Uranium Industry Re-Development and Expansion in the Early 21st Century:

Supplying Fuel for the Expansion of Nuclear Power in the U.S. -

The Environment vs. The Paradigm

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Basis of Opinions Presented

- Mr. M. Campbell serves as Chairman of the Uranium Committee, Energy Minerals Div., AAPG.

- This presentation is based on the committee’s Uranium Report for 2005 (See References for URL).

- The EMD Uranium Committee members include:
  
  Joseph Evensen, Ph. D.,
  ExxonMobil Upstream Research Co.

  Henry M. Wise, P.G.,
  Eagle Construction & Environmental, Inc.

  and a number of Special Consultants.
Basis of Opinions Presented (Cont’d)

- Uranium Industry
- Geology, Hydrogeology, & Economics
- Environmental Industry

Opinions
Basis of Opinions Presented (Cont’d)

We are in this together; united we stand, divided we fall…
Fear of Nuclear Energy

Fear
Weapon of War, Hollywood & Press Media

Risk
Comparative Analysis w/ Other Types of Risk: NIMBY - Industry, Local, etc.

Assessment
Safety Record, Economic Advantage, Jobs, Technology, Management

Fear of Nuclear Energy
Energy Production by Major Source, 1949-2003


- Coal
- Crude Oil
- Natural Gas
- Nuclear Electric Power
- Hydroelectric Power
- NGPL
- Wood, Waste, Alcohol

* Natural gas plant liquids.
Energy Production in the U.S.

Energy Production by Major Source, 1949-2003

Changes in Coal Consumption

Changes in Natural Gas Consumption
Nuclear Generation of Electricity

U.S. Nuclear Electricity Generation, 1973 to 1999

Billion Kilowatt Hours

- Grandfather Economic Energy Report
- http://mwhodges.home.att.net/energy/energy.htm
- Data source: US DOE-BA

Last Nuclear Power Plant Constructed in U.S.: 1978

Increasing Reactor Efficiency

( Utilizing Optimum Capacity )

3-Mile Incident
Nuclear Power Plant Sites

Nuclear Power Plant Sites & Number of Reactors

Map from: American Nuclear Society, Inc.
Night Lights in U.S. - Electricity Usage
Nuclear Power Plants in the World

Where are the Plants? U.S., U.K., Canada, Europe, Eastern Russia, China, India, Pakistan, Japan, Korea, Mexico, Brazil, Argentina, etc.

Map from American Nuclear Society, Inc.
Night Lights in World - Electricity Usage

Where are the Plants? U.S., U.K., Canada, Europe, Eastern Russia, China, India, Pakistan, Japan, Koreas, etc.
Where are the Plants in Europe? U.K., Spain, France, Switzerland, Germany, Belgium, Czech Republic, Slovakia, Slovenia, Hungary, Romania, Bulgaria, Sweden, Finland, etc.
Night Lights in World - Electricity Usage

Where are the Other Plants? U.K., Canada, Eastern Russia, China, India, Pakistan, Japan, Koreas, Mexico, South Africa, etc.
Who has the greatest number of plants/area of country? Japan.
Uranium Exploration Trend Areas in U.S.

Major U.S. Uranium Trend Areas
(Does Not Include Frontier Uranium Areas)

Sources: Based on U.S. Department of Energy, Grand Junction Project Office (GJPO), National Uranium Resources Evaluation, Interim Report (June 1979) Figure 3.2; and GJPO data files.
Roll Front in Mine Pit Wall, Texas

Oxidized Zone

Ore Zone

Molybdenite Zone
Roll Front in Mine Pit Wall, Wyoming
CONCEPTUAL MODEL OF URANIUM ROLL FRONT DEPOSIT
(After Devoto, 1978)
Roll-Front Exploration Guide, Wyoming

Rubin, B., 1970
Roll Front in Mine Pit Wall, Texas (Cont’d)
Uranium Production

Good Science

$U_3O_8$ Production

Good Technology

Prices > $20.00
Uranium Production: In Situ Leaching

potable water well

plant

radon

evaporation pond

upper aquifer

leaching solution

ore

Reduced Zone

Oxidized Zone

Ground-Water Flow Direction
Uranium Production: In Situ Leaching

Typical 5-spot well pattern.
Uranium Production: In Situ Leaching

FLOW PROCESS SCHEMATIC

URANIUM EXTRACTION

YELLOWCAKE RECOVERY
Making Certain Assumptions,
One Full Barrel of Yellowcake ($U_3O_8$):

@ a Market Price of $20.00 / lb = $17,600.00

@ a Market Price of $40.00 / lb = $35,000.00
Uranium Prices

Production

Uranium Price

# Reactors

Supply

Demand
Uranium Prices (Cont’d)

