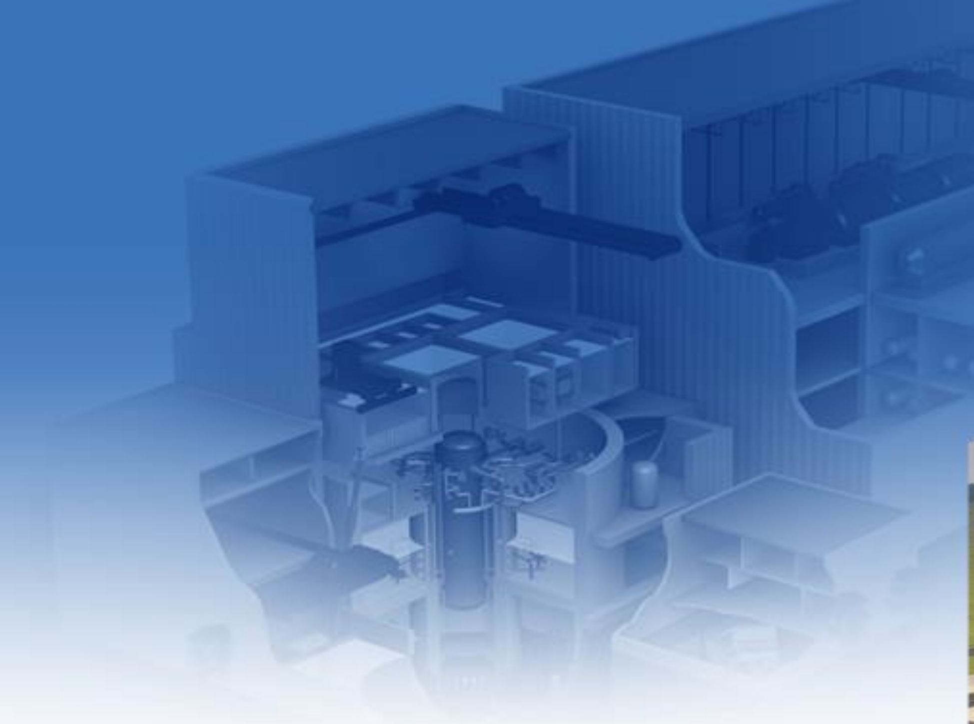

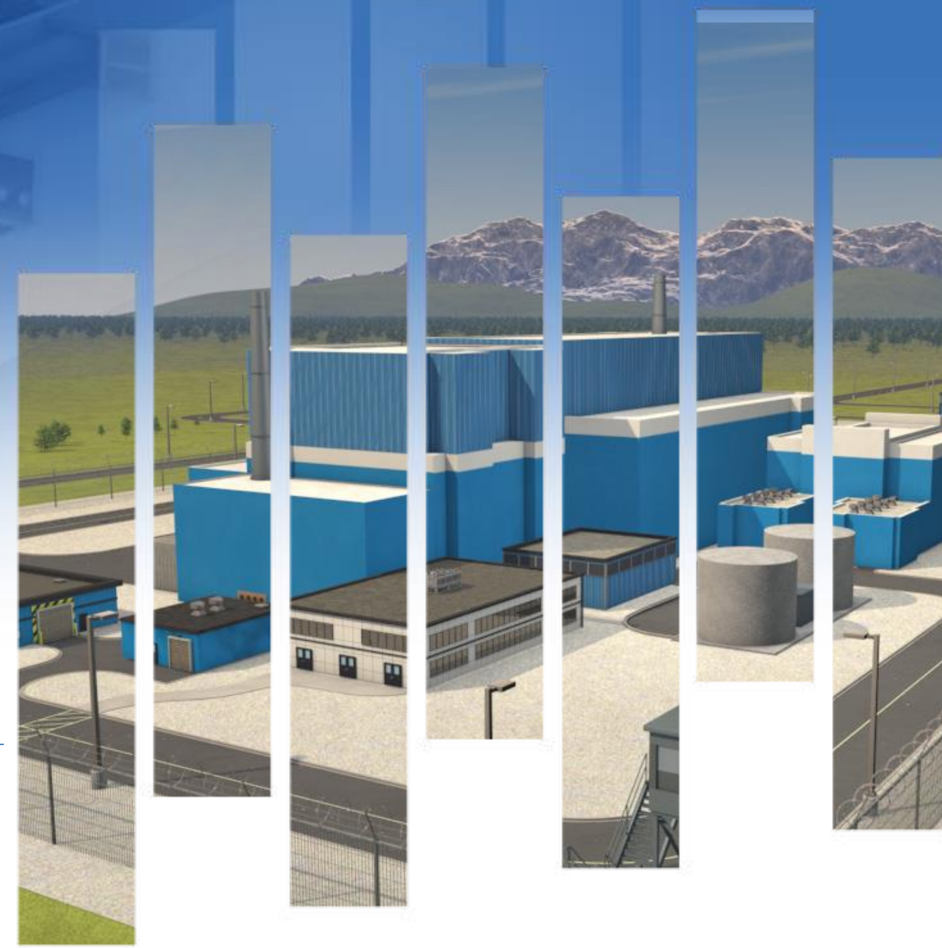

GE Hitachi's ABWR and ESBWR: safer, simpler, smarter

OECD/NEA Workshop on innovations in water-cooled reactor technologies

Issy-les-Moulineaux, Paris

11-12 February, 2015

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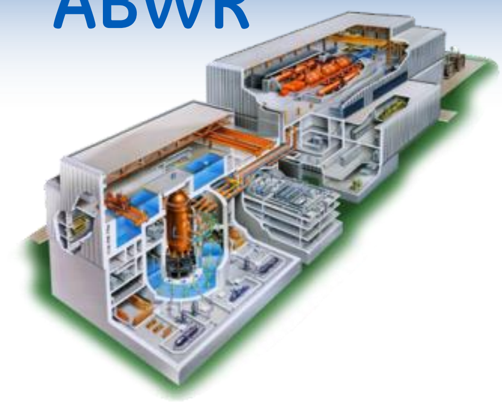
David Powell
Vice President Nuclear Power Plant Sales, Europe
GE Hitachi Nuclear Energy

GE Hitachi's new reactor portfolio

ABWR

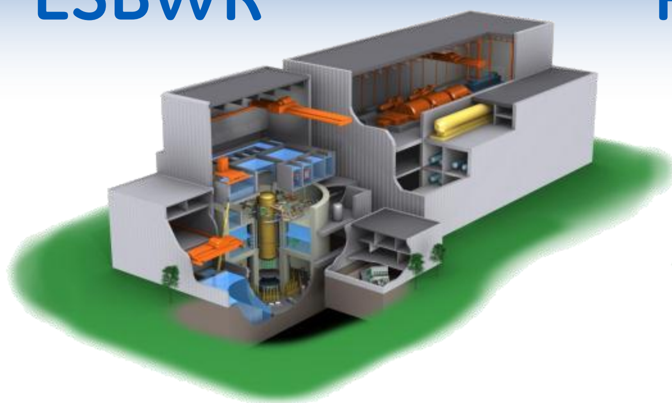


Operational Gen III active safety technology

NRC certified design

- Lowest core damage frequency of any Generation III reactor
- Extensive operational experience since 1996
- Licensed in US, Taiwan, Japan
- First concrete to first fuel … 39 to 45 months

ESBWR

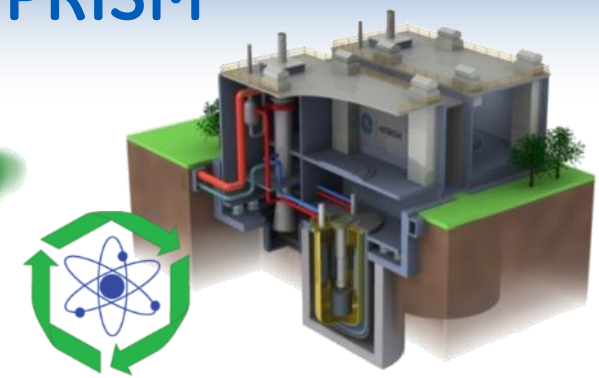


Evolutionary Gen III+ passive safety technology

NRC certified design

- Lowest core damage frequency of any reactor … safest design
- Passive cooling for >7 days w/o AC power or operator action
- Lowest projected operations, maintenance, and staffing costs[1]
- 25% fewer pumps, valves and motors than active safety plants

