Construction Technologies and Management for Nuclear Power Plant Projects

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IAEA/ANL Training Course on Leadership & Management of NPP Programmes
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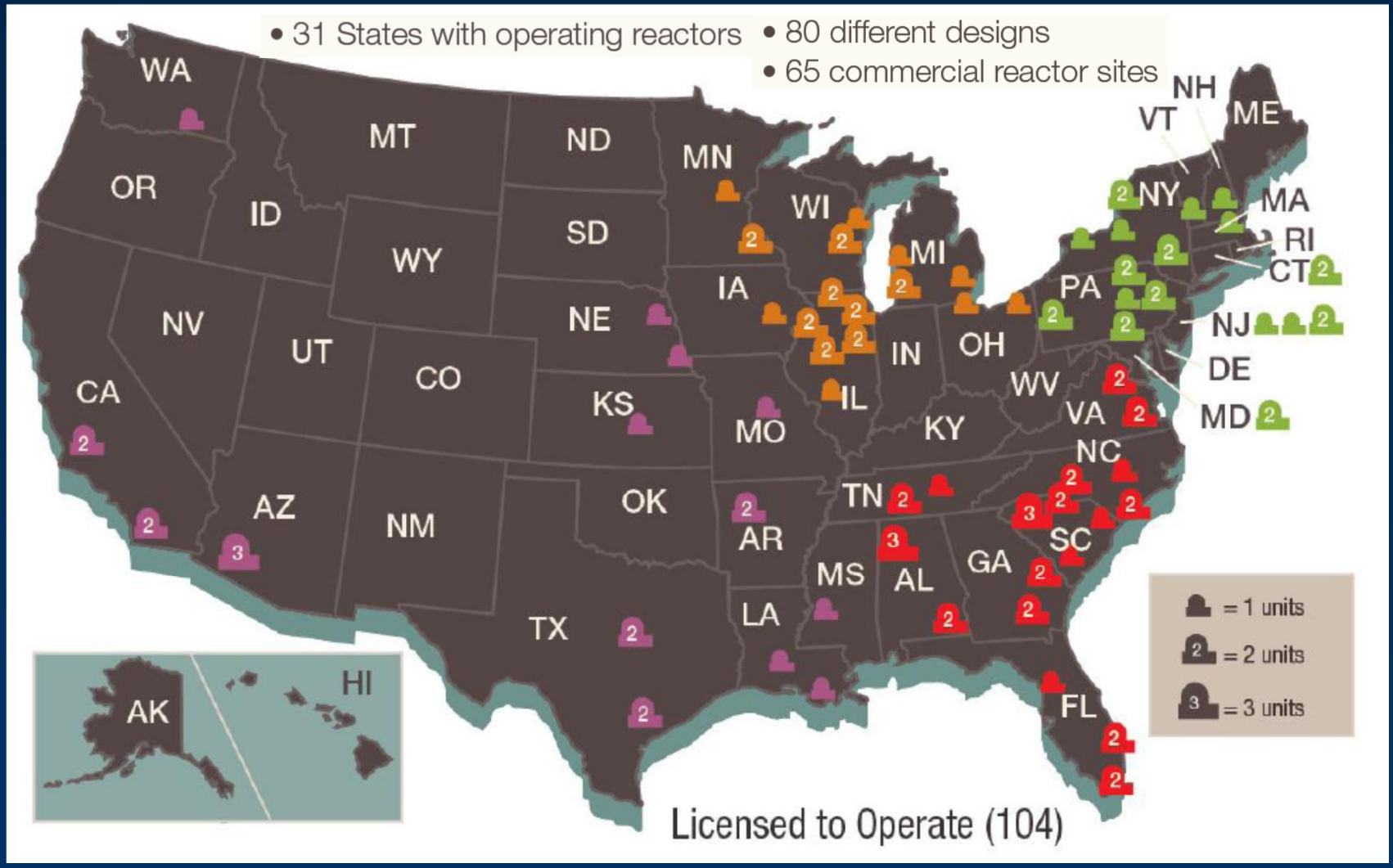
Topics

