Building New Nuclear Plants to Cost and Schedule – An International Perspective

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BNFL

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New Nuclear Plants Are Being Built Today

- Over the past decade or so there has been a running inventory of approximately 25 new nuclear plants under construction
- The vast majority have been in Asia, most notably in China, India, Japan, and Korea
- Other projects have emerged in Finland, Iran, Romania, and Russia
- China and the United States are about to embark on significant new build programs

What does recent experience tell us?

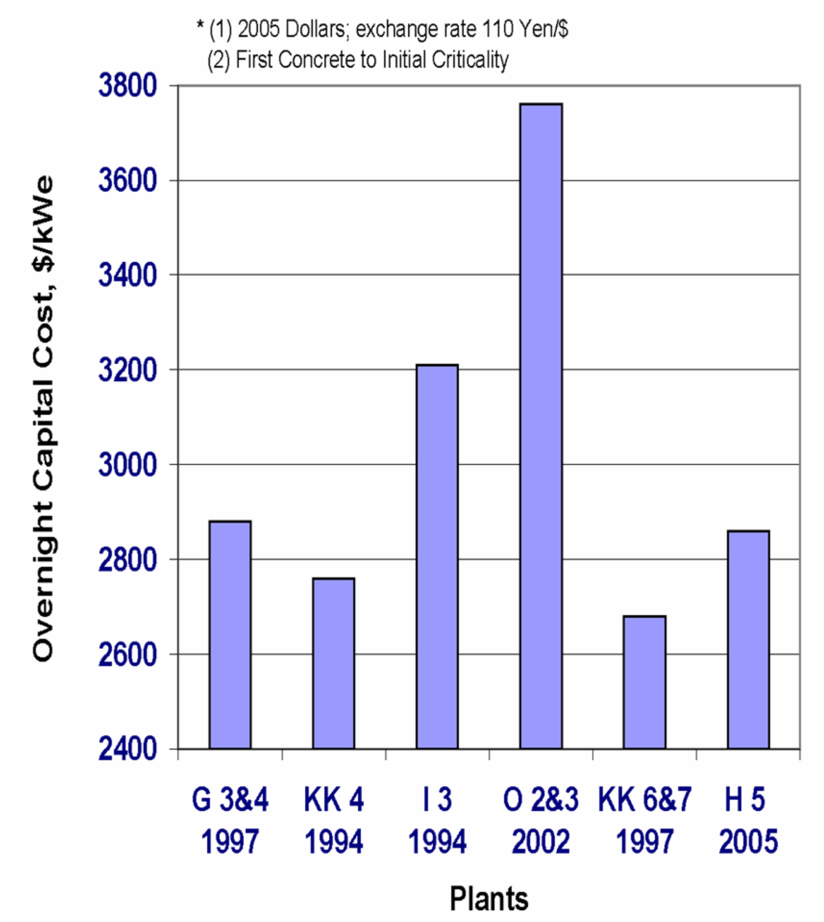
New Nuclear Construction - World

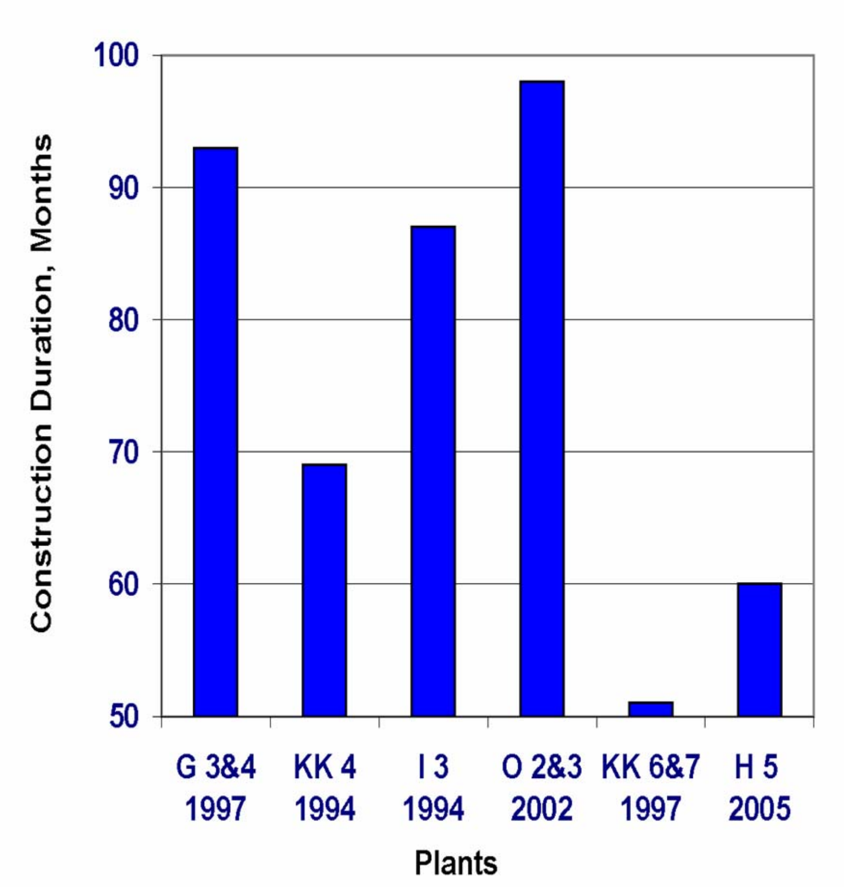
(Reference: Nuclear News, World List of Nuclear Power Plants, Dec. 31, 2004)

No.	Country	Plant Name	Location	Plant Type	NSSS Vendor	Construction Stage (%)
1	China	Tianwan-2	Jiangsu	PWR	ASE	70%
2	Taiwan	Lungmen-1	Taipei	ABWR	GE	57%
3	Taiwan	Lungmen-2	Taipei	ABWR	GE	57%
4	Finland	Olkiluoto-3	Turku-Pori	PWR	AREVA	10%
5	India	Kaiga-3	Karnetaka	PHWR	BHEL	45%
6	India	Kaiga-4	Karnetaka	PHWR	BHEL	28%
7	India	Kudankulam-1	Tamil Nadu	PWR	ASE	40%
8	India	Kudankulam-2	Tamil Nadu	PWR	ASE	40%
9	India	Rajasthan-5	Rajasthan	PHWR	BHEL	34%
10	India	Rajasthan-6	Rajasthan	PHWR	BHEL	19%
11	India	Tarapur-3	Maharashtra	PHWR	BHEL	73%
12	India	Tarapur-4	Maharashtra	PHWR	BHEL	88%
13	India	Kalpakkam	Kalpakkam	FBR	BHAVINI	0%
14	Japan	Tomari-3	Hokkaido	PWR	MHI	28%
15	Japan	Shika-2	Ishikawa	PWR	Hitachi	95%
16	Japan	Higashidori-1	Aomori	BWR	Toshiba	95%
17	Iran	Bushehr-1	Bushehr	PWR	ASE	75%
18	Romania	Cernavoda-2	Constanta	PHWR	AECL/Vickers	71%
19	Russia	Belakova-5	Saratov	PWR	MTM	High
20	Russia	Kursk-5	Kursk	LGR	MTM	High
21	Russia	Rostov-2	Rostov	PWR	MTM	High
22	S.Korea	Shin Kori-1	Busan	PWR	Doosan	Low
23	S.Korea	Shin Kori-2	Busan	PWR	Doosan	Low
24	S.Korea	Shin Wolsong-1	Ulsan	PWR	Doosan	Low
25	S.Korea	Shin Wolsong-2	Ulsan	PWR	Doosan	Low
26	N.Korea	KEDO-1	Kumho	PWR	Doosan	33%*
27	N.Korea	KEDO-2	Kumho	PWR	Doosan	35%*