PRISM



Revolutionary Gen IV sodium cooled technology

Ultimate used fuel solution

- Passive air-cooling w/no operator or mechanical actions needed
- Ultimate answer to the used fuel dilemma - reduce nuclear waste to ~300-year radiotoxicity[2] while generating new electricity
- Also solution for Pu disposition

1 Claims based on the U.S. DOE commissioned 'Study of Construction Technologies and Schedules, O&M Staffing and Cost, and Decommissioning Costs and Funding Requirements for Advanced Reactor Designs' and an ESBWR staffing study performed by a leading independent firm

2 To reach the same level of radiotoxicity as natural uranium

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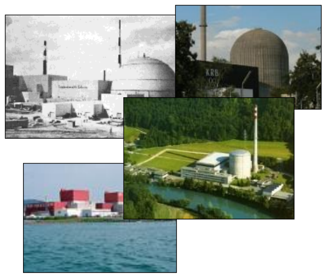
GEH new nuclear plant development

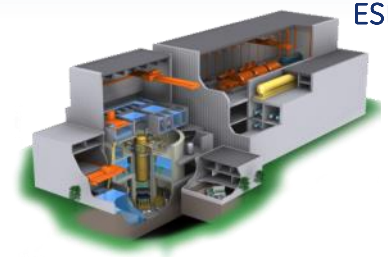
Borax BWR test facility

Worldwide BWR fleet



K6/K7 – First ABWRs

ESBWR

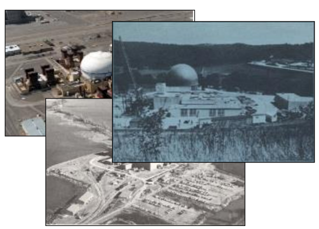


1950's 1980's 2000's

lessons learned … customer input … new features … testing … studies … detailed design

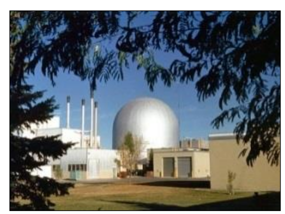
EBR

US sodium reactor experience

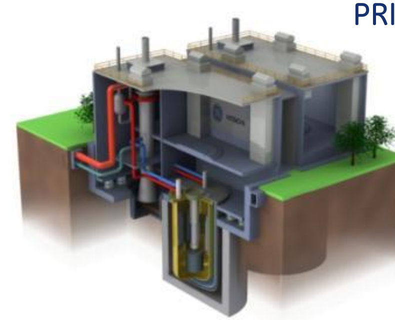


SEFOR, Fermi I, Seawolf, FFTF

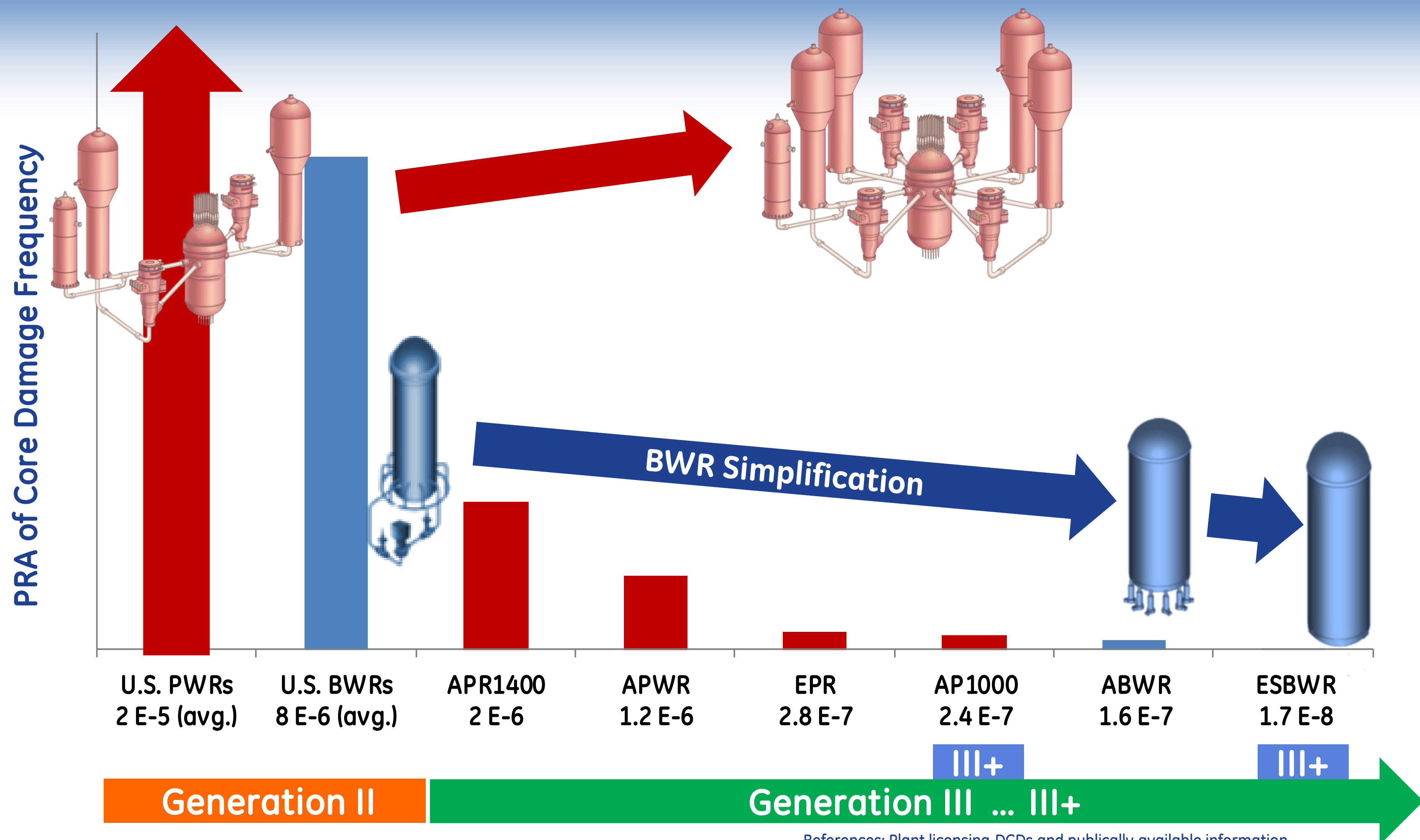
EBR-II



PRISM



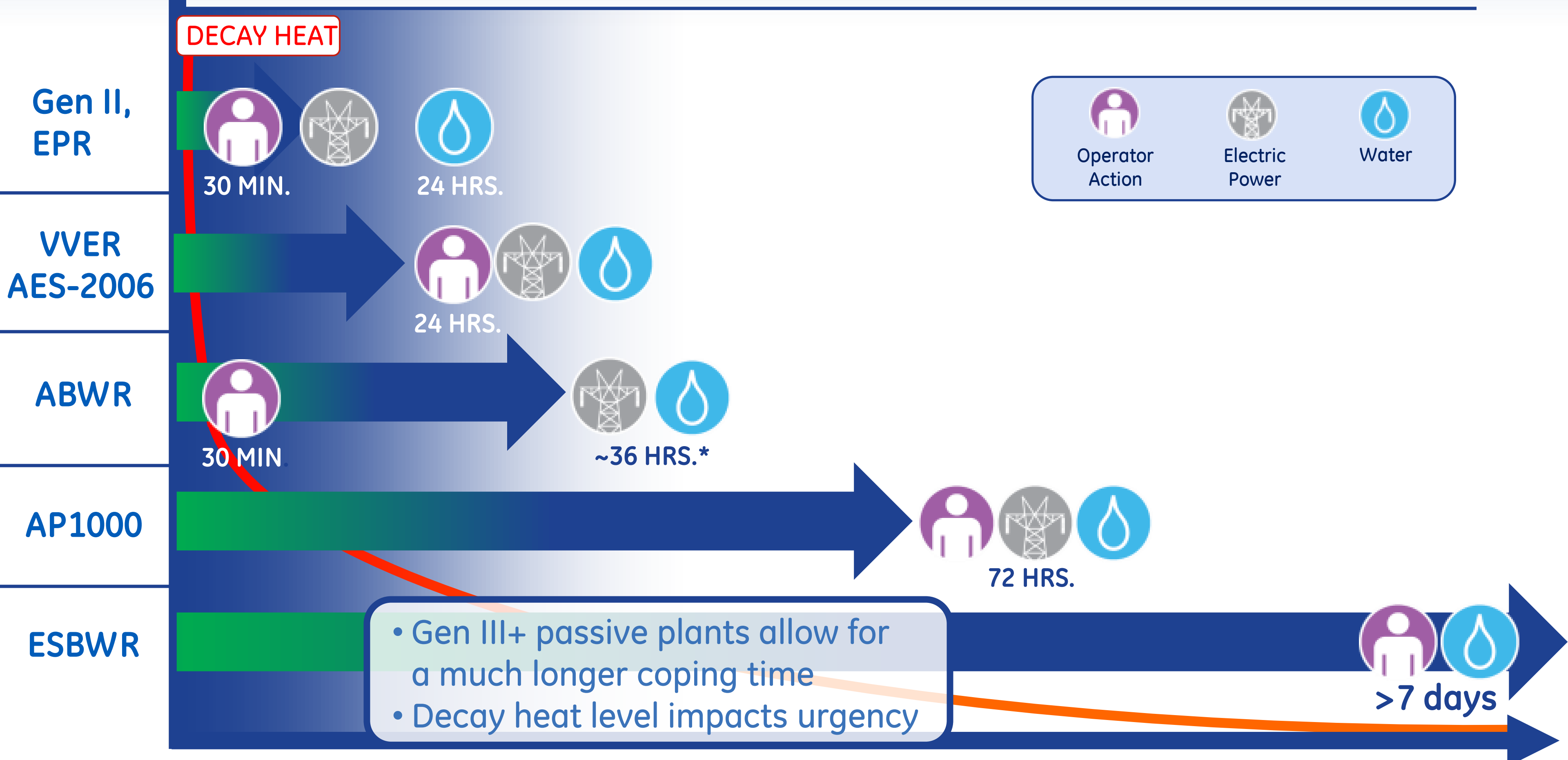
BWRs are simpler, safer, easier to operate