- Background
- Lessons Learned
- Examples of New Technology and Management

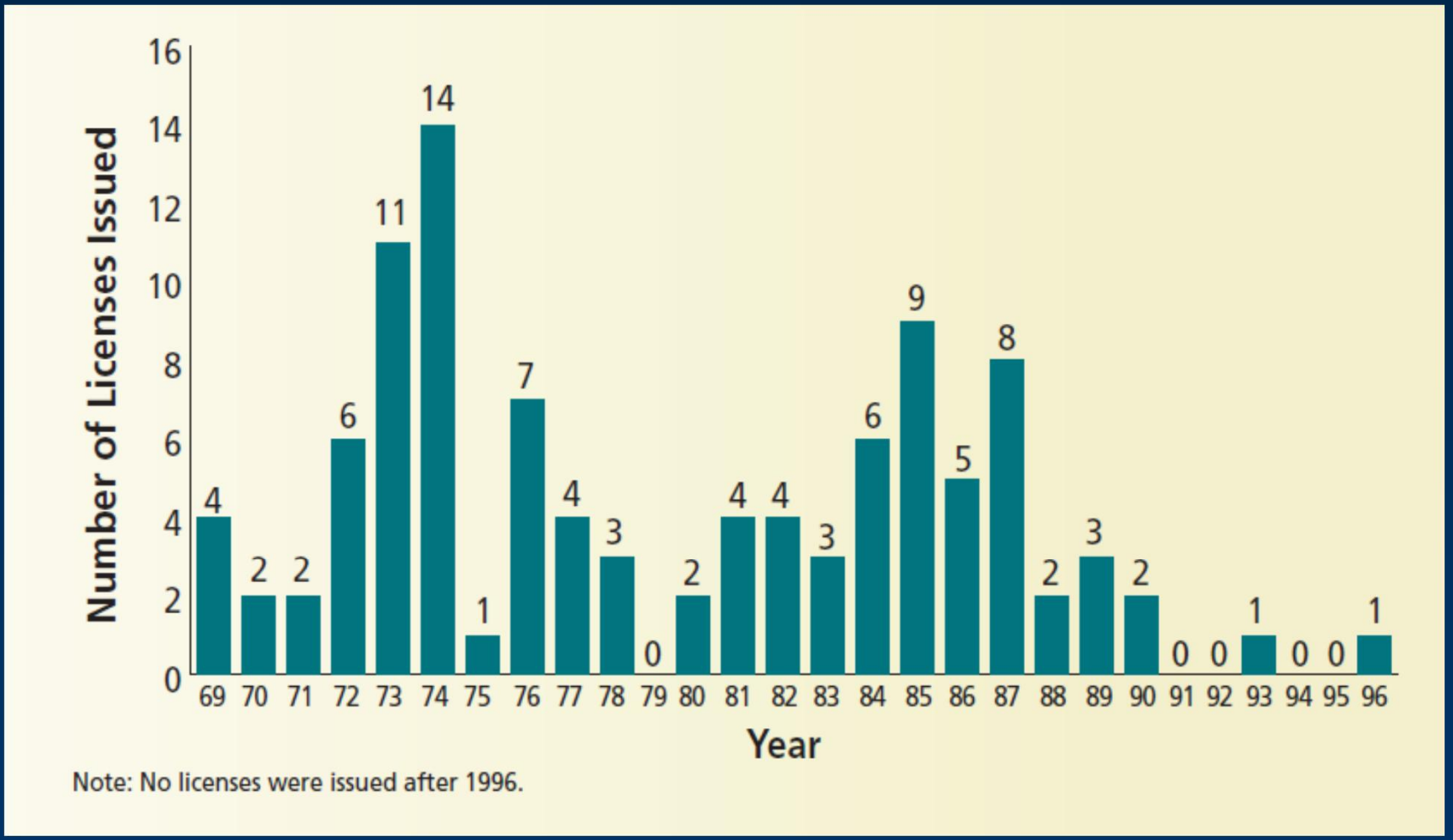
Background

U.S. Operating Nuclear Power Plants - 104



Background

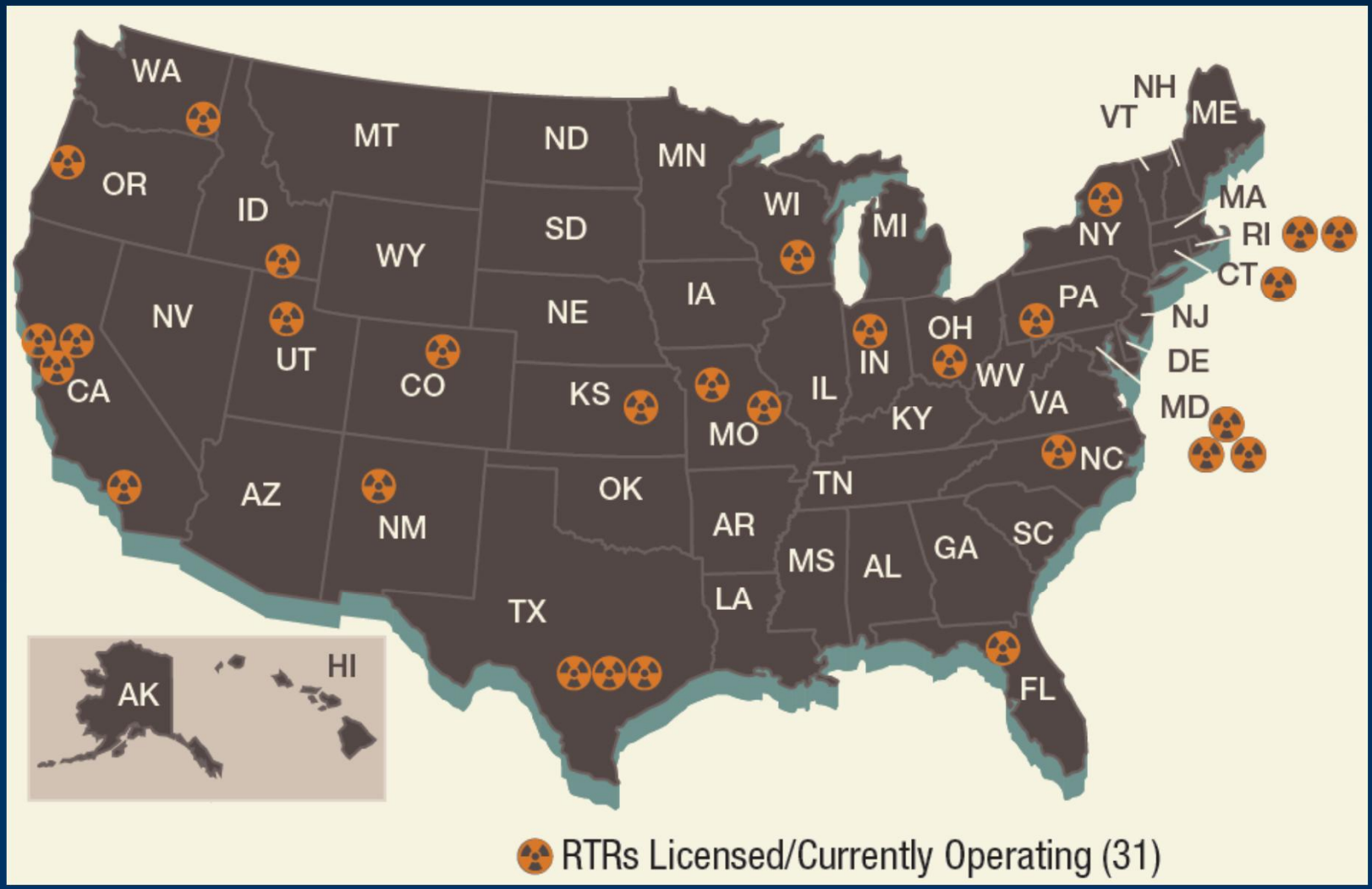
Commercial Nuclear Power Reactor Licenses



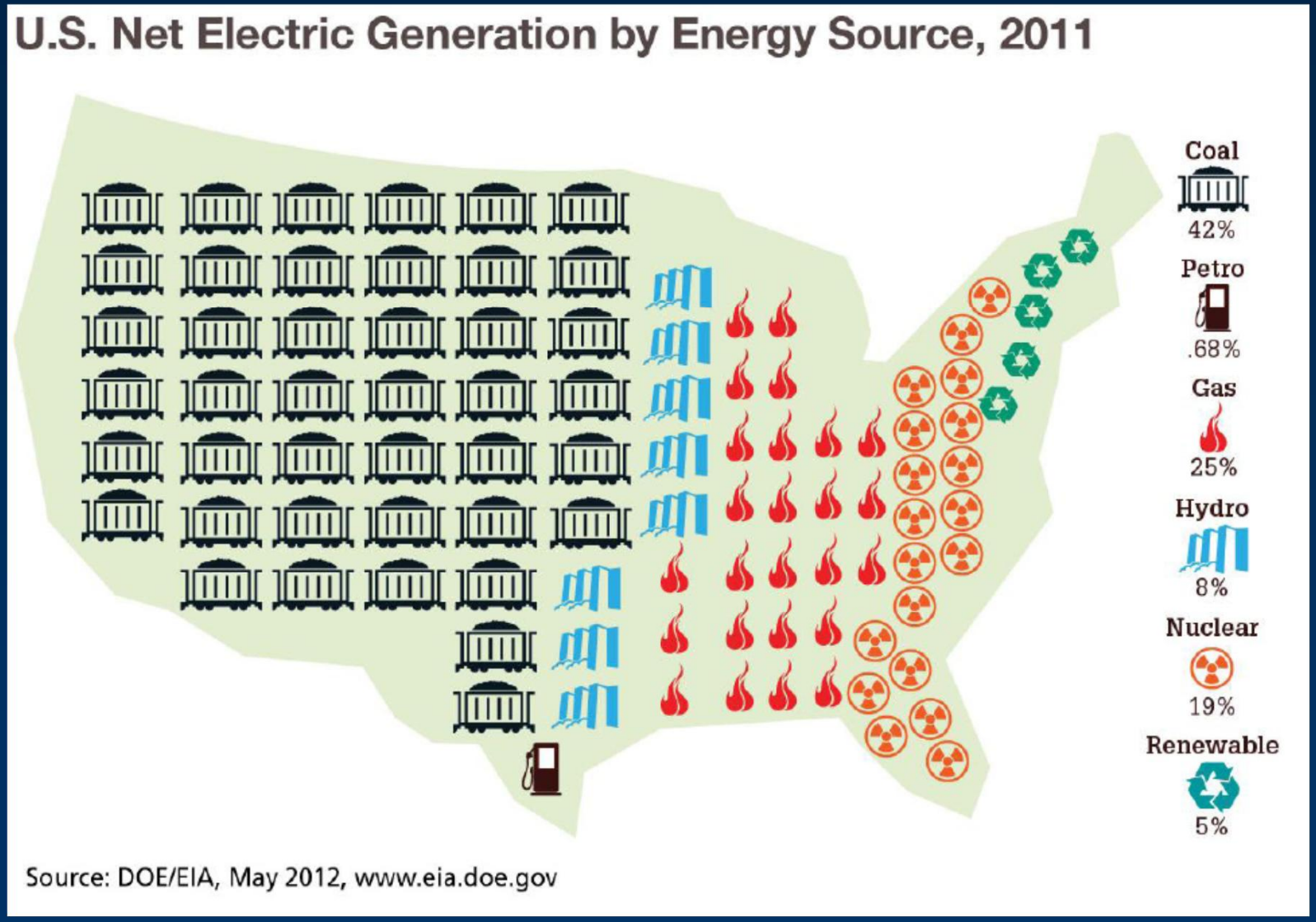
Note: No licenses were issued after 1996.

Background

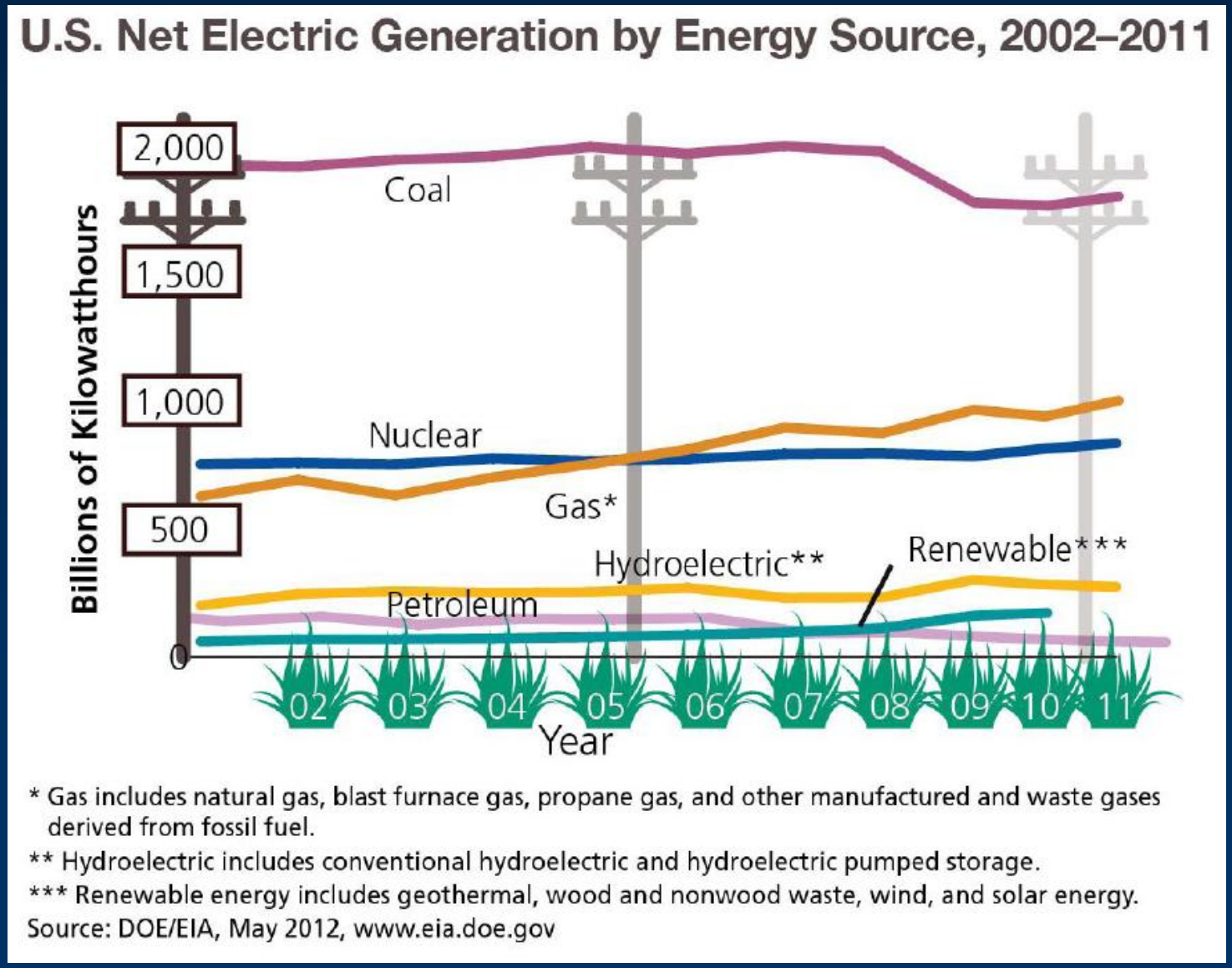
Nuclear Research and Test Reactors in U.S.



