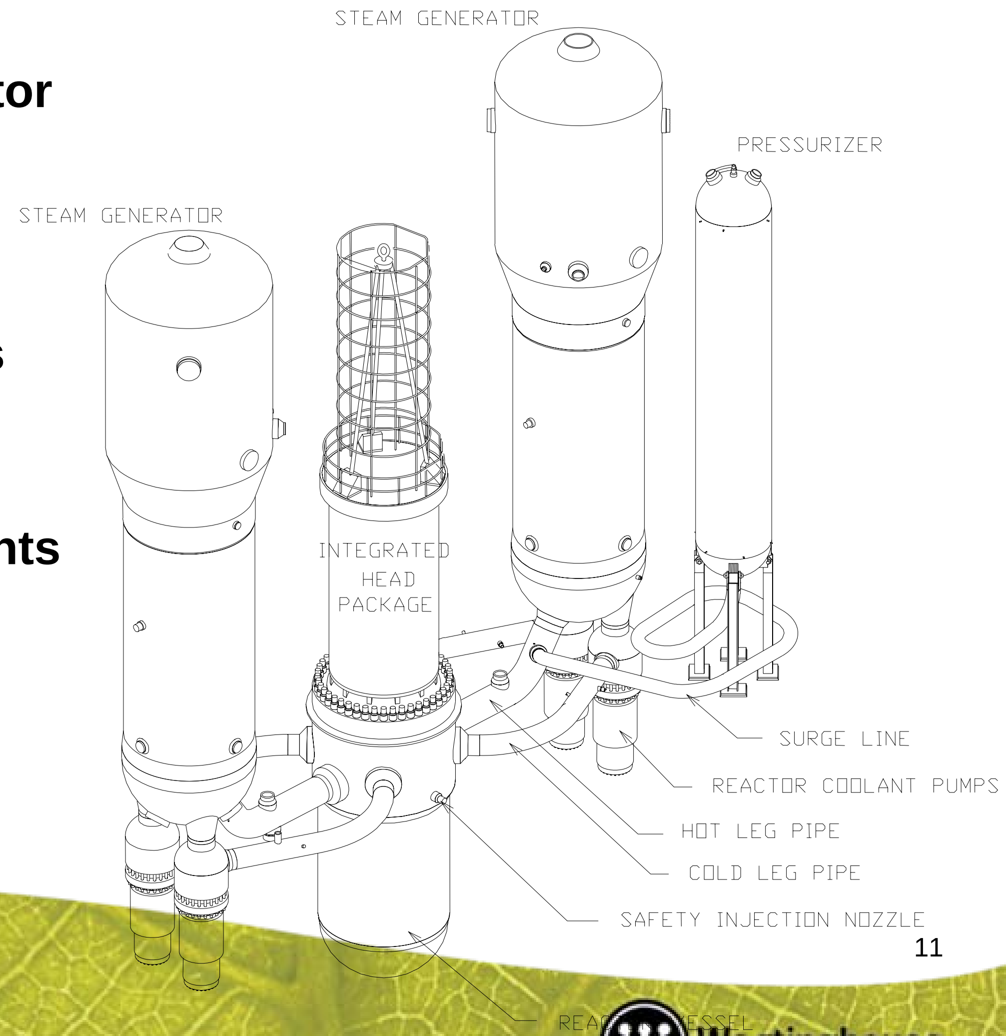
Reactor Coolant System Loop – Building Interface and Primary Shield



- Hot Leg ID (31 in), Cold Leg ID (22 in), and Surge Line ID (18 in)

Proven AP1000 Major Components

- Canned motor Reactor Coolant Pumps mounted in steam generator lower head
  - No shaft seals
- Simplified Main Loop
  - Reduces welds 50%, supports 80%
- Pressurizer
  - 50% larger than operating plants
  - Eliminate PORV



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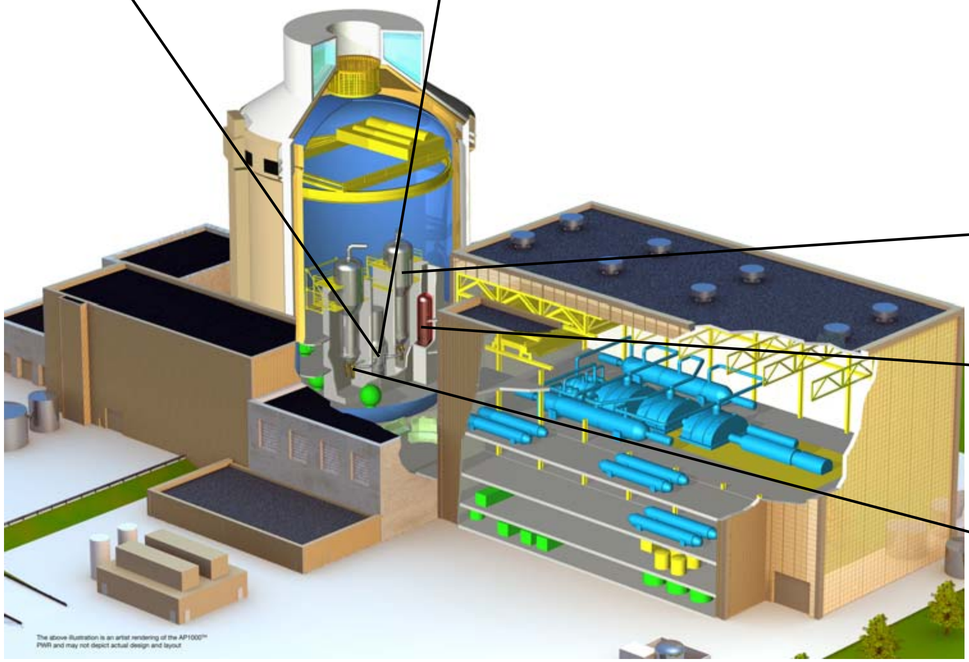
Proven AP1000 Components

Reactor Vessel Internals

Doel 4, Tihange 3

Control Rod Drive Mechanisms

Westinghouse plants worldwide



Fuel

South Texas 1&2, Doel 4, Tihange 3

Large Model F steam generators

ANO-2, San Onofre, Waterford, Palo Verde

Pressurizer

70 Westinghouse plants worldwide

Canned motor reactor coolant pumps

Fossil boilers and other industrial applications (inverted canned motor pumps)

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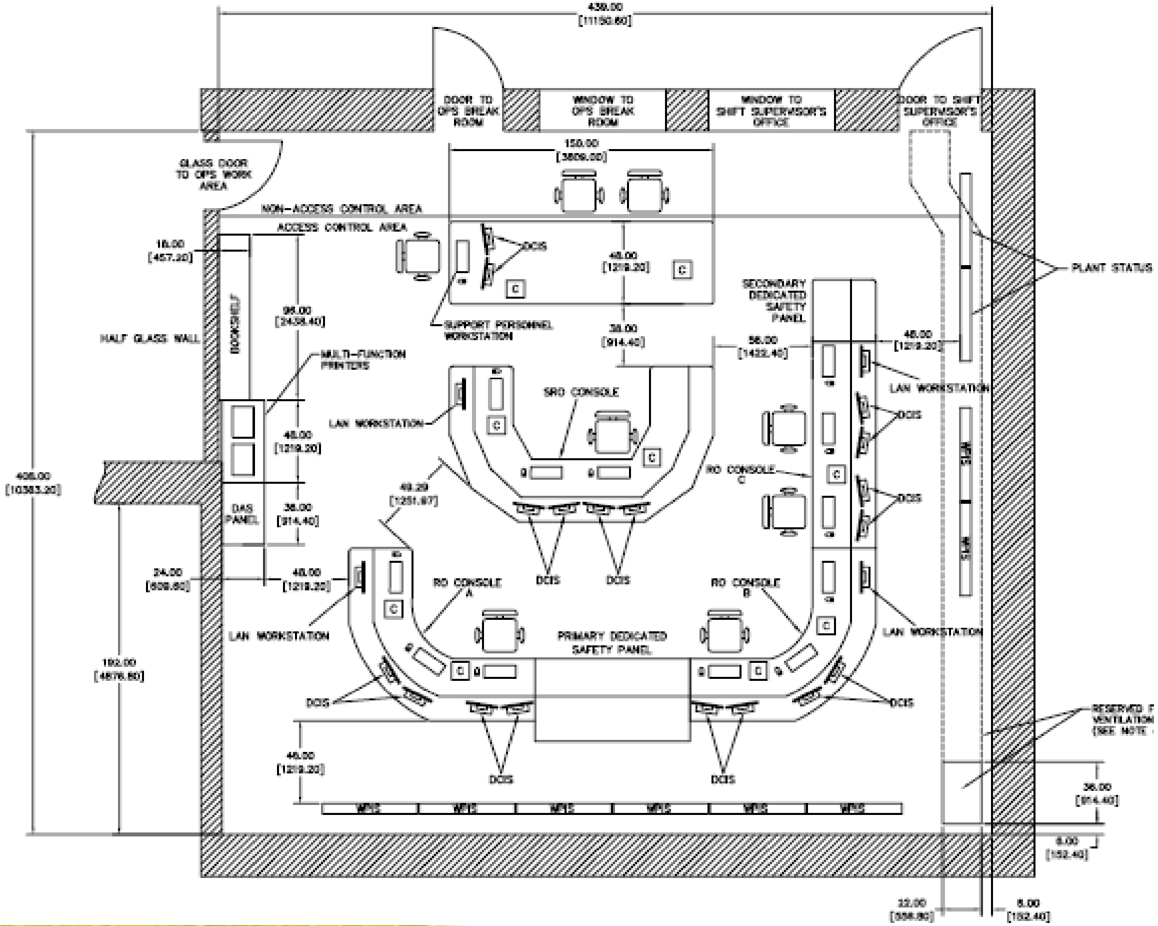
Comparison of Selected Parameters

