Nuclear Energy in Idaho: Prospects and Impacts

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Association of Idaho Cities
Workshop on Securing our Energy Future

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INL

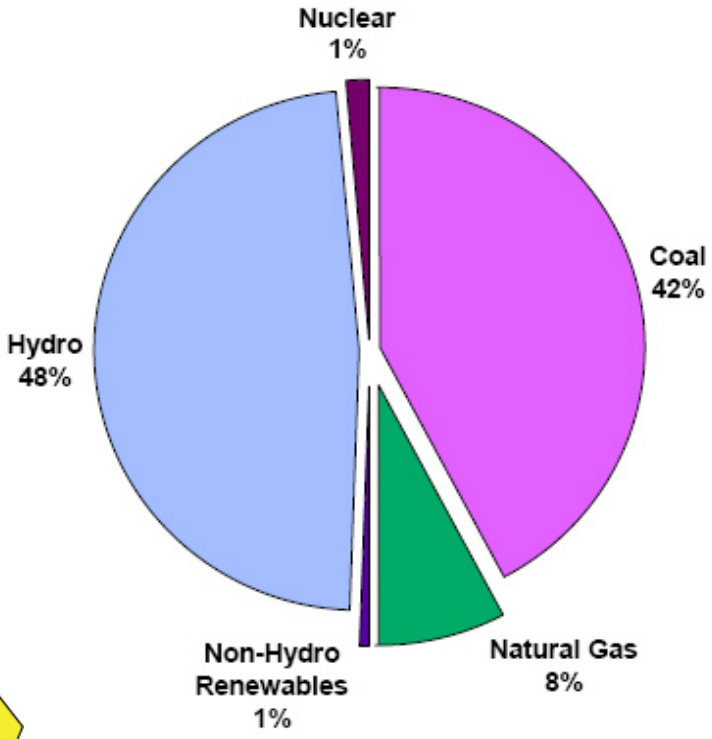
Questions to Explore

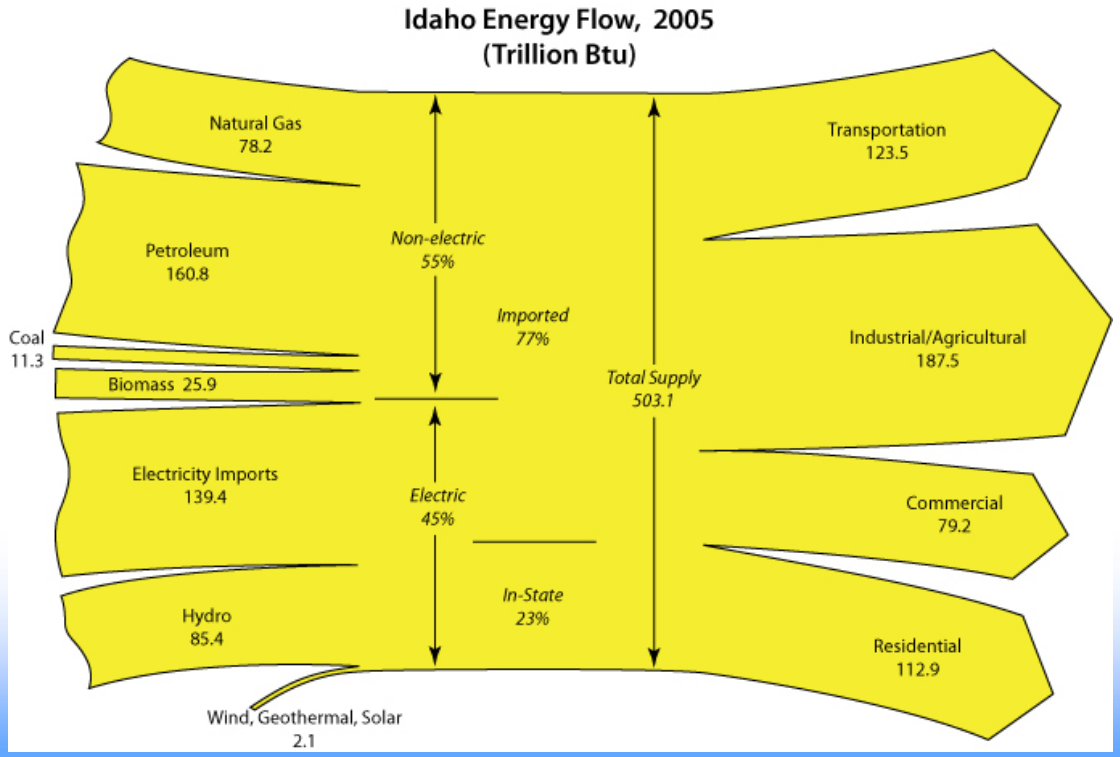
- ***Is there potential for a nuclear power plant in Idaho ? What would be its impacts?***
- ***What's the experimental reactor being talked about at the INL ?***
- ***What's the enrichment plant all about ?***

Idaho's Energy Picture - current

- **Idaho imports 80% of all its energy**
  - **$2.5B sent out of state annually**
- **Idaho imports 45% of its electricity**
- **Used 2,693 aMW in 2005**
  - **Only 1% from non-hydro renewables, mostly wind**

Figure 2.8. Idaho's 2005 Electricity Fuel Mix

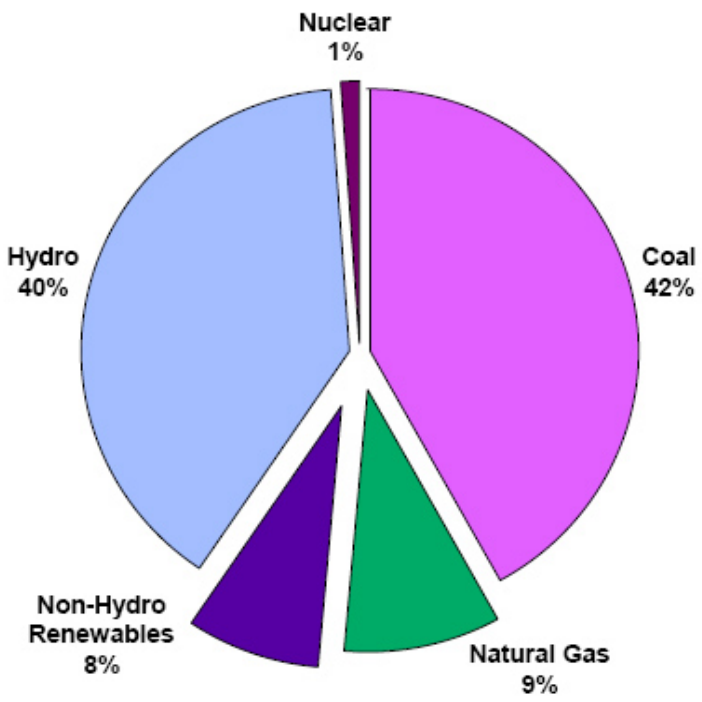




Idaho's Energy Picture – in just 8 years

- **Idaho 2007 Energy Plan: 3,240 aMW by 2015**
  - **Projects need for an additional 550 aMW**
  - **Conservation avoids a further 190 aMW**
  - **Hydro ↓8 points (flat aMW)**
  - **Coal flat % (+230 aMW)**
  - **Wind ↑7 points (+230 aMW)**
  - **Nat gas ↑1 point (+75 aMW)**
- **Recent change in Idaho Power's plans**
  - **Coal no longer a preferred option**
  - **Natural gas addition of 250 MW in 2012**

Figure 3.2. 2015 Fuel Mix for Electricity Production



- **Regional long-term additions (by 2015)**
  - **PacifiCorp +3820 MW (1600 wind)**
  - **Idaho Power +358 MW (250 wind)**
  - **Avista +357 MW (100 wind)**

