



**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

**Rocky Mountain Natural Gas Strategy Conference
& Investment Forum: Session 1**

Presented by

Colorado Oil & Gas Association

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Basis of Opinions Presented

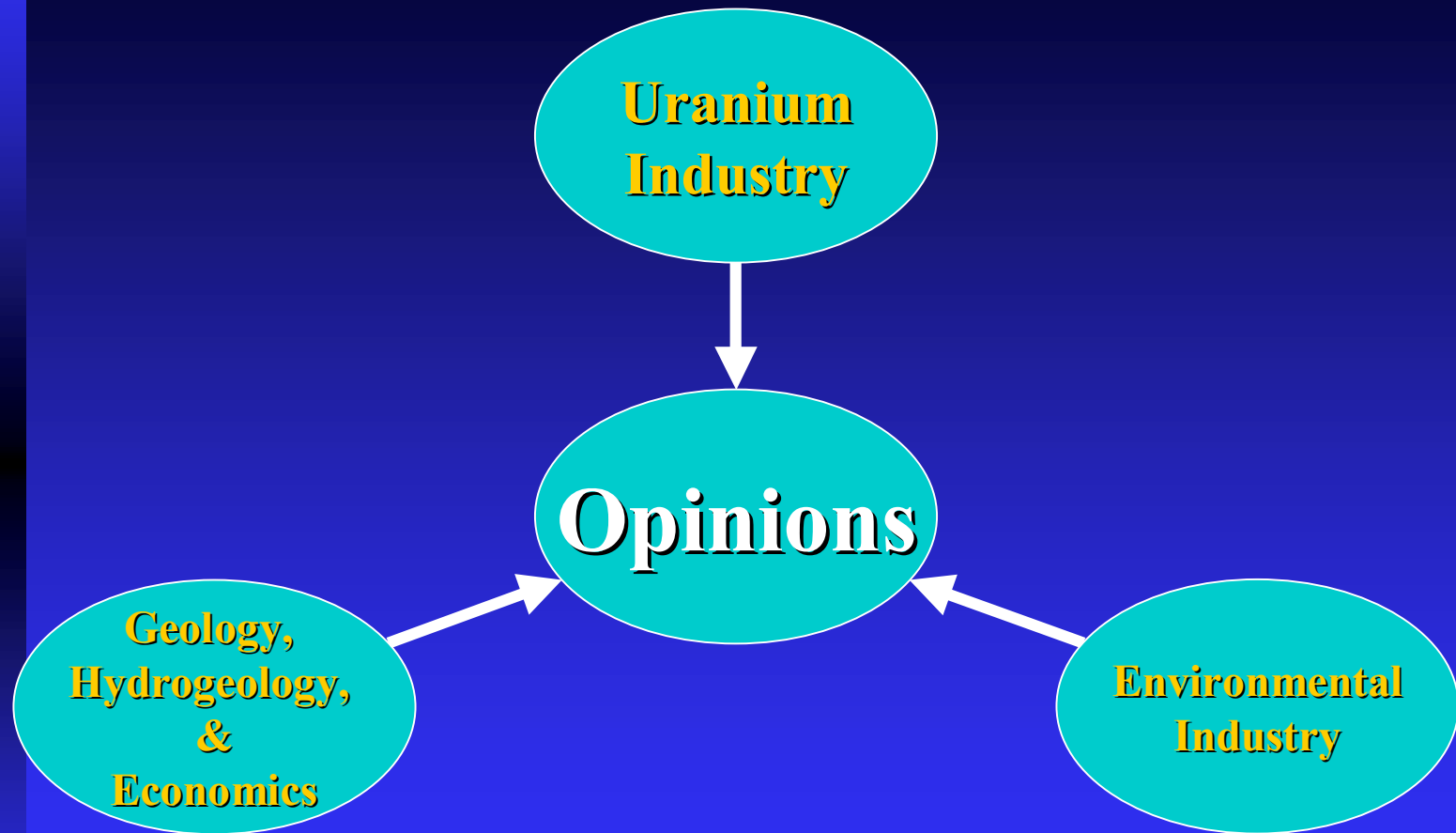
- **Mr. M. Campbell serves as Chairman of the Uranium Committee, Energy Minerals Div., AAPG.**
- **This presentation is based on the committee's Uranium Report for 2005 (See References for URL).**
- **The EMD Uranium Committee members include:**
Joseph Evensen, Ph. D.,
ExxonMobil Upstream Research Co.

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

and a number of Special Consultants.

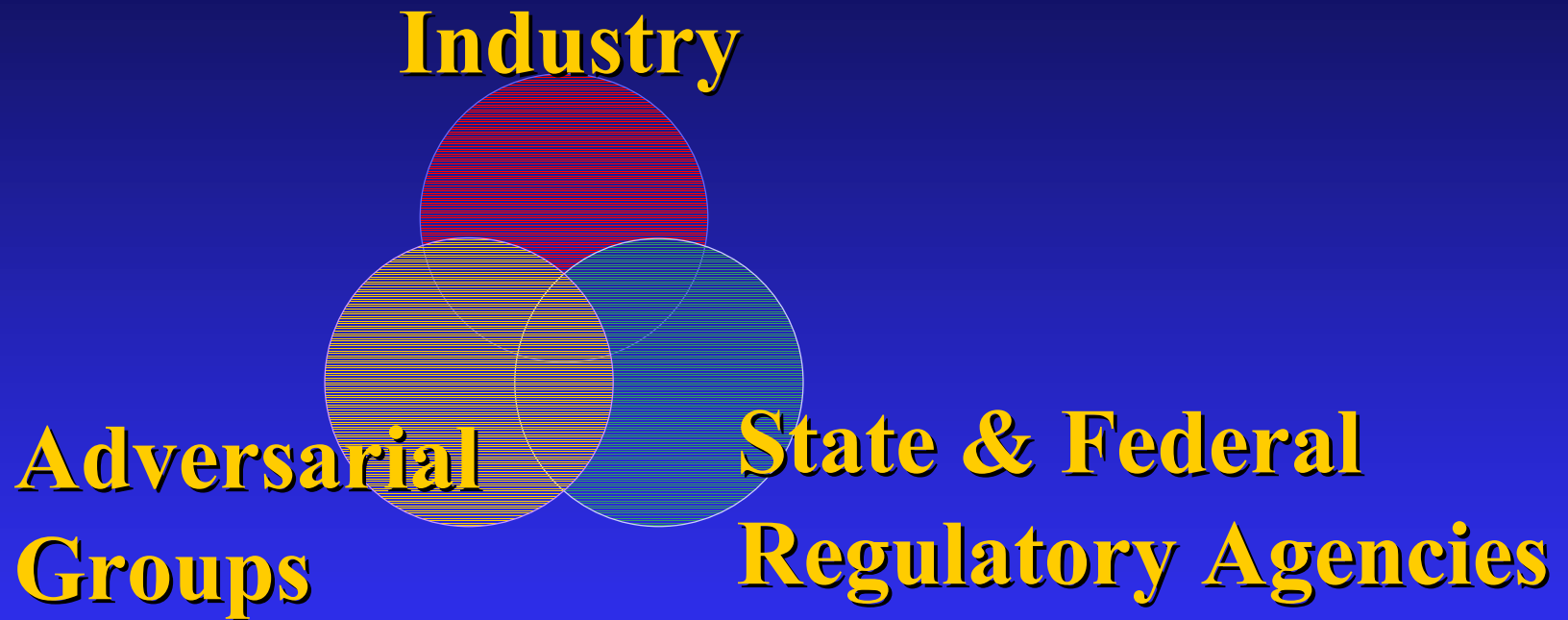


Basis of Opinions Presented (Cont'd)