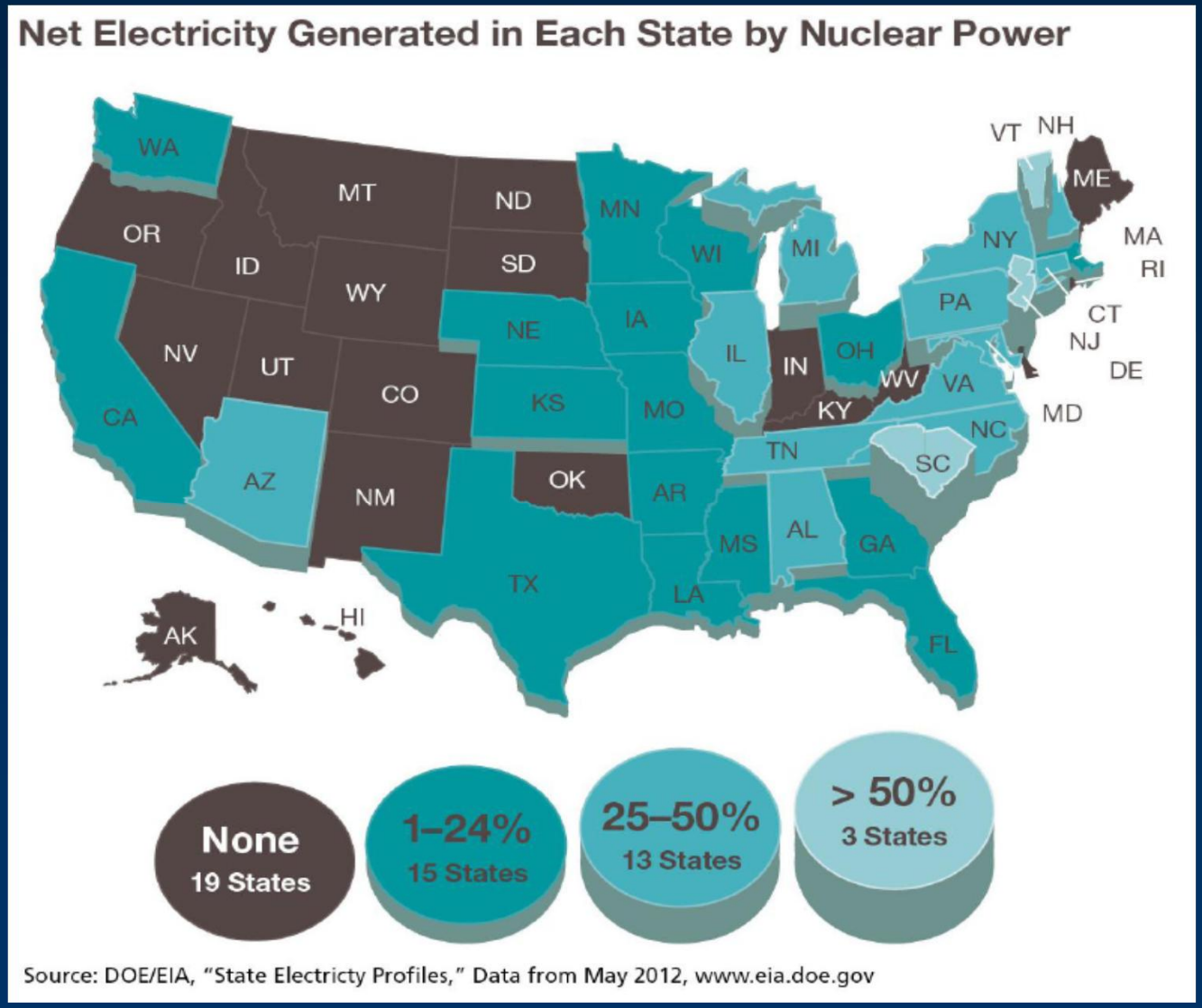
Background


U.S. Net Electric Generation by Energy Source, 2011
Coal
42%
Petro
.68%
Gas
25%
Hydro
8%
Nuclear
19%
Renewable
5%
Source: DOE/EIA, May 2012, www.eia.doe.gov

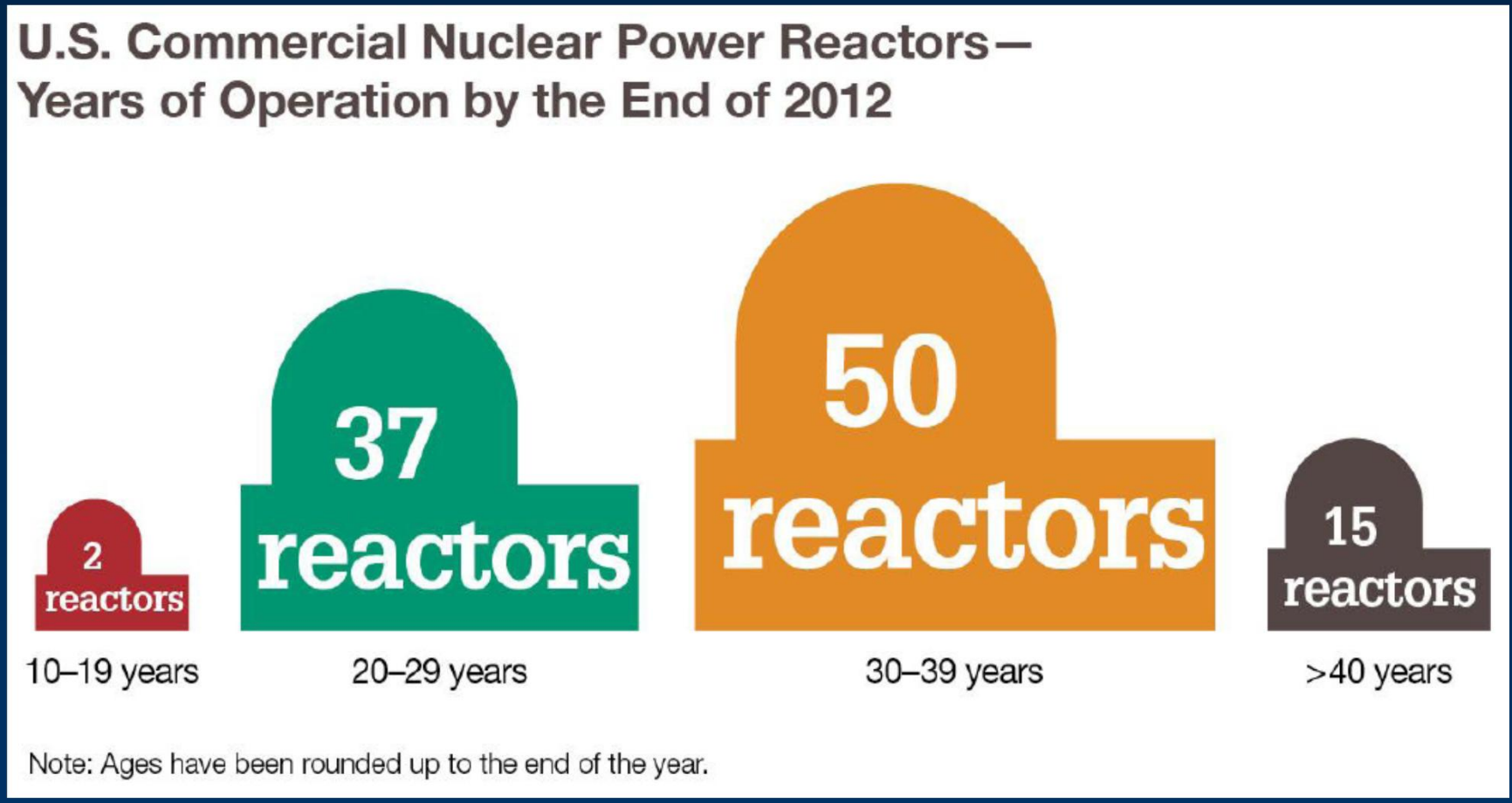
Background


U.S. Net Electric Generation by Energy Source, 2002–2011
Billions of Kilowatthours
2,000
1,500
1,000
500
0
Coal
Nuclear
Gas*
Hydroelectric**
Renewable***
Petroleum
02
03
04
05
06
07
08
09
10
11
Year
* Gas includes natural gas, blast furnace gas, propane gas, and other manufactured and waste gases derived from fossil fuel.
** Hydroelectric includes conventional hydroelectric and hydroelectric pumped storage.
*** Renewable energy includes geothermal, wood and nonwood waste, wind, and solar energy.
Source: DOE/EIA, May 2012, www.eia.doe.gov