Projected Regional Additions: 2500 Baseload and 2000 Wind

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Nuclear's Fit with Regional Plans

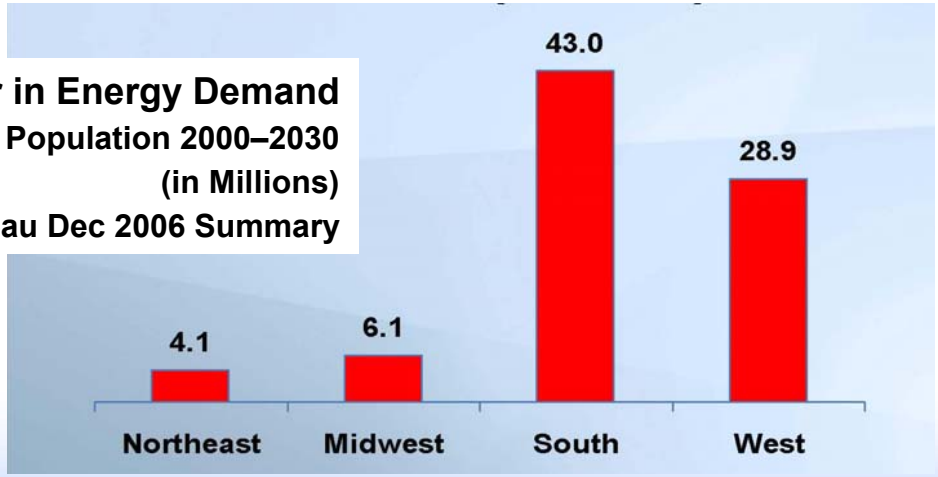
For growth

- **A nuclear plant (1600 MW) could fit the regional need**
- **It would greatly reduce the need for natural gas**

For reducing GHG emissions

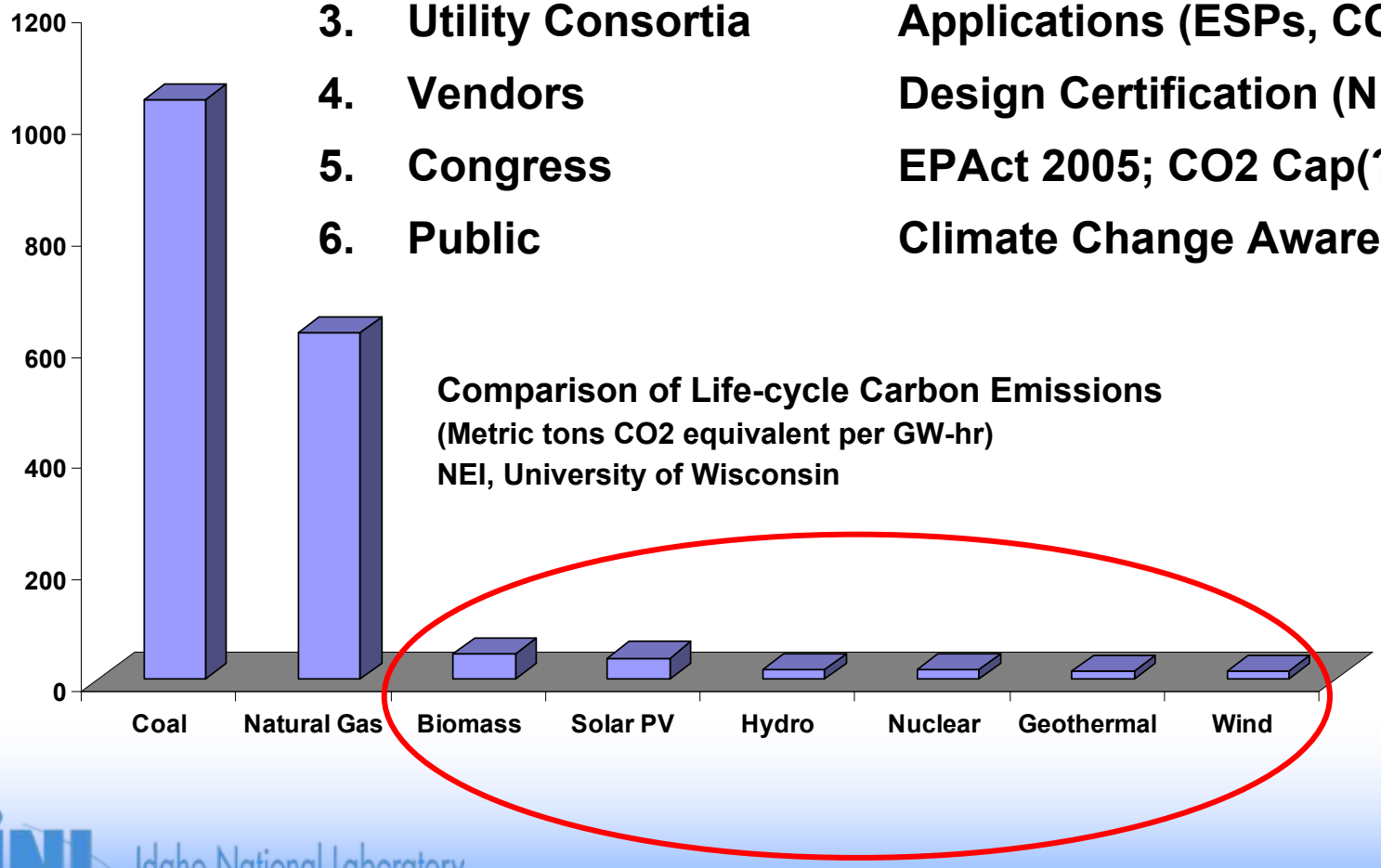
- **A nuclear plant would avoid 850 MW coal and 750 MW of natural gas additions in the region**
- **Avoids about 10 million tons CO2 emissions/year —more than Idaho causes today for its electricity**

Population is a Key Factor in Energy Demand
Changes in U.S. Population 2000–2030
(in Millions)
NEI, U.S. Census Bureau Dec 2006 Summary



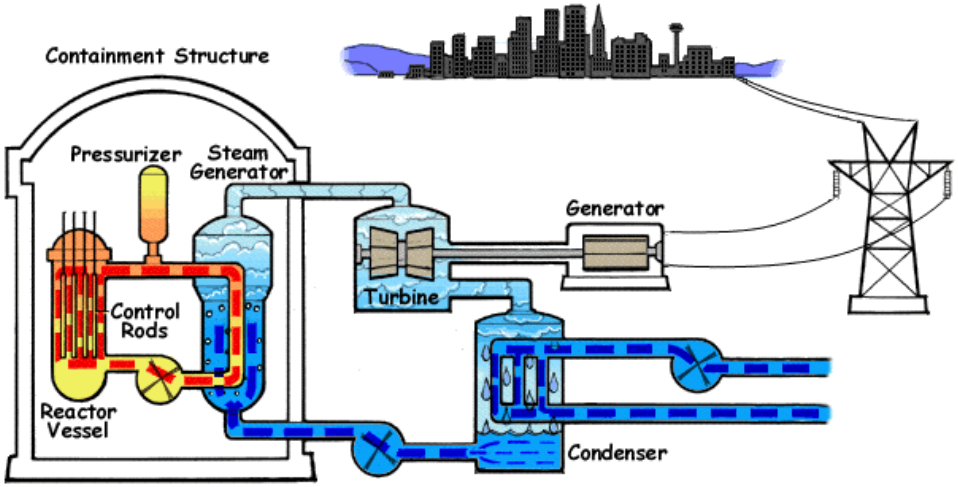
Nuclear: What's been Changing?