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

Assessment

Safety Record,
Economic Advantage, Jobs,
Technology, Management

Risk

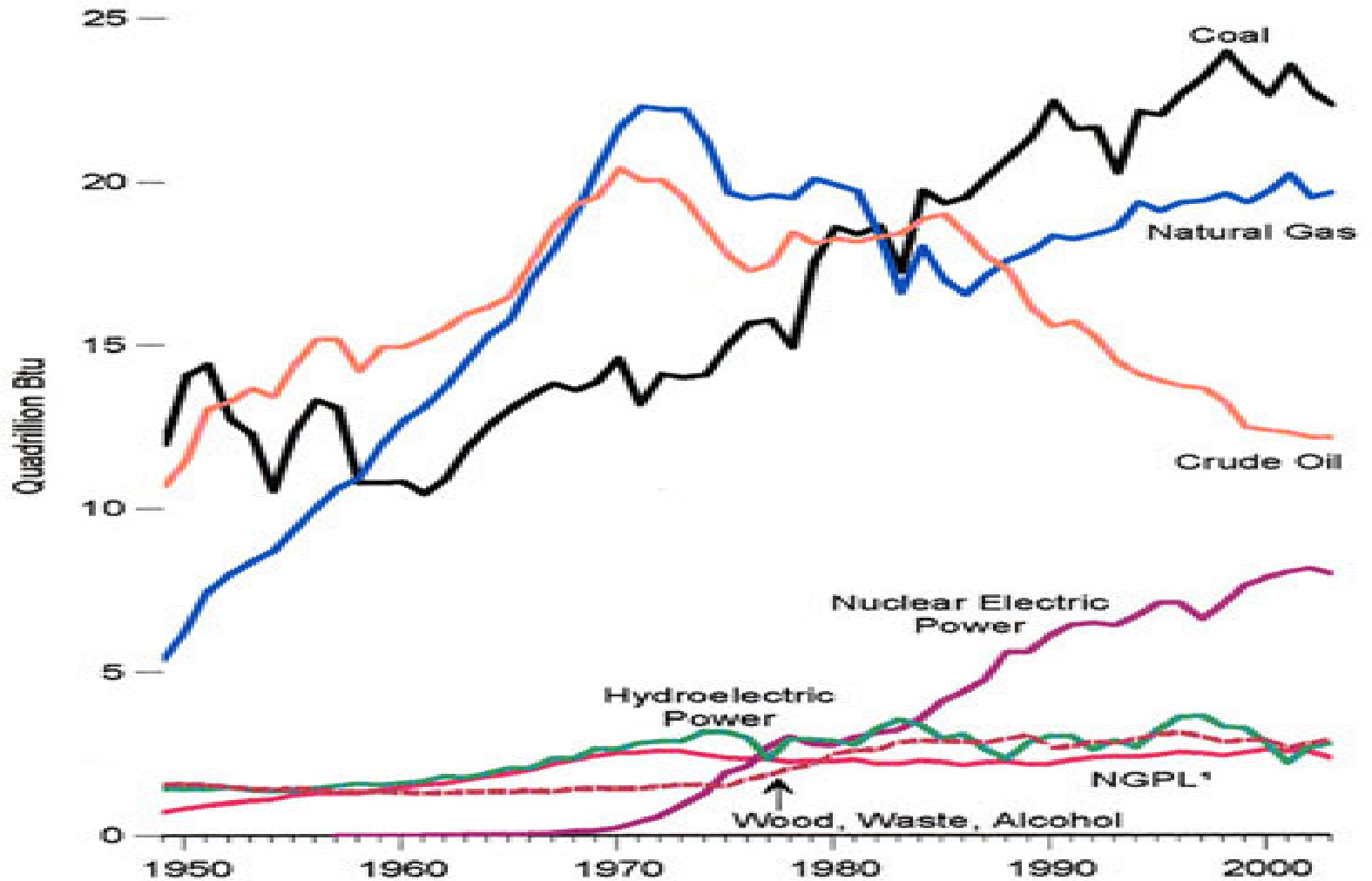
Comparative Analysis
w/ Other Types of Risk:
NIMBY - Industry, Local, etc.



Energy Production in the U.S.

Energy Production by Major Source, 1949-2003

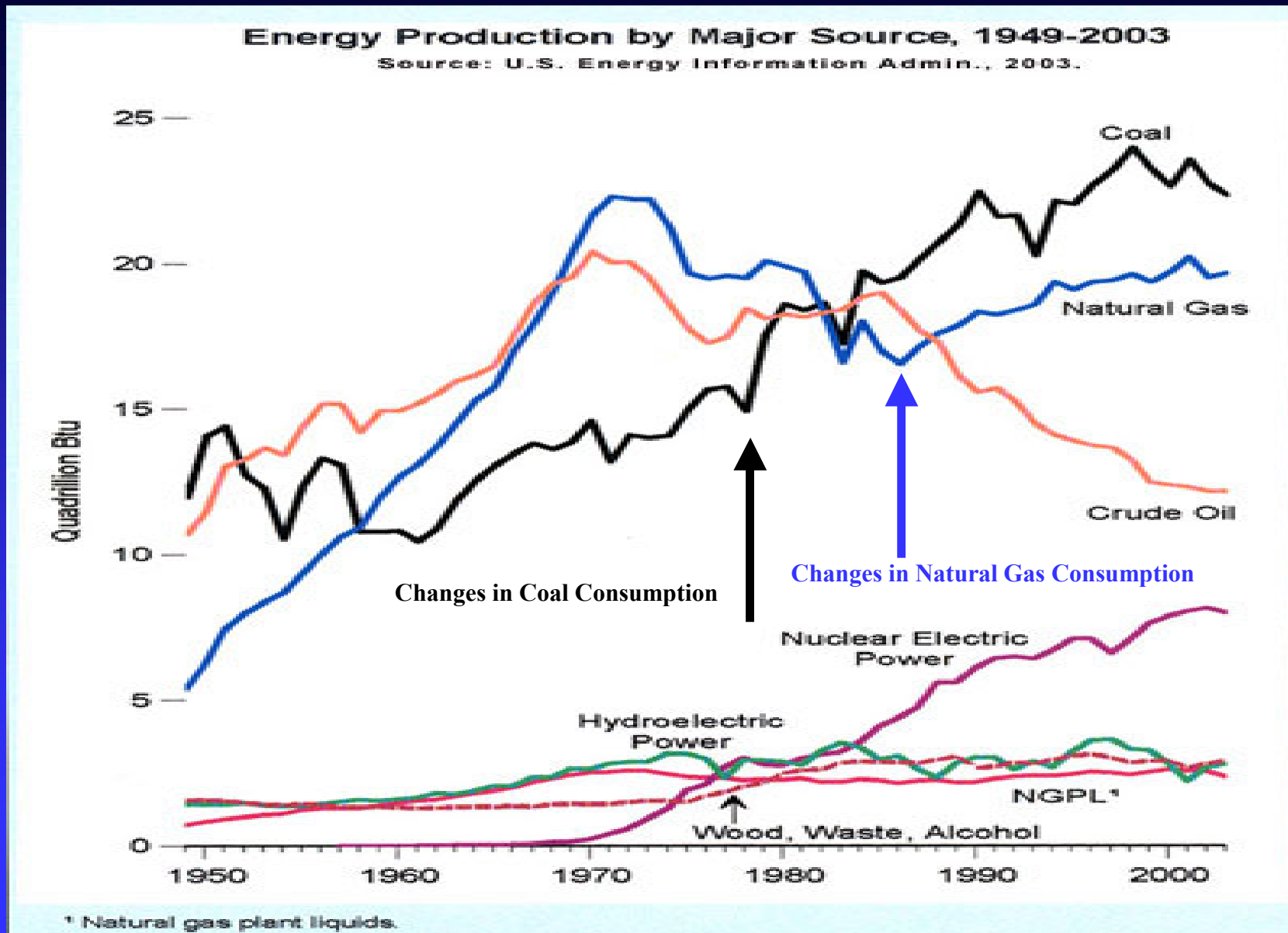
Source: U.S. Energy Information Admin., 2003.