*currently suspended

New Plant Construction Experience in Japan*



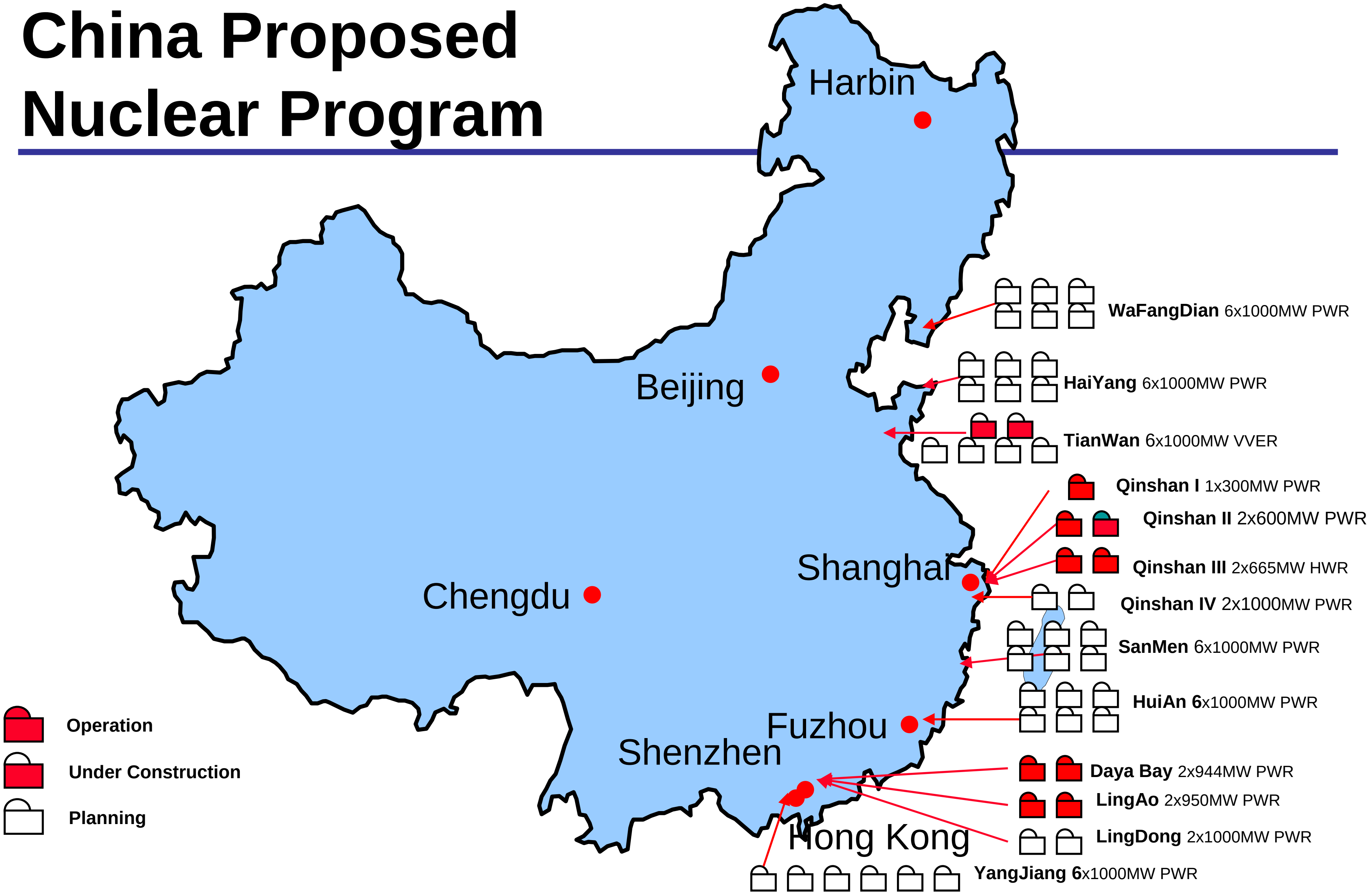


Japanese New Plant Experience

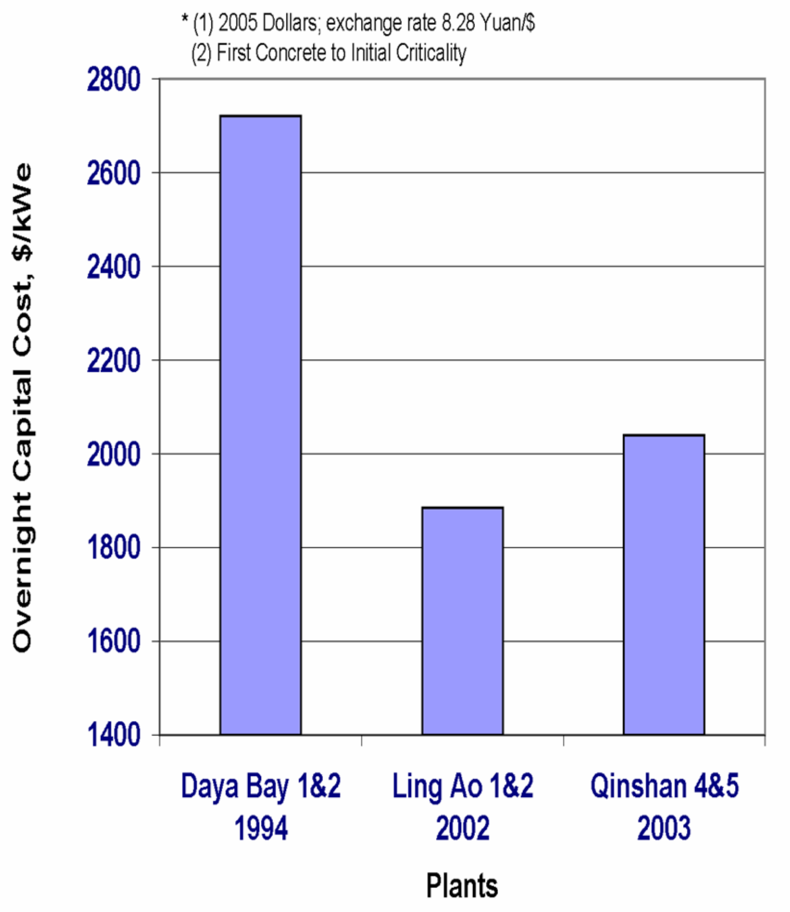
- Universally high construction costs (>$2600/kWe)
- Long construction schedules (except the last two projects)
- Lack of standardization results in significant first-of-a-kind costs on each project
- Industry problems and political issues can dramatically impact new nuclear plant construction projects