1.	NRC	Licensing (Part 52)
2.	DOE	Sponsorship (NP2010)
3.	Utility Consortia	Applications (ESPs, COLAs)
4.	Vendors	Design Certification (NRC)
5.	Congress	EPAct 2005; CO2 Cap(?)
6.	Public	Climate Change Awareness



Comparison of Life-cycle Carbon Emissions
(Metric tons CO2 equivalent per GW-hr)
NEI, University of Wisconsin

A Quick Primer *(more coming later…)*

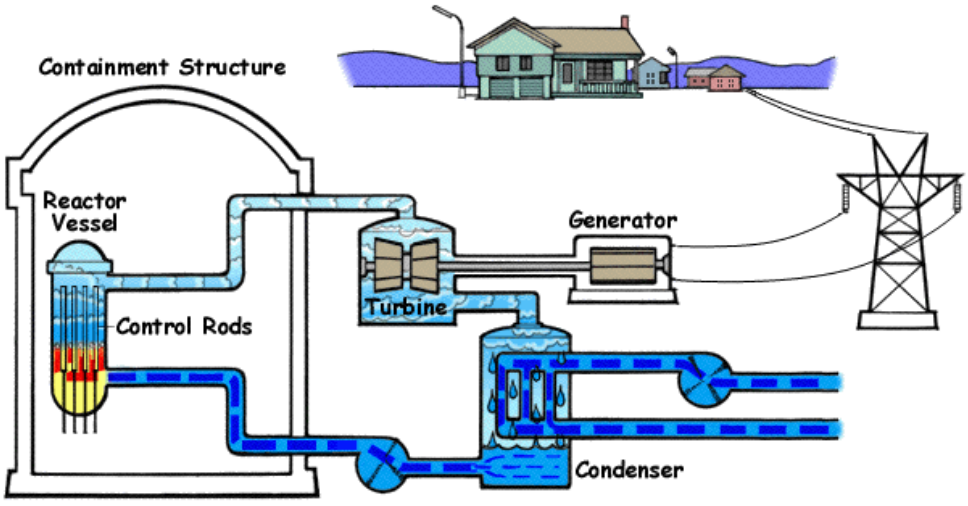


Pressurized Water Reactor (PWR)

High pressure prevents boiling

Steam generated in a second loop

Waste heat to the environment in a third loop



Boiling Water Reactor (BWR)

Lower pressure lets coolant boil

Waste heat in a second loop

Both are known as Light Water Reactors (LWRs)

Today's Nuclear Plant Designs (LWRs)

Name	Vendor	Type	Size (MWe)
ABWR [a, b, c(1997), d] Advanced Boiling Water Reactor	GE/Hitachi, or Toshiba	BWR	1300
AP1000 [b, c(2006), d, e] Advanced Pressurized (Water Reactor)	Westinghouse	PWR	1150
ESBWR [c(2009), d, e] Economic Simplified Boiling Water Reactor	GE/Hitachi	BWR	1400
EPR [b, c(2010), d] Evolutionary Pressurized (Water) Reactor	Areva	PWR	1600
APWR [b, c(2010), d] (US-)Advanced Pressurized Water Reactor	Mitsubishi	PWR	1700

a: Plants in operation worldwide

b: Plants under construction worldwide

c: Design certification by NRC (year certified or expected)

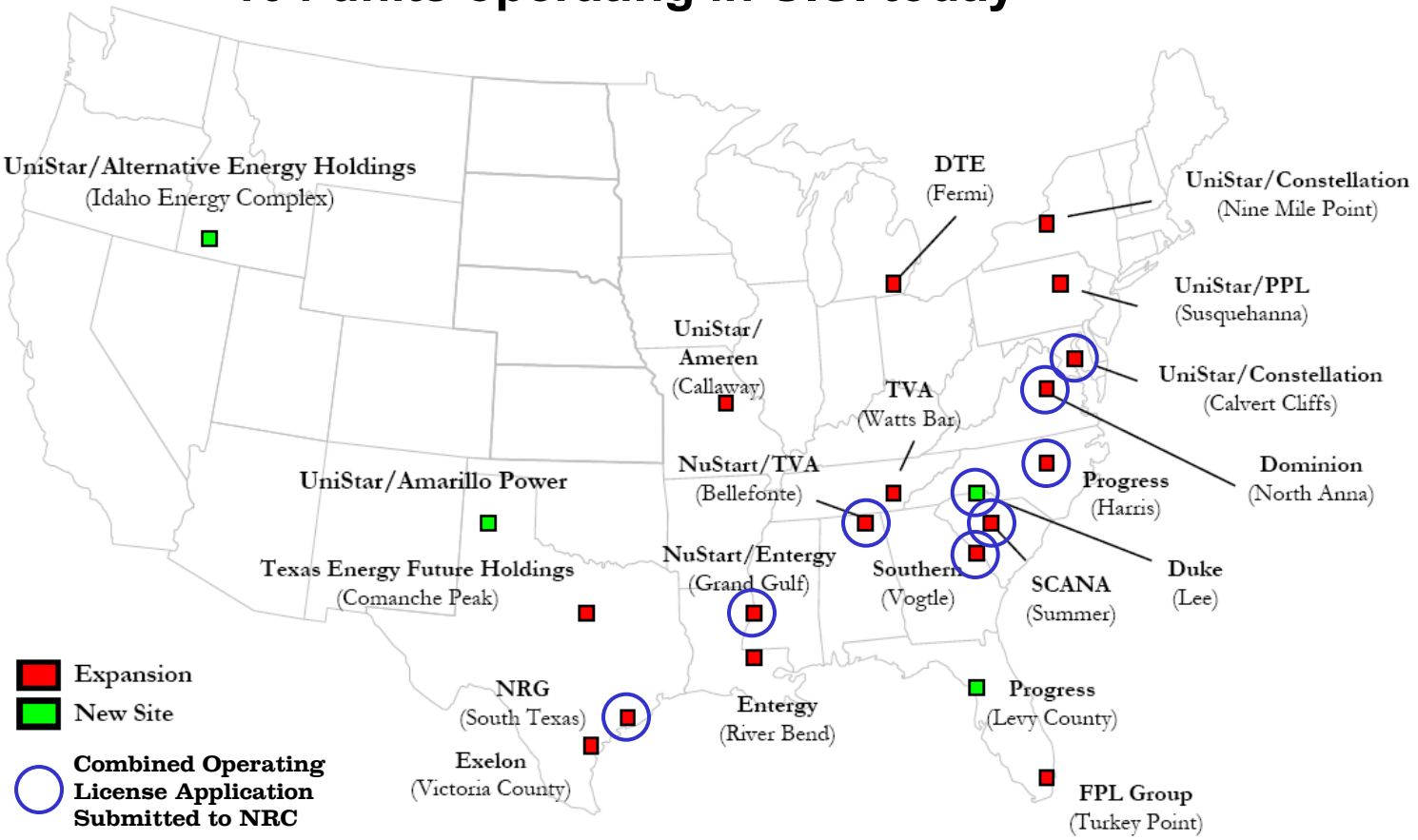
d: Plant named in a license application in the US

e: Passively safe design

The most viable are those with NRC design certification

Distribution of Proposed New Plants

- 9 applications submitted to NRC for 15 new units
- 104 units operating in U.S. today