* Natural gas plant liquids.



Energy Production in the U.S.

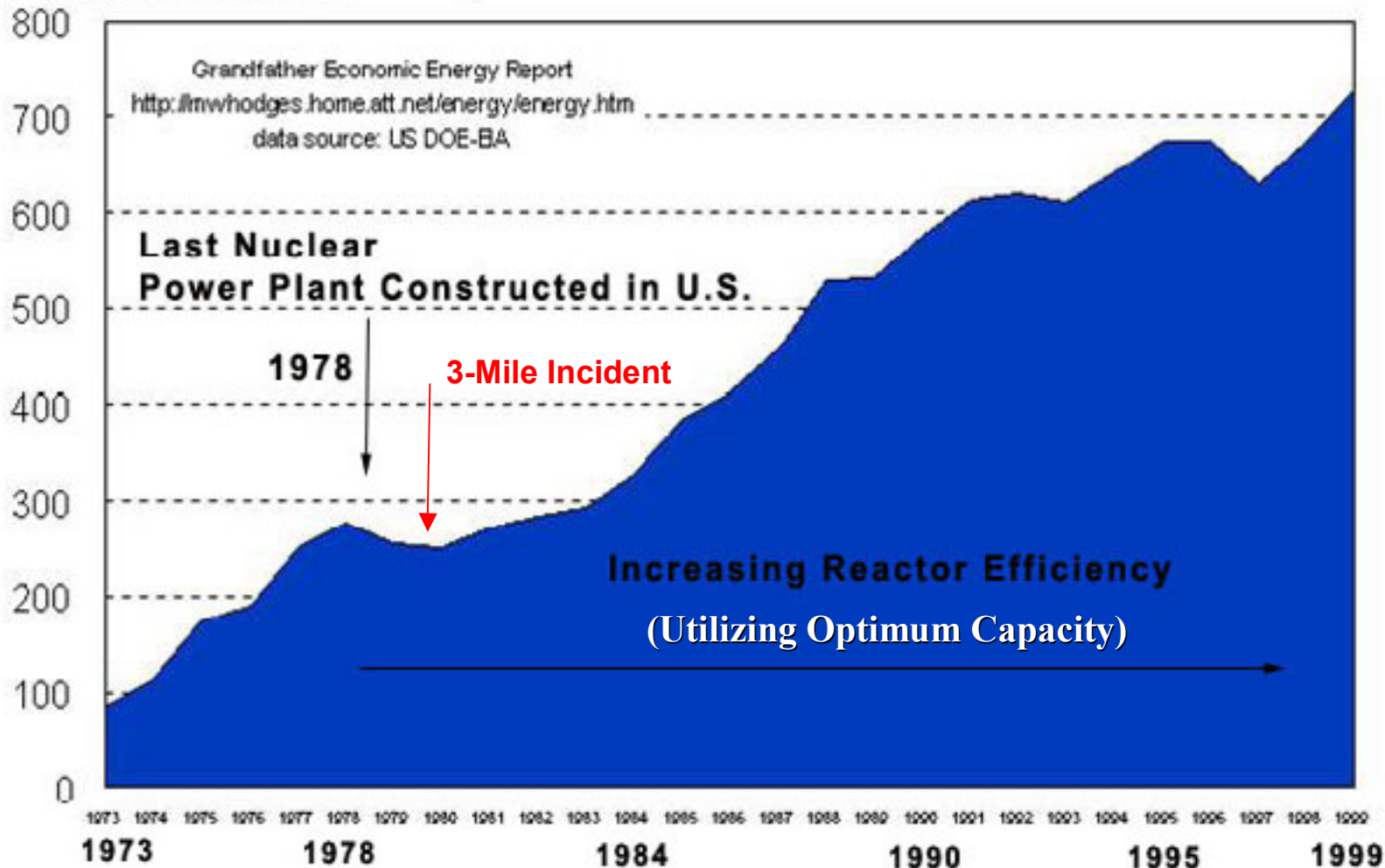




Nuclear Generation of Electricity

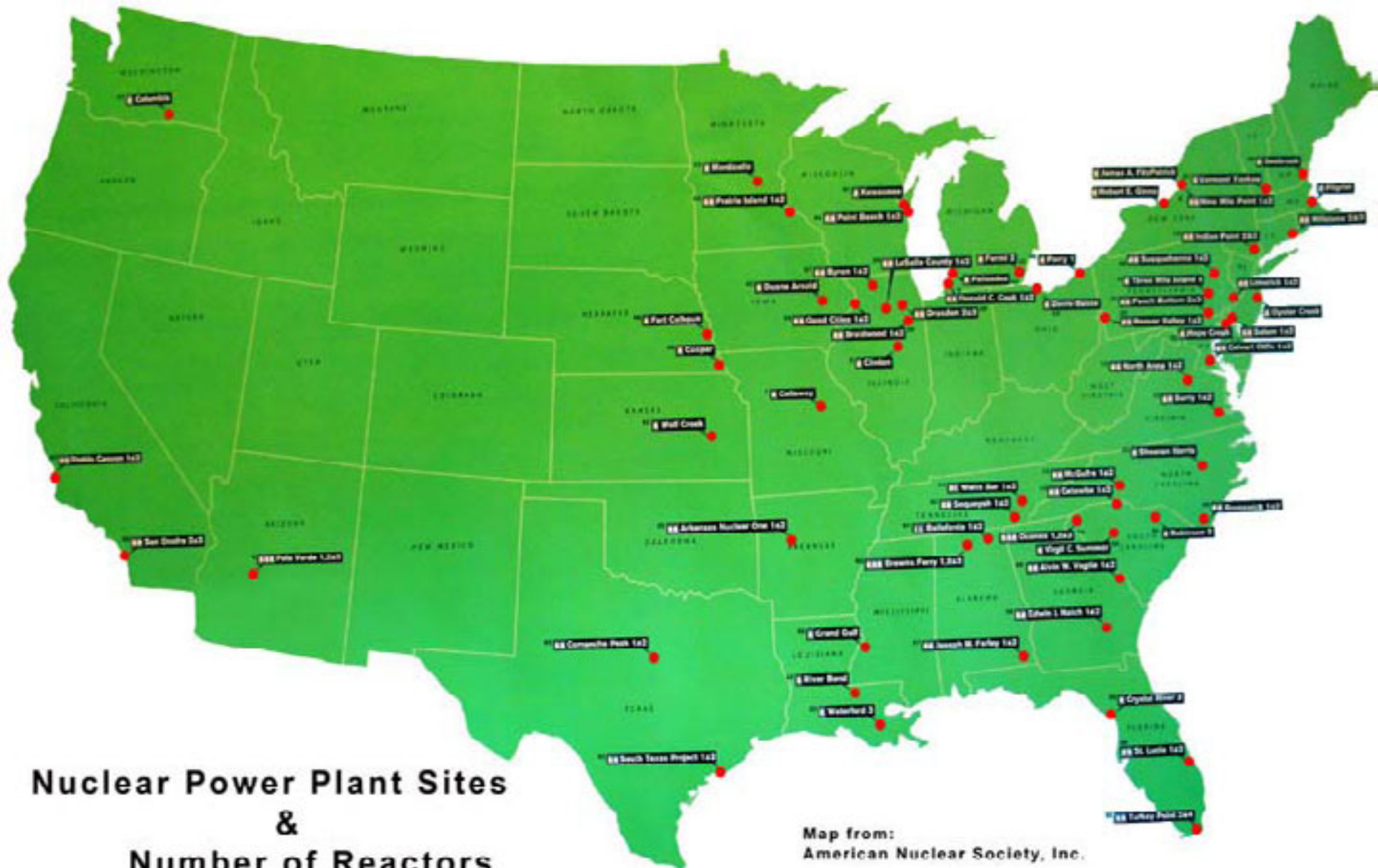
U.S. Nuclear Electricity Generation, 1973 to 1999