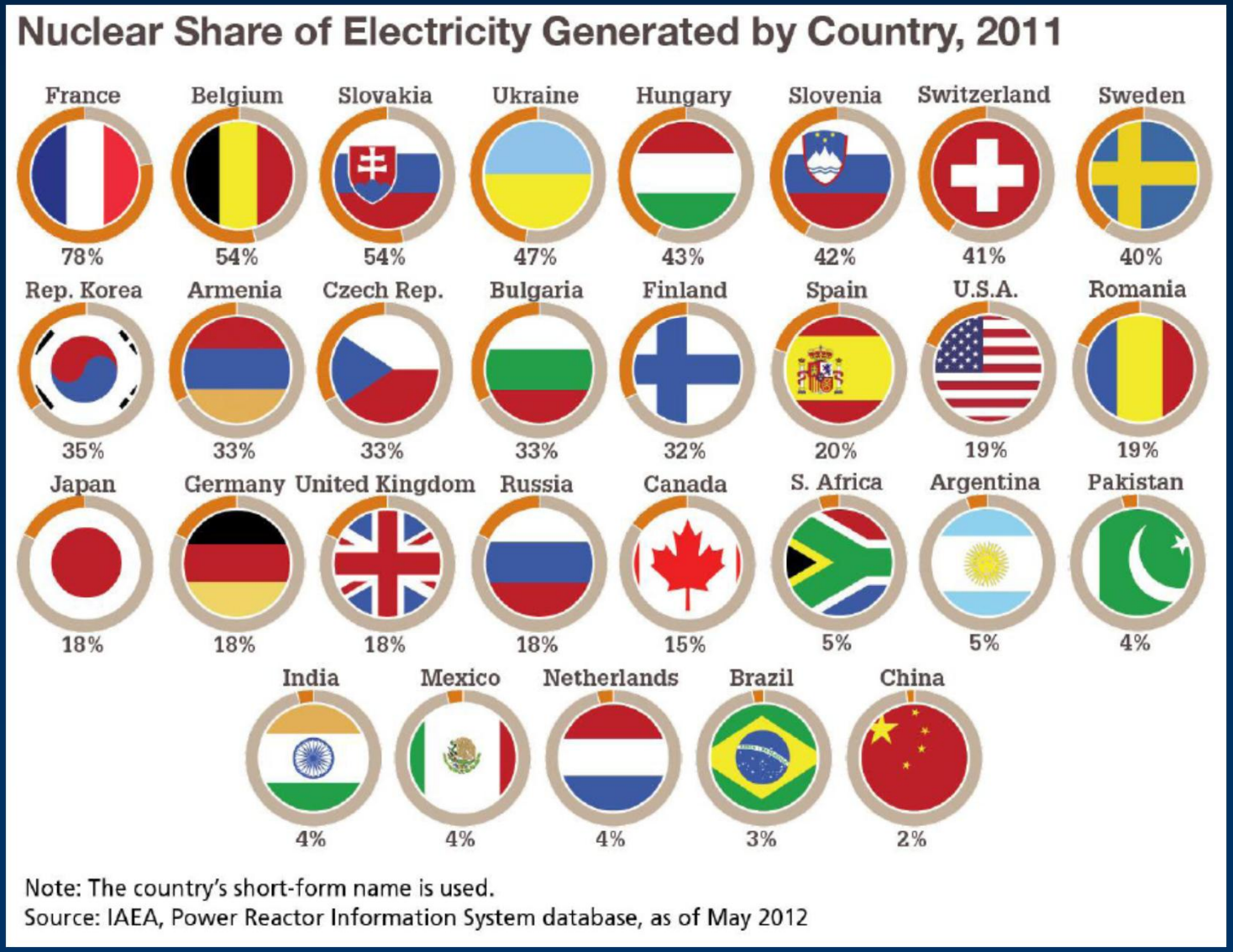
Background


Net Electricity Generated in Each State by Nuclear Power
WA
OR
CA
ID
NV
MT
WY
UT
AZ
CO
NM
ND
SD
NE
KS
OK
TX
MN
IA
MO
AR
LA
WI
IL
MS
MI
IN
KY
TN
AL
OH
WV
GA
FL
SC
NC
VA
PA
NY
MD
DE
NJ
CT
RI
MA
VT
NH
ME
AK
HI
None
19 States
1–24%
15 States
25–50%
13 States
> 50%
3 States
Source: DOE/EIA, "State Electricty Profiles," Data from May 2012, www.eia.doe.gov

Background


U.S. Commercial Nuclear Power Reactors—
Years of Operation by the End of 2012
2 reactors
10–19 years
37 reactors
20–29 years
50 reactors
30–39 years
15 reactors
>40 years
Note: Ages have been rounded up to the end of the year.

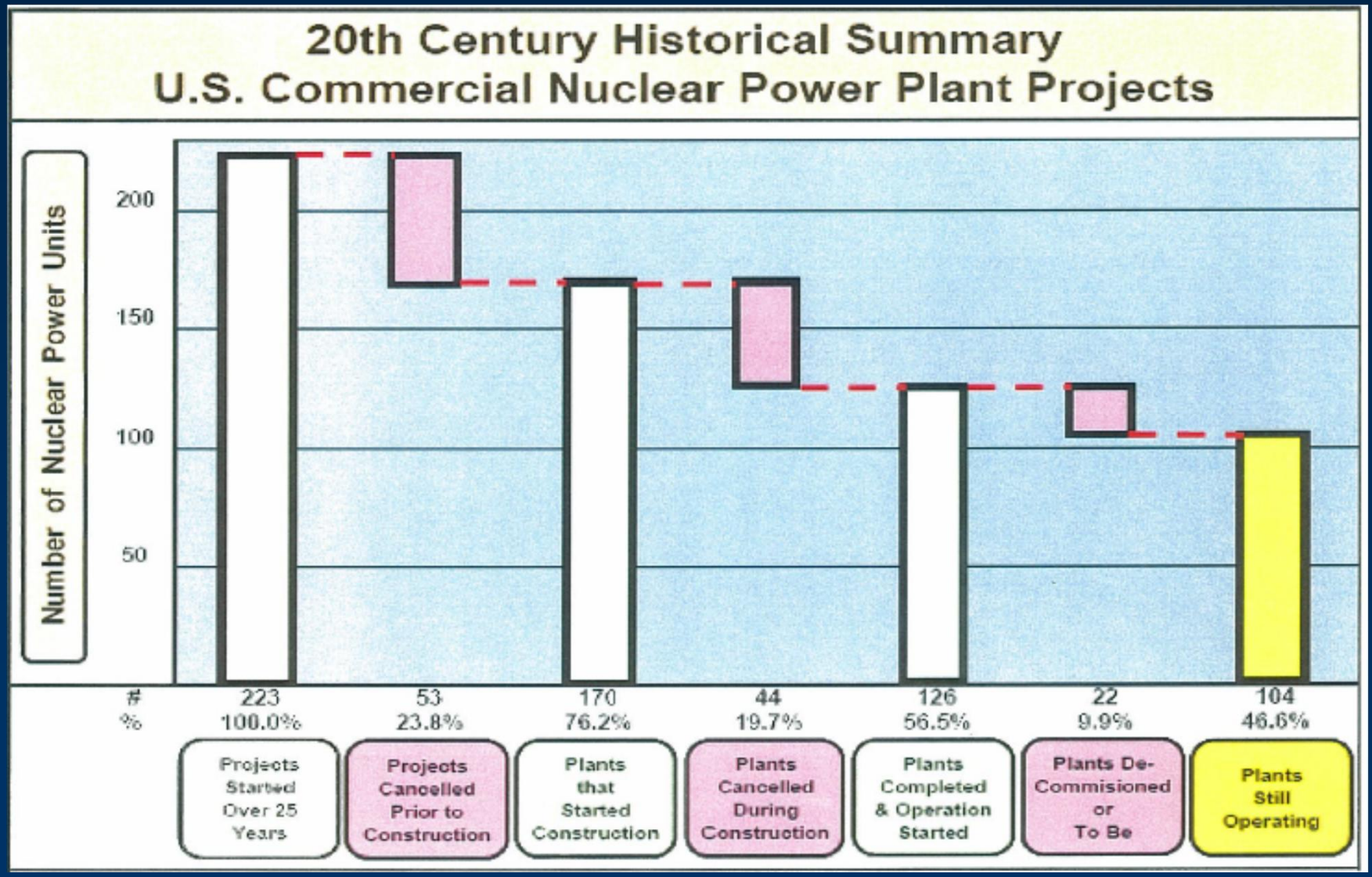
Background


Nuclear Share of Electricity Generated by Country, 2011
France 78%
Belgium 54%
Slovakia 54%
Ukraine 47%
Hungary 43%
Slovenia 42%
Switzerland 41%
Sweden 40%
Rep. Korea 35%
Armenia 33%
Czech Rep. 33%
Bulgaria 33%
Finland 32%
Spain 20%
U.S.A. 19%
Romania 19%
Japan 18%
Germany 18%
United Kingdom 18%
Russia 18%
Canada 15%
S. Africa 5%
Argentina 5%
Pakistan 4%
India 4%
Mexico 4%
Netherlands 4%
Brazil 3%
China 2%
Note: The country's short-form name is used.
Source: IAEA, Power Reactor Information System database, as of May 2012