Constellation Energy, Feb 2008

Two Sets of Very Important Issues

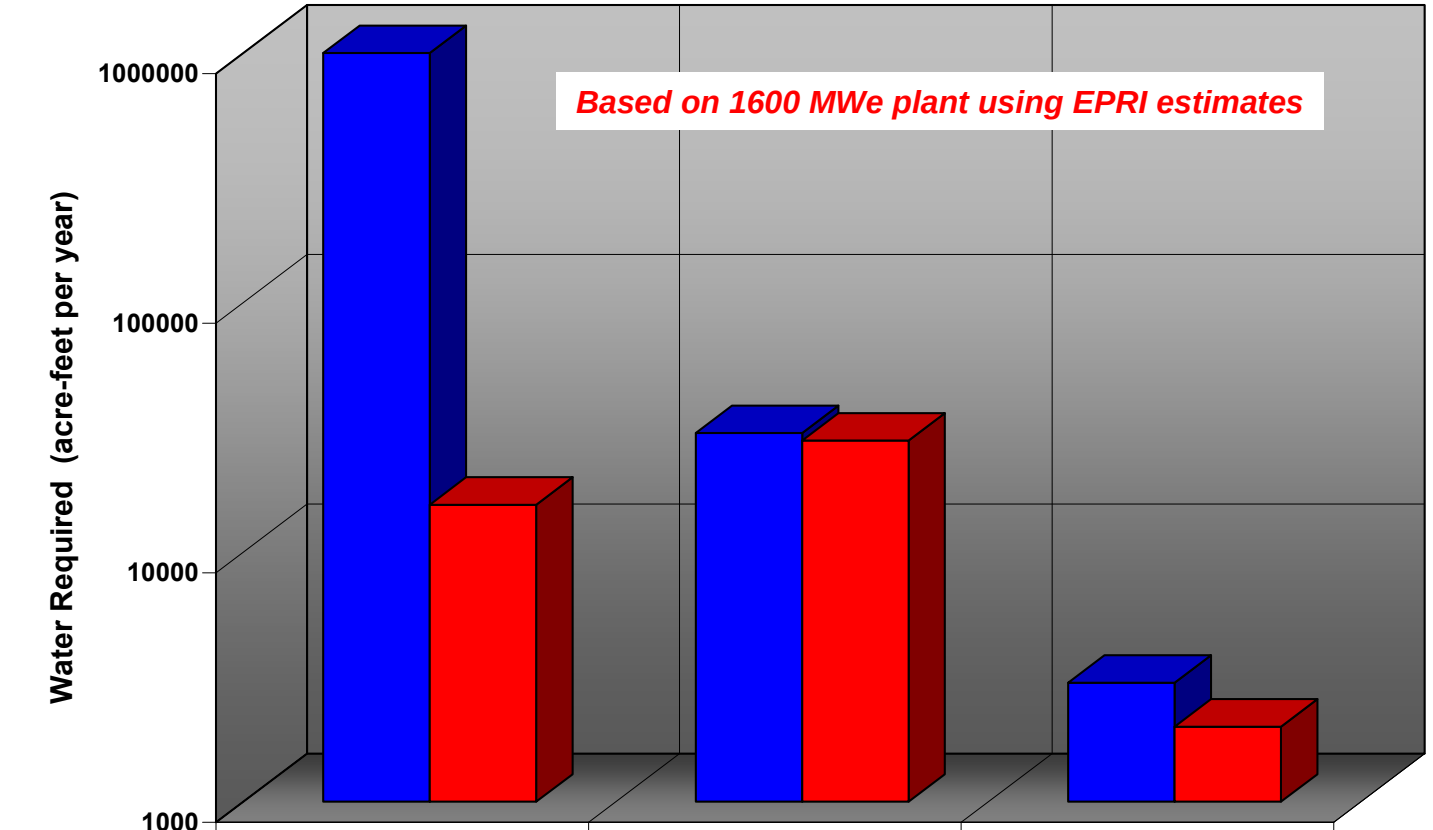
- **Public acceptance**
  - Water use
  - Spent nuclear fuel
  - Seismic
  - Safety
  - Merchant plant perceptions
- **Owner costs, financing and schedule**
  - Infrastructure to produce heavy components and nuclear-grade equipment
  - Transportation of heavy components
  - Construction/operation workforce
  - Cost of new plants

Cooling Technology

- **Once-through**
  - High withdrawal / moderate consumption
  - Water returns 10–15C warmer
- **Evaporative towers**
  - Moderate withdrawal and consumption
  - Would use ½% of the water used to irrigate the Snake River Plain
- **Dry cooling towers**
  - Low withdrawal and consumption
  - Established technology
    - Wyodak plant (360 MW coal)
    - South Africa (2 x 4000 MW coal)
  - Parasitic power losses (avg 2%)
  - Interest at N Anna in ‘hybrid’ cooling

Rancho Seco (900 MWe) cooling towers near Sacramento, CA in 1980s

Water Needed for Cooling



	Once-through Cooling	Evaporative Cooling	Dry Cooling
Withdrawl	1000000	30000	3000
Consumption	15500	28000	2000

Alternative technologies could make a big difference

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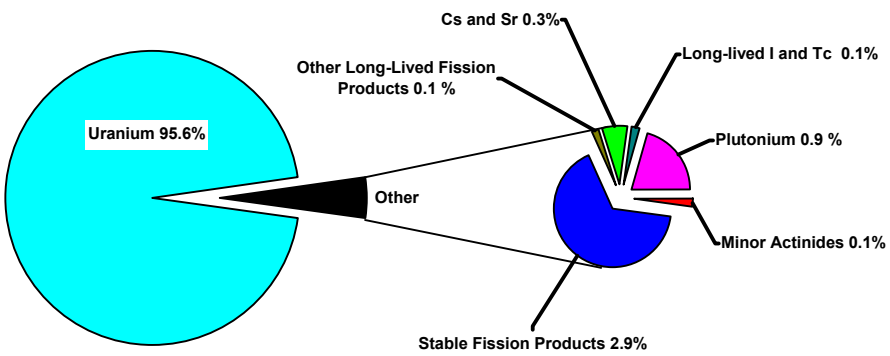
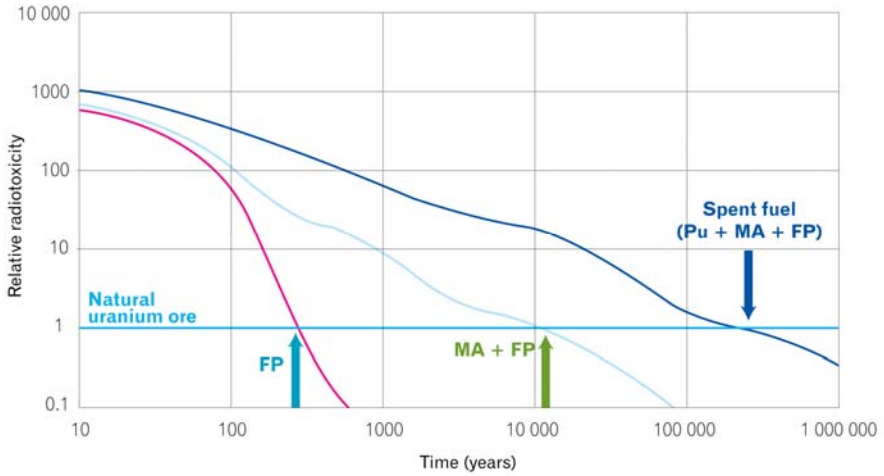
Primer: What's in Spent Nuclear Fuel?