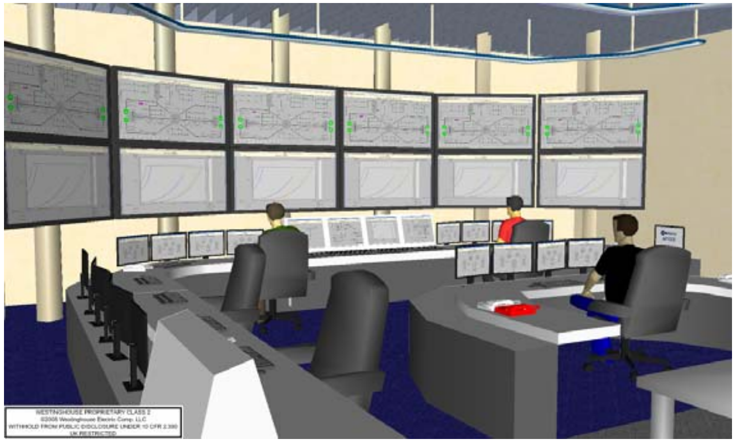
PARAMETER	Doel 4 / Tihange 3	AP1000
Net Electric Output, MWe	985	1117
Reactor Power, MWt	2988	3400
Hot Leg Temperature, ^{o}F	626	610
Number of Fuel Assemblies	157	157
Type of Fuel Assembly	17x17	17x17
Active Fuel Length, ft	14	14
Linear Heat Rating, kW/ft	5.02	5.71
R/V I.D., inches	157	157
Vessel Thermal Design Flow, gpm	295,500	299,880
Steam Generator Surface Area, ft^2	68,000	125,000
Reactor Coolant Pump Flow, gpm	103,400	78,750
Pressurizer Volume, ft^3	1400	2100

Advanced Control Room

AP1000 Main Control Area Layout



Main Control Room 3D Model (2)



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Major Safety Advancements of AP1000

- No Reliance on AC Power
- No Operator Action Required to Assure Safety
- Long Term Plant Safety Assured without Active Components (Natural Forces Only)
- Containment is Not Breached for Postulated Design Basis Events
- In Severe Accidents, Reactor Vessel Cooling Keeps Core in Vessel
- Large Margin to Safety Limits
- Defense in Depth - Active Systems Provide ADDITIONAL first line of defense

Passive Safety – What's it all about?

- Passive Safety Systems utilizes naturally occurring physical phenomena such as natural circulation of air, water and steam
- Gravity and gas pressure drive the flow of cooling water
- Natural heat transfer occurs through conduction, convection and evaporation
- There are no safety related pumps and motor-operated valves
- A few battery powered valves align the passive safety systems upon actuation signals
- Reactor safety functions are achieved without using any safety related AC power

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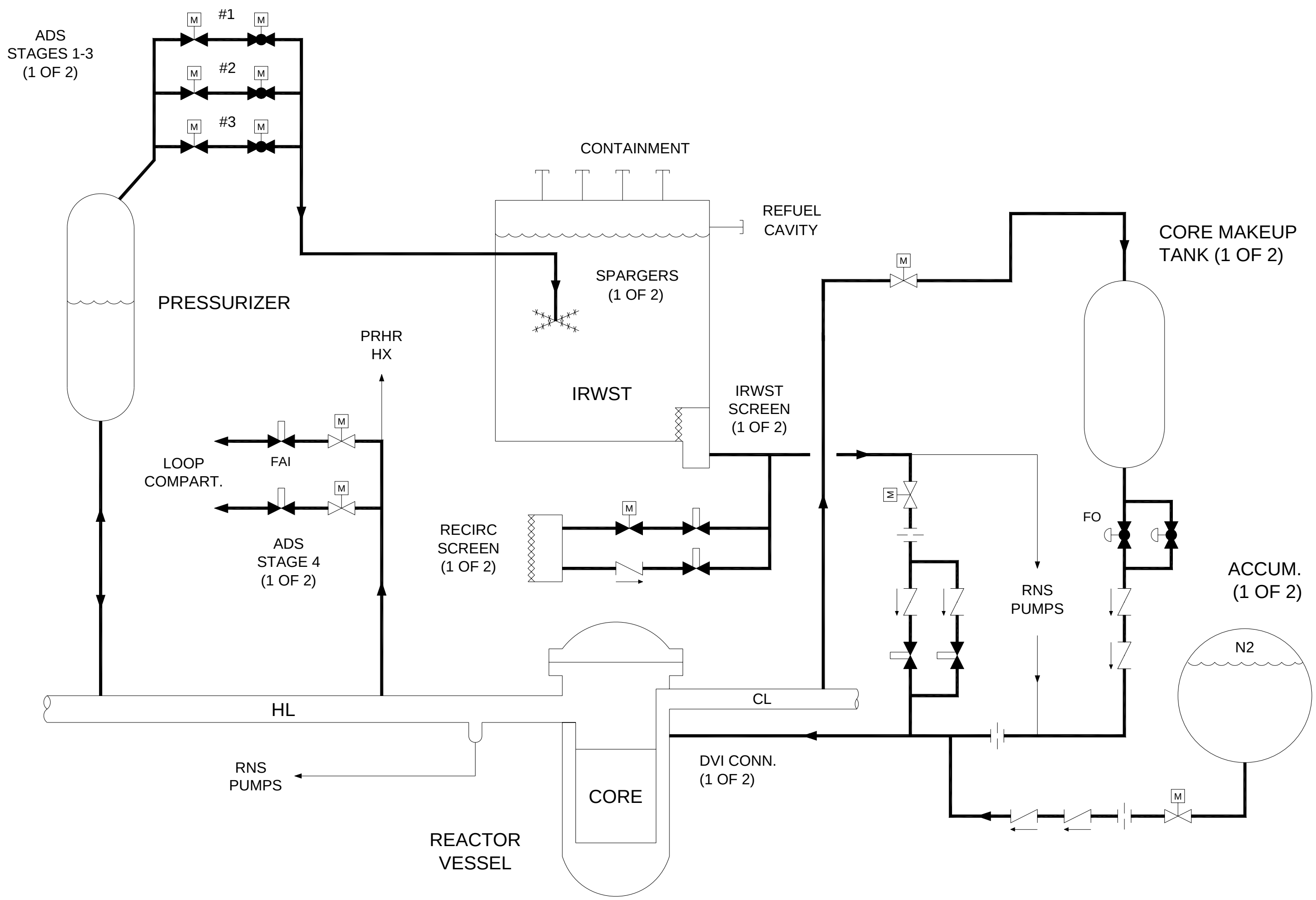
Approach to Safety

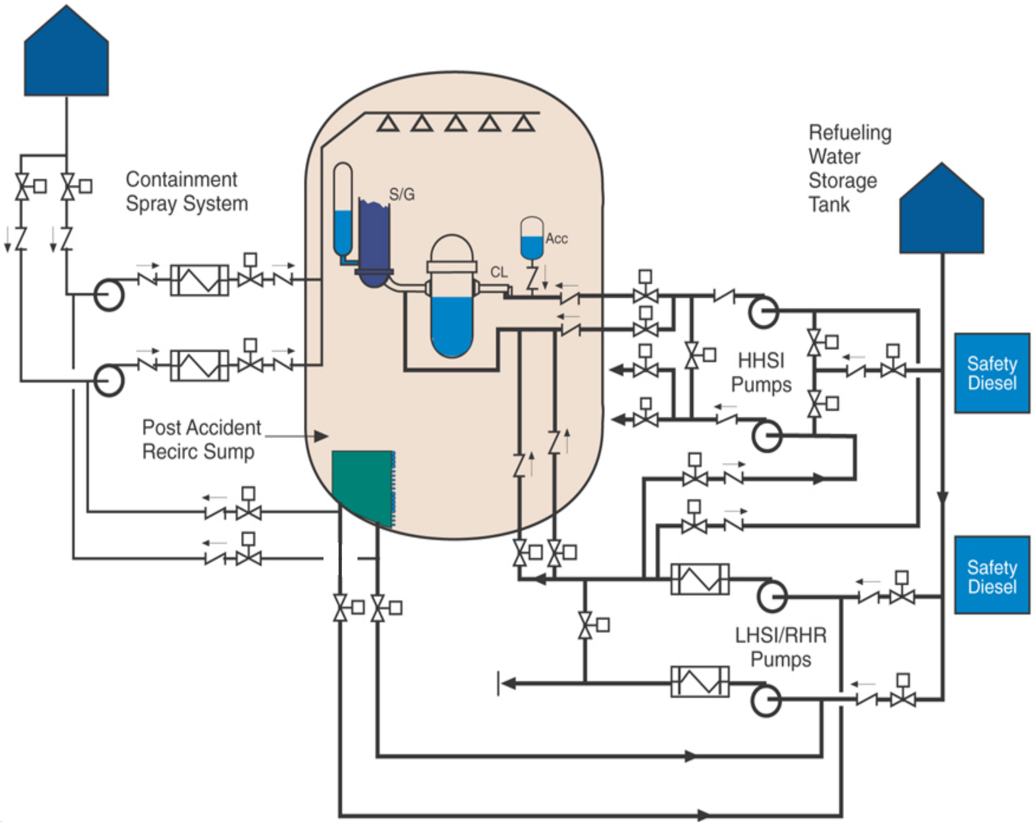
- Passive safety-related systems
  - Use “passive” process only, no active pumps, diesels, …
    - One time alignment of valves
    - No support systems required after actuation
      - No ac power, cooling water, HVAC, I&C
  - Greatly reduced dependency on operator actions
  - Mitigate design basis accidents without non-safety systems
  - Meet NRC PRA safety goals without use of non-safety systems
- Active non-safety-related systems
  - Reliably support normal operation
    - Redundant equipment powered by on-site diesels
  - Minimize challenges to passive safety systems
  - Not required to mitigate design basis accidents

