U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Nuclear Energy Technology Assessment

Presentation to QTR Workshop

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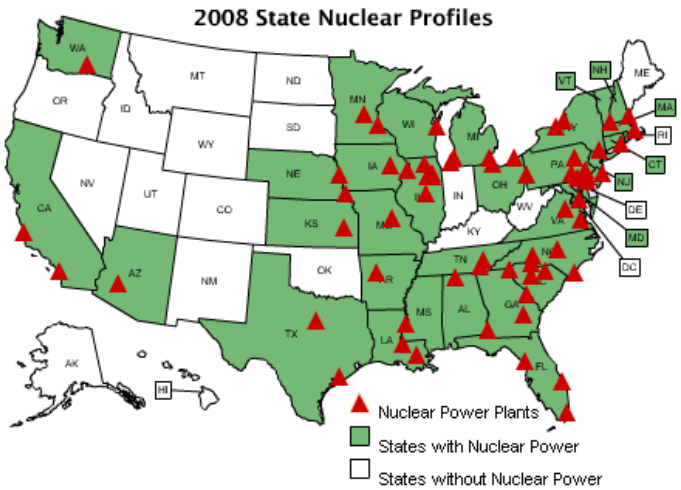
Outline

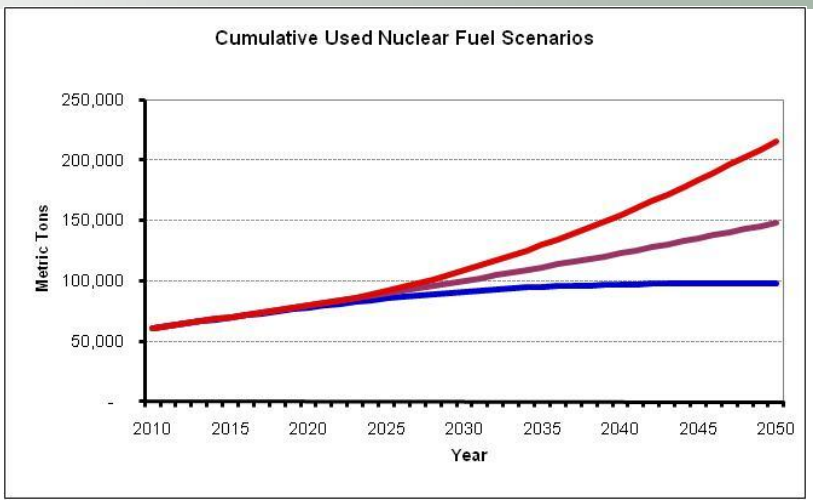
- **Background**

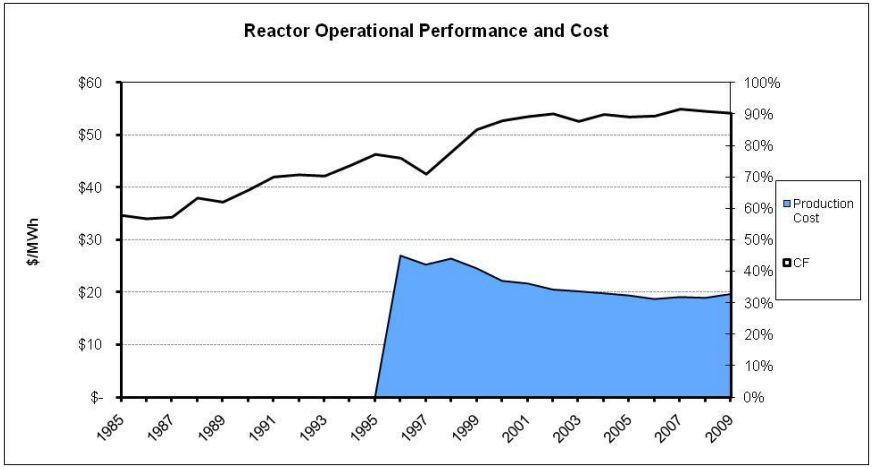
- **Technologies Assessed:**
  - Current Fleet
  - Generation III
  - Small Modular Reactors (LWR)
  - Generation IV
  - Used Fuel Management

- **Not Included**
  - Uranium mining and enrichment
  - Replacement of uranium in fuel cycle