Billion Kilowatt Hours

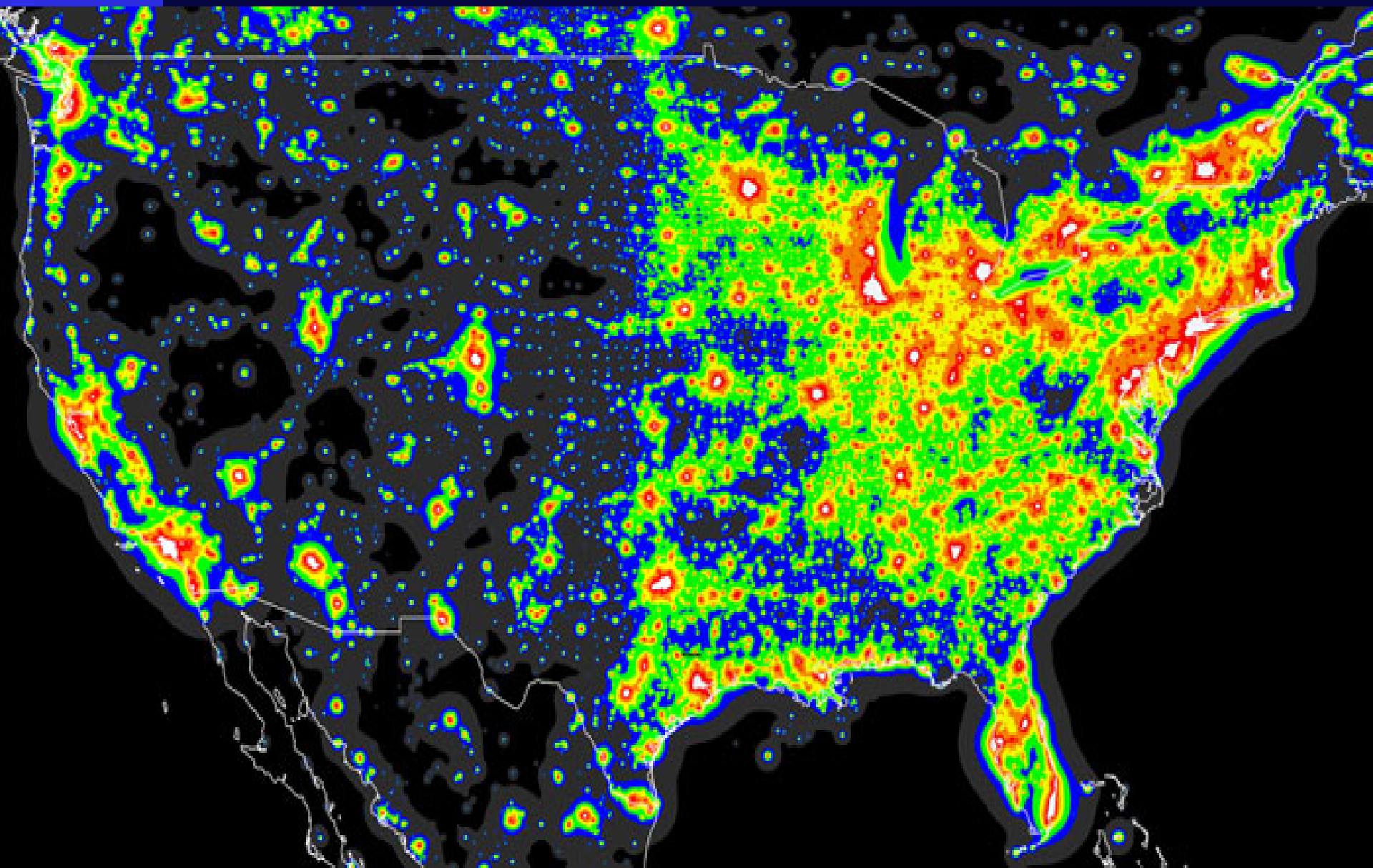




Nuclear Power Plant Sites

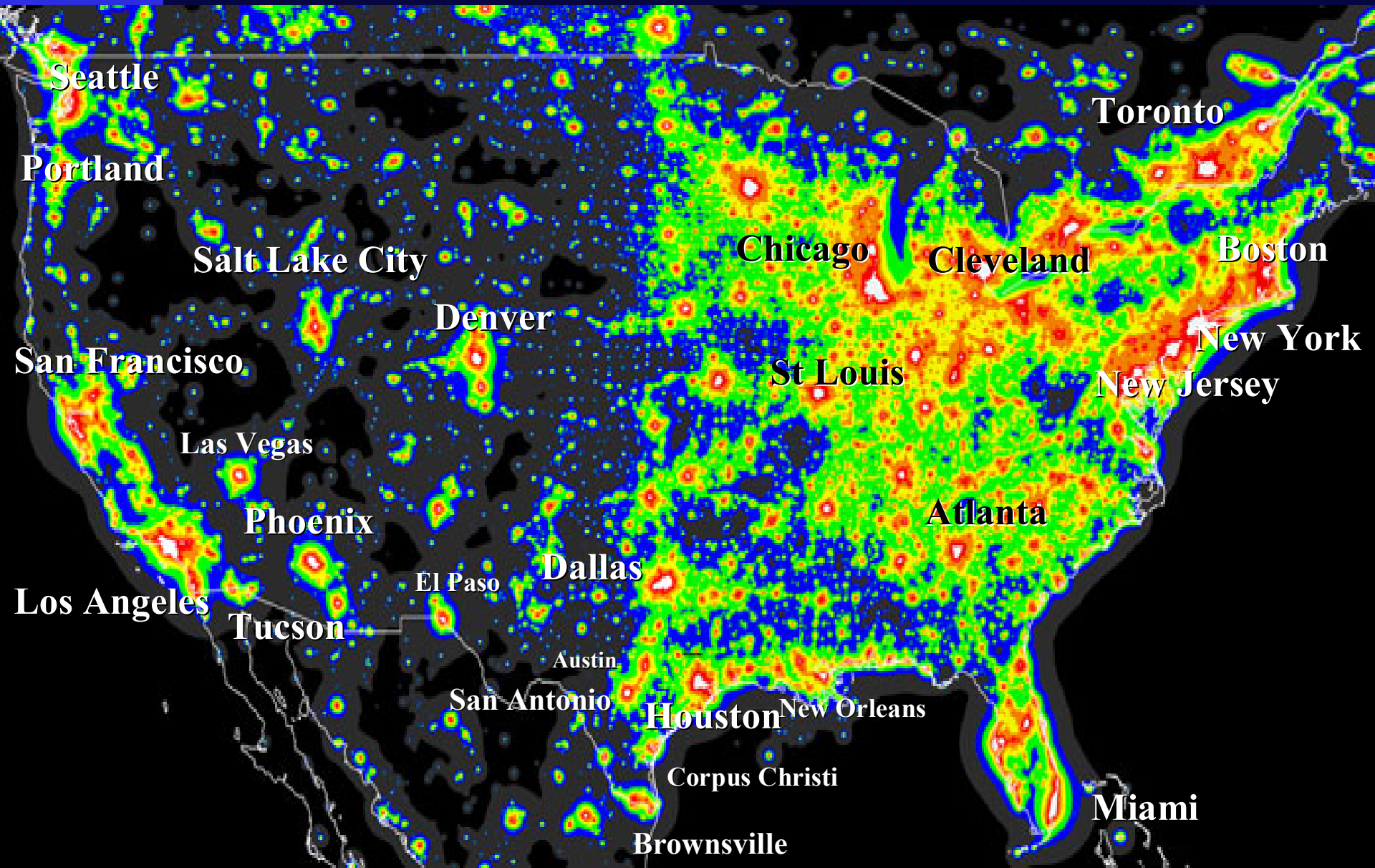


Night Lights in U.S. - Electricity Usage



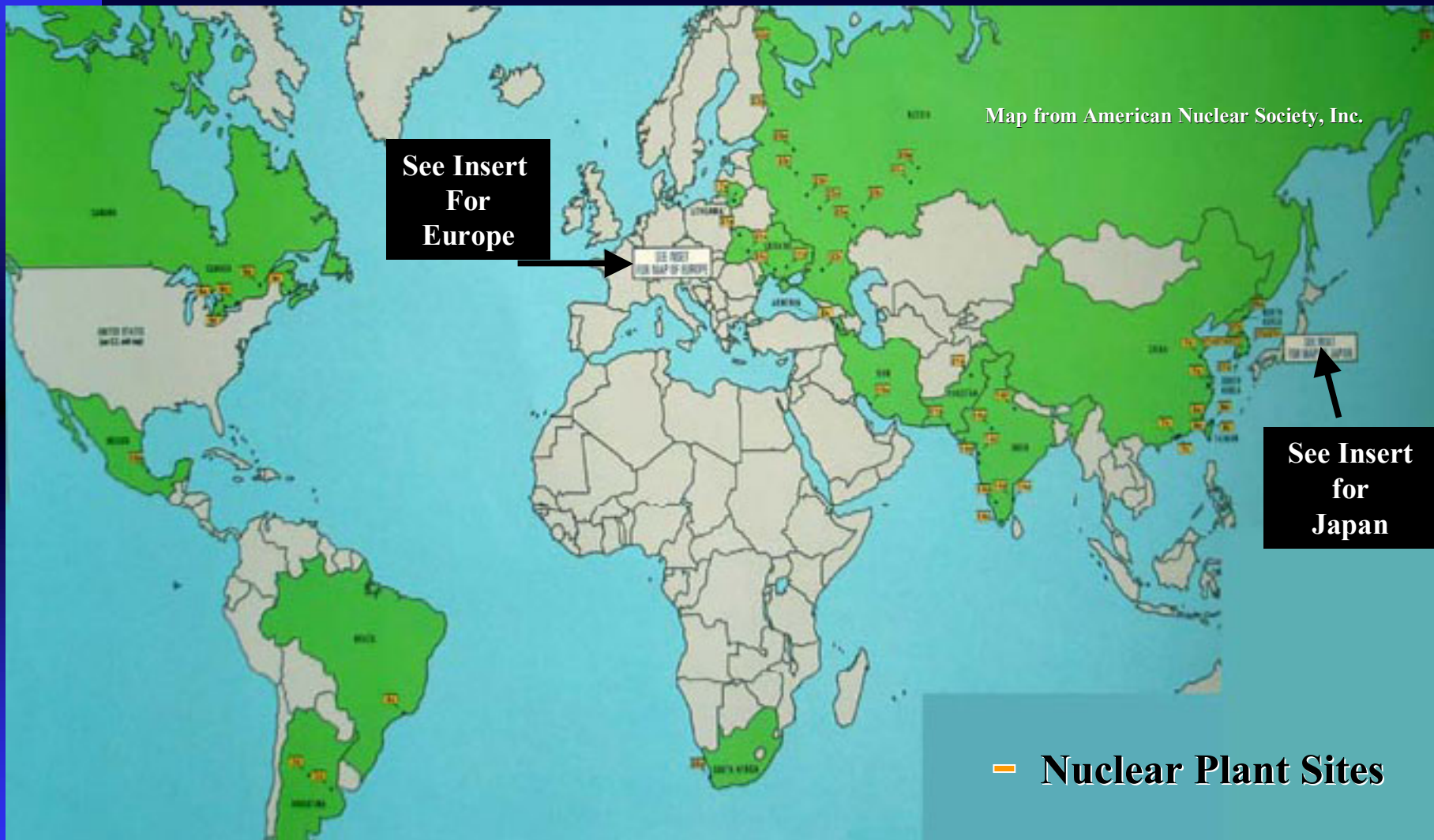