References: Plant licensing DCDs and publically available information
Note: PRA of CDF is represented in at-power internal events (per year)
Note: NSSS diagrams are for visualization purposes only

Best-in-class SBO response

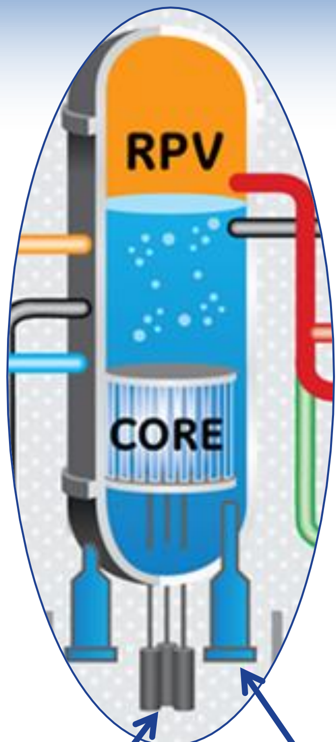
Responses needed to prevent core damage during extended loss of all AC power



*ABWR DCD credits water addition at 8 HRS.

References: AP1000: US DCD Rev. 18 Section 8.5.2.1; EPR: US DCD Rev. 1 Section 8.4; VVER AES-2006: Stuk Preliminary Safety Assessment

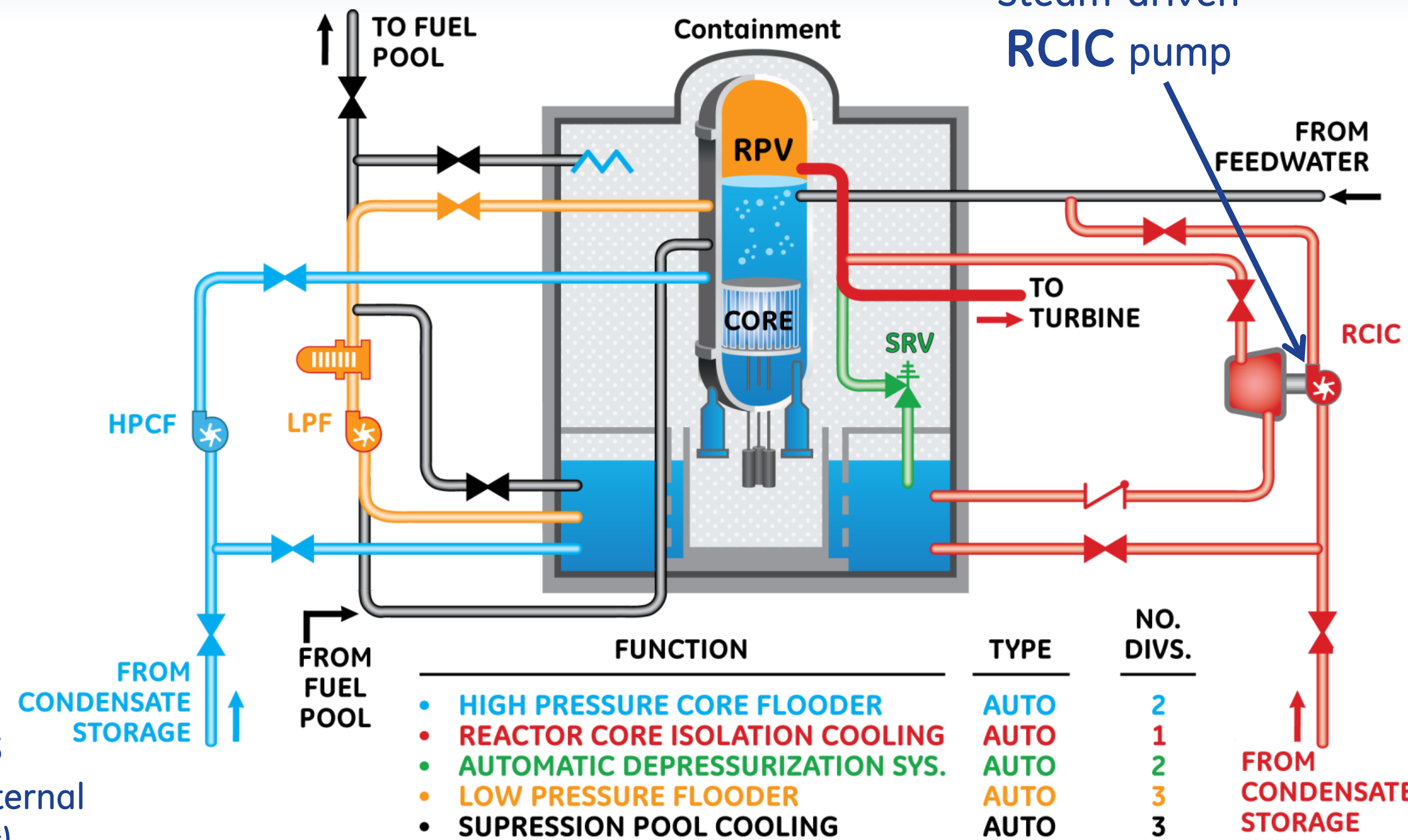
ABWR features and improvements



FMCRDs (Fine Motion Control Rod Drives)

RIPs (Reactor Internal Pumps)

ECCS - 3 Division Active Emergency Core Cooling System



FUNCTION	TYPE	NO. DIVS.
• HIGH PRESSURE CORE FLOODER	AUTO	2
• REACTOR CORE ISOLATION COOLING	AUTO	1
• AUTOMATIC DEPRESSURIZATION SYS.	AUTO	2
• LOW PRESSURE FLOODER	AUTO	3
• SUPRESSION POOL COOLING	AUTO	3
• WETWELL SPRAY	MAN	2
• DRYWELL SPRAY	MAN	2
• SHUTDOWN COOLING	MAN	3
• FUEL POOL COOLING SUPPORT	MAN	2

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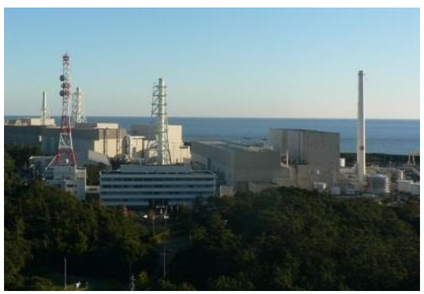
ABWR project experience