AP1000 Passive Safety Injection

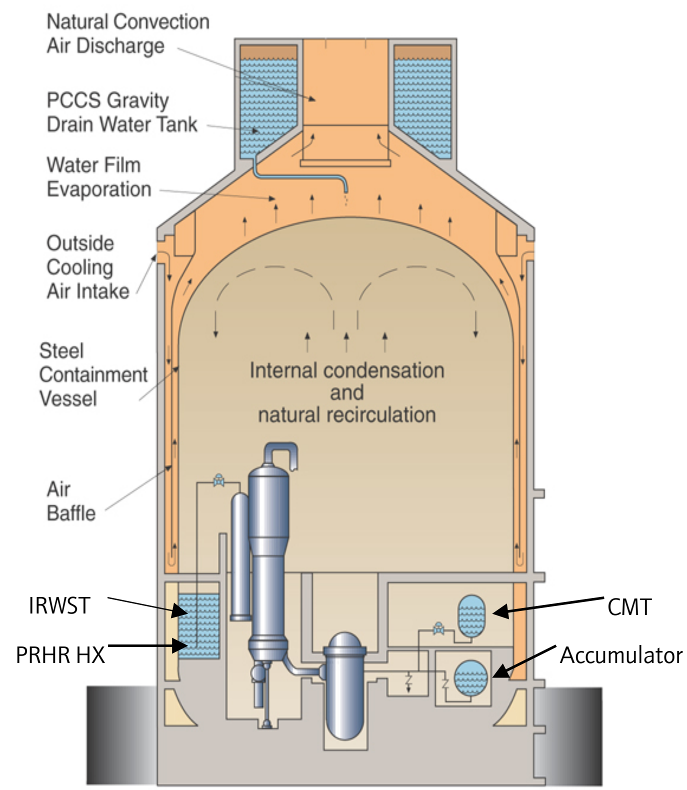


Simplification of Safety Systems Dramatically Reduces Building Volumes

Standard PWR

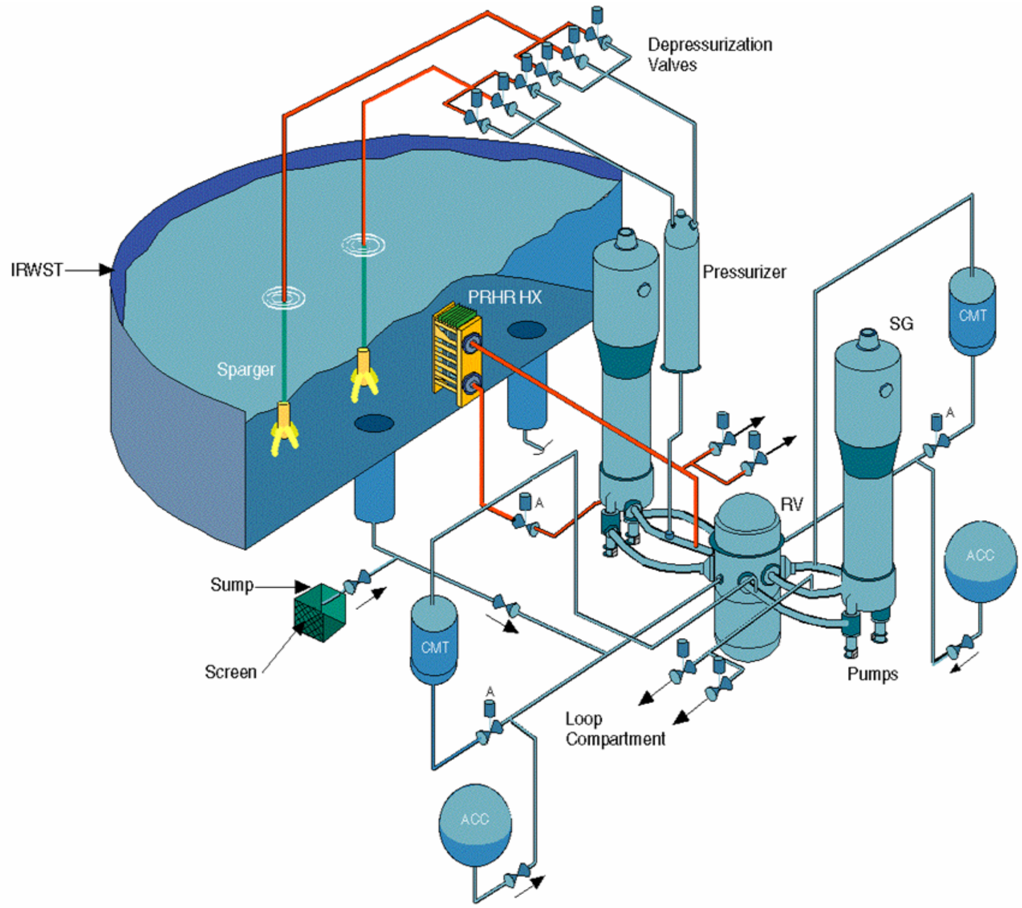


AP1000

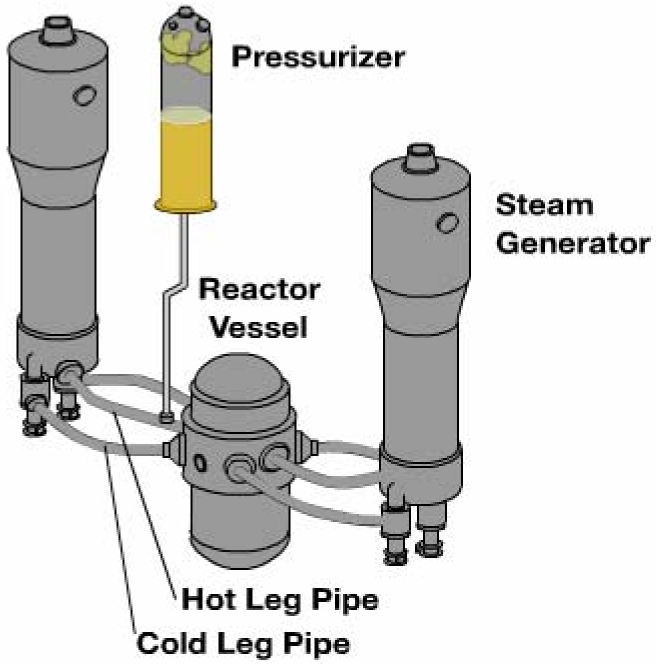


Simplicity in Design and Safety

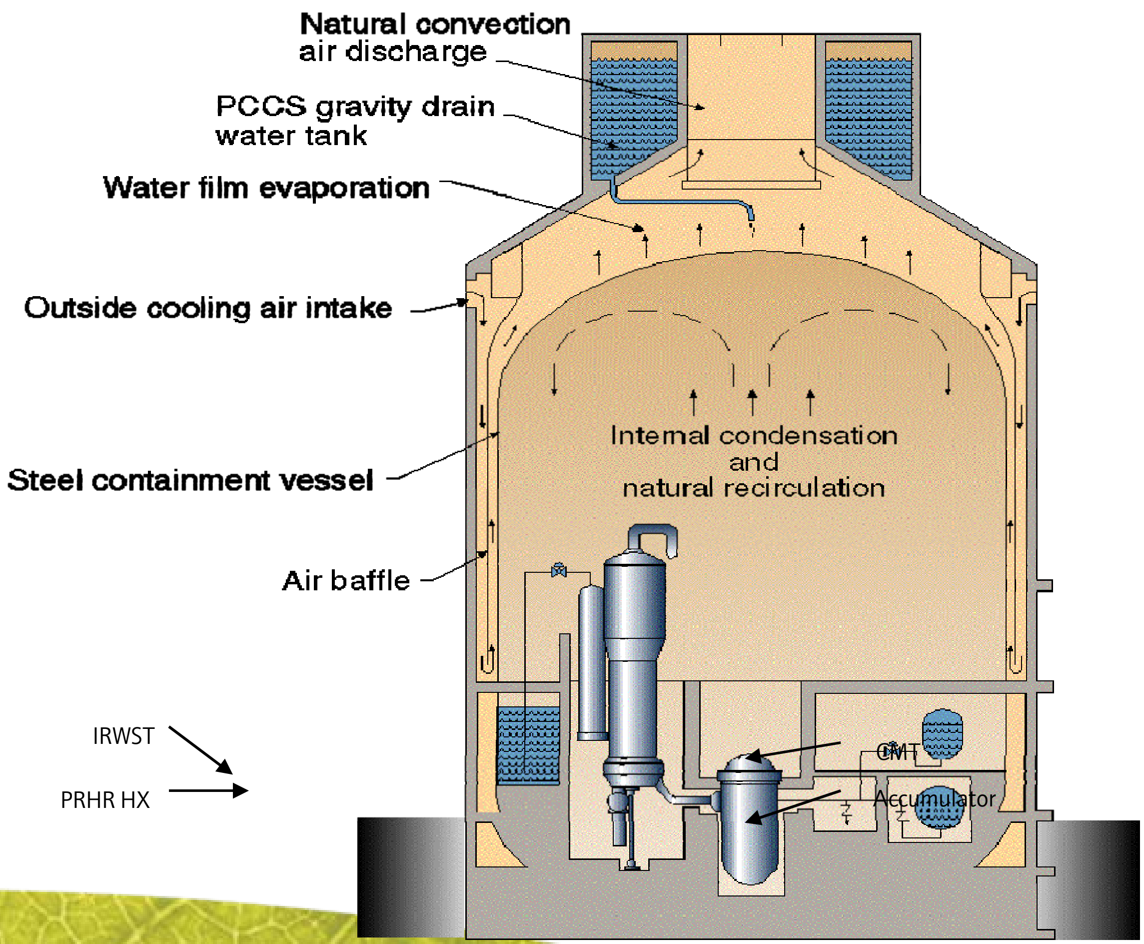
- Proven 2 - loop reactor coolant system with canned motor pumps
- Use of passive safety systems
- No reliance on safety grade AC power
- In – vessel retention for severe accidents
- No operator action for 72 hours



Passive Core Cooling System at Work



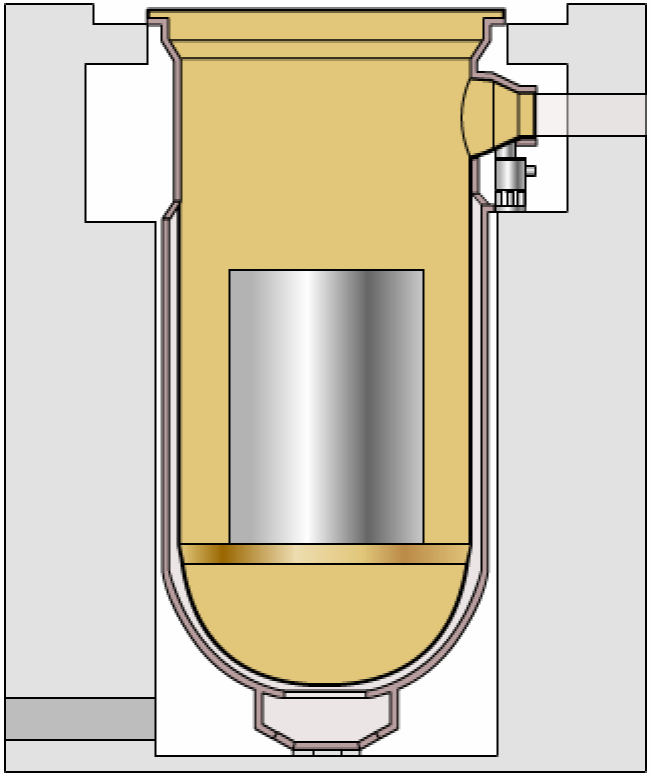
Passive Containment Cooling System



AP1000 Ultimate Heat Sink is the Atmosphere

Severe Accident Mitigation In-Vessel Retention

- Core melt scenario AP1000 designed to retain core debris **<u>within the reactor vessel</u>**
  - Cooling water flow path in vessel/insulation annulus
  - Cooling flow driven by natural circulation
  - Water source: In containment refueling water storage tank
  - Automatic depressurization
- Large release frequency: 5.9 x 10-8 per reactor year; URD requires < 10-6