Isotopic basis

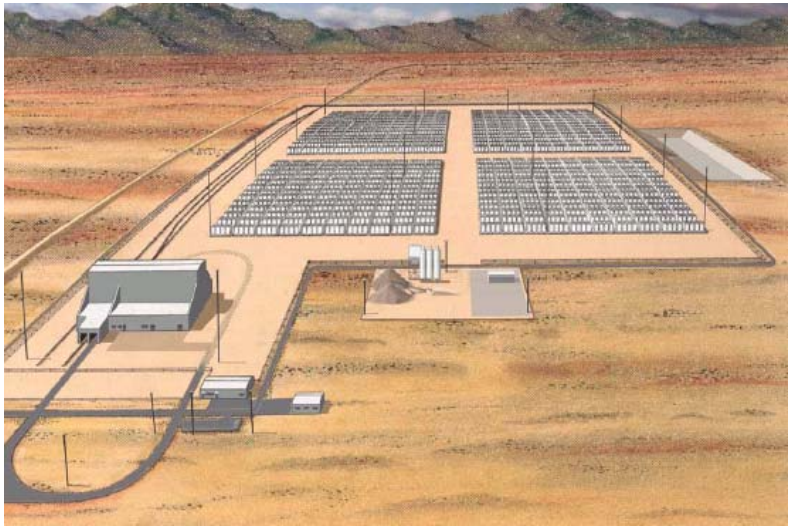


- **The minor actinides (Np, Am, Cm), Pu, and long-lived fission products (LLFPs) are largely responsible for the very long term heat and radiological hazards**
  - **Pu could be recycled as mixed oxide (MOX) fuel in LWRs**
  - **Minor actinides (MA), Pu and LLFPs could be recycled in fast reactors**
- **Recycle of Pu, MA and LLFPs would benefit Yucca**
- **Very few in industry see an economic value to recycling until U ore becomes much more expensive**

SNF: Yucca Mountain Going Slowly

- **All plants have a contract with DOE to receive their spent nuclear fuel (SNF)**
- **DOE has not received any spent fuel to date, citing delays in Yucca Mtn, but has collected 1 mill/kWhr from the utilities to pay for it**
- **Waste Fund is now $20.5B, and growing $750M yearly**
- **NRC license application was submitted in Jun 2008 (4 yr decision)**
- **Congress directed DOE to consolidate SNF from 39 sites ► 1-2 sites**

Yucca Mountain, Nevada

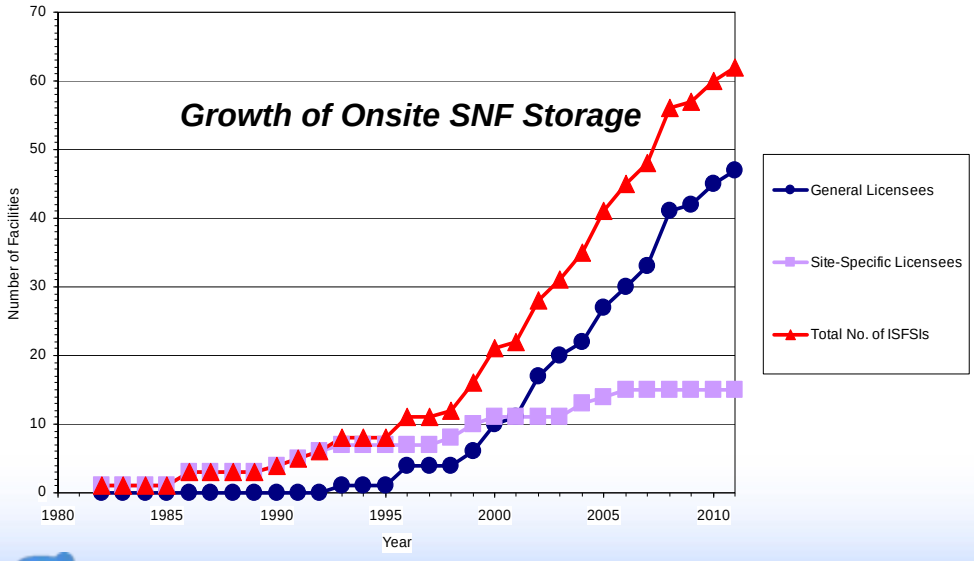


Interim Above-Ground Storage Concept

SNF: On-Site Storage Steps Up

- **Most plant owners are now storing spent fuel onsite in above ground dry storage casks**
  - **The largest casks store about one year's worth of spent fuel, and cost about $1M each**
  - **Ongoing dry storage operations cost about $2M annually at a plant**
  - **The NRC licenses the casks in 20 year increments, and testing continues to determine any life-limiting effects. The practice is likely to continue indefinitely.**

On-site storage buys <u>decades</u> for Yucca Mtn to open



Dry storage at at Connecticut Yankee

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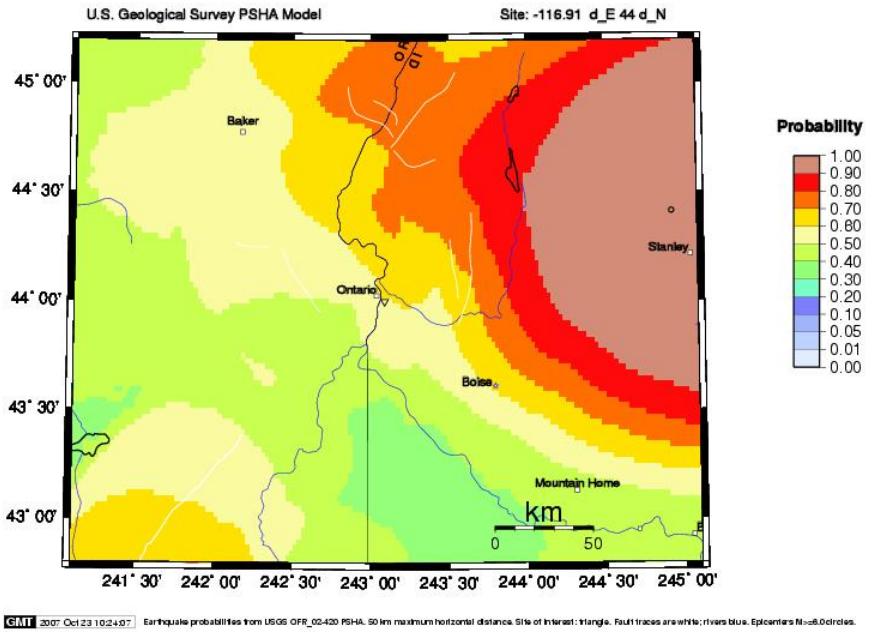
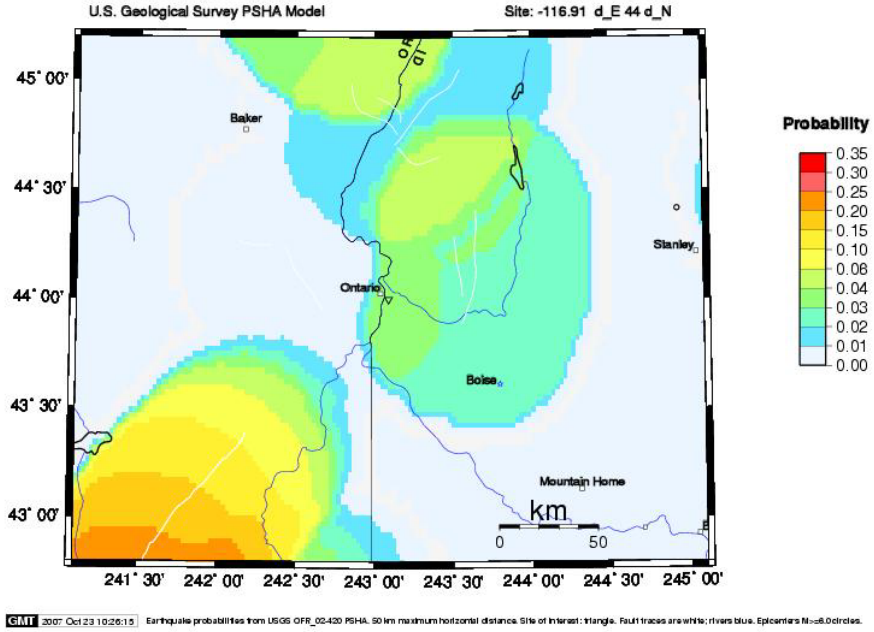
Seismic Hazard