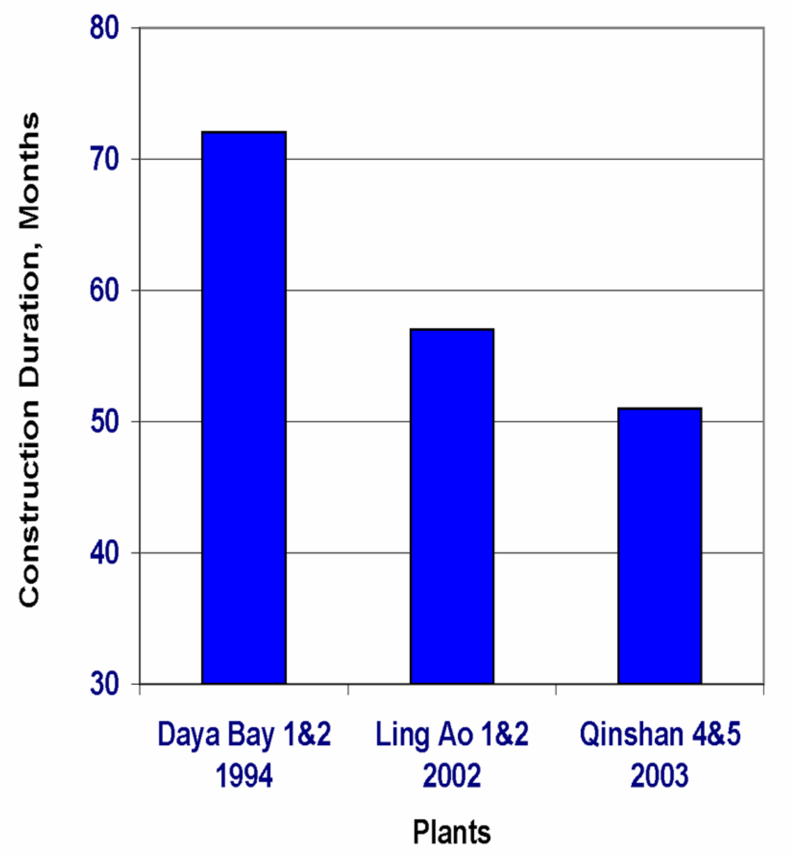
Not a good example to follow!