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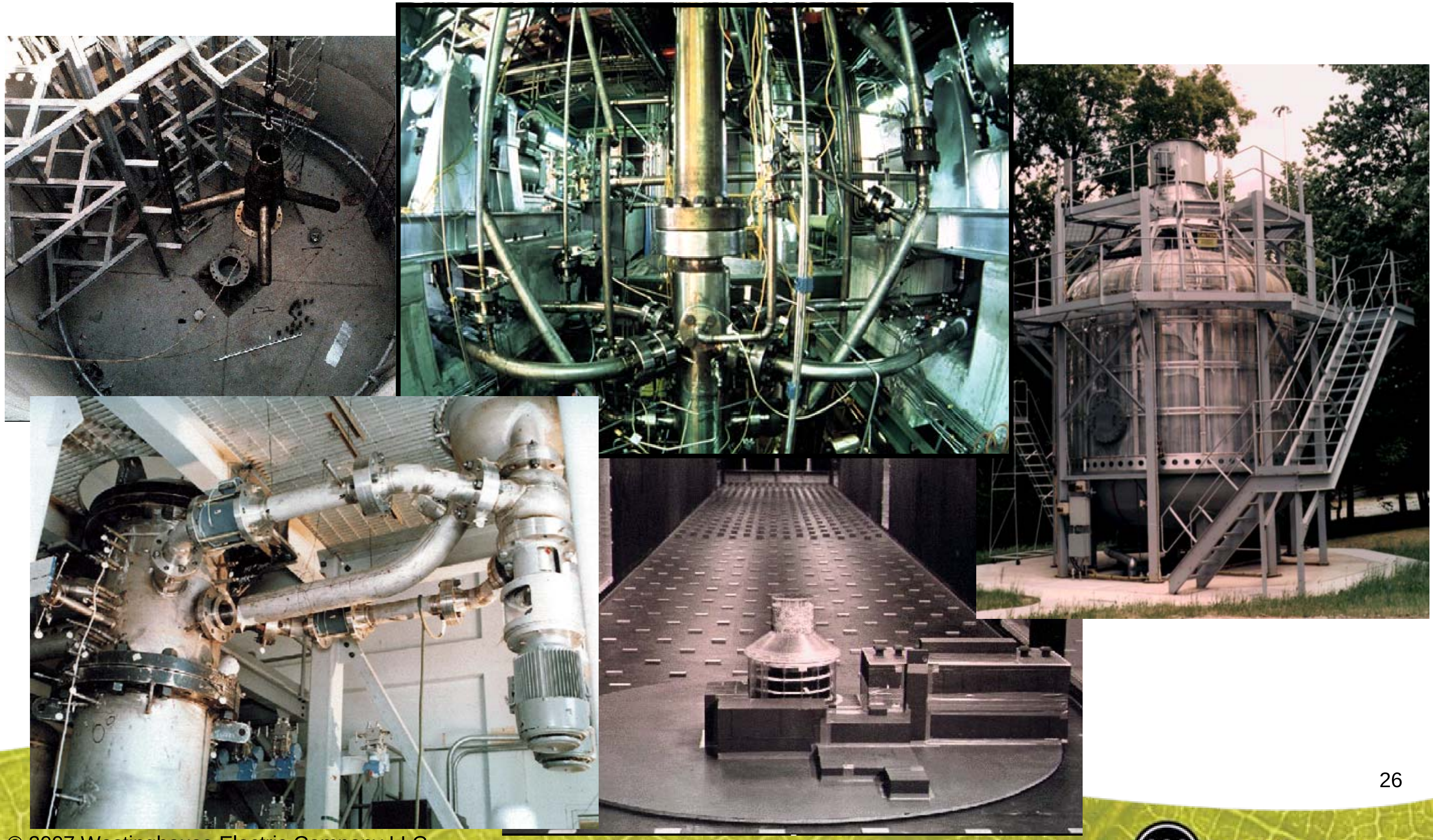
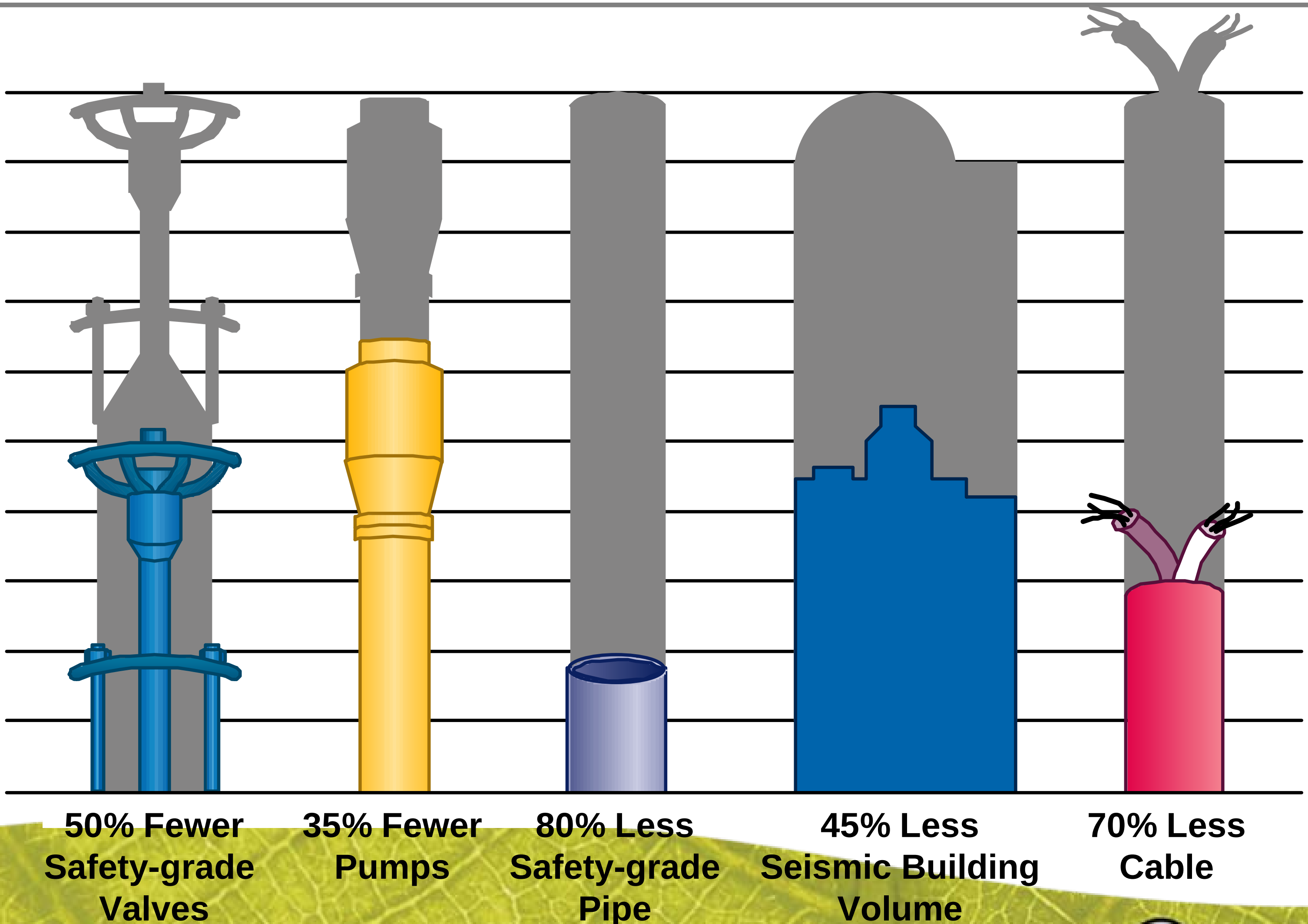
AP1000 Most Tested Reactor



Passive Containment Cooling Test Facility Demonstrated the Effectiveness of Passive Containment Cooling

AP1000 Passive Safety System Design Improves Economics and Construction Schedule



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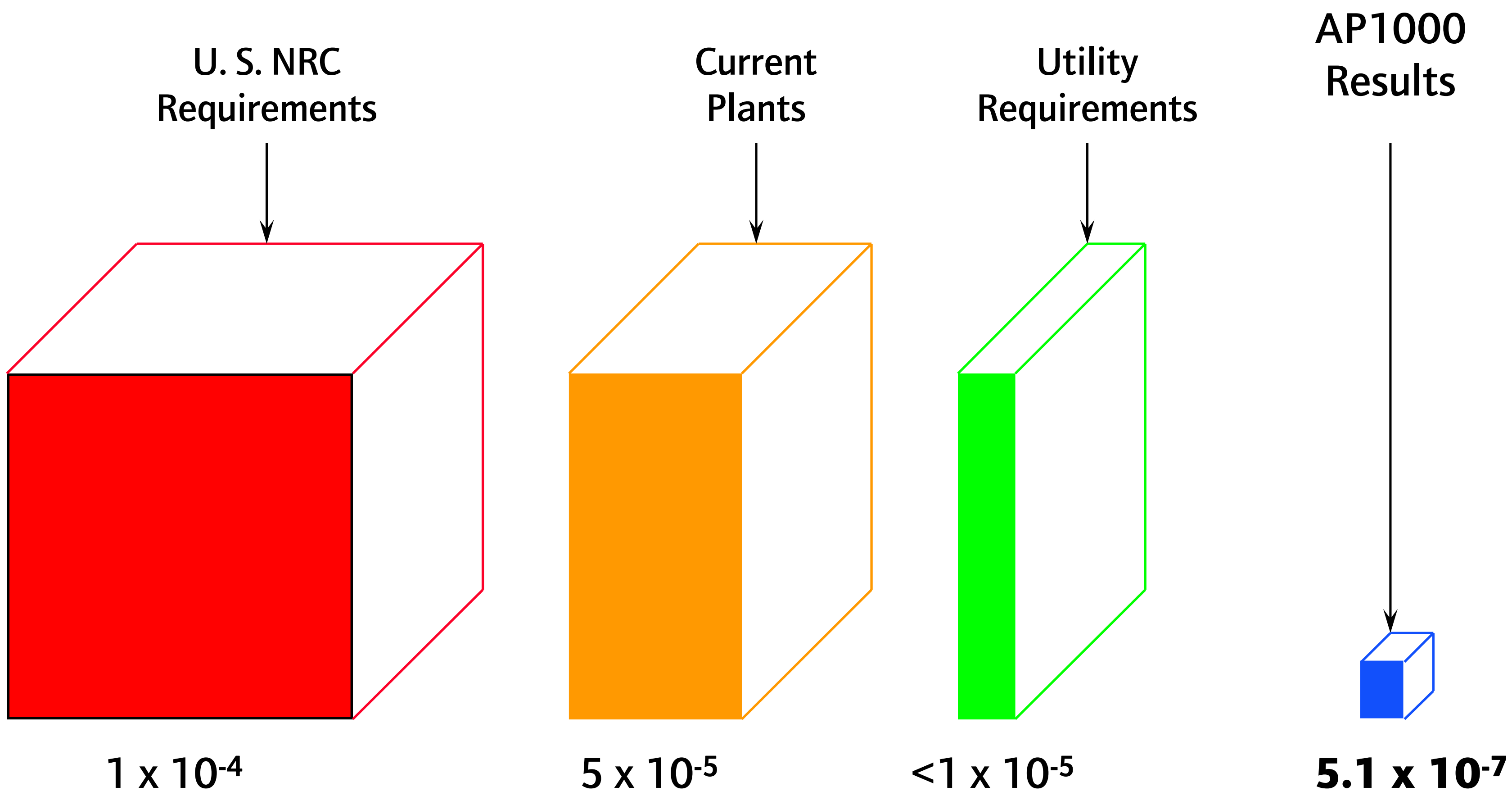
AP1000 Provides Safety and Investment Protection