Operational

Constructed on time
... 39-45 months

Kashiwazaki-Kariwa 6
COD 1996
Kashiwazaki-Kariwa 7
COD 1997



Hamaoka-5
COD 2005

Shika-2
COD 2006

Under Construction

Ohma 1
38% complete

Shimane 3
94% complete

Lungmen 1&2
94% complete
Pre-op testing

The only Gen III Reactor with operating experience ... +25 years

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ESBWR significant attributes

Safer

- Safest reactor design available … lowest CDF
- Passive accident response with no AC power or operator action
- Hands-free 72-hour design basis accident response
- **Passively cools for 7+ days following SBO** … >2x better than AP1000

Passive safety utilizing the laws of nature: **natural circulation and gravity**

Simpler

- 25% fewer safety-related components than active plants … 11 fewer systems than ABWR
- Simpler to operate and maintain … fewer plant transients and online surveillances

Smarter

- 1520 MWe with 20% fewer staff and lowest projected O&M cost per MWe
- No steam generators to replace
- Dominion & DTE selected ESBWR … NRC certification Oct 2014

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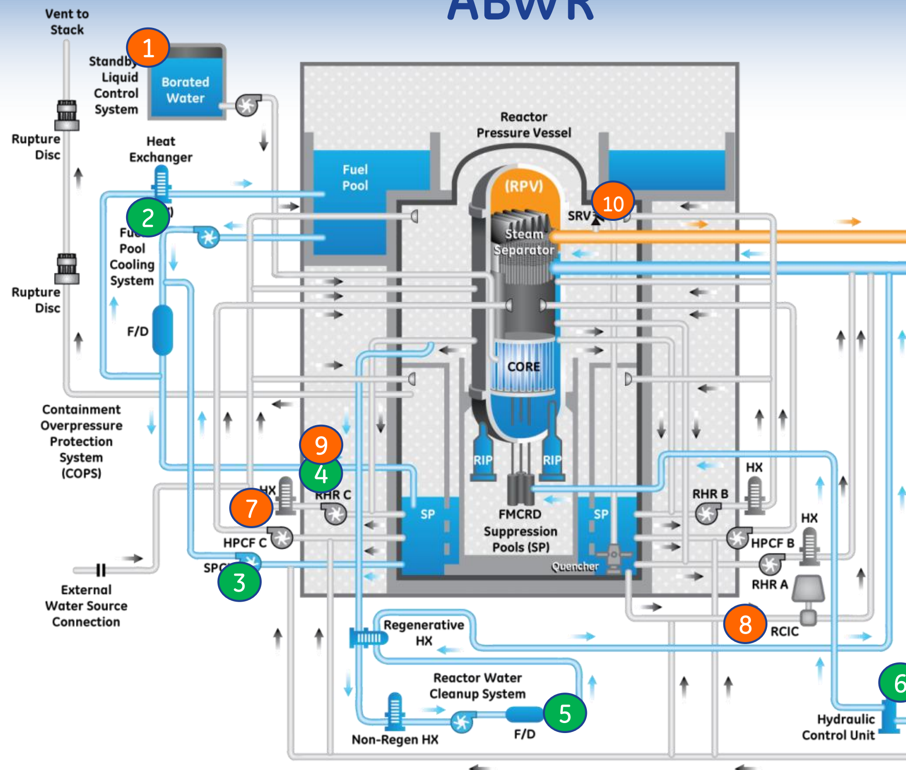
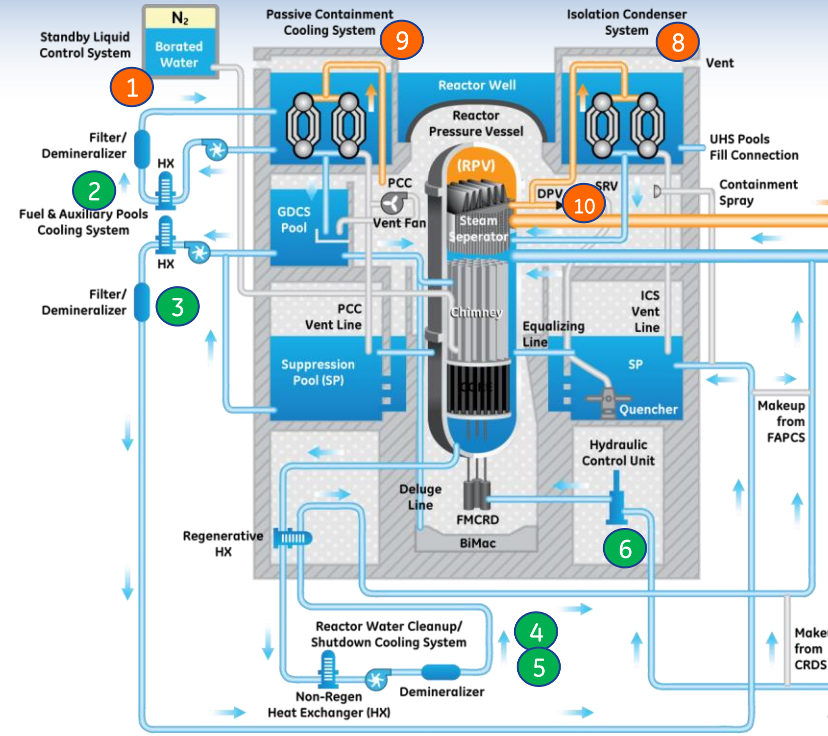
ABWR to ESBWR evolution: Nuclear Island

ABWR



ESBWR



1. Standby Liquid Control System – **simplified** design
2. Fuel and Aux Pool Cooling – **equivalent** designs
3. Suppression Pool Cooling & Cleanup System – **equivalent** capability
4. Residual Heat Removal System – **equivalent** for shutdown cooling
5. Reactor Water Cleanup System – **equivalent** designs
6. Hydraulic Control Unit – **equivalent** design
7. High Pressure Core Flooder – **replaced** by HP CRD makeup
8. Reactor Core Isolation Cooling – **replaced** by Isolation Condenser
9. Residual Heat Removal Containment Spray – **replaced** by PCCS
10. Safety Relief Valves – **Diversified** by Depressurization Valves

Systems are Equivalent or Simplified

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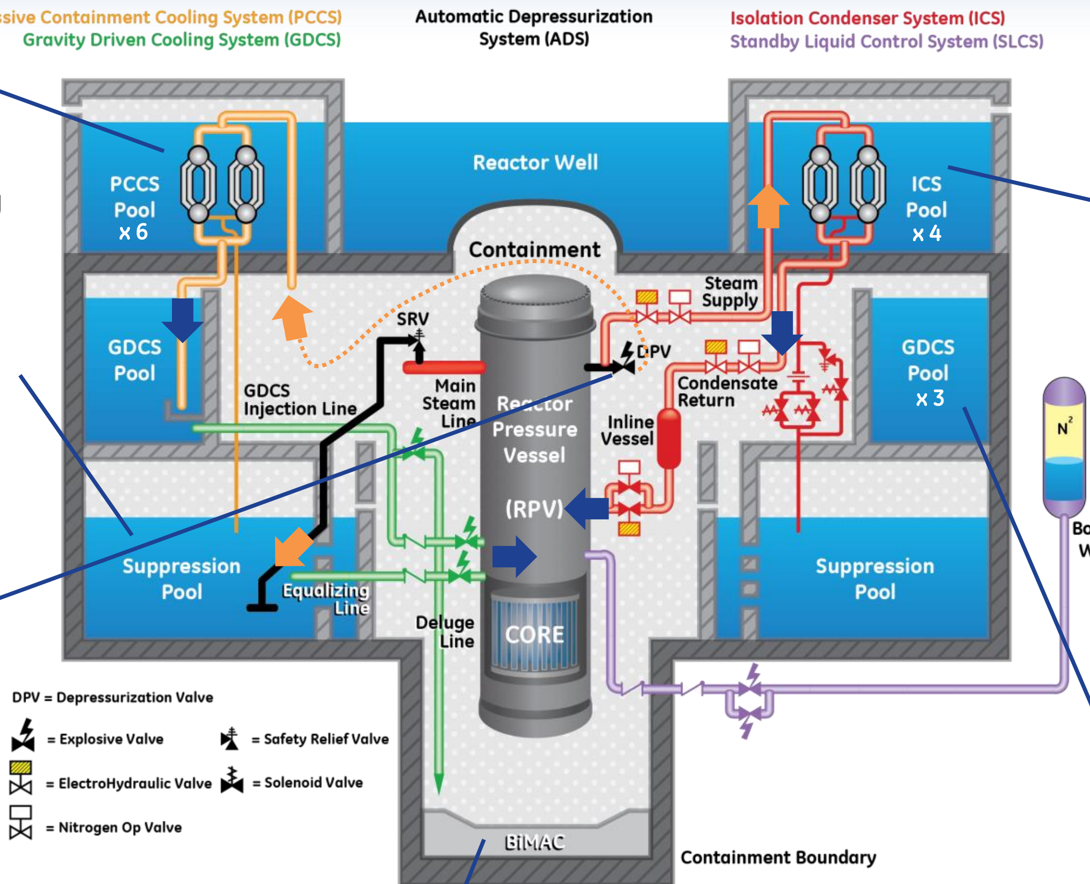
ESBWR passive safety systems

No AC power or operator action required!