China Proposed Nuclear Program



New Plant Construction Experience in China*



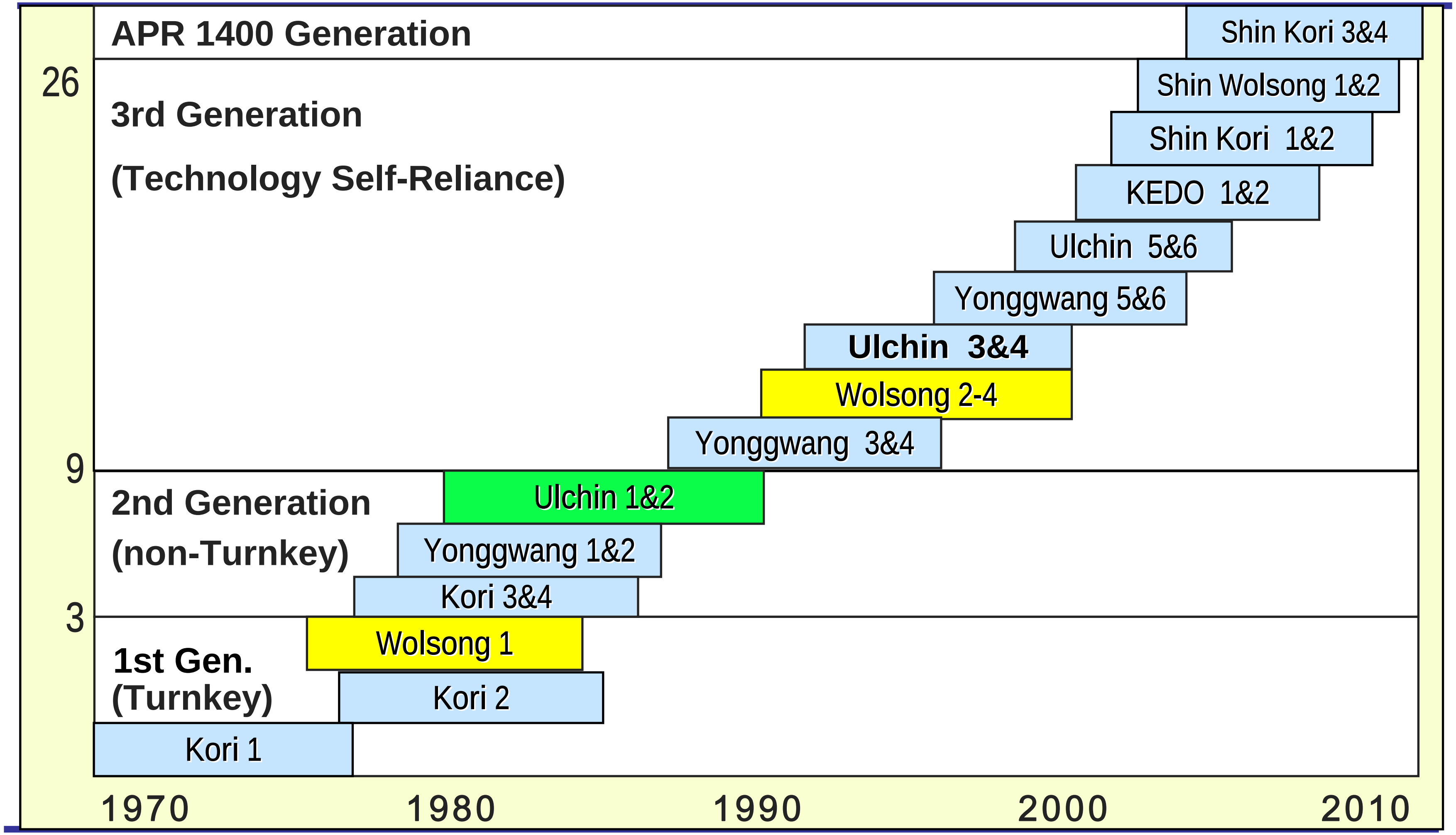


Chinese New Plant Experience

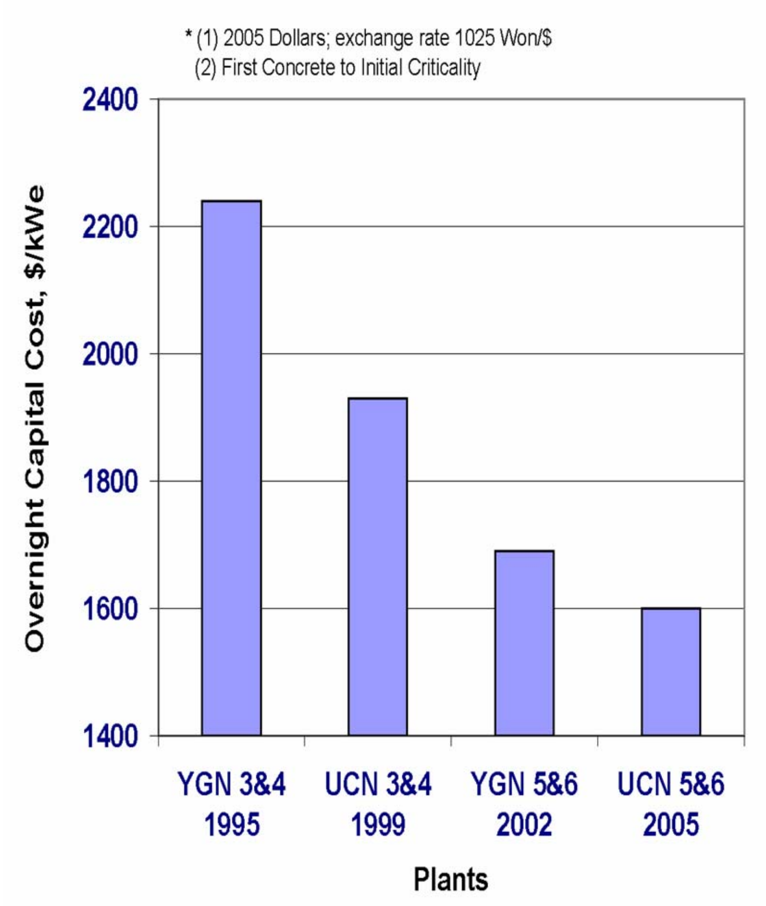
- Construction costs have generally come under control ($1800-2000/kWe), but low local labor costs should have achieved much better results
- Lack of standardization results in significant first-of-a-kind costs on some new projects
- Use of “old” designs has helped keep schedules acceptable while increasing localization

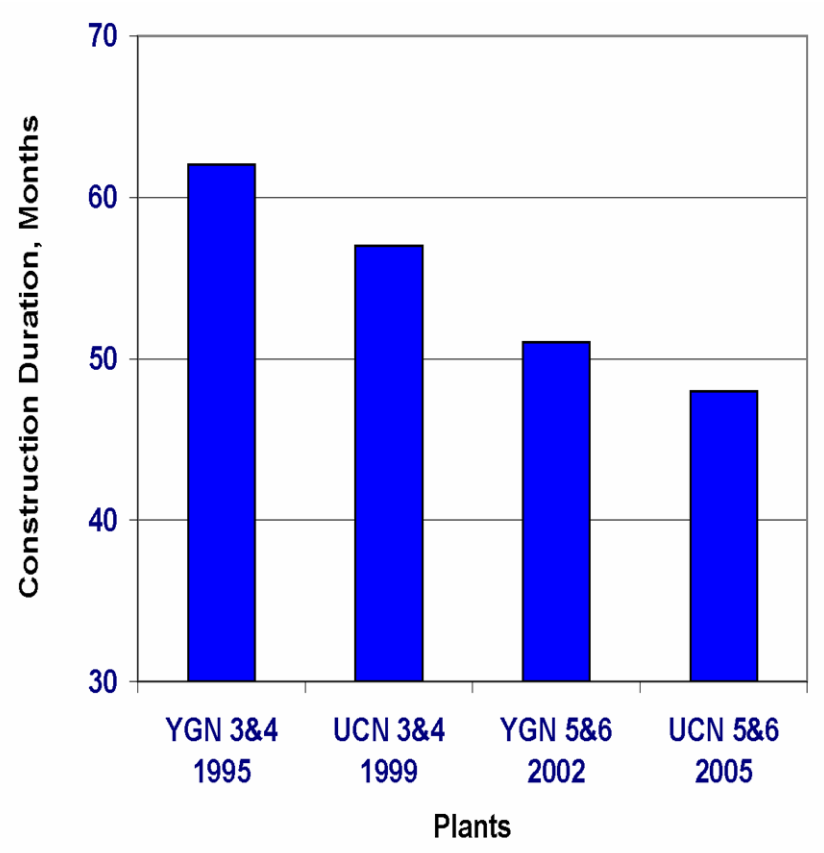
Intent of standardizing on advanced PWR with localization should show significant improvement on future projects!

Evolution of Korea Nuclear Program



New Plant Construction Experience Korea*



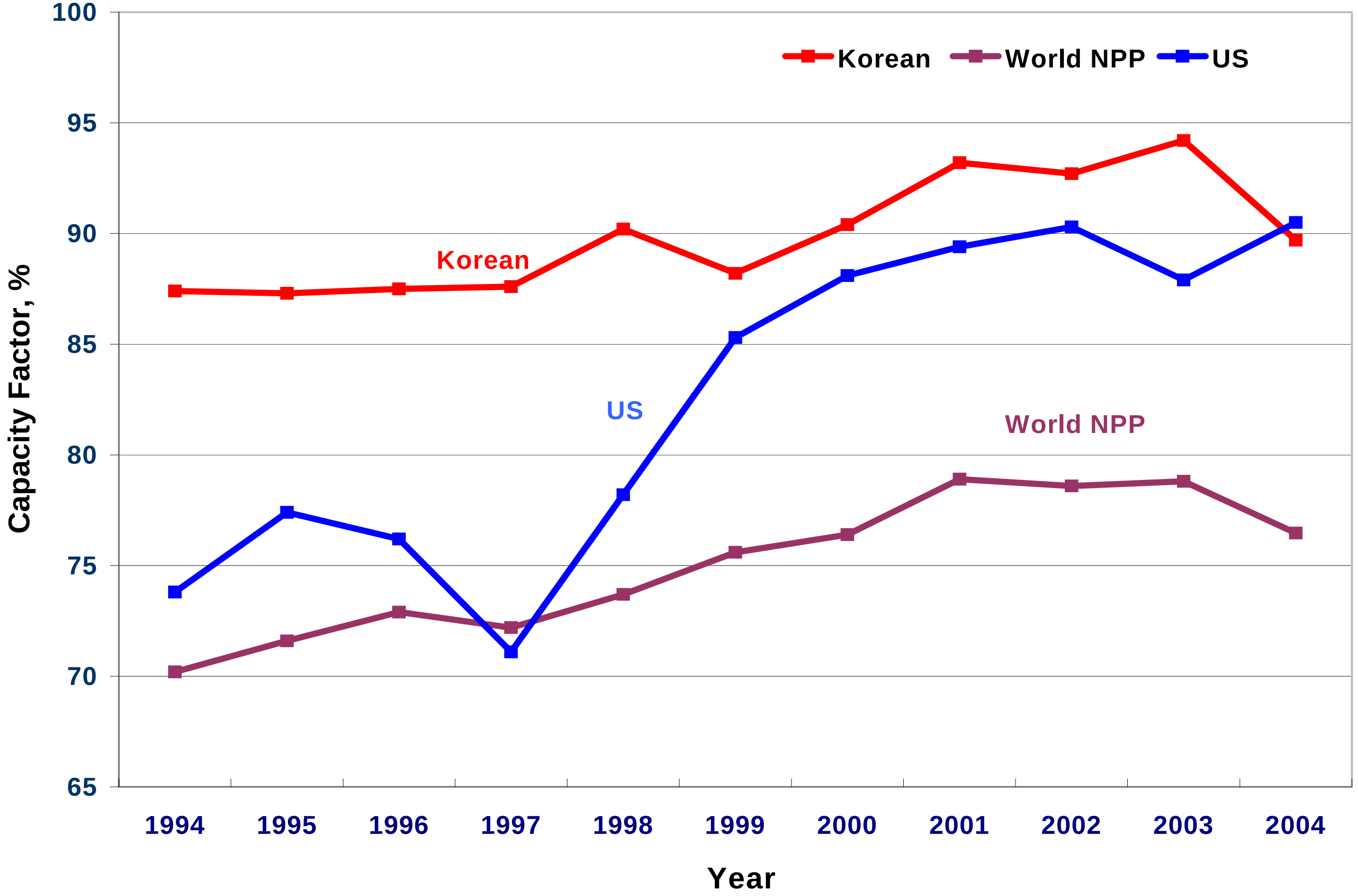


Korean New Plant Experience

- **Standardization has resulted in excellent cost and schedule performance**
- **Future projects projected to result in <$1500/kWe overnight capital cost and <4 year construction schedule**
- **Localization (>85% domestically) controls capital outflow and makes project less susceptible to currency fluctuations**

Excellent example for future new plant build programs!