Topics

- Lessons Learned

Historical Perspective



Lessons Learned

Nuclear Plant Design

THEN

- New Technology
  - Scale up Problems from Military Reactors
  - Difficulties Adapting to New Requirements
- Rapid Changes In Designs
  - Competition Driven
  - Size Doubled Every Decade
  - Unresolved Safety Issues
- Individually Designed Plants
  - Different A-Es
  - Competitive Procurement
  - Customized Designs
- Plants Were Not Designed with Constructability in Mind

NOW

- Proven Technology
  - Plants are Based on Commercial Plant Designs
  - Plants are Designed Around Stable Requirements
- Design Stability
  - Based on Proven Designs
  - Certified Designs
  - USI's Resolved
- Standard Plant Designed
  - Predetermined Design Teams
  - Standardized Components
  - Identical Units
- Modular Plant Design For Construction

Lessons Learned

Construction Methodology

THEN

- Multiple Prime Contractors
- Immature design at onset of construction
  - 25% design completion at start
- Models were not detailed or used
- Stick-built approach
- Manual techniques
  - Scheduling tools
  - Document and Data control
  - Measurement and positioning systems
  - Primarily manual welding
- Complicated I&C cabling and systems
- Limited heavy lifting capabilities

NOW

- EPC Approach
- Design Complete before construction
  - Design at 85% before Construction
- 3D CAD models with interactive features
- Standardized modular approach
- Automation
  - Sophisticated scheduling software
  - Automated data and document control
  - GPS and Laser measurement and positioning systems
  - Automated and enhanced manual welding techniques
- Simplified Digital and Fiber Optic systems
- Expanded Lifting and hauling capabilities

Lessons Learned

Owner/Operators

THEN

- Little Nuclear Background
  - Technology was too new
  - When Most Started it was too late to gain experience
  - Most Personnel were new hires
- Misunderstood Nuclear QA
  - Record Keeping was Seen as a Nuisance
  - Compliance with Procedures was Spotty
  - Quality was Inspected In rather than Built in
- No Confidence in Payoff
  - No operating history
  - No basis for optimism

NOW

- All Operate Many Plants
  - Industry has Consolidated into the hands of Specialist Companies
  - Lots of experienced personnel available
- Committed to Nuclear QA
  - Record Keeping is Ingrained in organizations
  - Compliance with Procedures is Demonstrated
  - Quality Programs are Robust and Effective
- Certain in Payoff
  - Positive operating history
  - Best Economical Solution to Electricity Production

Lessons Learned

Regulatory Process

THEN

- 10CFR50
- Two-Step Process
  - Construction Permit
  - Operating License
- Ratcheting Requirements
  - New Technology
  - Uncertain Safety
  - Uncertain Environmental Impact
  - Political Pressure Driven by Fear of the Unknown
  - Activist Interveners
- Issues Can Be Raised Repeatedly
- Few People Trained in Process

NOW

- 10CFR52
- One-Step Process
  - Combined License
  - ITAAC
- Stable Requirements
  - Proven Technology
  - Demonstrated Safety
  - Documented Environmental Impact
  - Political Pressure to License New Plants
  - Activist Interveners Fragmented by Global Warming Issue
- Issues Can Be Raised Only Once
- Many People Trained in Process

Lessons Learned

Today's Improved U.S. Industry Efforts

- Advanced nuclear plant designs
- Streamlined regulatory process
- Federal incentive program for financing and insurance
- Modest inflation and financing rates
- Standardized designs for nuclear power plants
- More sophisticated management processes/software
- Modularization approach to construction
- Integrated material management planning techniques

Lessons Learned: First-of-a-kind projects are not fully understood, degraded nuclear supply chain, and global supply chain logistics and risks

Lessons Learned

One-step process, 10 CFR 52, COL authorizes construction and operation

THEORY: *Pre-approved certified standard design and site in advance of large financial commitment*

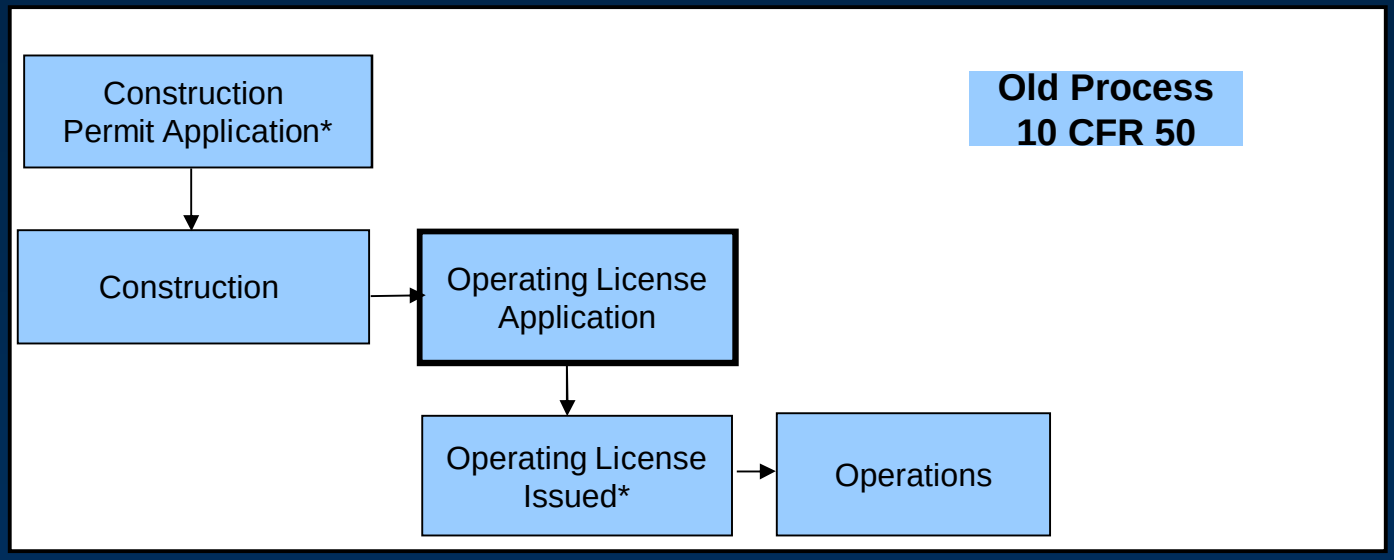
ACTUAL: *Process allows COL to incorporate a design that is not yet approved and for optional early site permit inclusion*

- Opportunity to "bank" ESP in advance of financial commitment
- Issues decided once – finality at each stage
- COL design-centered reviews provide further standardization

Demonstrated improvements in hearing process:

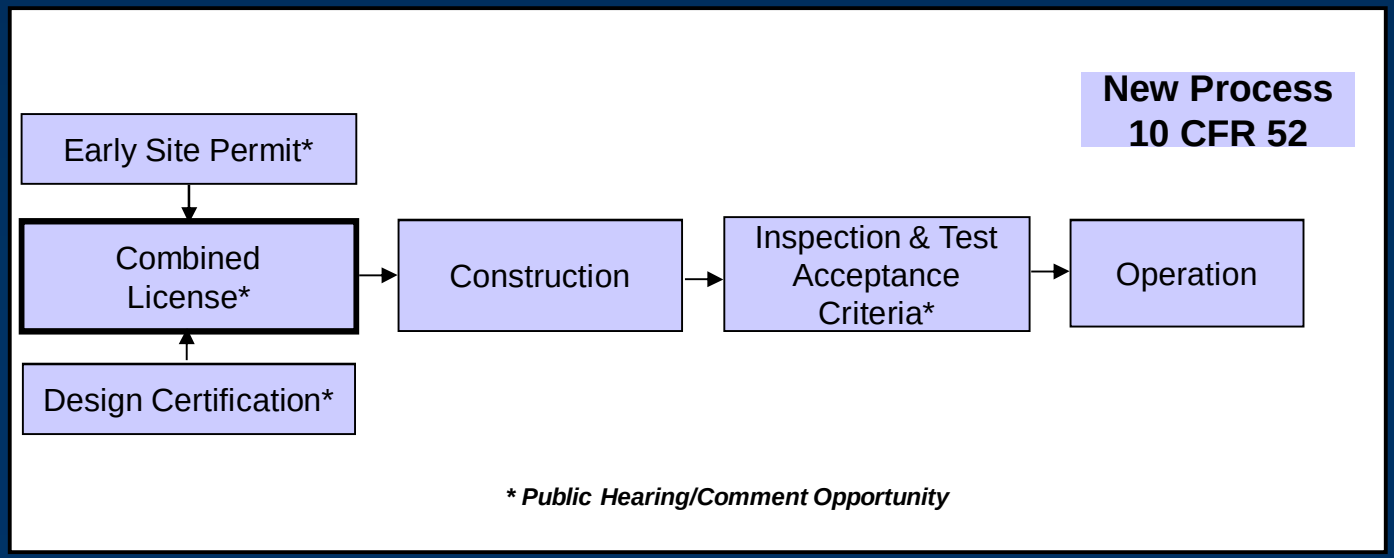
- Rules of practice tightened
- ASLB case management tightened
- Objective basis for operational decision