Passive Containment Cooling System: Passively transfers decay heat out of containment, sending water to GDCS pools

Suppression Pool: Provides heat sink for initial LOCA depressurization

Automatic Depressurization System: Passively depressurizes the reactor and keeps it depressurized following a LOCA



BiMAC core catcher: Passively cooled core catcher

Isolation Condenser System: Closed-loop cooling system transferring reactor decay heat to atmosphere; activates automatically if DC power is lost

Standby Liquid Control System: Passively injects borated water into the reactor for backup shutdown capability

Gravity Driven Cooling System: Passively injects water into the reactor via gravity in case of LOCA

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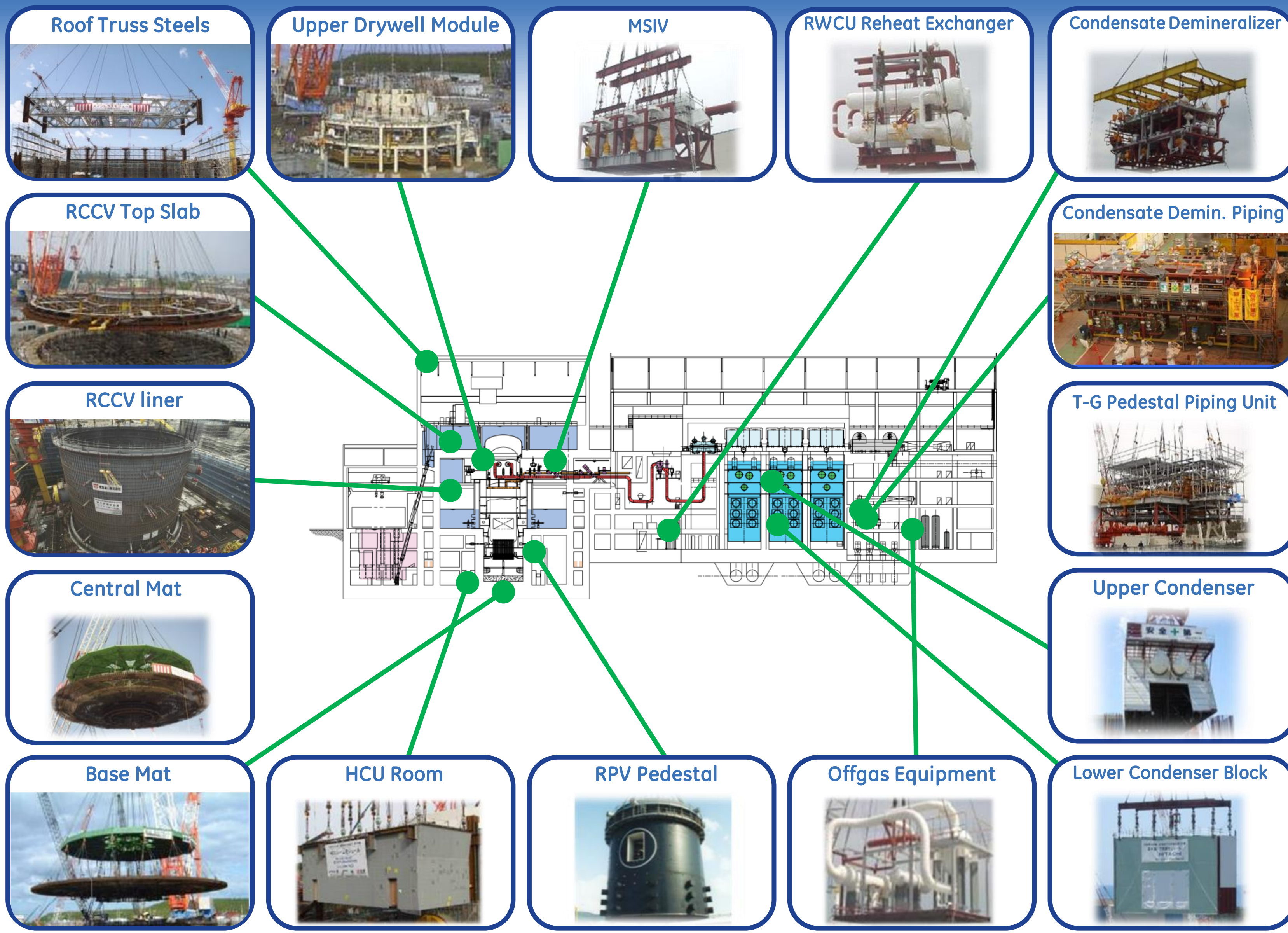
ESBWR modularization – based on ABWR



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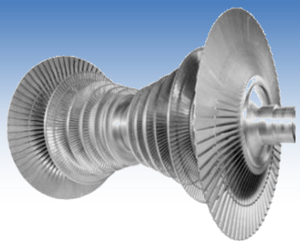
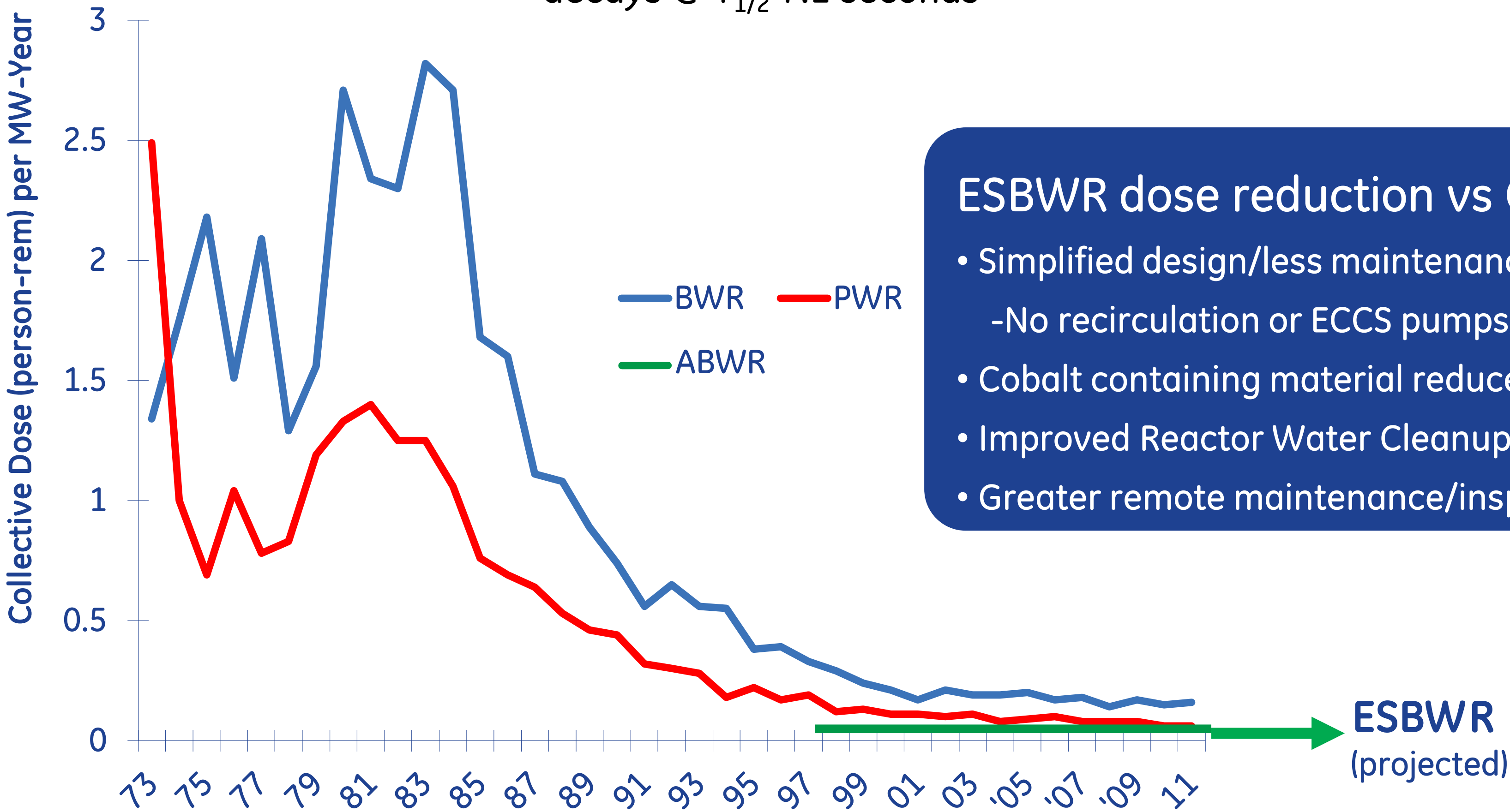
ESBWR reduces dose

