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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M. D. Campbell and Associates, L.P.
Houston, Texas
Michael D. Campbell, P.G., P.H.
Managing Partner
and
M. David Campbell, P.G.
Partner and Program Manager

M. D. Campbell and Associates, L.P.
Houston, Texas

www.mdcampbell.com
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)

Opinions

Uranium Industry

Geology, Hydrogeology, & Economics

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

Fear
Weapon of War, Hollywood & Press Media

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

Risk
Comparative Analysis w/ Other Types of Risk: NIMBY - Industry, Local, etc.
Energy Production in the U.S.

Energy Production by Major Source, 1949-2003

- Coal
- Natural Gas
- Crude Oil
- Nuclear Electric Power
- Hydroelectric Power
- Wood, Waste, Alcohol
- NGPL¹

¹ 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

* NGPL: Natural gas plant liquids.
Nuclear Generation of Electricity

U.S. Nuclear Electricity Generation, 1973 to 1999

Billion Kilowatt Hours

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

Last Nuclear Power Plant Constructed in U.S.

1978

3-Mile Incident

Increasing Reactor Efficiency

(Ulilizing Optimum Capacity)
Nuclear Power Plant Sites
Night Lights in U.S. - Electricity Usage
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, Koreas, Mexico, Brazil, Argentina, etc.
Night Lights in World - Electricity Usage

Where are the Plants? U.S., U.K., Canada, Europe, Eastern Russia, China, India, Pakistan, Japan, Koreas, etc.
Nuclear Power Plants in Europe

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

Oxidized Zone

Ore Zone
Roll-Front Exploration Guide, Wyoming

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

Ore Zone

Proto-Ore Zone
Uranium Production

Good Science

U$_3$O$_8$ Production

Good Technology

Prices > $20.00
Uranium Production: In Situ Leaching

- Oxidized Zone
- Reduced Zone
- Ground-Water Flow Direction
- leaching solution
- potable water well
- plant
- radon
- evaporation pond
- upper aquifer
- confined deep aquifer
Uranium Production: In Situ Leaching

Typical 5-spot well pattern.
Uranium Production: In Situ Leaching
Making Certain Assumptions, One Full Barrel of Yellowcake (U₃O₈):

- @ 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)

Spot-Price History of $U_3O_8$
1948 - 2005

- 1st Electricity Produced from Nuclear Fusion
- Last Nuclear Plant Built in U.S.
- 3-Mile Island Incident
- Chernobyl

2004 Dollars

Current (Old) Dollars

$ per Pound U3O8
$110.00
$100.00
$90.00
$80.00
$70.00
$60.00
$50.00
$40.00
$30.00
$20.00
$10.00
$0.00


See Next Figure
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
Uranium Production (Cont'd)

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
Economics & Environmental Issues (Cont'd)

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
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?

Covered over the past 40 years:

**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

Environmental Monitoring Wells

Field Reconnaissance & Mining Claims
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.
AAPG, Energy Minerals Div., Uranium Section URLs and References: http://emd.aapg.org/members_only/uranium/links.cfm (Members Only 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