Core Damage Frequency per Year (All Events)

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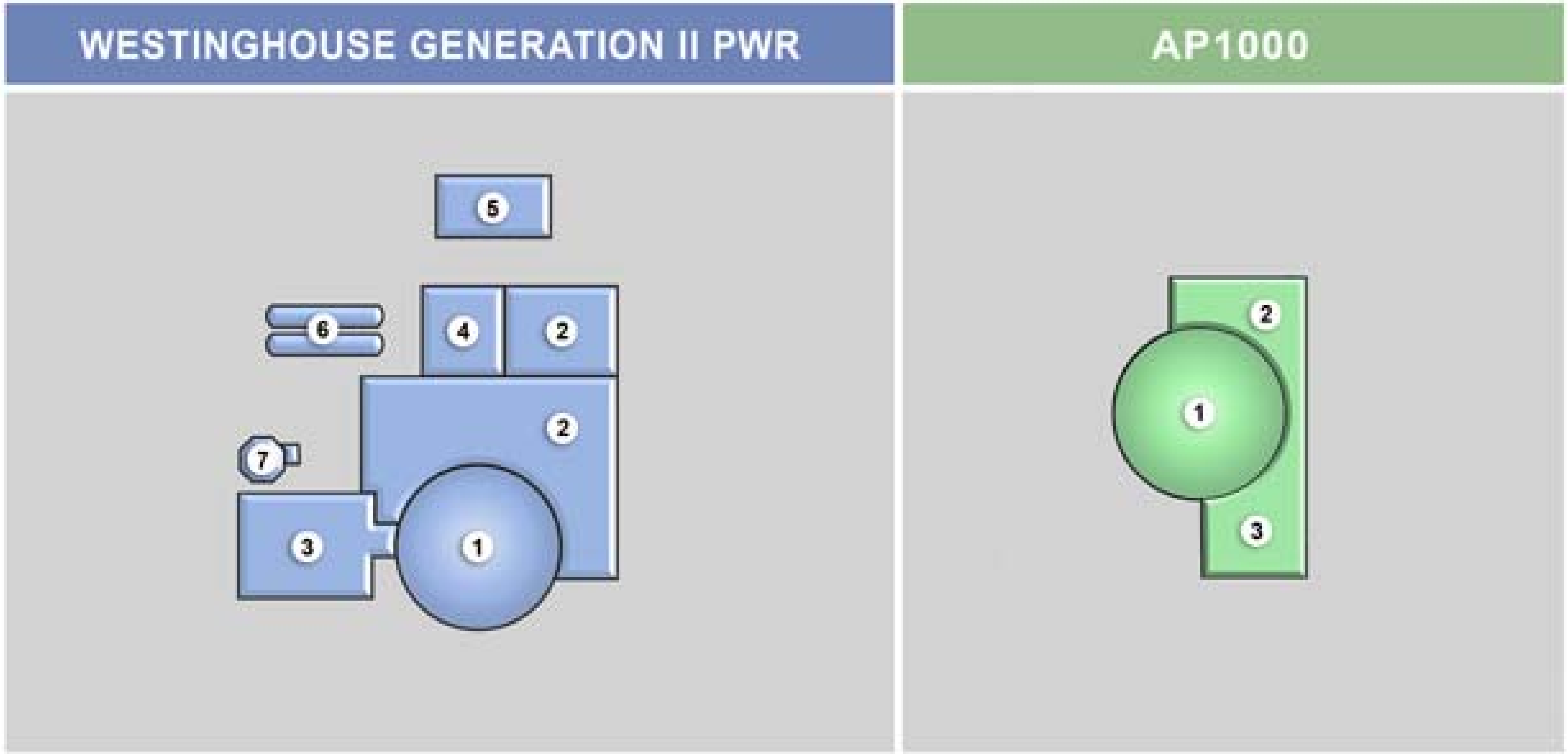
Comparison of Seismic Category I Buildings



0 20 40 60 80 100m

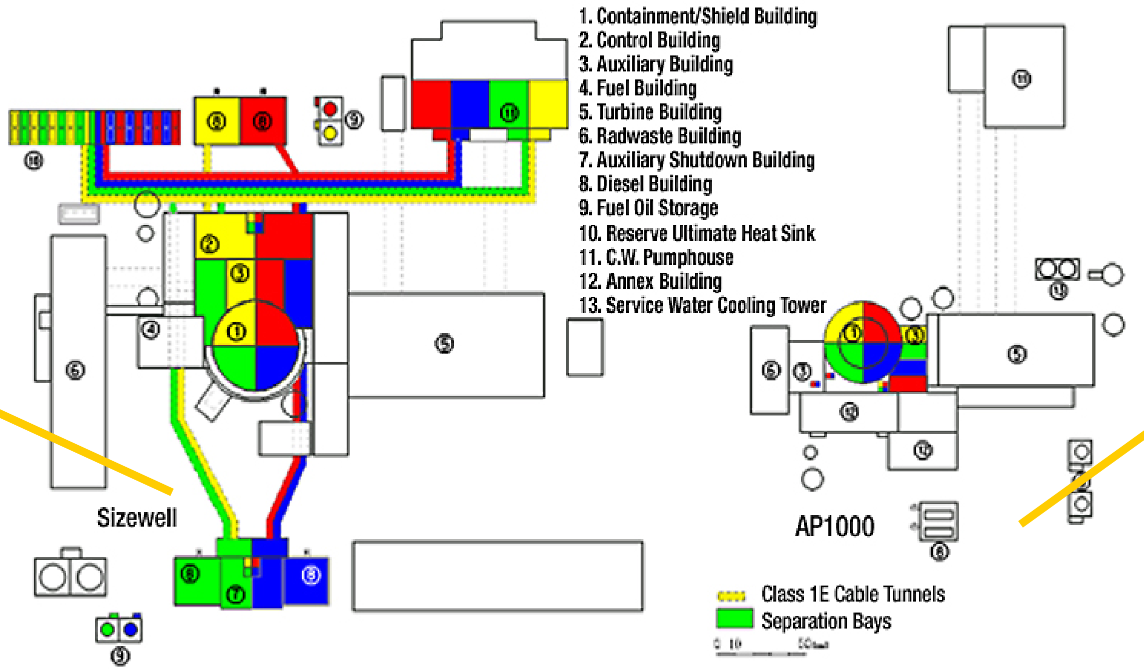
1. Shield / Containment
2. Auxiliary Building
3. Fuel Area
4. Diesel Generators
5. Essential Service Water Pumphouse
6. Emergency Fuel Oil Storage
7. Refueling Water Storage Tank

AP1000 Construction Simplification

Think: 1) more power/m³ of concrete, 2) less to decommission

	Concrete, m^3	Rebar, metric tons	Power, MWe
Sizewell B:	520,000	65,000	1188
AP1000:	<100,000	<12,000	1117

Sizewell B



AP1000

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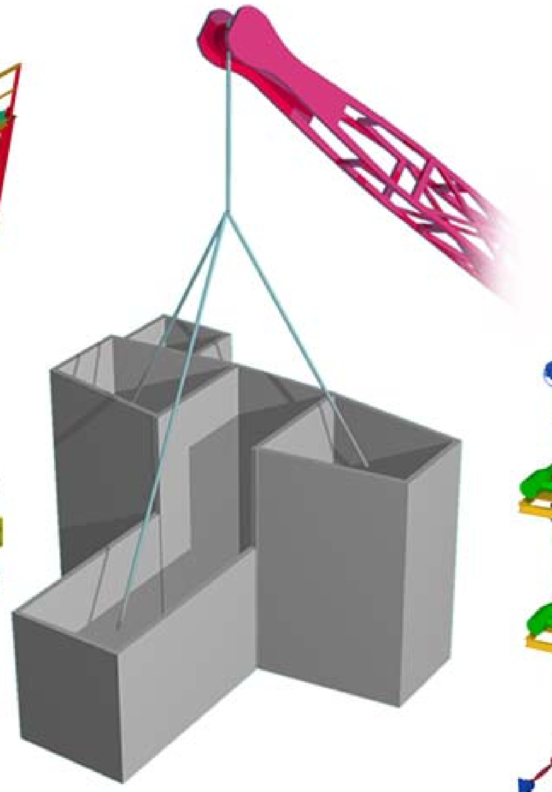
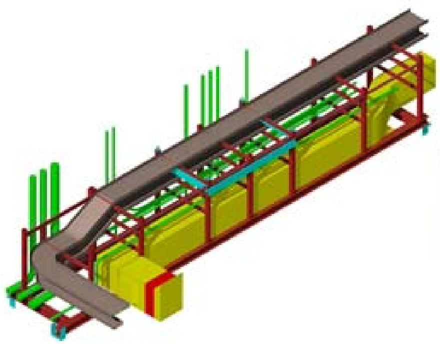
Modules Designed into AP1000 from the Beginning