Overview of 10 CFR 50 vs. 52



Old Process 10 CFR 50

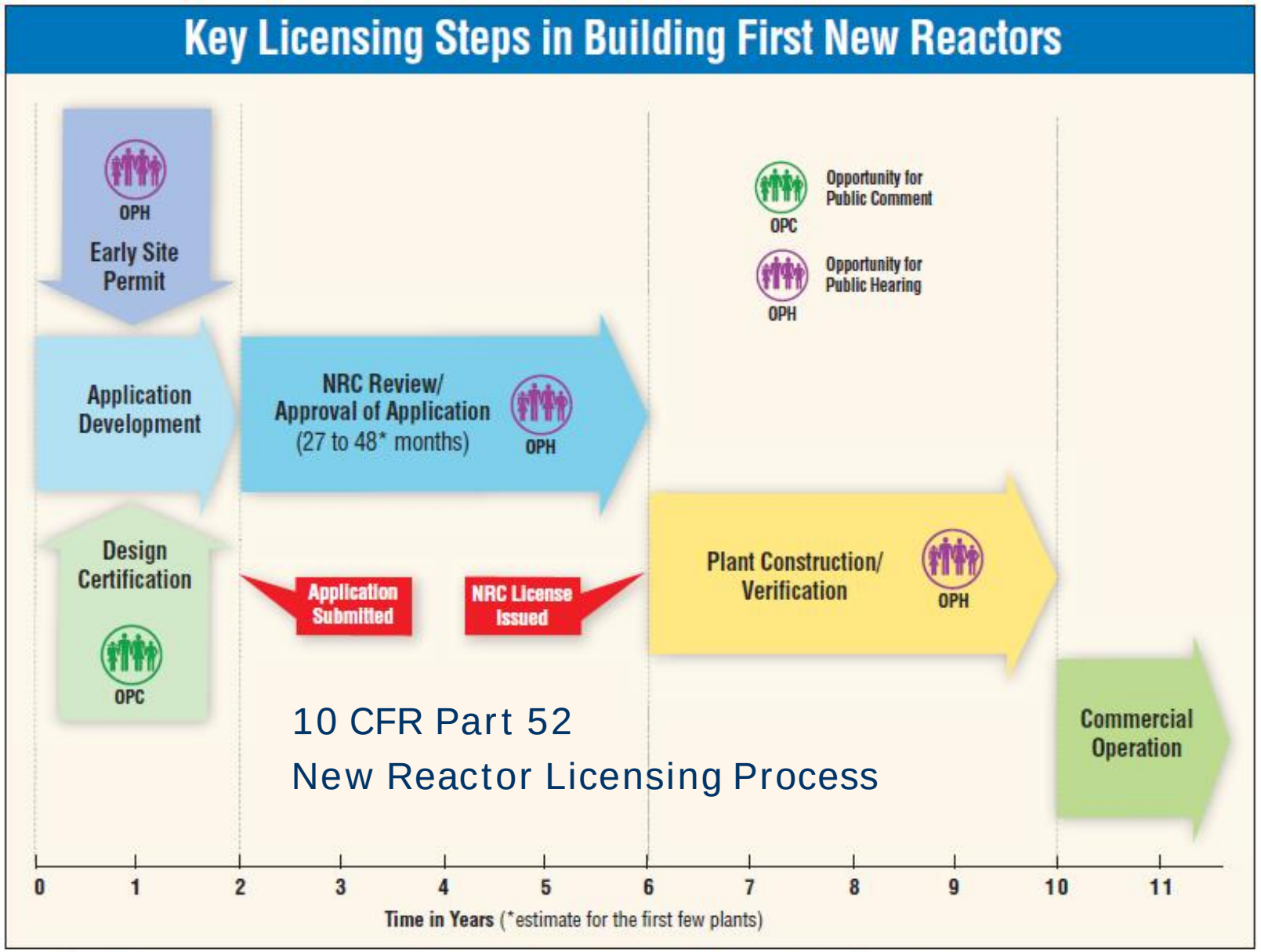
Significant capital committed with no assurance that facility would ultimately be approved



New Process 10 CFR 52

Upfront approval of plant design, site acceptability and operational plan; with demonstration of overall implementation of approved plan

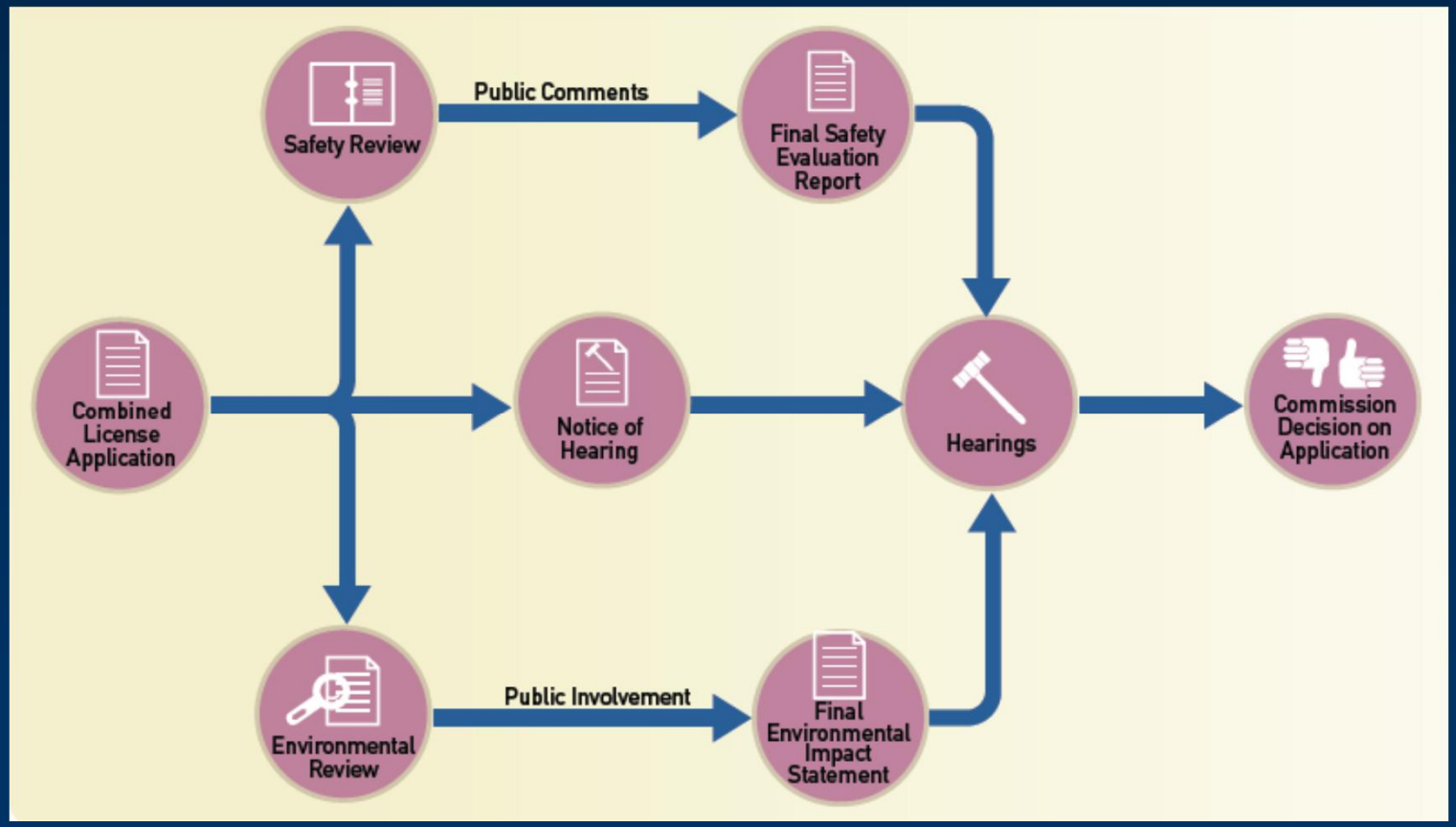
**** Public Hearing/Comment Opportunity***



The NRC's new licensing process offers multiple opportunities for public input.