- Shielding minimizes N-16 operating radiation
- N-16 is not an issue during maintenance … decays @ $T_{1/2}$ 7.1 seconds





ESBWR dose reduction vs GEN II

- Simplified design/less maintenance
  - -No recirculation or ECCS pumps/pipes
- Cobalt containing material reduced 50+%
- Improved Reactor Water Cleanup
- Greater remote maintenance/inspection

Source: U.S. NRC; Hitachi GE

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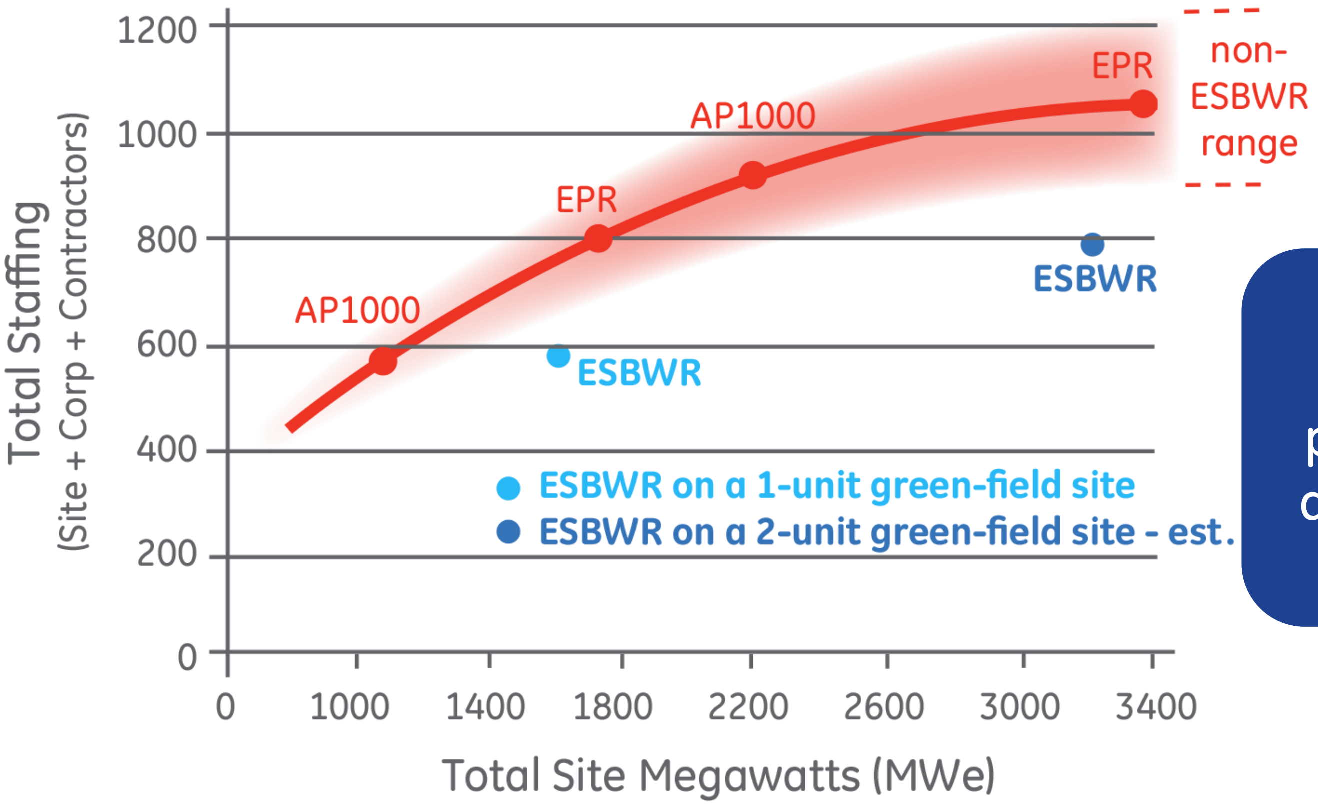
ESBWR requires reduced staffing

Comparison of Projected Gen III/III+ Nuclear Plant Staffing Requirements



ESBWR requires significantly fewer plant personnel than any other Generation III/III+ design

Source: An ESBWR staffing study performed by a leading independent firm

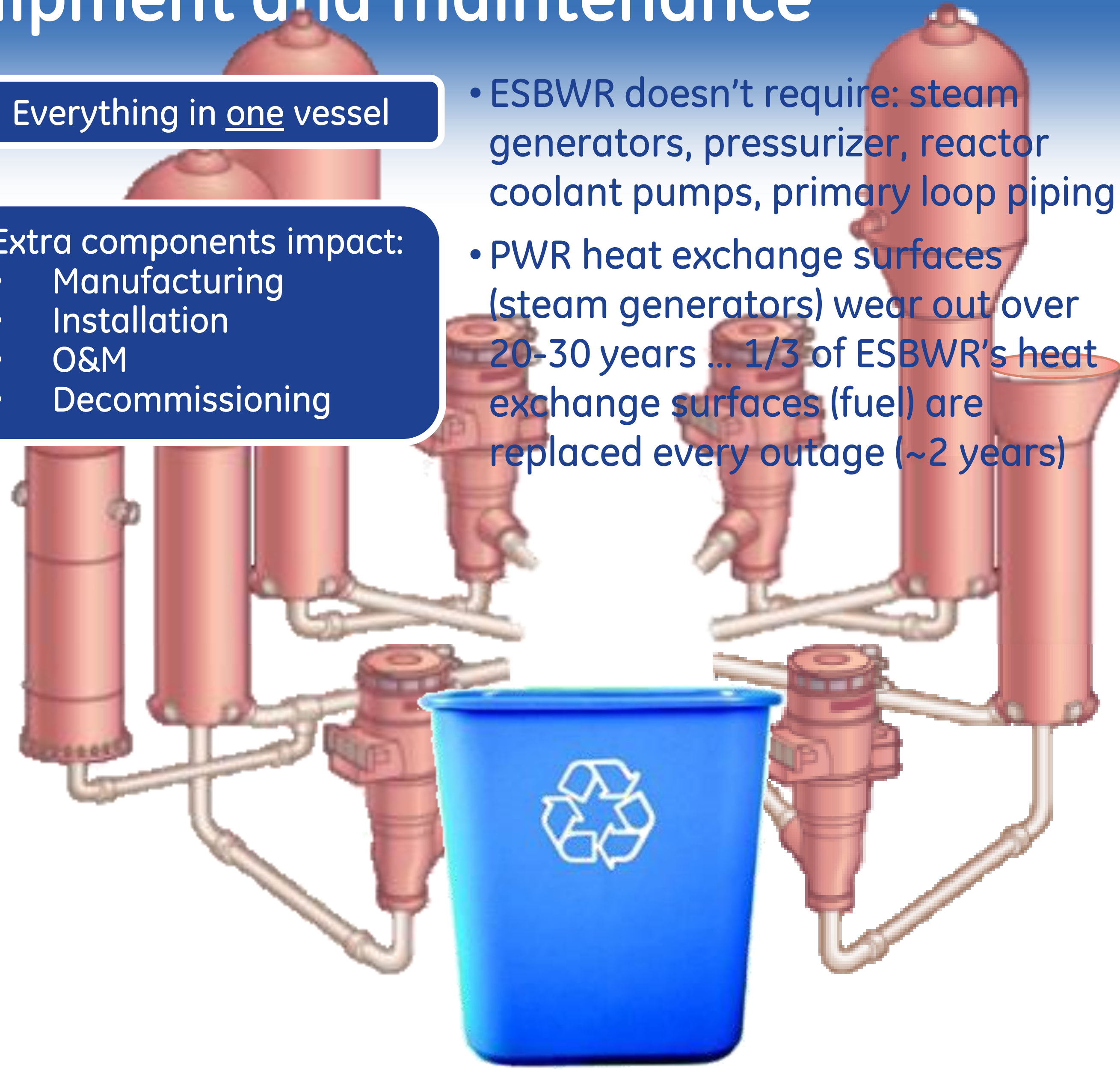
Reduced equipment and maintenance

ESBWR

Everything in one vessel

Extra components impact:
- Manufacturing
- Installation
- O&M
- Decommissioning

- ESBWR doesn't require: steam generators, pressurizer, reactor coolant pumps, primary loop piping
- PWR heat exchange surfaces (steam generators) wear out over 20-30 years … 1/3 of ESBWR's heat exchange surfaces (fuel) are replaced every outage (~2 years)