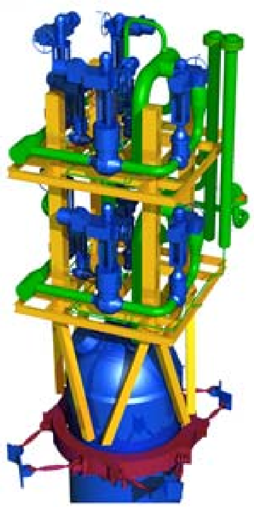
Pump/Valve Module



Structural Module



Raceway Module



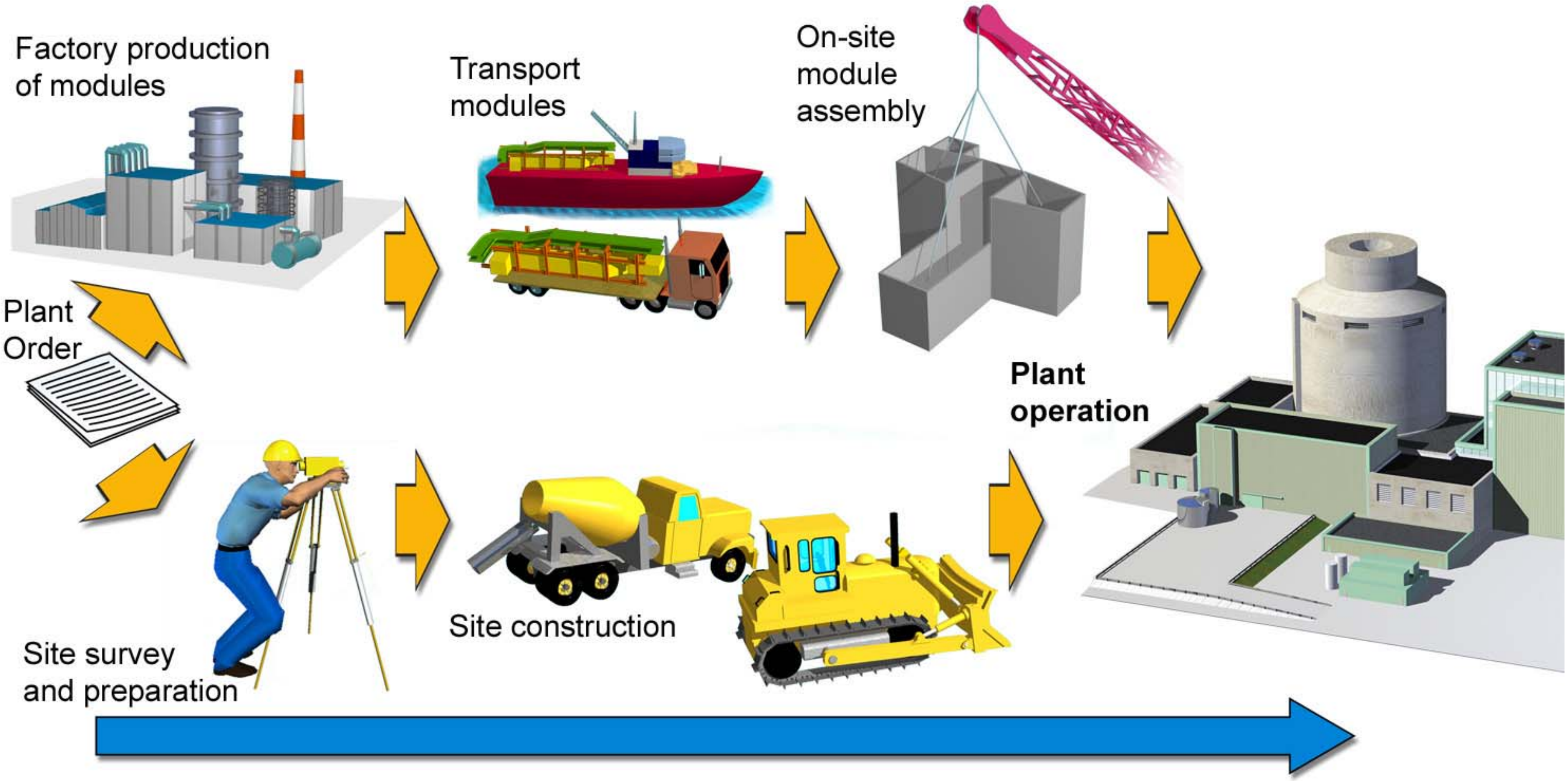
Depressurization Module

Module Type	Number
Structural	122
Piping	154
Mechanical Equipment	55
Electrical Equipment	11
TOTAL	342

Module Program

- Structural steel and plate modules designed to be fabricated, outfitted, installed and then filled with concrete after installation.
- The process effectively removes the reinforcing steel installation (typically a largely manual operation) from the work face to the fabrication facility and implements it in parallel with other installation activities.
- The scope and content of these modules includes multi floors, rooms/areas and all disciplines.

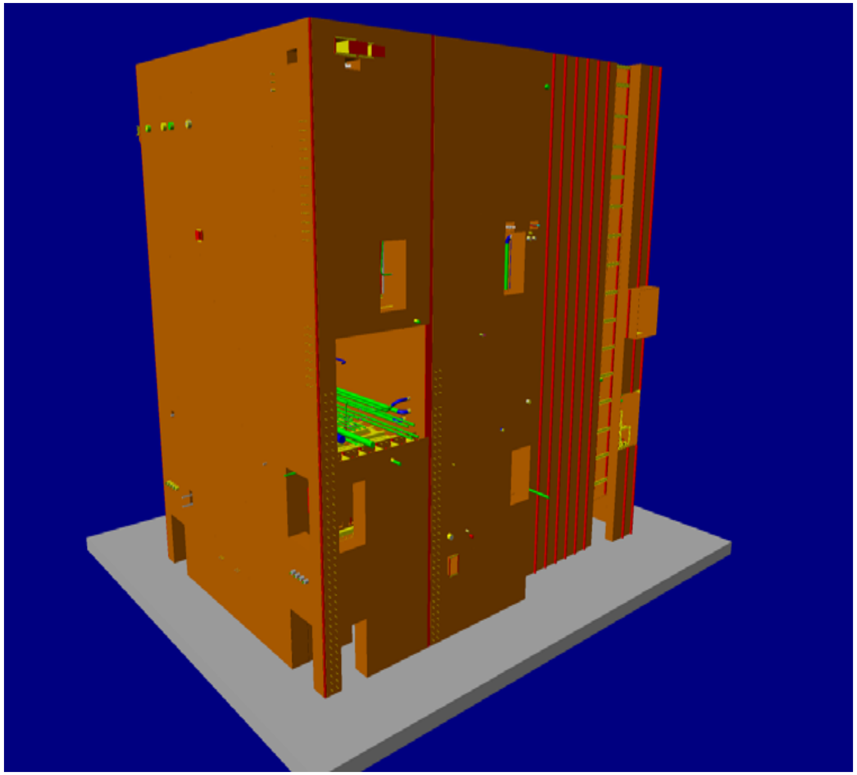
Modular Construction Allows More To Be Done in Parallel
Result: Shorter Construction Schedule



Module Program

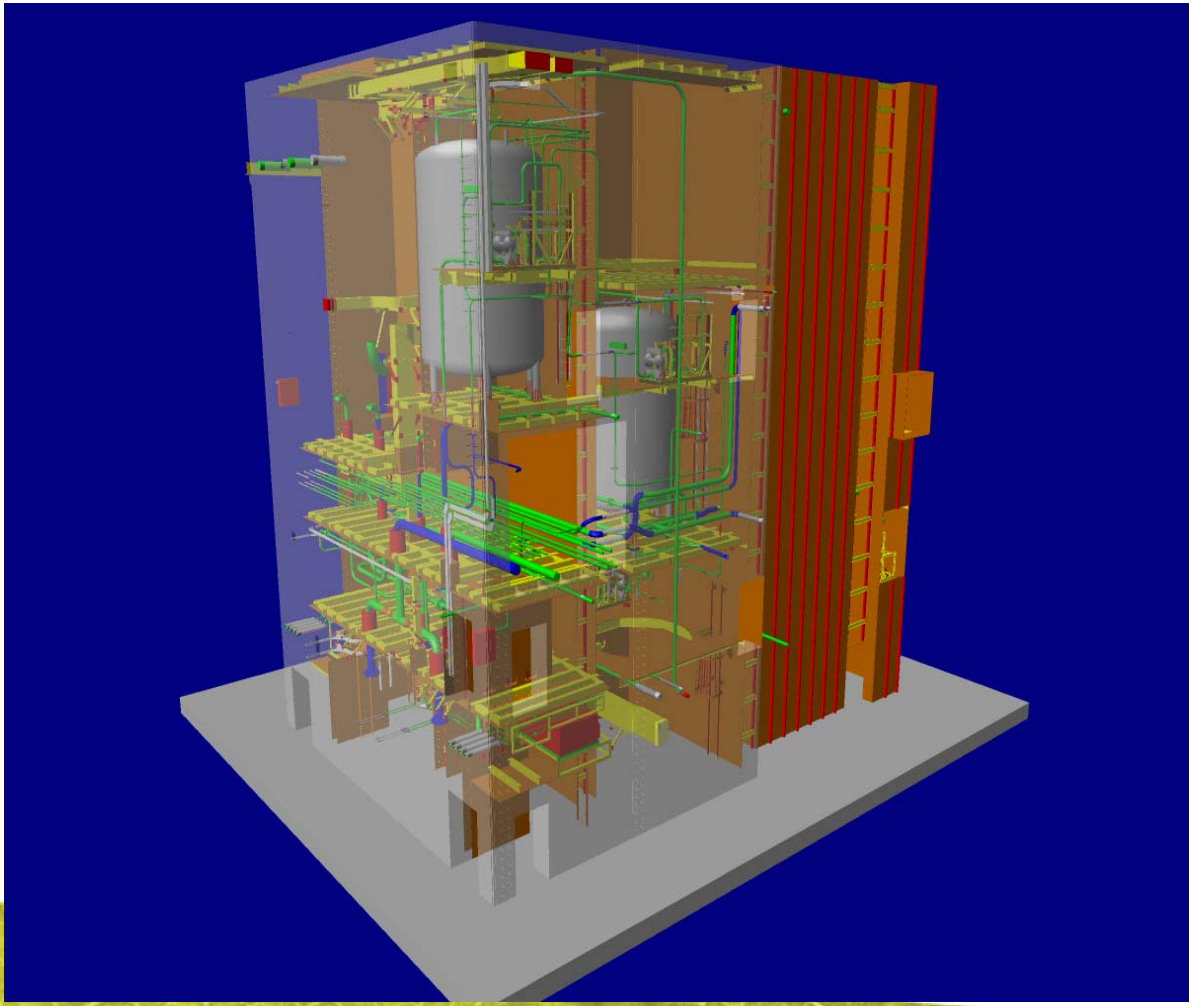
CA 20 Overview

- Overall Dimensions:
  - Width: 46.5 ft.
  - Length: 67.3 ft.
  - Height: 68.8 ft.
- Estimated Weight:
  - Walls and Floors: 770 tons
  - Outfitting (components, piping, rebar): 89 tons
  - Total Outfitted: 859 tons