Regulatory and Legislative Development

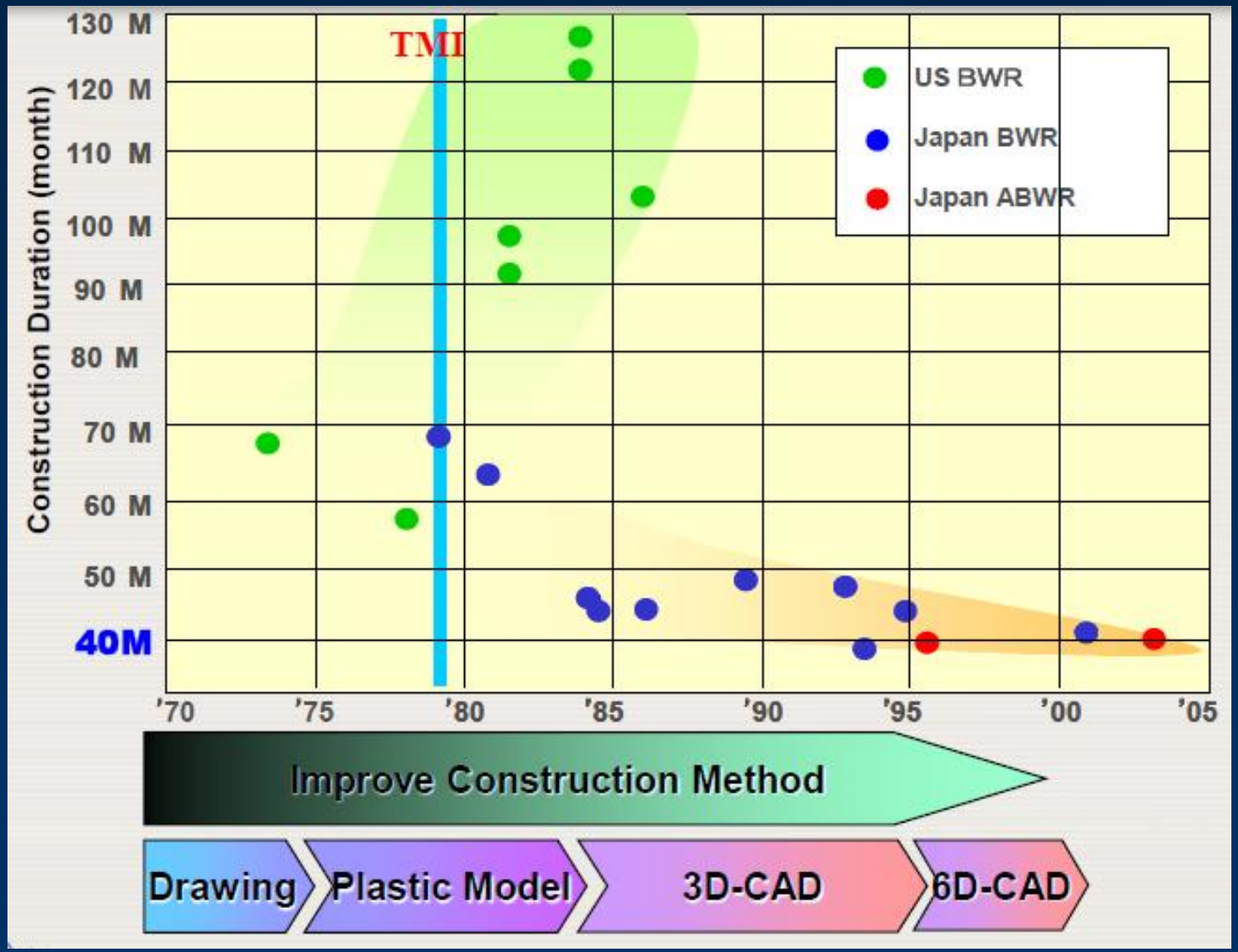
10 CFR Part 52, New Reactor Licensing Process



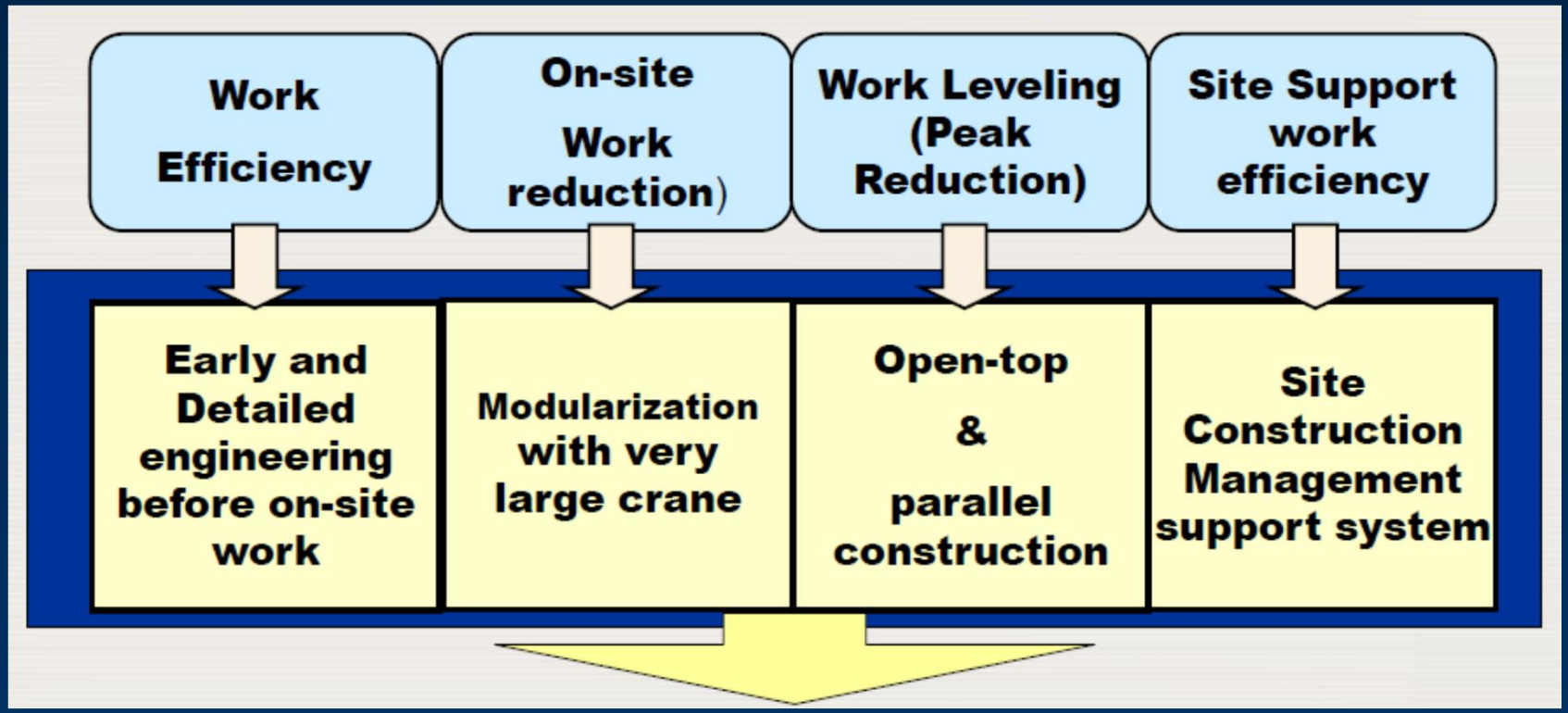
Topics

- Examples of New Technology and Management

Schedule Impact of Example Improvements



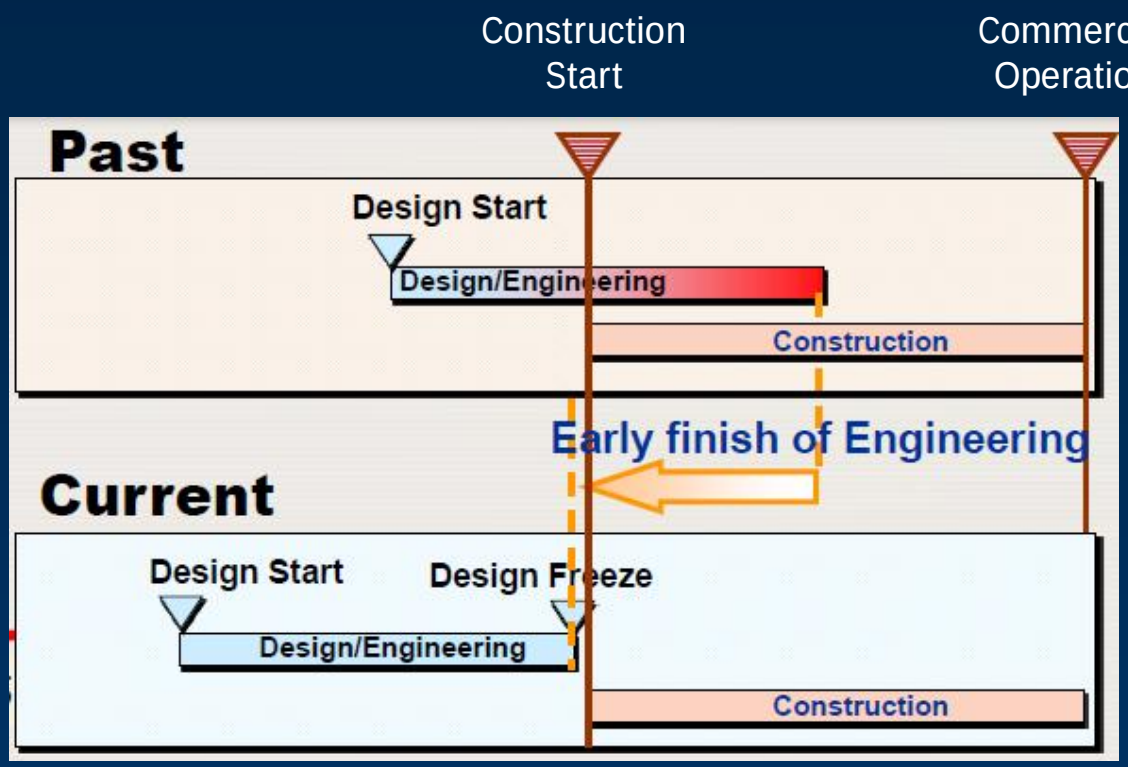
Strategies for Reduced Construction Period



