U.S. Uranium and Nuclear Power Outlook: 2008 - 2030

Presented to:
National Research Council of the National Academies

Presented by:
Tom Pool
Chairman, International Nuclear

November 18, 2008
U.S. Electricity Generation 2006

- Coal: 49%
- Petroleum: 2%
- Natural Gas: 20%
- Nuclear: 20%
- Hydro: 7%
- Renewables: 2%

Nuclear power is important in the US
Deregulation gave nuclear power a profit motive.
Nuclear Power – Impetus for Growth

- Global Warming – Minimal Carbon Emissions
- Acid Rain – Minimal SO₂ Emissions
- Energy Independence – US Fuel Aplenty
- Technology is here now
- Low Operating Costs
- Stellar Safety Record
- Minimal Environmental Footprint
Electricity Production Costs
(Operation, Maintenance & Fuel)

cents per kilowatt-hour

Coal
Gas
Nuclear
Petroleum
Nuclear Power – Constraints on Growth

• High Capital Cost, Particularly in the Current World Financial Crisis
Nuclear Power – Means of Growth

• Capacity Factor
• License Extensions
• Uprates
• New Units
Capacity Factor - U.S. Nuclear Reactors
US Reactor License Extensions
(20 years)

- Renewed – 49
- Filed for Renewal – 17
- Expected to File – 33
- Thus, 99 out of 104 existing licenses are expected to be renewed.
- ~2000 reactor years, ~2,000,000 mW years
U.S. Nuclear Reactor Uprates

megawatts per year

Cumulative U.S. Reactor Uprates

megawatts

New Reactor Outlook

• 3 Early Site Permit Applications (ESP) Approved by NRC

• 2 Additional ESP Applications Under Review by NRC

• 24 Combined Construction and Operating License Applications (CCOL) Submitted to NRC

• 6 Additional CCOL Applications Expected
Nuclear Generating Capacity – U.S.A.
(WNA 2007)
World Uranium Requirements Forecasts
(US Energy Information Administration)

2000 = Clinton/Gore
2001 = Bush/Cheney
An intense safety culture exists at nuclear power plants
U.S. Energy Production Fatalities
(1992-2006)
Radiation Safety

• Linear-No-Threshold
  – Any additional radiation causes more cancers

• Hormesis
  – Low level radiation stimulates natural protection systems
U.S. Uranium Balance

Consumption and Production

million pounds U3O8 per year


Consumption: pink triangles
Production: blue triangles
Uranium Supply - USA

Other
Namibia
South Africa
Kazakhstan
Uzbekistan
Russia
Australia
USA
Canada

millions of pounds U3O8 per year

United States

Canada
U.S. Uranium Reserves

New Mexico

Wyoming

Arizona, Colorado, Utah

Texas

Nebraska, S. Dakota, Other

million pounds U3O8

<$30/lb  <$50/lb

- Colorado Plateau: 2,500 million pounds U3O8
- Wyoming Basins: 650 million pounds U3O8
- Texas Coastal Plain: 500 million pounds U3O8
- Basin & Range: 400 million pounds U3O8
- Central & Southern Rockies: 200 million pounds U3O8
- Northern Rockies: 100 million pounds U3O8
- Other Regions: 200 million pounds U3O8

million pounds U3O8
**Phosphates**

- The US has huge resources of uraniferous phosphates in the southeastern US and in the northern Rockies: >40 billion pounds $\text{U}_3\text{O}_8$
- Uranium in these phosphates is recoverable at moderate to high cost.
  - Research is underway under private auspices to reduce costs.
- Uranium in these phosphates currently goes into fertilizer products and onto the fields.
US Uranium Resources - Credibility

- Responsibility of US Energy Information Administration
- Last Major Update Was 1984
- Subsequent Updates Made By Subtraction and Inflation Adjustments
- Necessary and Important for Long-Term Policy Decisions
US Uranium Resources: Socio – Political Lock-Up

• Virginia – Moratorium (de facto) on Uranium Mining
• Montana – Moratorium (de facto) on Uranium Milling
• New Mexico – Large-Scale Navajo Cultural Issues
• Arizona – Grand Canyon Issues
Uranium - US Secondary Supply