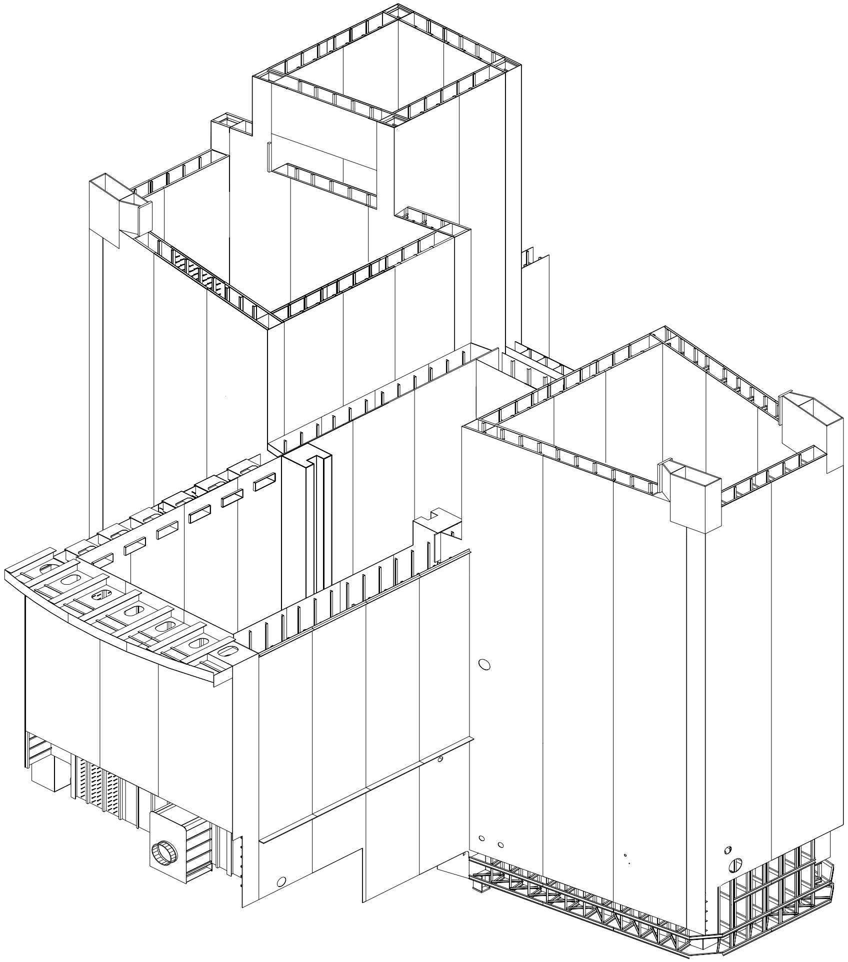
Module Program

CA 20 view with walls removed to show outfitted equipment prior to installation

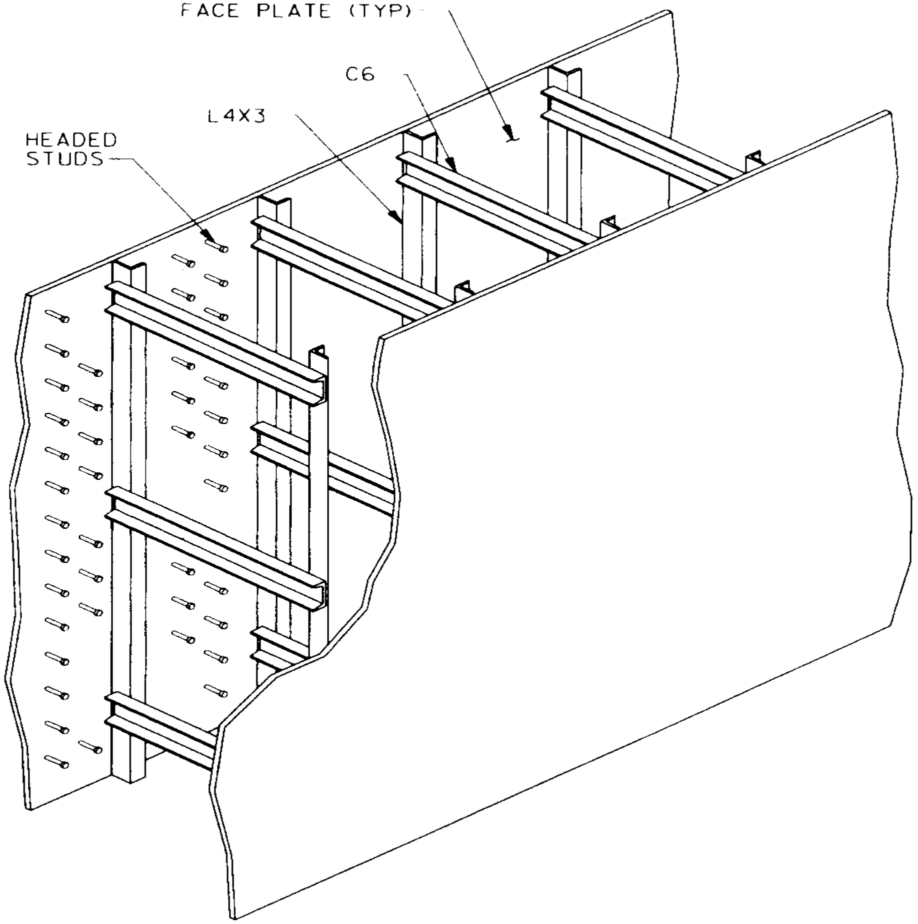


Module Program

Composite Structural Module CA 01

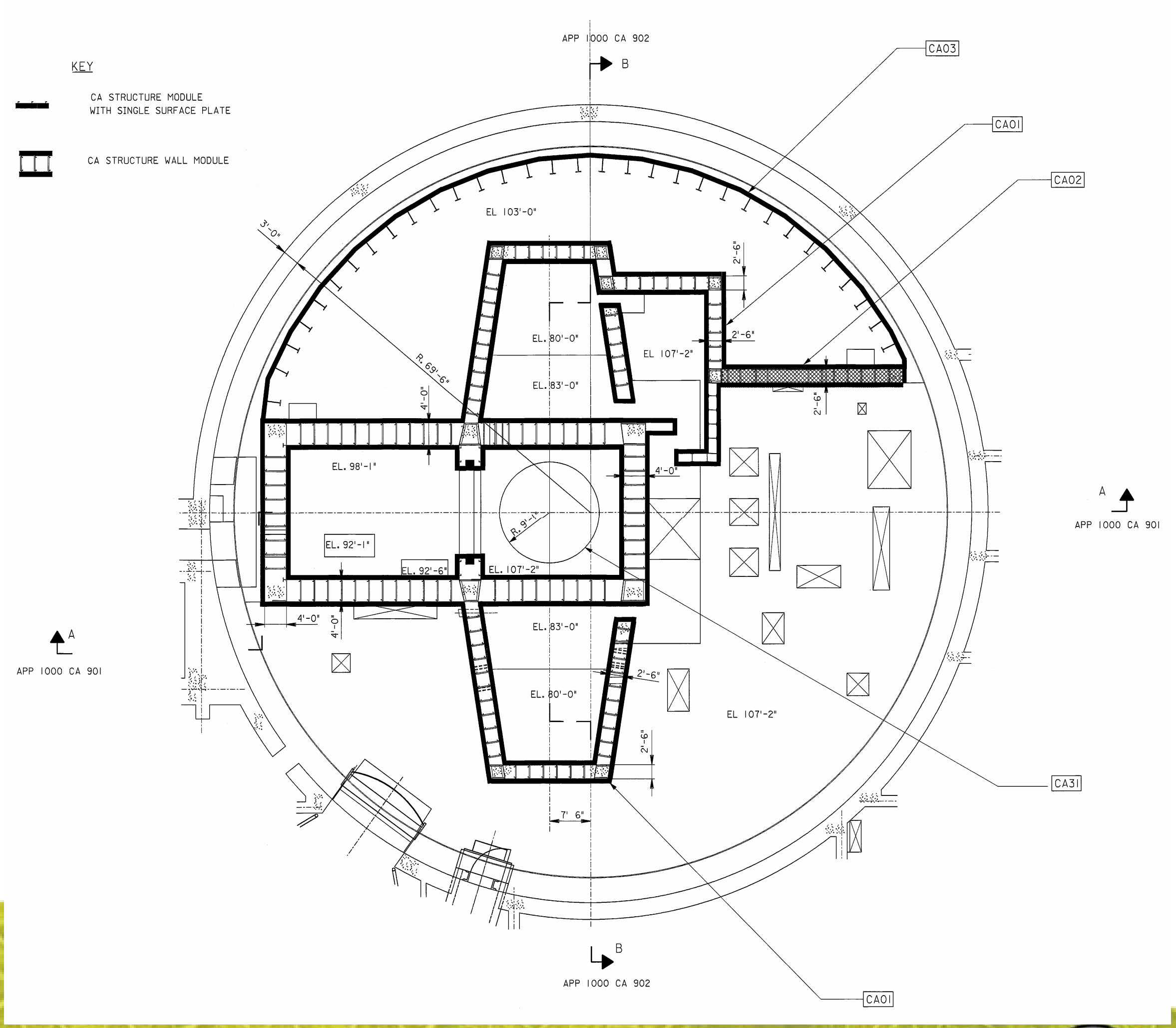


Steel Plate Structural Wall Module*

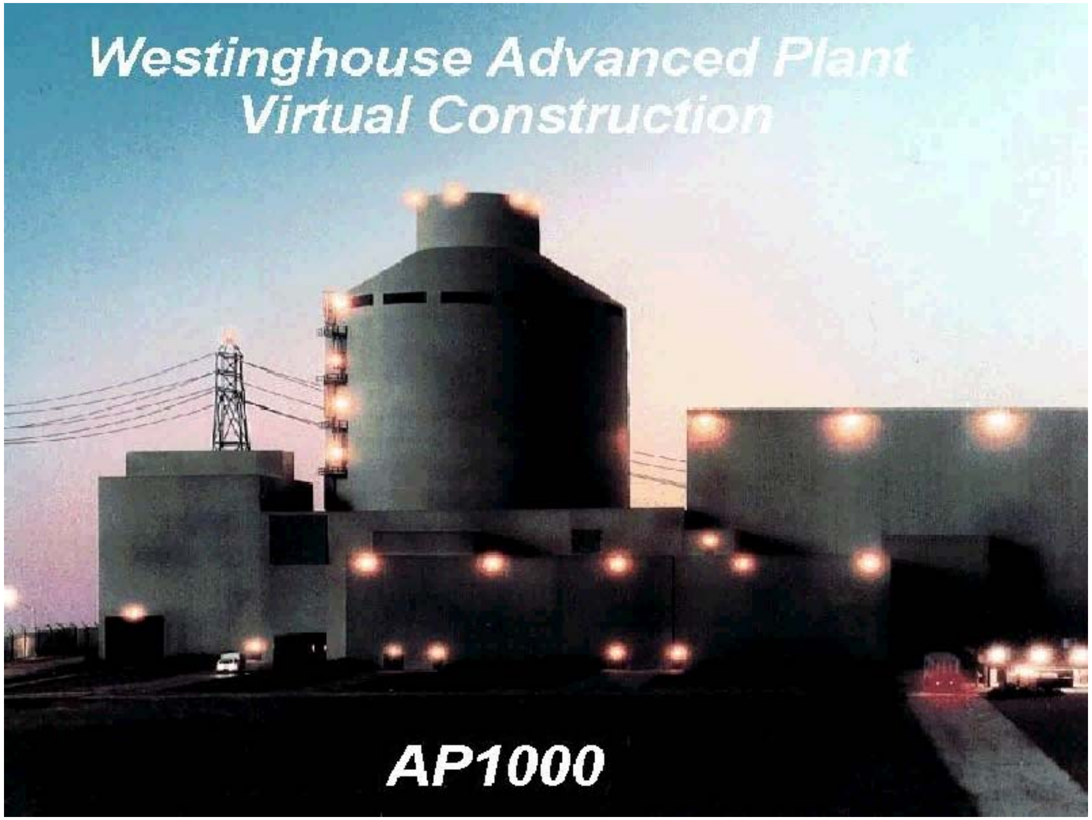


Module Program

- CA 01



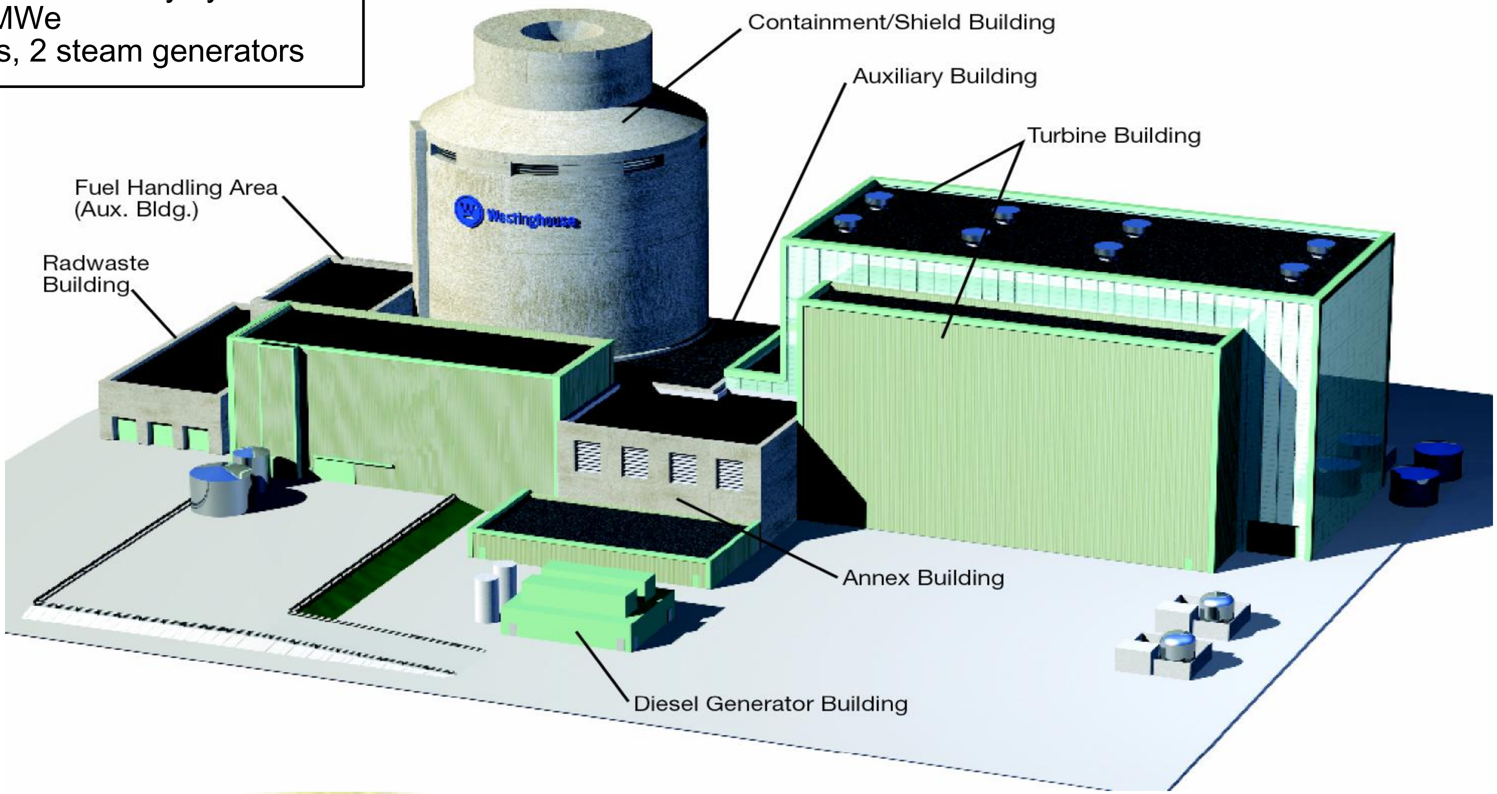
Construction Program



The Westinghouse AP1000™

A compact station

- 3415 MWt. Primary system
- 1117 MWe
- 2-loops, 2 steam generators



Meets European Utility Requirements

- EUR (European Utility Requirements) effort launched in December 1991 by five European Utilities, later joined by six others