Night Lights in U.S. - Electricity Usage





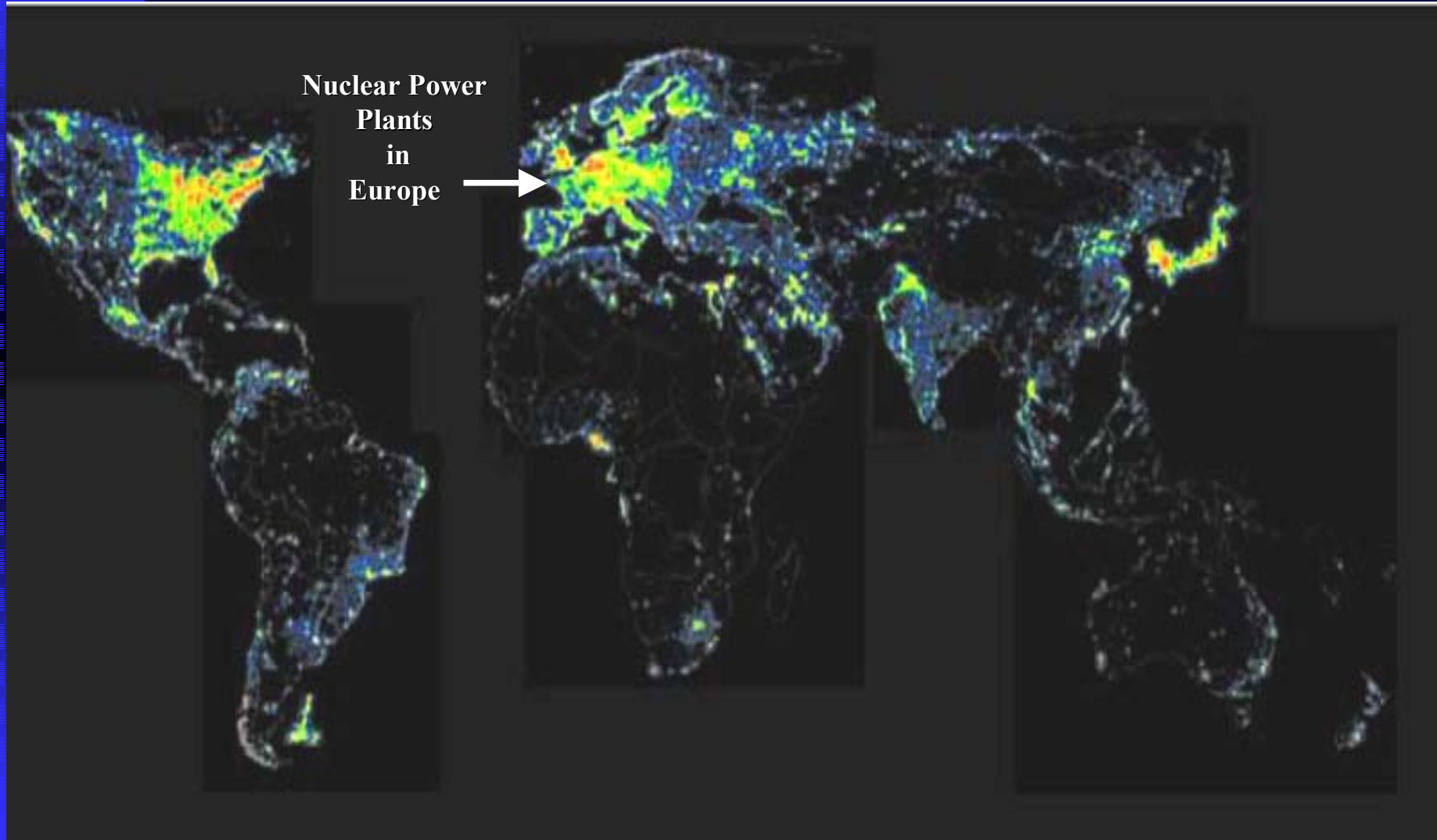
Nuclear Power Plants in the World



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

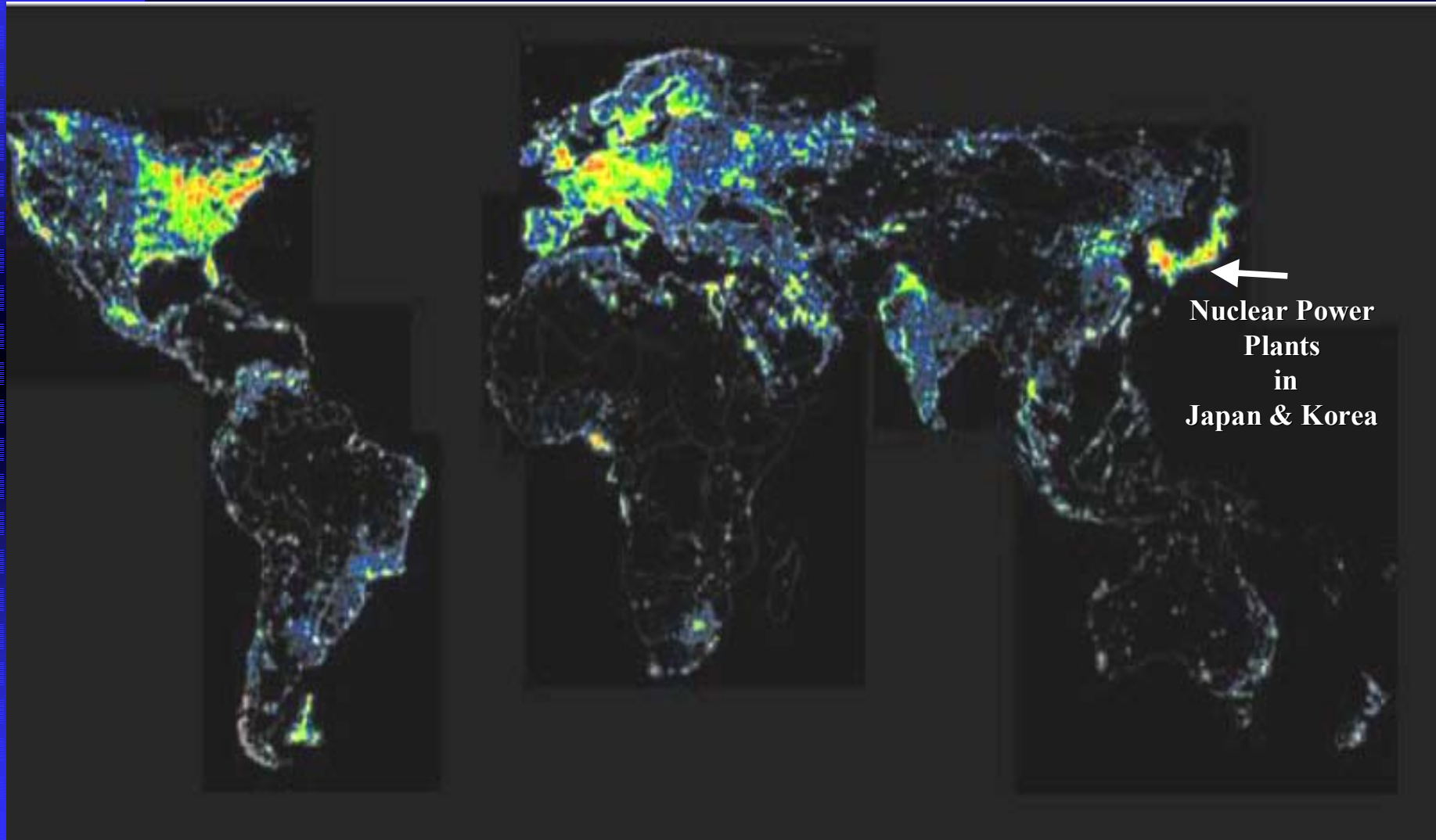
Map from American Nuclear Society, Inc.