Operating Reactor Performance



What Recent Construction Experience Tells Us

- Current Generation II plants can be built for $1500 - $2000/kWe
- Construction schedules between 4 to 5 years (first concrete to criticality) can be achieved with traditional techniques
- Series build of a standard design can obtain cost reductions of ~30%
- Political and regulatory uncertainty can have dramatic impacts on both cost and schedule

Ulchin site

A Historical Perspective

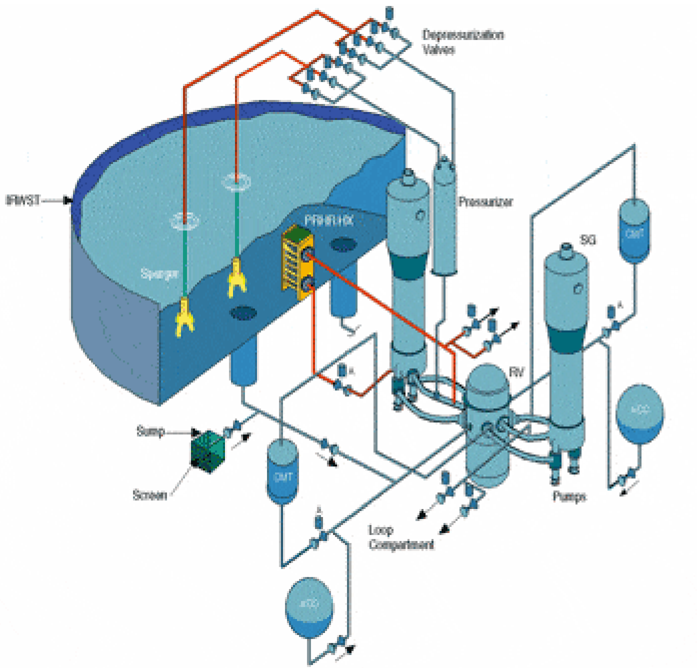
- Nuclear power reactors have been complicated systems with numerous active components
- The quest for improved performance and enhanced safety has been pursued through increased redundancy and diversity of systems and equipment
- Construction has been accomplished with traditional “stick build” techniques with large on-site work forces
- Operators were required to take action in a relatively short time in response to plant upset conditions
- Transients were complicated by operators misinterpreting what was happening

A Better Solution for New Plants - Simplification

- Simplicity 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 the reduction of the number and safety classification of components
- Simplicity in Operations through increased operator response times and man-machine interface advancements
- Simplicity in Maintenance through the reduction in number and safety classification of components

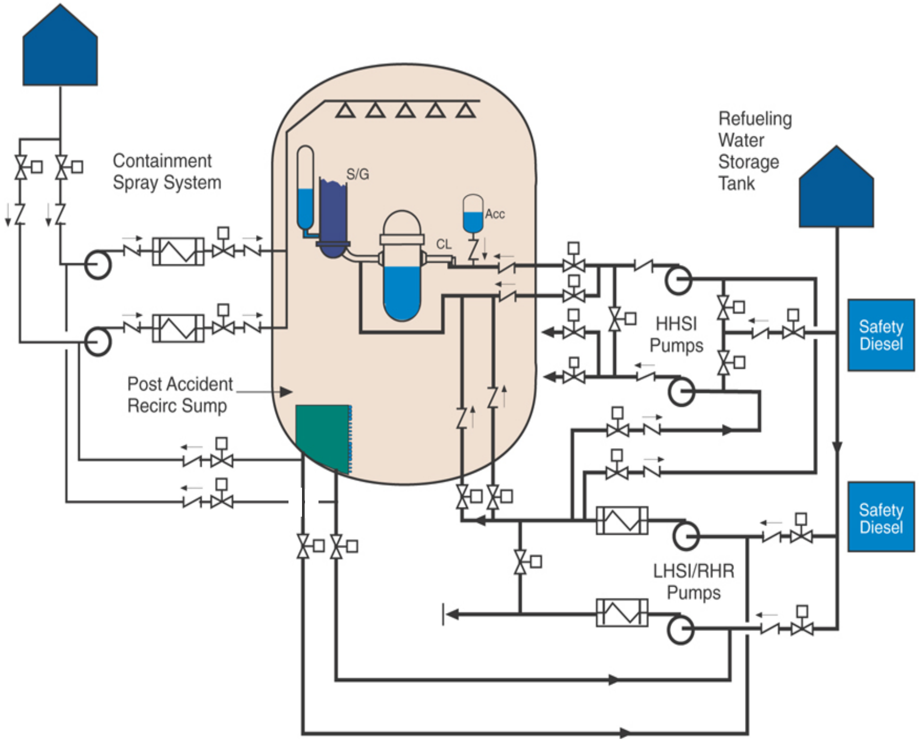
How is Simplification of Design Achieved for AP1000?

- Use of simple 2-loop reactor coolant system with canned motor pumps
- Use of passive safety systems
  - Passive decay heat removal
  - Passive safety injection
  - Passive containment cooling
- No reliance on safety grade AC power
  - Elimination of emergency diesel generators and their support systems
  - Elimination of all safety grade active components and their support systems

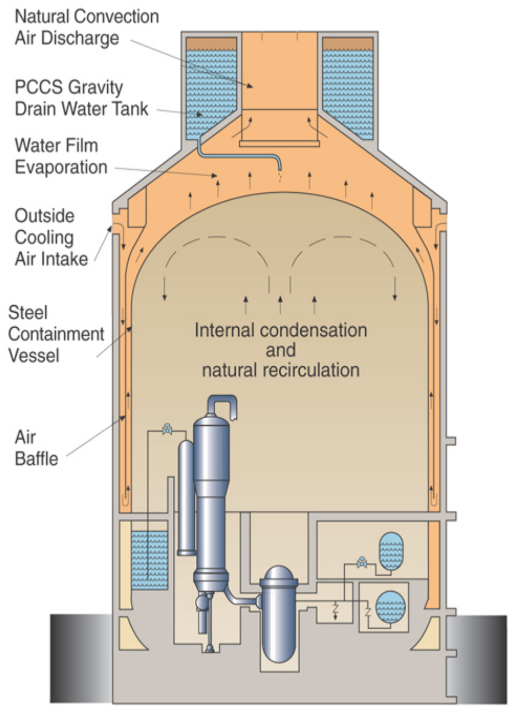


How is Simplification of Design Achieved for AP1000? (cont'd)