- AP1000 compliance assessment is detailed and thorough: over 5000 requirements have been assessed
- EUR Certified

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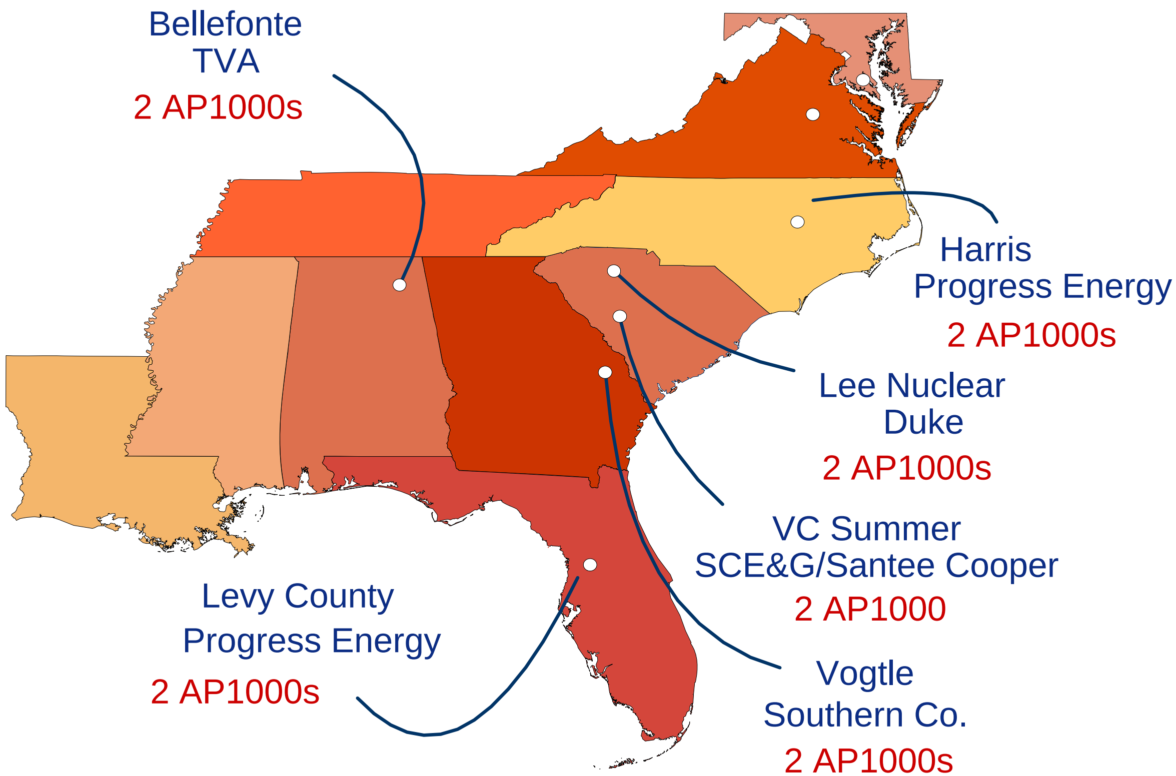
Proposed AP1000 Sites in U.S.



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AP1000 Units in China

Two units at Haiyang
Two units at Sanmen

Preliminary design, engineering and long-lead procurement work has already begun.

Power plant construction is expected to begin in 2009, with the first plant becoming operational in late 2013. The remaining plants are expected to come online in 2014 and 2015.

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Questions

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