Beginning of New Era
Uranium Production

Present Worldwide Consumption by 435 Reactors:

180 million lbs U₃O₈/yr

U. S. Consumption by 104 Reactors:

43 million lbs U₃O₈/yr

or 414,000 lbs U₃O₈/Reactor/2-3 yrs

Field Deposits

Fuel Supply

“Megatons to Megawatts”

Increased Reactor Efficiency
U.S. Uranium Mine Production, 1993-2004

Uranium Production (Cont’d)

U.S. Uranium Concentrate Production and Shipments, 1993-2004

Uranium Production (Cont’d)

Owners and Operators of U.S. Civilian Nuclear Power Reactors Maximum Contracted Purchases of Uranium from Suppliers, in Effect at the End of 2004, by Delivery Year, 2005-2008

Source: Energy Information Administration, Form EIA-858 "Uranium Marketing Annual Survey" (2004).
Uranium Production (Cont’d)

Employment in the U.S. Uranium Production Industry by Category, 1993-2004

Economics & Environmental Issues

Popular Support

Nuclear Power Expansion in U.S.

Advantageous Cost to Produce Electricity

Prices > $20.00 / Pound U₃O₈
Land Needed by Wind or Solar Energy to Match Annual Nuclear Energy Production*

Wind Turbines  Solar Cells

Area equal to Minnesota  Area equal to West Virginia

* 768 billion kilowatt-hours
Economics & Environmental Issues (Cont’d)

New Technology Required to Reduce CO₂ Emissions
Nuclear Power Plant Safety

Over Past 40 Years:

1) Outstanding Safety Record
2) Improved Technology
3) Improved Operations Management
4) Improved Construction Cost Management
Nuclear Waste Transportation & Storage: Fear of Nuclear Waste?

Waste Transportation:
1) Major Container Research &
2) Improved Technology

Waste Storage:
1) Favorable Geologic &
2) Hydrogeologic Studies

International Activities:
Favorable Results in:
1) Canada, 2) Belgium, 3) France, etc.
Nuclear Waste Transportation & Storage: Fear of Nuclear Waste? (Cont’d)

Waste Transportation:
Container Research & Improved Technology
(See References)

Waste Storage:
Geologic & Hydrogeologic Studies
(See References)
Nuclear Waste Transportation & Storage: Fear of Nuclear Waste? (Cont’d)

Fear
Exposure?
Drinking Water?
Hollywood
&
Press Media

Assessment
Safety Record, Good Science
New Technology, Improved Management

Risk
Comparative Analysis
w/ Other Types of Risk:
NIMBY - Industry, Local, &
w/ International Solutions
(See References)
Geologic Research in Uranium Exploration

Technical Literature, Core Analyses, and Economic Assessments
Uranium Exploration

Claim Locations w/ GPS

Drilling

Coring & Logging

...and More Drilling
Uranium Field Work

Underground Mines

Field Reconnaissance & Mining Claims

Environmental Monitoring Wells
...And there are always disagreements....
Conclusions…
Nuclear Power is One of the Answers…

Now and Later

Fission is the Bridge to Fusion

"The energy gap between decreasing supply and increasing demand will develop when peak oil production occurs sometime after 2020. At that point, the long-term solution to energy supply will be conversion to nuclear, solar, and hydrogen power."

From: Limerick, P.N., et al., 2003

Graph courtesy of John D. Edwards.
References

AAPG, Energy Minerals Div., Uranium Section URLs and References:
http://emd.aapg.org/members_only/uranium/links.cfm (Members Only Page)

http://emd.aapg.org/technical_areas/uranium.cfm (Public Page)


References (Cont’d)


References (Cont’d)


**On Nuclear Waste Transportation & Storage:**
**Facts about Radiation:**
http://www.ocrwm.doe.gov/factsheets/doeymp0403.shtml

**Yucca Mt., Nevada:**
http://www.ocrwm.doe.gov/index.shtml
References (Cont’d)

U.S. DOE Nuclear Remediation Programs (By State):
http://www.em.doe.gov/doe/em/frontdoor/0,2195,14763,00.html

Google for numerous other Web sites containing other information. For example: Pro-Coal Use in Texas:
http://www.rrc.state.tx.us/tepc/616presentations/EPCcoalpresentation.pdf

For a comprehensive list of URLs and References on Uranium Exploration, Development, Prices, and Associated Environmental Issues, see: AAPG, Energy Minerals Div., Uranium Section Members Only Page:
http://emd.aapg.org/members_only/uranium/links.cfm

For an online source of this presentation, see:
http://www.mdcampbell.com/Denver/CampbellCOGAConferenceSession1.ppt

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