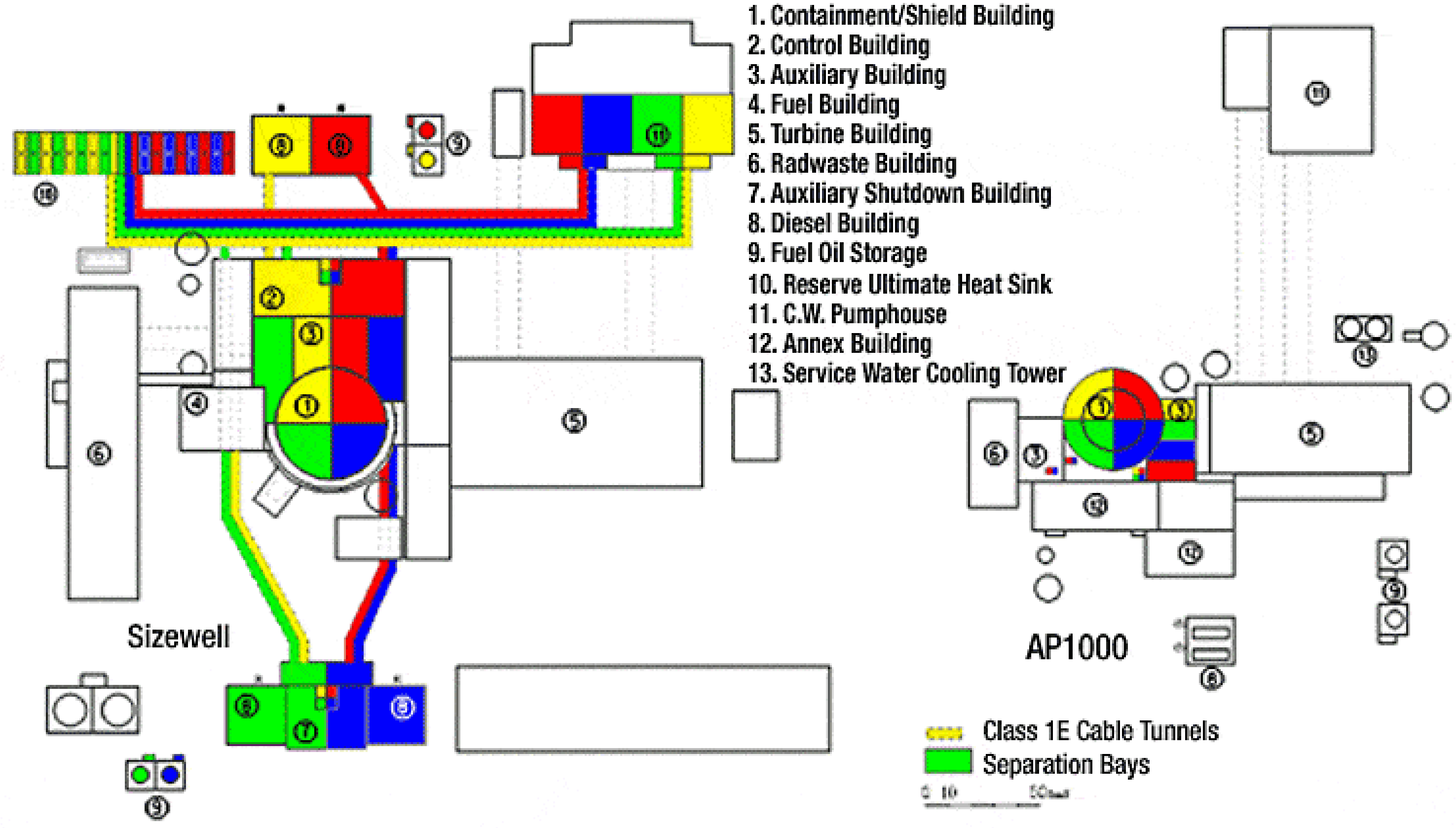
Standard PWR



AP1000



Physical Comparison of Current Evolutionary Plant and AP1000 Passive Plant



Sizewell B **AP1000**

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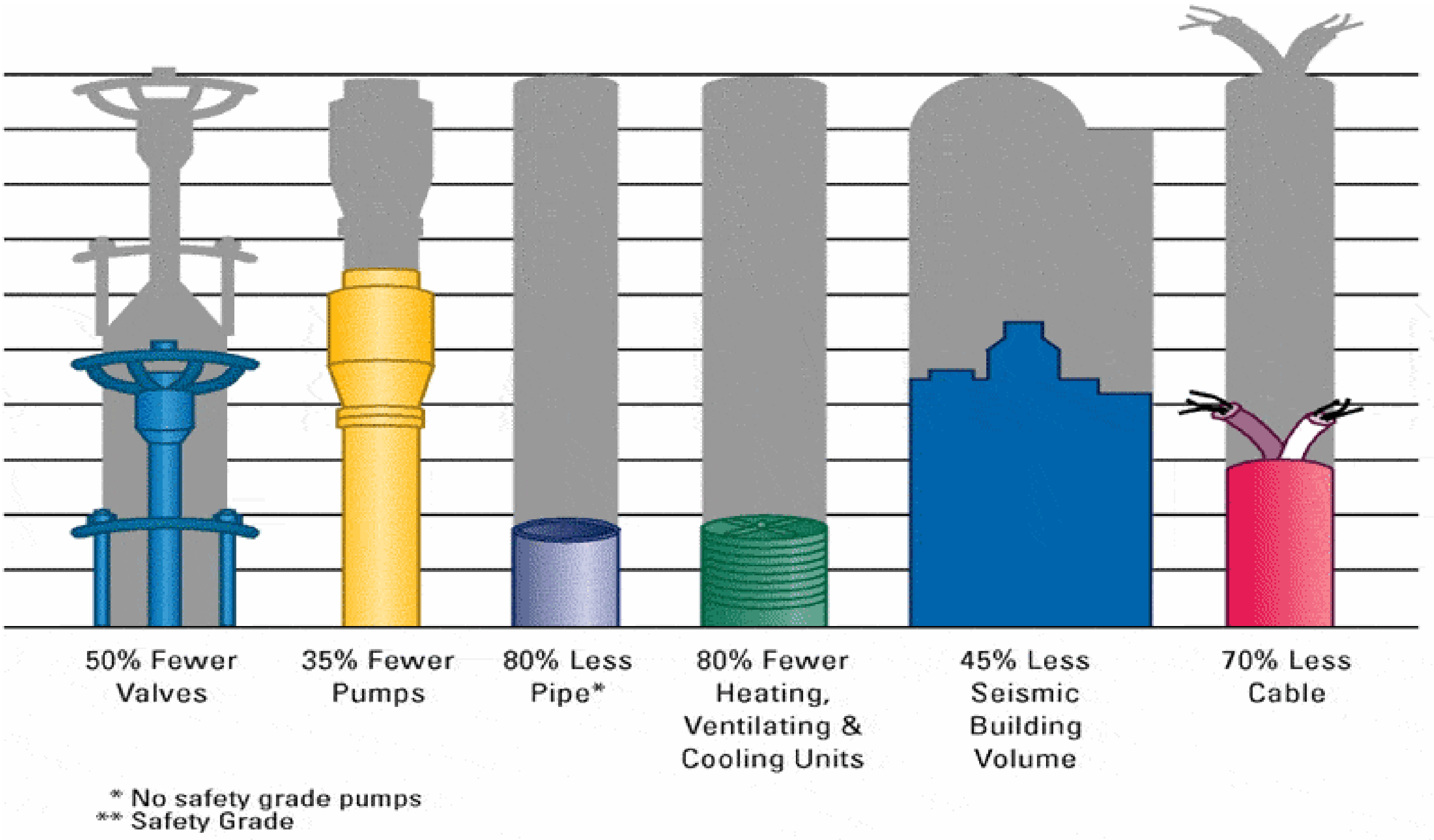
Simplification of Design Eliminates Components and Reduces Cost