Reduced Construction Period to ~ 38 months*

* based on actual first ABWR in Japan

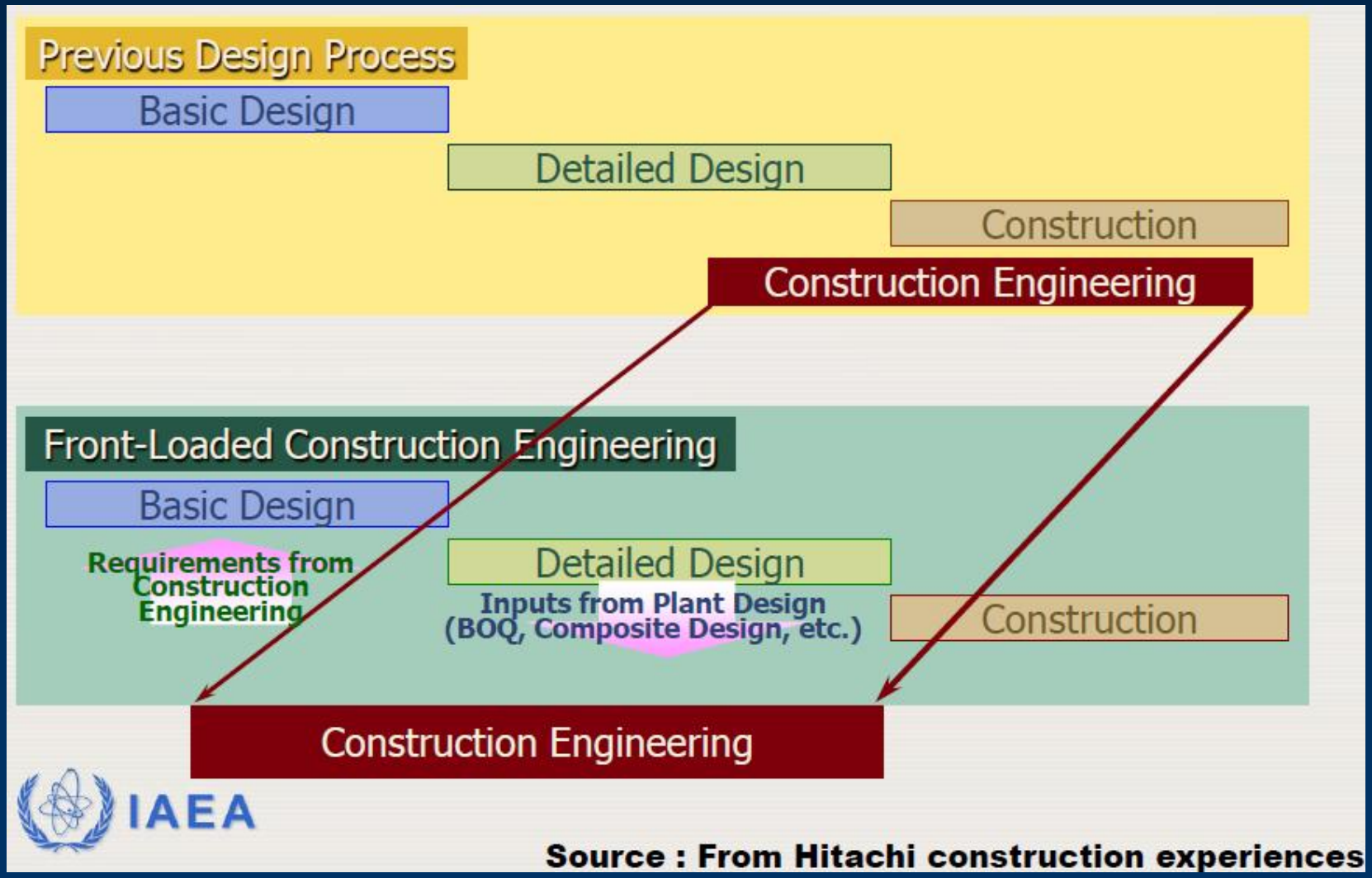
Resource Hour Reduction with Early Engineering



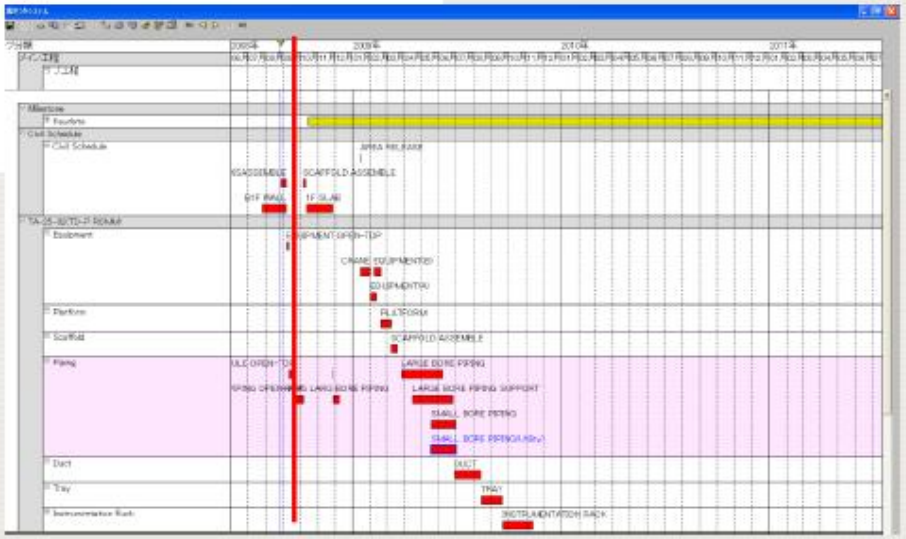
Reduced Site Resource Hours by ~ 40%*

* Detailed engineering before construction start

Resource Hour Reduction with Early Engineering



Construction Management with 6D Model



3D-model linked with schedule, resources, and quantities of material = 6D-model

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Open Top Construction

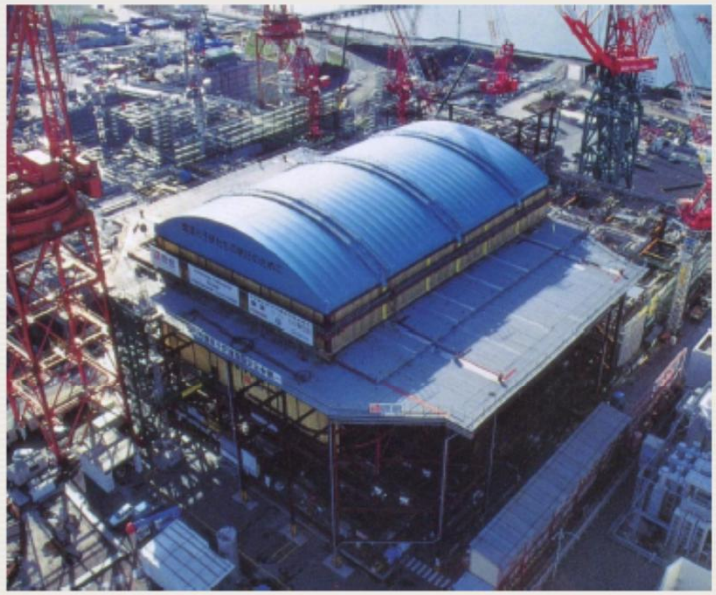
- Integrating the construction of the building walls/slabs with the modules, equipment/mechanical and electrical commodities installation.
- Reduces temporary openings, the material handling costs of bulk commodities
- Require Very Heavy Lift Cranes

SG Installation in Qinshan, China

All Weather Construction

All Weather construction method to mitigate severe weather conditions, i.e. heavy snowfall, seasonal high wind:

- A temporary/structural steel frame covered with a tent;
- Movable temporary roofs for the open top construction by a VHL crane;
- A temporary/permanent overhead crane and hoists with monorails;
- Permanent stair cases providing the floor access during the construction



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Steel Plate Reinforced Concrete Construction

- The SC Structure was fully applied to a incinerator building, which deals with wastes from the nuclear power plants in Kashiwazaki-Kariwa site in Japan.
- The SC structure has been demonstrated to be applied to a building related to the nuclear facilities by TEPCO.
- The construction duration has been reduced by 25% compared with the RC structure.

Questions?