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

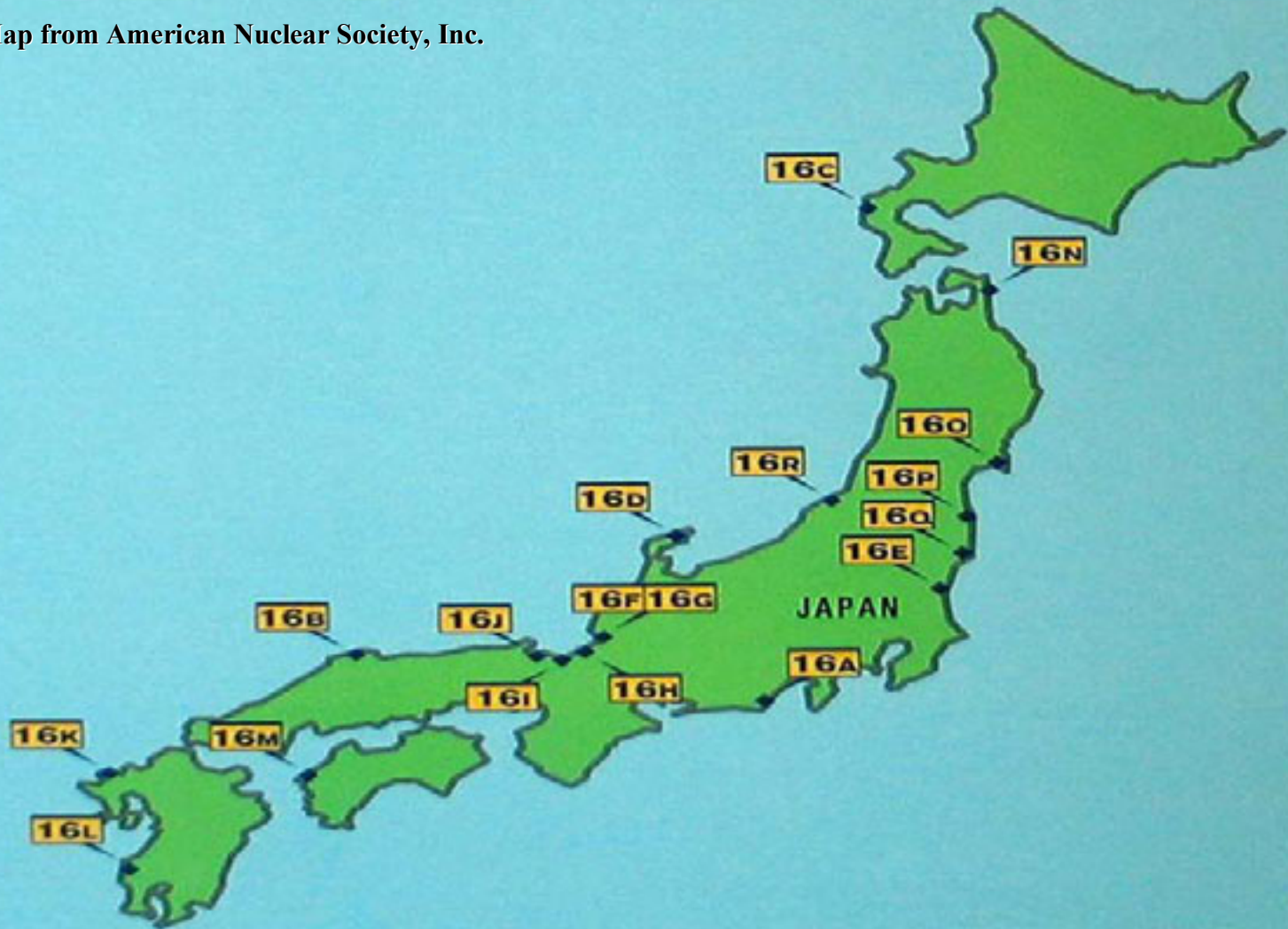


Where are the Other Plants? U.K., Canada, Eastern Russia, China, India, Pakistan, Japan, Korea, Mexico, South Africa, etc.