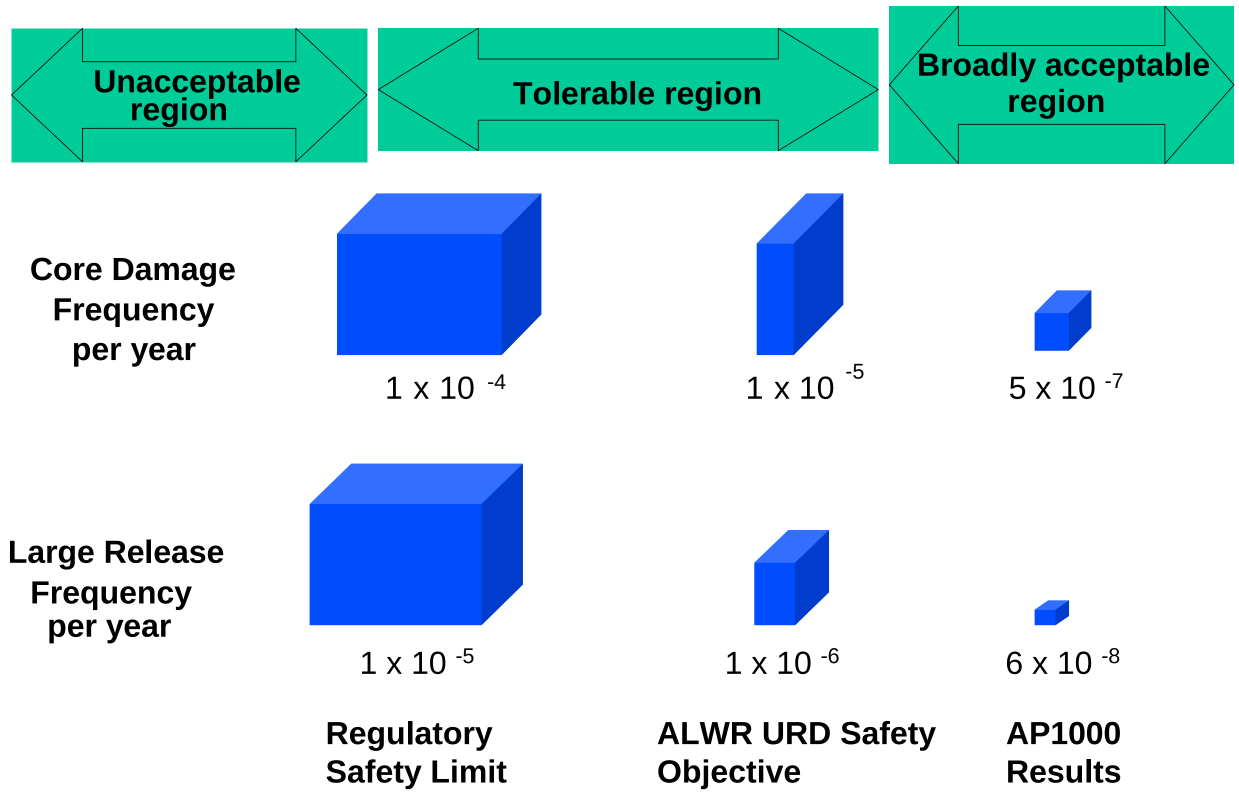
** No safety grade pumps

Advantages of Passive Safety Systems

- Less high cost active equipment and high cost seismic building volume
- Lower maintenance costs
- Lower staffing levels
- Less reliance on operators during postulated accidents

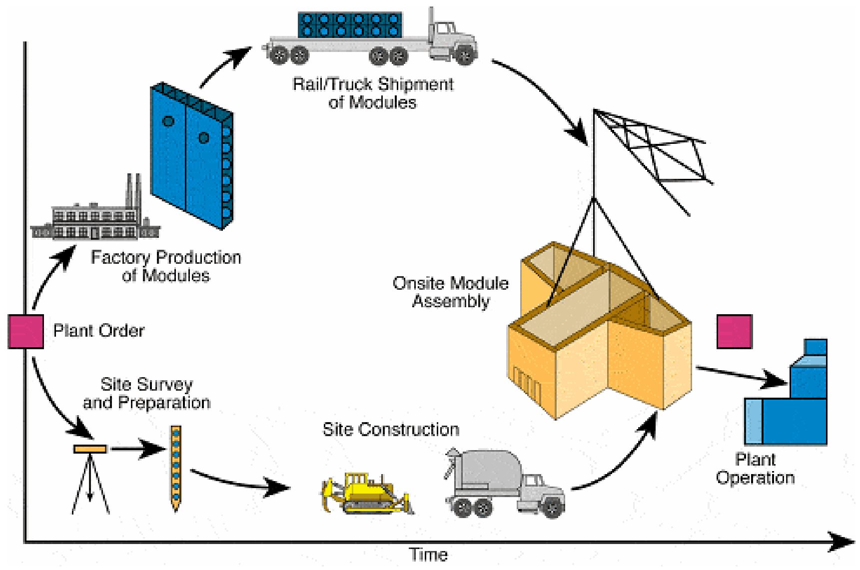
Lowest costs and highest level of safety!

AP1000 Passive Design Provides Enhanced Safety



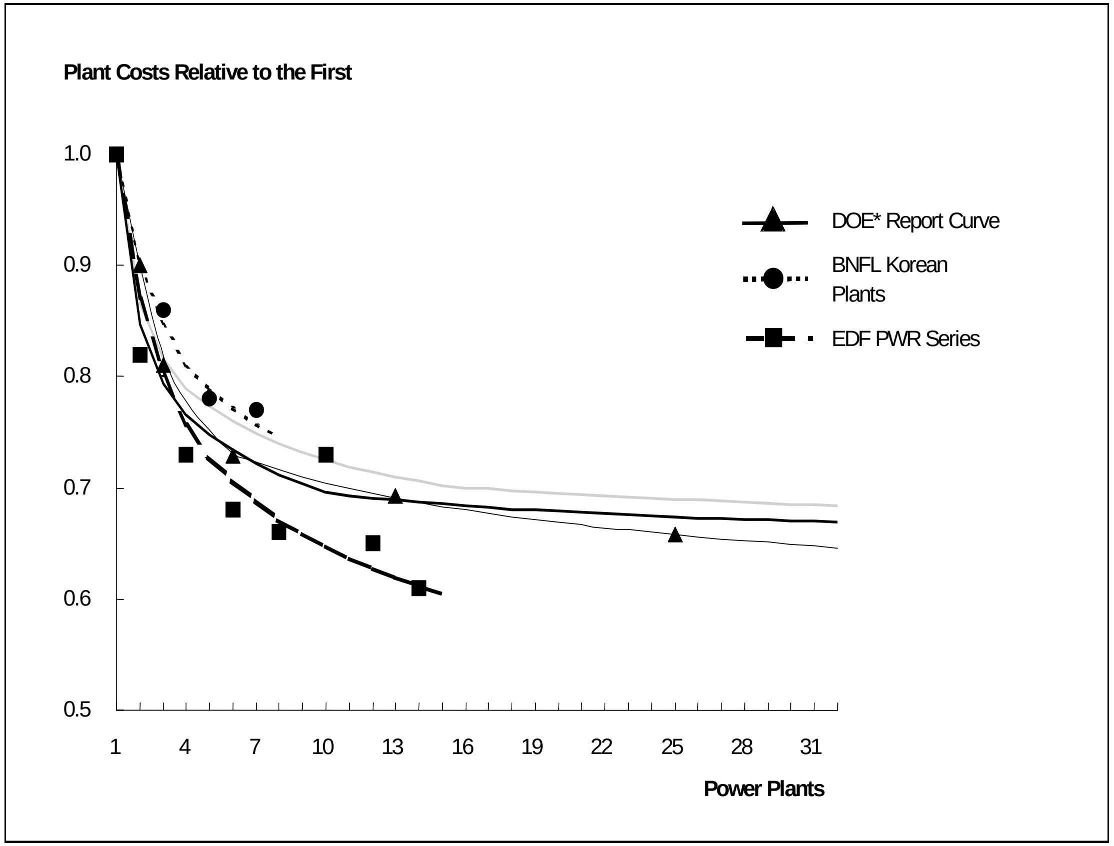
Reduction in Construction Cost and Schedule through Modularization