- **Design based on all seismic data and characteristics within ~25 miles; No simple criteria to evaluate a given Idaho site**
- **Recent 6.8 magnitude Niigata quake in Japan did not irreparably damage their 7 units (based on information to date)**

Probability of a Magnitude 6 earthquake within 50 km in the next 1000 years



Probability of a Magnitude 7 earthquake within 50 km in the next 1000 years



Seismic design can significantly affect plant capital cost

Public and Worker Safety

Public exposure and accident risk

- **Routine exposure about 1/10,000th your natural exposure**

Average annual natural background radiation dose	3.0 mSv
additional from man-made sources	0.66
10,000 miles air travel (for example)	0.1
living within 50 miles of a nuclear plant (avg)	0.00009
living near a coal plant (stack emissions)	0.00030

- **Accident risk less than 1/1,000th your other risks**
  - **For people near a nuclear plant, NRC policy is to keep the risk of immediate or latent fatality less than 1/1000th the sum of all other risks they're normally exposed to**

Worker safety

- **US nuclear plants achieved a record in 2006: 0.12 injuries or illnesses per year per 100 workers — about one-tenth that of office workers**

Merchant Plant Concerns and Benefits

– **Merchant plants sometimes painted as unscrupulous**
  - **Nuclear plants must operate at full capacity**
    – **Long term power contracts are essential**
    – **PUC would review Idaho's for need and value**
    – **FERC and PUC would oversee access to transmission**
  - **All 17 nuclear plants sold since 1998 are merchants**
    – **Good experience with them**

\+ **Significant revenues to the local citizens and State**
  - **~500 jobs at the plant, 50% more in surrounding area**
  - **~$40M plant payroll**
  - **~$15M income and indirect taxes estimated**
  - **~$25M annual property taxes estimated**

Infrastructure for Components

- About 20 US plants and another 20-30 worldwide could potentially be ahead of a new plant order in Idaho
- Only one steel works in the world capable of ultraheavy forging
  - Japan Steel Works is doubling their capacity by 2010
  - China, Korea and France are upgrading capabilities
- Only 100 N-stamp suppliers in US, down from 500 in 1980

JSW Muroran plant near Sapporo, Japan

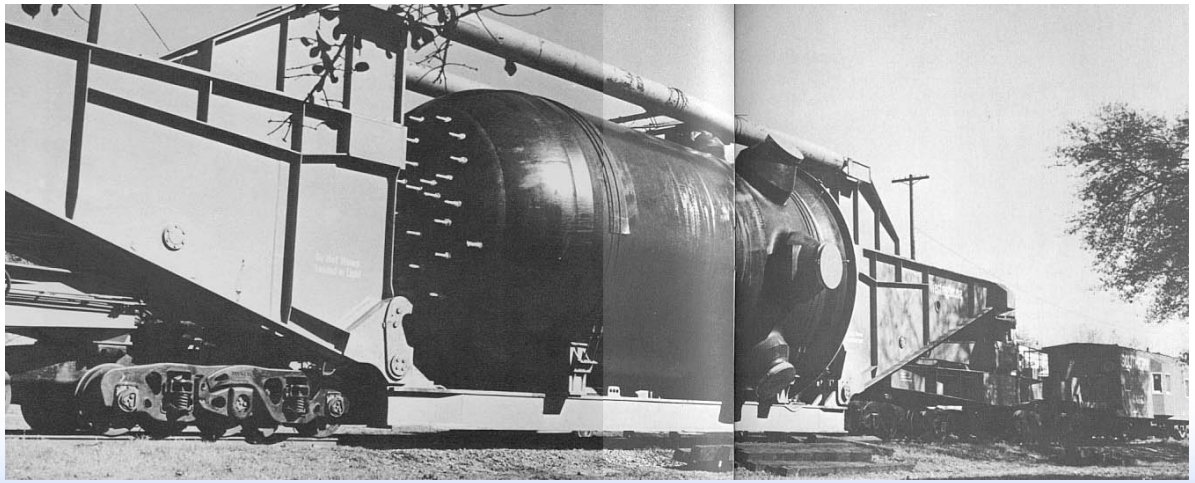
ABWR reactor pressure vessel

Transport of Heavy Components

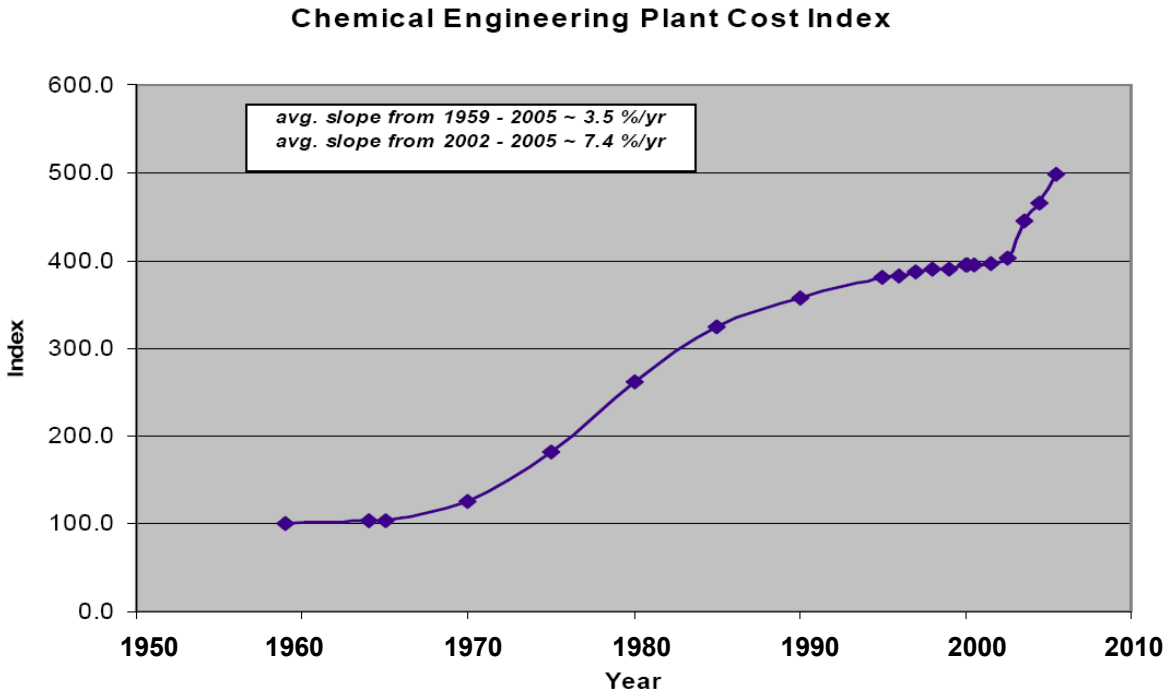
- **Reactor pressure vessels (RPVs) are very big**
  - **Modern RPVs weigh about 550 tons (PWR); 900 tons (BWR)**
  - **40’ tall x 18’ dia (PWR); 70’ x 24’ (BWR)**
- **Transport overland by Schnabel rail cars**
  - **Largest hauls 900 tons; loaded with RPV, it is over 300’ long**
- **Western loading gauge is 16.5’ high above the rails, and 11’ wide**
- **Overland transport from Columbia river is 250 miles**

Westinghouse PWR RPV on a three day, 250 mile move (from Charlestown to Charlotte) to the McGuire nuclear station in North Carolina in 1974.