Nuclear Power Plants in Japan

Map from American Nuclear Society, Inc.

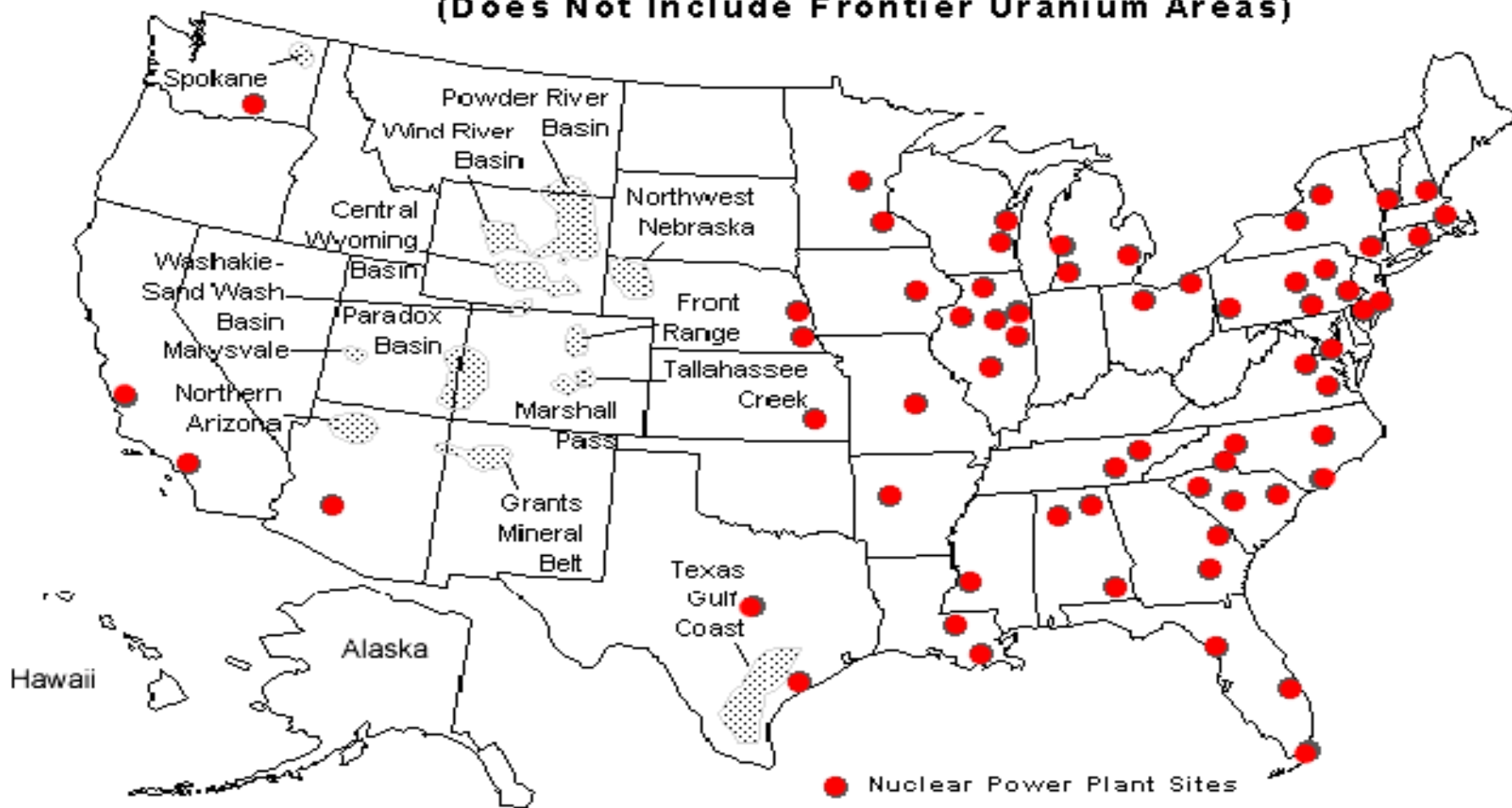


Who has the greatest number of plants/area of country? Japan.



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.