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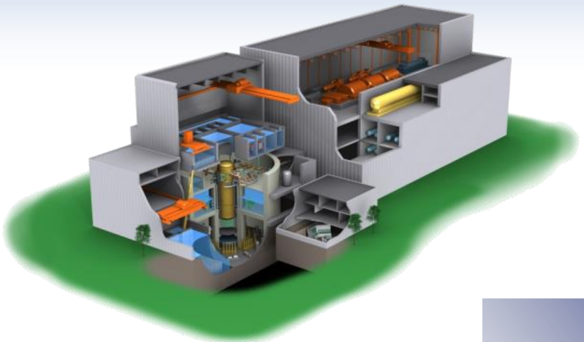
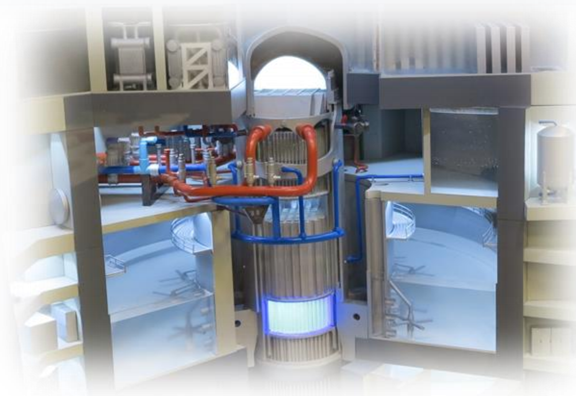
ESBWR offers substantial O&M improvements



Passive safety & simplified design

Easier to maintain



- 25% fewer safety-related components
- 11 systems eliminated – others combined or simplified
- Lowest O&M costs of any Generation III+ technology*
- 50+% more fuel bundles exchanged in same outage time

Simpler to operate

- Hands-free 72-hour design basis accident response; 7+ day SBO
- Lowest staffing requirements … 20% lower staffing per MWe*
- Fully digital I&C
- Fewer plant transients
- Fewer online technical specification surveillances

* Claims based on the U.S. DOE commissioned 'Study of Construction Technologies and Schedules, O&M Staffing and Cost, and Decommissioning Costs and Funding Requirements for Advanced Reactor Designs' and an ESBWR staffing study performed by a leading independent firm

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In conclusion …

- GE Hitachi has been bringing innovation to nuclear for 60 years
- Portfolio includes the two safest light water reactor designs in the world
  - 4 ABWRs built on time and budget … only GEN III reactors with operating experience
  - ESBWR recently certified by US NRC … provides >7 day passive cooling
- Focused on simpler, safer and smarter reactor designs to meet the global demands for nuclear power.

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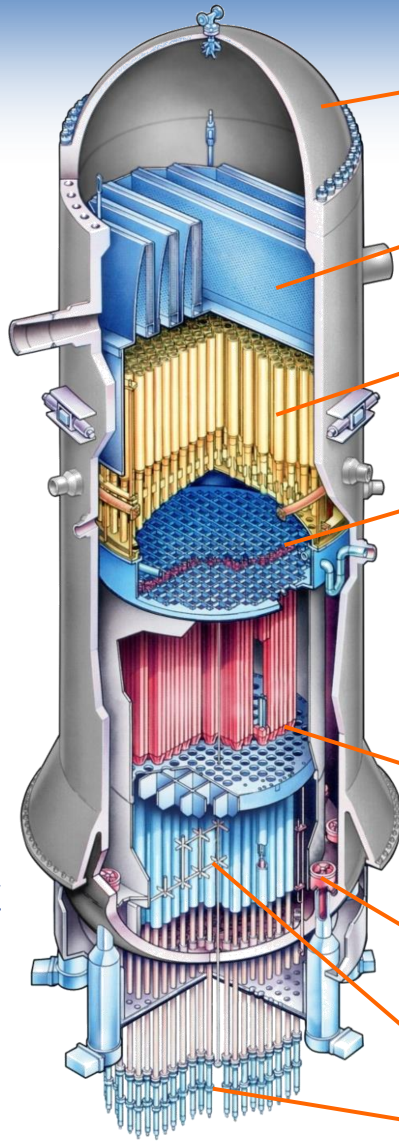
Back-up information

The Advanced Boiling Water Reactor



BWR Fuel Assembly
- 90 fuel rods encased in a 'channel'
- 2 water rods
- Part-length rods
- Burnable absorbers

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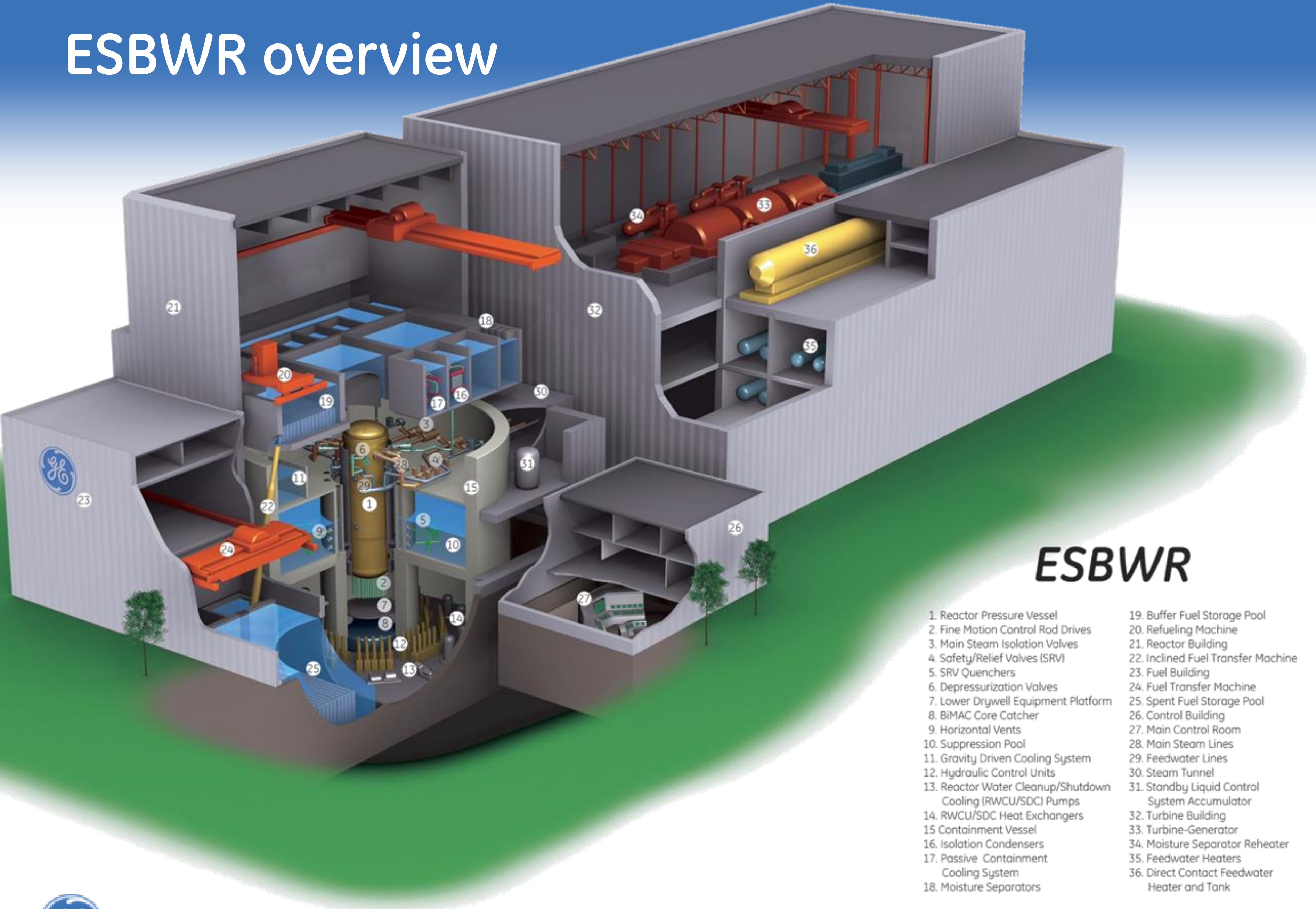
ESBWR overview