The load was 350 tons, and reached 22 feet above the rails.



Escalation of Materials & Construction



(% per year)	Escalation 1986-2003	Escalation 2004-2007
Cement	2.7	11.6
Iron/Steel	1.2	19.6
Heavy Constr.	2.2	10.5

Source: American Electric Power

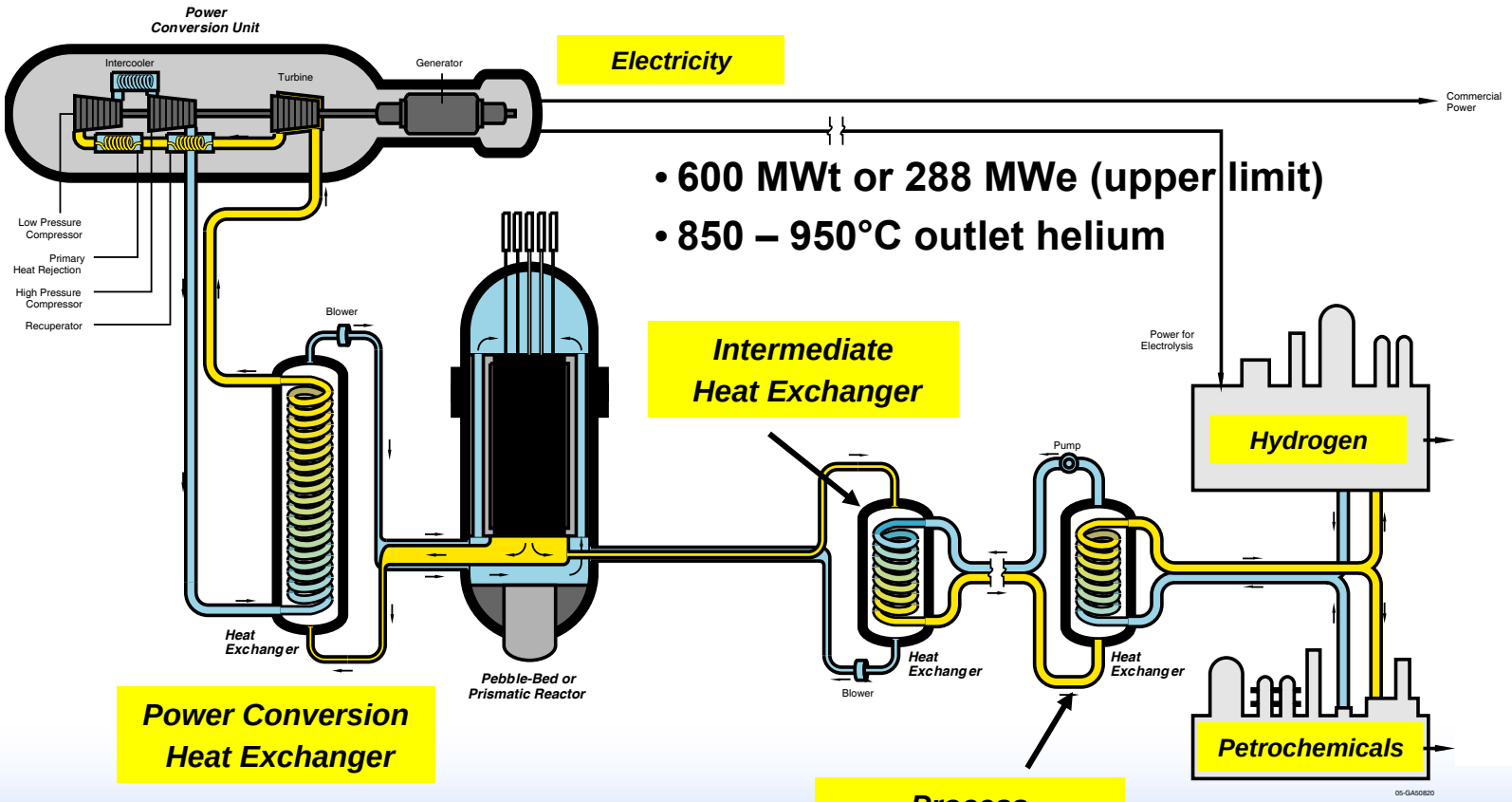
Cost of a New Nuclear Plant

	Capital Cost $/kW	LCOE ¢/kWh
MIT (2003)	2000–2500	5–6
University of Chicago (Aug 2004)	1853	5–8
Standard & Poor's (May 2007)	4000	9–10
Keystone Study (Jun 2007, updated)	3600–4000	9–14
Moody's (Oct 2007)	5000–6000	
California Energy Comm (Dec 2007)	2950	9–12

These reports have many differing assumptions

NGNP Power, Heat and H2 Production

- Next Generation Nuclear Plant proposed at INL
- 30% of U.S. natural gas used for process heat (8% for making H2)



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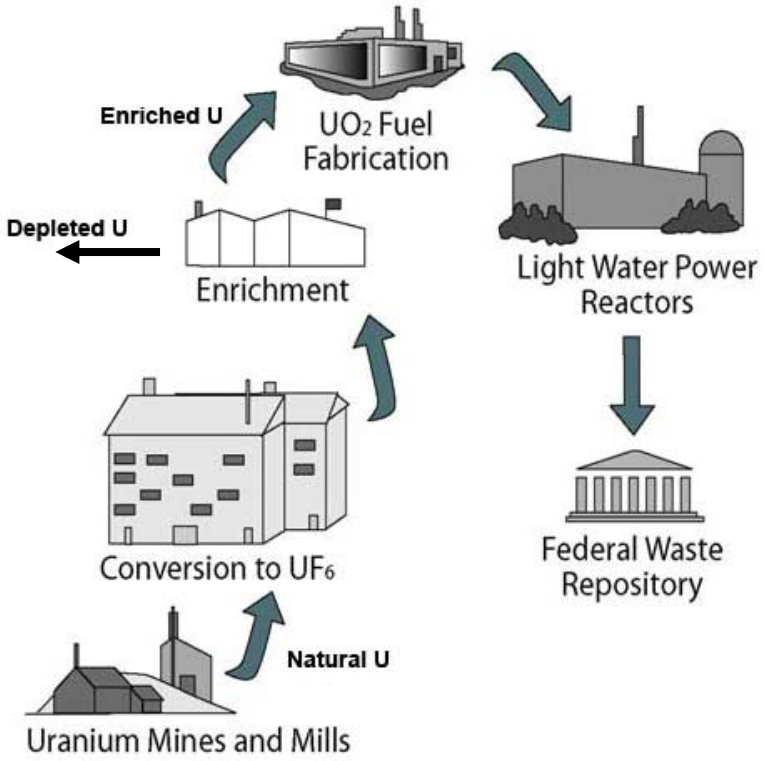
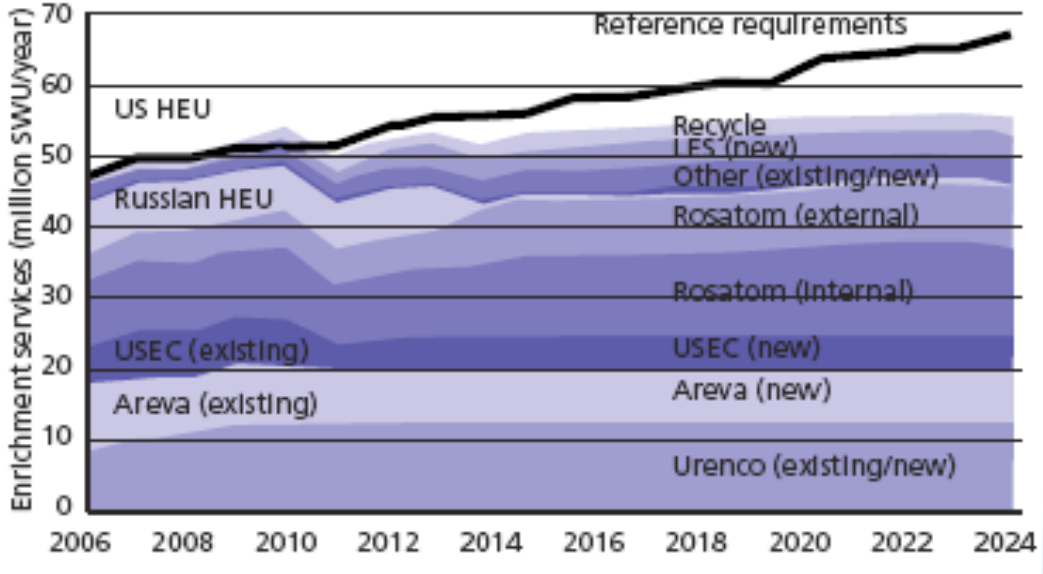
Primer: Nuclear Fuel and Enrichment