- **Inventories ~ 160 M lbs U$_3$O$_8$**
  - US DOE ~ 50 M lbs U$_3$O$_8$
  - Suppliers ~ 30 M lbs U$_3$O$_8$
    - Producers
    - Traders
  - Utilities ~ 80 M lbs U$_3$O$_8$

- **Enrichment Tails/Depleted Uranium ~ 400 M lbs U$_3$O$_8$**
  (Potential @ $50 - $100/lb U$_3$O$_8$)

- **US Nuclear Weapons ~ 200 M lbs U$_3$O$_8$**
U.S. Uranium Inventories

Utilities
Suppliers
U.S. Government
Uranium from Nuclear Warheads
(Highly Enriched Uranium)

13,795 Russian nuclear warheads dismantled and blended into nuclear fuel to date. Total of 20,000 scheduled by 2013.
Historical Uranium Prices

US $ per pound U3O8

Nominal $ - Constant 2008 $
Recent Uranium Spot Market Prices
Uranium Rush
An exciting new electric game for the family

Make a million dollars!

Your 'Geiger counter' lights and buzzes your way to fun and fortune
Uranium Recovery Methods 1

- Conventional Mining
  - Surface
  - Underground

- Conventional Milling
  - Acid
  - Alkaline

- In Situ Recovery
  - Acid
  - Alkaline
Uranium Recovery Methods 2

• By Product
  – Copper (Australia)
  – Gold (South Africa)
  – Process Waste (USA)
  – Phosphoric Acid (USA Historical)

• Potential Methods
  – Hydraulic Borehole Mining
  – Engineered Percolation Recovery (Heap Leaching)
US Uranium Production by Method

- million pounds U3O8 per year

- by-product
- conventional
- in situ recovery
Highland Open Pit Mine, Wyoming
Uranium Mill - Colorado
Pigeon Mine Site
During Full Production and Ore Sorting
November 16, 1989
(view looking north)
Pigeon Mine Site
Reclamation Completed April 1, 1991
(view looking north)
Smith Ranch, Wyoming
In Situ Recovery Uranium Mine
Regulatory Progress

• NRC Early Site Permits

• NRC “Standard” Reactor Design Acceptance

• NRC Combined Construction and Operating License

• NRC Draft Generic Environmental Impact Statement for In Situ Recovery
Regulatory Issues

• NRC Backlog and Timelines

• EPA – “Nothing is below regulatory concern to the EPA”

• Overlapping Regulatory Jurisdictions
  – Federal, State, County
  – “Indian Country”, New Mexico

• Interveners *Ad Infinitum, Ad Nauseum*
  – Too much opportunity to delay/derail a reasonable process
Regulatory Issues

- Restoration to “Class of Use” for in situ recovery projects
- Consideration of “natural attenuation” for in situ recovery projects
- Reconsideration of the concept that in situ recovery constitutes “milling underground”
Opposition

Most Opposition to Nuclear Power and Uranium Can Be Characterized as:

- Lack of Understanding (Fear of the Unknown)
  - Connection With Nuclear Weapons
  - Chernobyl & Three Mile Island
- Prejudice
- Mysticism
- Political Positioning
- Over Reaction
- Media Sensationalism
- Mistrust of Government Regulators
Rebuttal to Opposition

• Stakeholder Identification
• Stakeholder Engagement
• Stakeholder Education
• Transparency
• Regulatory Perfection
US Uranium & Nuclear Key Elements

• Modest growth in US nuclear power
  – Capital cost is major constraint

• Large US uranium resources
  – Mainly moderate to high cost

• Production increasingly focused on in situ recovery
  – Lower cost & lower environment impact

• Overlapping regulatory regimes
  – Federal, State, County
US Uranium & Nuclear Key Elements

- Interveners *ad infinitum, ad nauseum*

- Health & Safety
  - Exemplary!!!
  - Hormesis vs. Linear-No-Threshold

- Politics – Outlook is poor

- Sustainability – Fuel for >100 years

- Personnel – Behind the curve