- Establishes parallel construction paths for structural, piping, and mechanical equipment modules
- Shifts labor from field to factory
- Allows better reproducibility and quality
- Lesson learned can be incorporated by stable work force



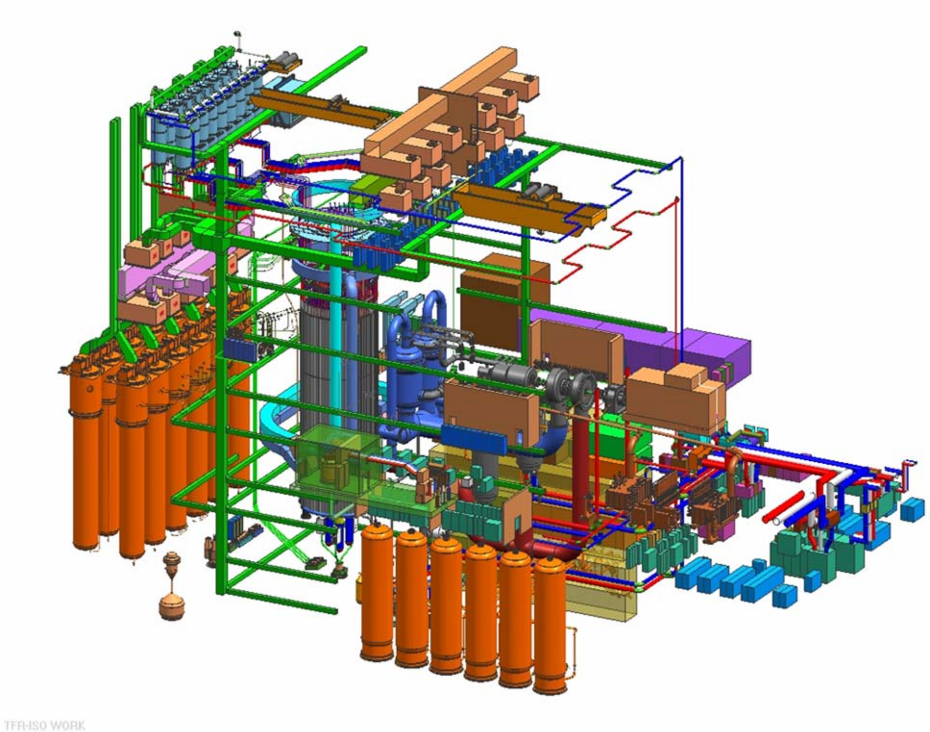
Reduction in Cost through Standardization

- Single first-of-a-kind engineering
- Reuse of same documentation
- Lesson learned from one project implementation to another by both factory and field labor
- Reduced spare parts inventory



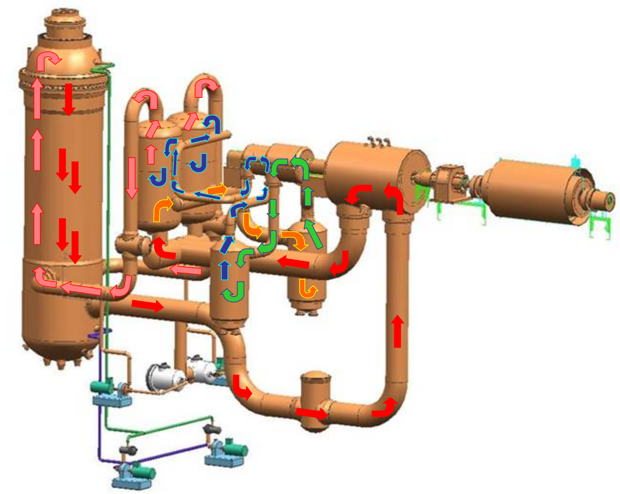
Pebble Bed Modular Reactor (PBMR) A Simple and Economic Design

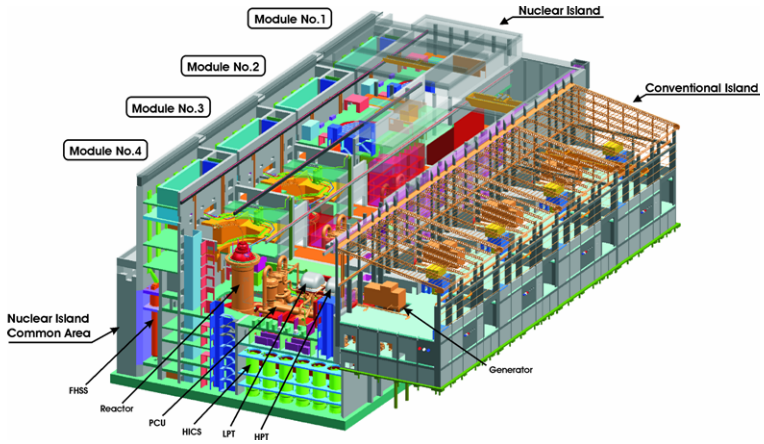
- High-temperature (900°C) helium cooled reactor (165 MWe)
- Coated particle fuel in spherical elements
- On-line/on-power refueling
- Direct cycle gas turbine
- High thermal efficiency
- Inherent passive safety
- Life of plant fuel storage on site



Modular Plants Like PBMR Can Exhibit Benefits

- **Short lead time for capacity additions**
- **Capital investments in small increments**
- **Small market tariff disruptions when commissioned**
- **Rapid learning due to repetition and factory fabrication**
- **Opens up other markets to nuclear reactors**
  - **Process Heat**
  - **Hydrogen Generation**





New Nuclear Plants Can Be Built to Cost and Schedule

- Improved plant design by simplification
- Better economics through standardization and modularization
- Greater reproducibility through shift toward factory fabrication
- Enhanced safety by use of passive systems