ESBWR

1. Reactor Pressure Vessel
2. Fine Motion Control Rod Drives
3. Main Steam Isolation Valves
4. Safety/Relief Valves (SRV)
5. SRV Quenchers
6. Depressurization Valves
7. Lower Drywell Equipment Platform
8. BiMAC Core Catcher
9. Horizontal Vents
10. Suppression Pool
11. Gravity Driven Cooling System
12. Hydraulic Control Units
13. Reactor Water Cleanup/Shutdown Cooling (RWCU/SDC) Pumps
14. RWCU/SDC Heat Exchangers
15. Containment Vessel
16. Isolation Condensers
17. Passive Containment Cooling System
18. Moisture Separators
19. Buffer Fuel Storage Pool
20. Refueling Machine
21. Reactor Building
22. Inclined Fuel Transfer Machine
23. Fuel Building
24. Fuel Transfer Machine
25. Spent Fuel Storage Pool
26. Control Building
27. Main Control Room
28. Main Steam Lines
29. Feedwater Lines
30. Steam Tunnel
31. Standby Liquid Control System Accumulator
32. Turbine Building
33. Turbine-Generator
34. Moisture Separator Reheater
35. Feedwater Heaters
36. Direct Contact Feedwater Heater and Tank

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ESBWR overview

ESBWR Parameters

- Core Thermal Power Output....... 4500 MWt
- Plant Net Electrical Output[(1)]....... 1530 MWe
- Reactor Operating Pressure........ 7.17 MPa (1040 psia)
- Feedwater Temperature[(2)] .... 216°C (420°F)
- RPV
  - Diameter.................................... 7.1 meters (23.3 feet)
  - Height... 27.6 meters (90.5 feet)
- Reactor Recirculation.................... Natural Circulation
- Fuel.. 1132 fuel bundles
  Shortened length of 3m
- Average power density................. 54.3 kW/liter
- Control blades................................ 269 Fine Motion Control Rod Drives (FMCRDs)

(1) Typical (site dependent)

(2) Nominal Rated Operation

Fuel bundle … evolutionary product development

GE14

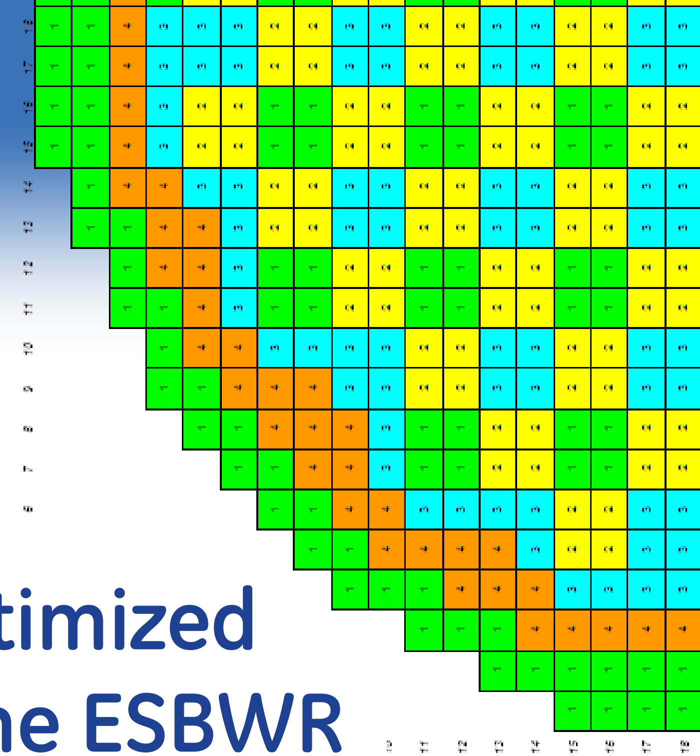
~30,000 produced
Introduced in 1998

GNF2 Advantage™

~8,300 produced
to date

GNF2e

Shorter, otherwise
same as rest of fleet



… optimized for the ESBWR

Same as GNF2 Advantage™ … only shorter

- 10x10 same pitch & diameters (rods/pellets)
- 14 partial length rods
- 2 single piece water rods, same diameters
- 8 Inconel spacers
- DefenderTM Lower Tie Plate
- No finger springs

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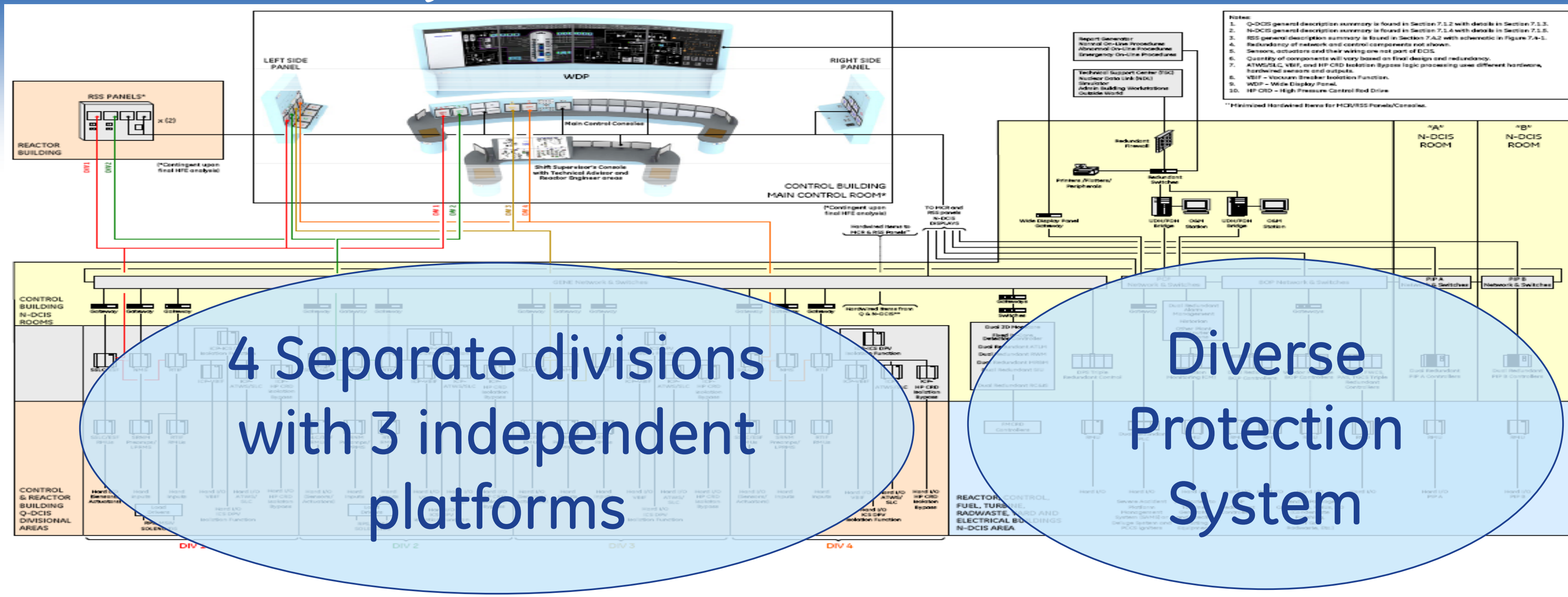
ESBWR safety I&C



Each modular division features unique operation, vendor, and wiring & power:

1. RTIF Reactor Trip
2. Safety Systems
3. Independent Control Platform

Digital backup to the safety system with redundant and reverse SCRAMs

Based on IEEE Std 603

Criteria for Safety Systems for Nuclear Power Generating Stations

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