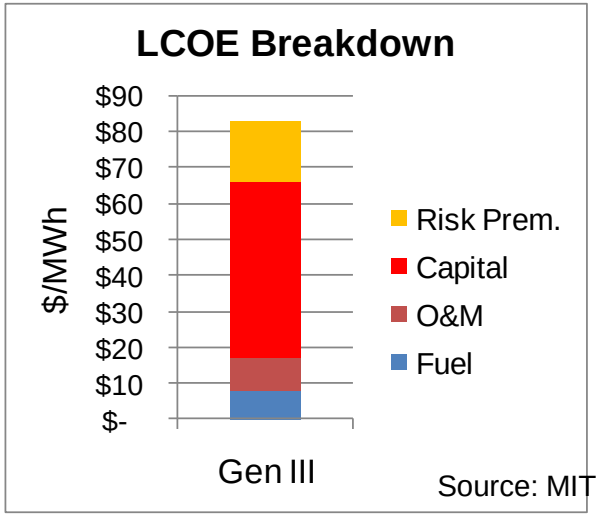
Background





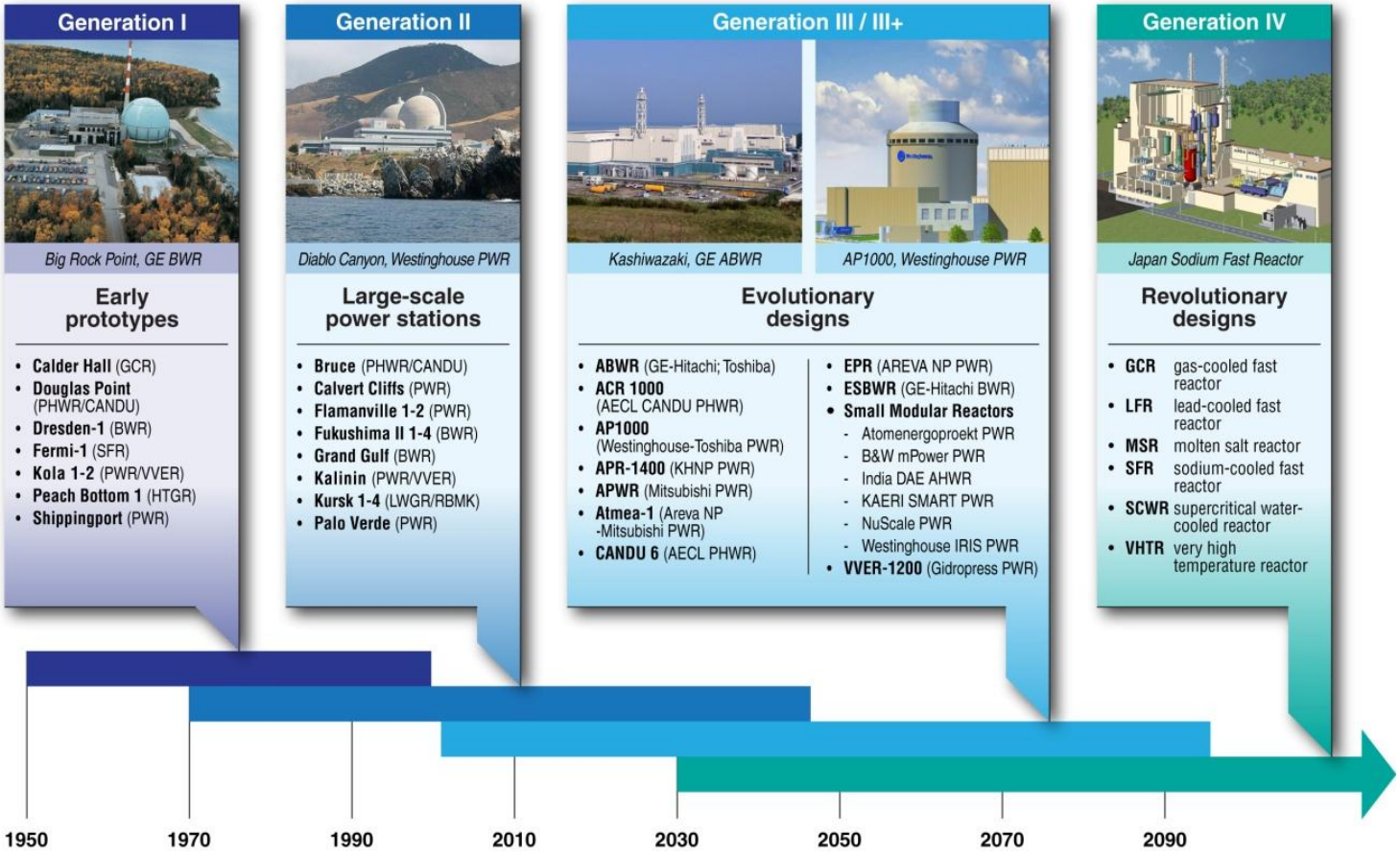


Source: EIA, NEI



Source: MIT

Nuclear Reactor Generations



Current Fleet

Generation II reactors largely ordered in the 1970s
Sized from 600 MW to 1,200 MW – little standardization

Starting Point:

104 Reactors (~100 GW)
67 received 20-year license renewals
- 33 more under review or expected

6 GW of uprates since 1977
Expect ~2,700 GWe-yr until retirement

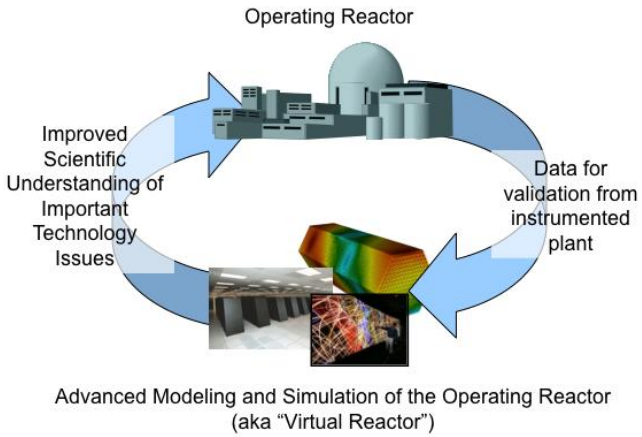
Potential for Improvement:

All 104 receive at least one renewal
- 75 receive a second

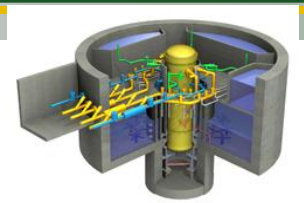
10 GWe of uprates
Additional 1,750 GWe-yr

Steps to Get There:

Fundamental understanding of material aging
Advanced fuel/cladding
Improved instrumentation and control
Advanced modeling and simulation
- Improved characterization of risks



Generation III



Generation III – improved efficiency and safety
Standardized designs, handful of vendors in U.S.

Starting Point:

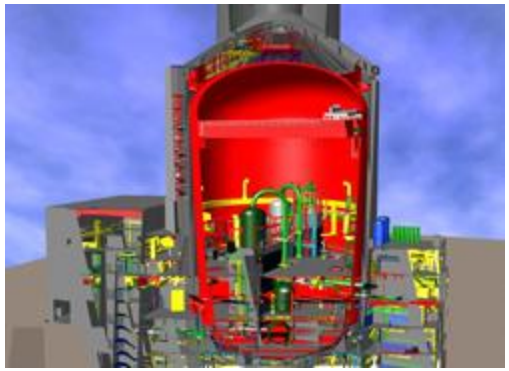
Four reactors (ABWR) built in Japan
Under construction in Asia, Europe
Pre-construction in U.S.
Expect $4,000 - $5,000/kW first plants
- Challenging investment for utilities

Potential for Improvement:

Predictable regulatory processes
Reduce costs for later waves
- Incorporate lessons
- Technological advances

Steps:

Completed NP 2010 program
Programs and policies mitigating investment risk
Demonstration of successful construction and startup
Advanced structural materials and fuels
Advanced fabrication and construction techniques



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Small Modular Reactors

LWRs sized from about 40 MW but less than 300 MW
Desirable safety and security characteristics – uncertain economic tradeoffs

Starting Point:

Early design stage U.S. and abroad
Built around current fuel cycle
LWR technology to facilitate licensing
- Still many years and $X00 M

LCOE of first movers may be > Gen III

Potential for Improvement:

Efficiencies from factory
Smaller footprint
– More sites
Reduced workforce
– Reduced O&M cost

Steps:

First designs through certification, operators through license
Establish technical basis for regulatory framework
Advanced materials – increased compactness
Advanced simulation – natural circulation

Generation IV

Revolutionary designs – beyond current LWRs (2030+)
Address sustainability, safety, economics, nonproliferation

Starting Point:

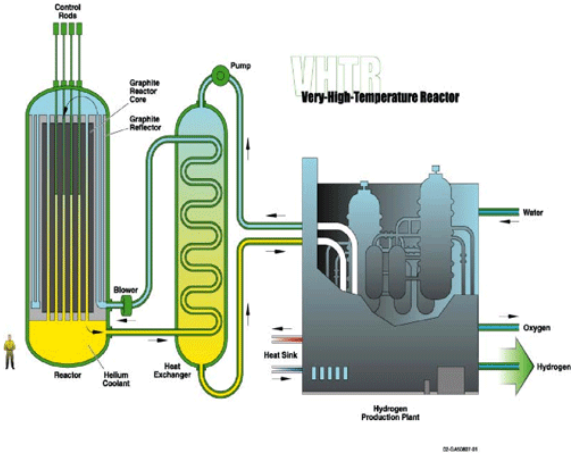
International collaboration on R&D
National prototype demonstration
U.S. focus on high-temperature
and fast reactors
Early models will compromise ideals

Potential for Improvement:

Inherent safety features
Higher temperatures
- Efficiency and applications
More efficient fuel cycles

Steps:

High-performance materials
– withstand temperatures and compatible with coolants
Fuels and cladding enabling high burnup
Advanced energy conversion systems
Demonstrate new technologies



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Used Fuel Management

Government bears responsibility for long-term management
Blue Ribbon Commission to recommend paths forward

Starting Point:

Used fuel stored at reactor sites
- Pools or dry casks

Historical policy of direct disposal
Recycling in use in other countries
- U.S. R&D on advanced recycling

Potential for Improvement:

Three possible strategies:
- Once-through
- Modified open cycle
- Full recycle

Steps:

Establish extended dry cask storage
Identify and characterize geologic repository for waste
Advanced fuel performance – burnup/transmutation
Advance separations – better nonproliferation than current