- World uses 50M SWU/yr of enrichment
- U.S. uses 20M SWU/yr
- 80% of U.S. enrichment needs imported
- Russian HEU provides about 50% U.S.
- Downblend will end in 2013
- New NM and ID plans will be 3M SWU



UX Consulting 2007

Enriching concentrates the U235 atoms in U

- Natural U: 0.7% U235
- Fuel: 4%
- HEU: 93%

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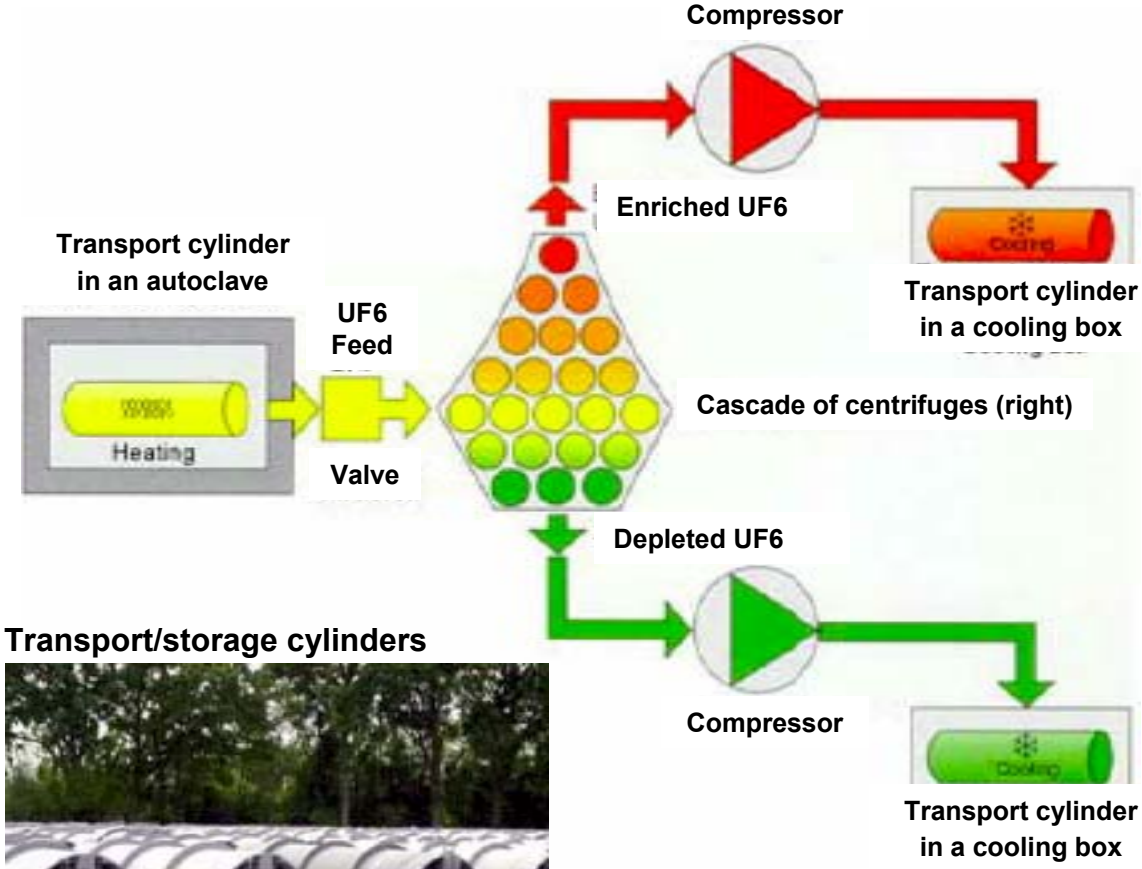
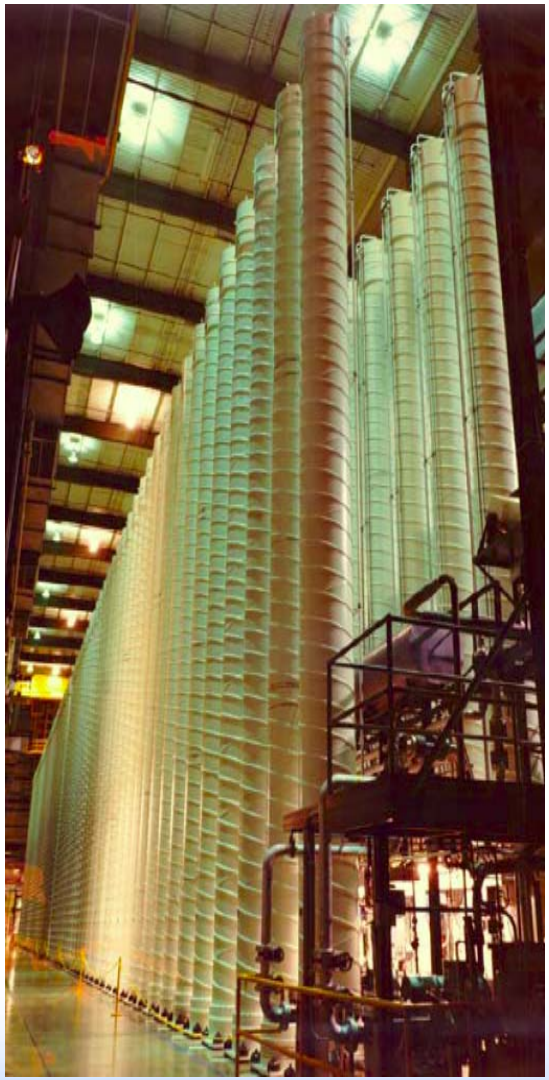
Primer: Enrichment Centrifuge Cascades



Transport/storage cylinders



Centrifuges in a cascade hall

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Summary

- **New nuclear plants will likely begin construction in a few years, in the Southeast**
- **If the 'first wave' is successful (cost & schedule), the potential is there for development in Idaho**
- **Public acceptance in Idaho very dependent upon addressing water, as well as the sensitivity to undue impact on the citizens in the State**
- **INL is developing a high temperature gas reactor for non-electric missions (process heat and hydrogen)**
- **The proposed enrichment plant has much lower impact than a nuclear reactor**