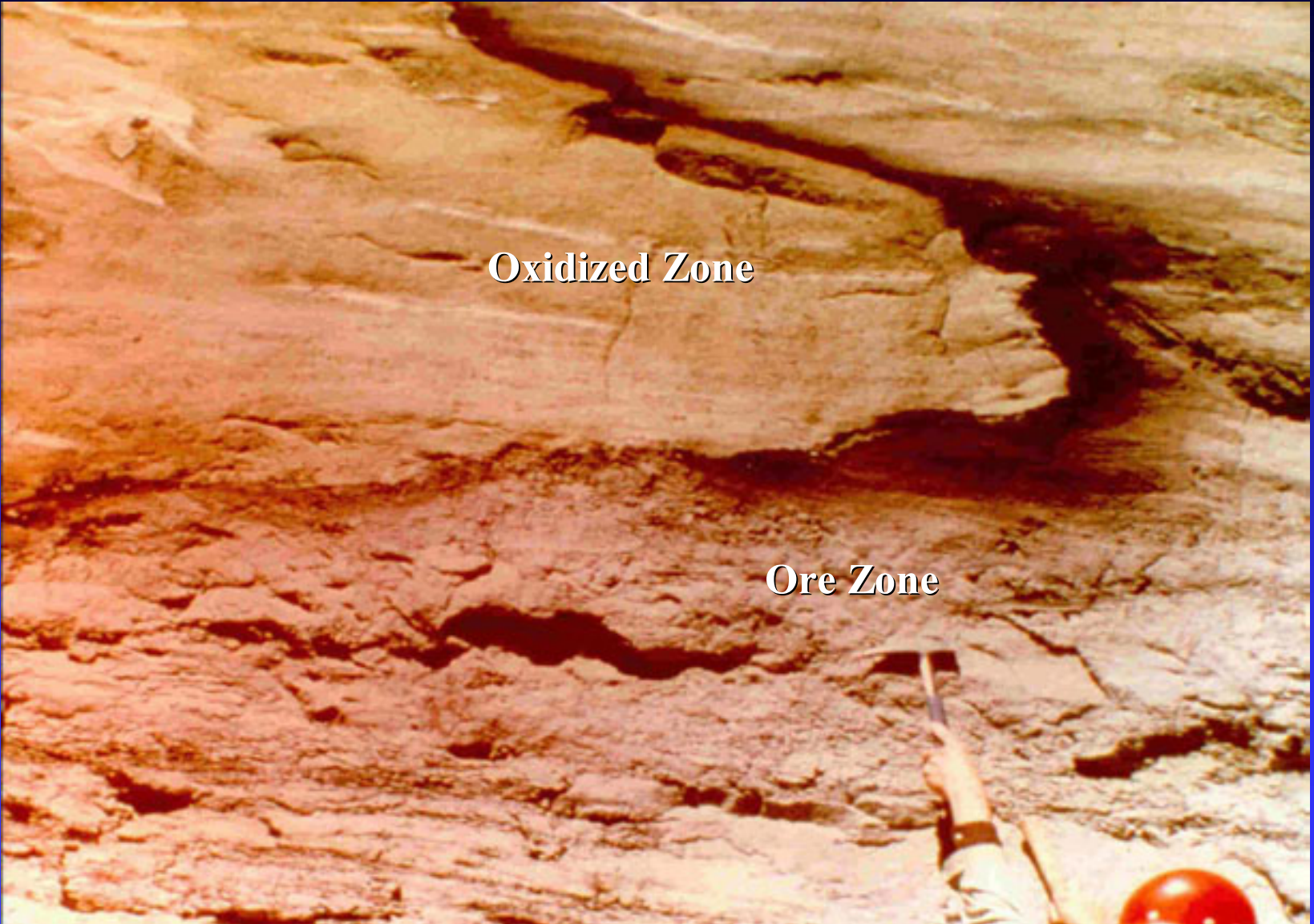


Roll Front in Mine Pit Wall, Texas





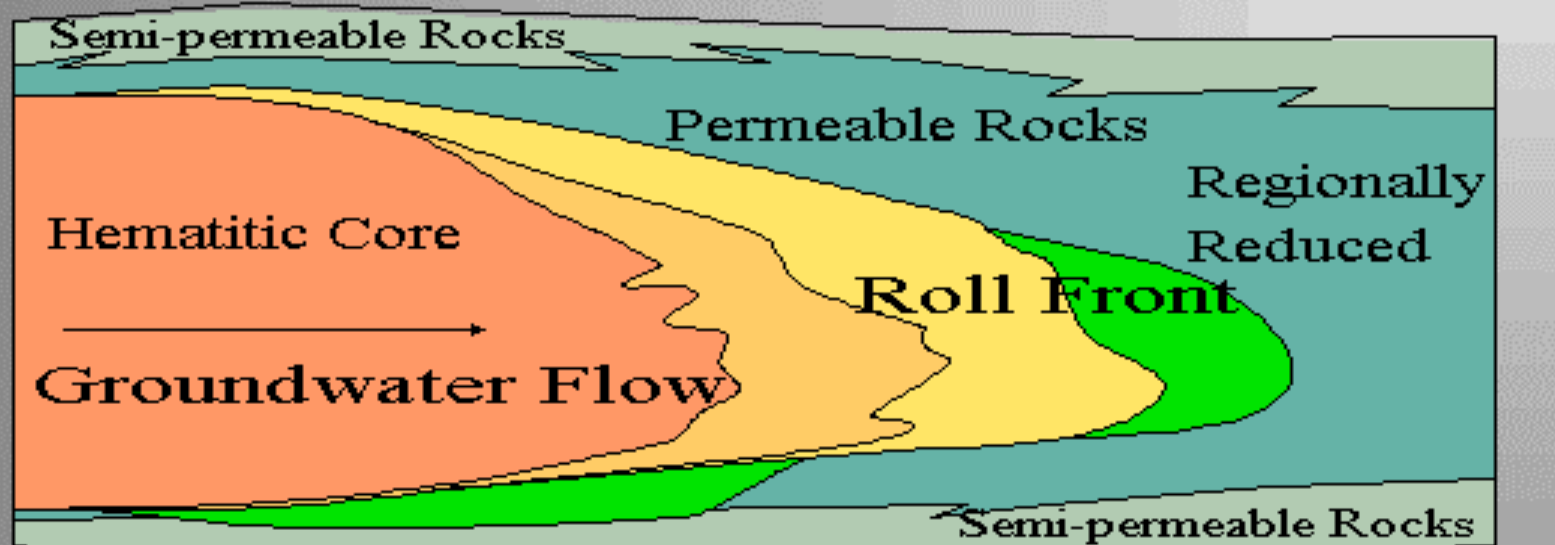
Roll Front in Mine Pit Wall, Wyoming





Uranium Exploration Guides

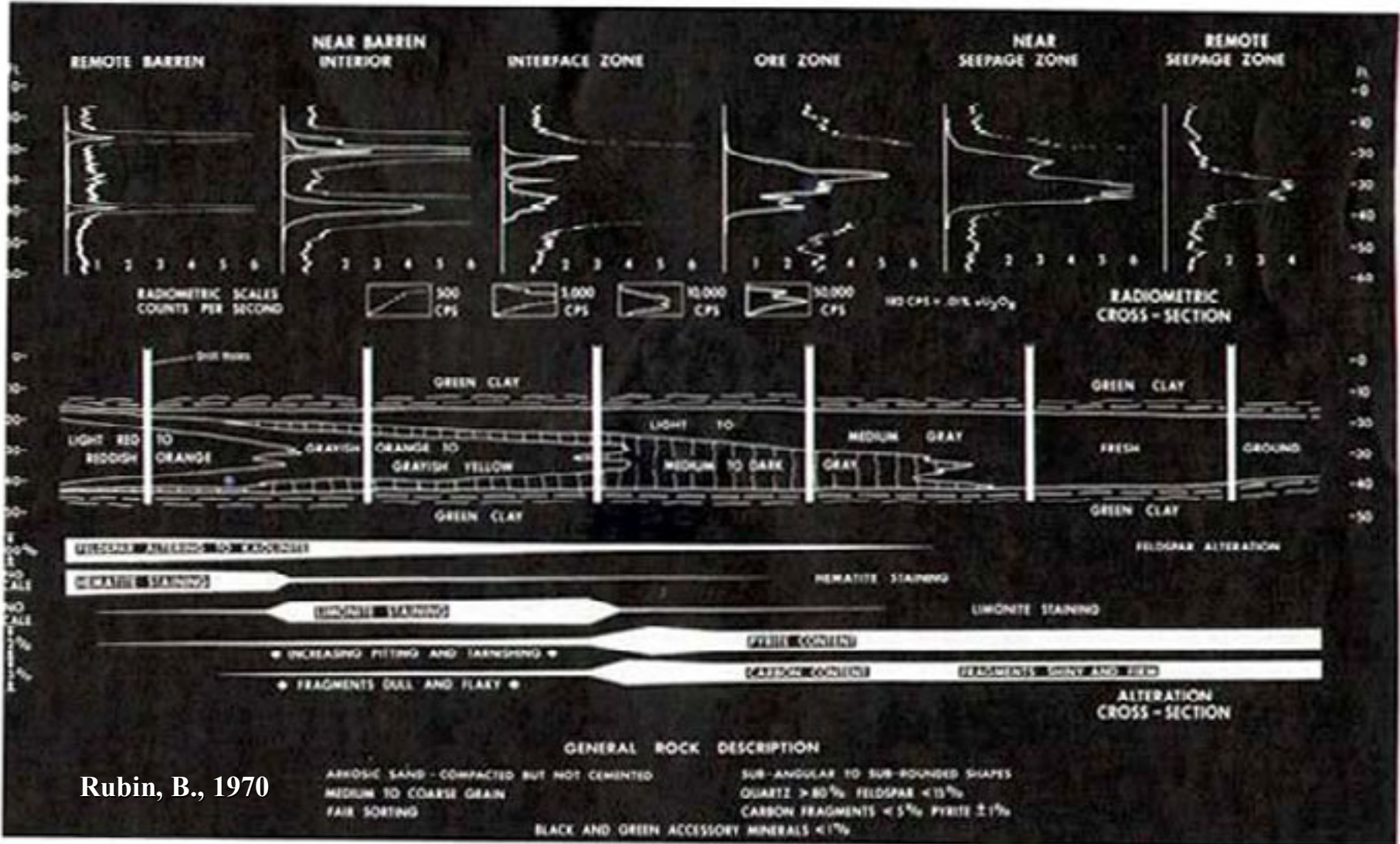
CONCEPTUAL MODEL OF URANIUM ROLL FRONT DEPOSIT (After Devoto, 1978)



Hematitic Core	Alteration Envelope	Ore-Stage Uranium	Ore-Stage Pyrite	Reduced Sandstone
Hematite Magnetite	Siderite Sulfur-S Ferroselite Goethite	Uraninite Pyrite FeS Selenium Ilmannite	Molybdenite Pyrite Jordisite Calcite	Pyrite Jordisite Calcite



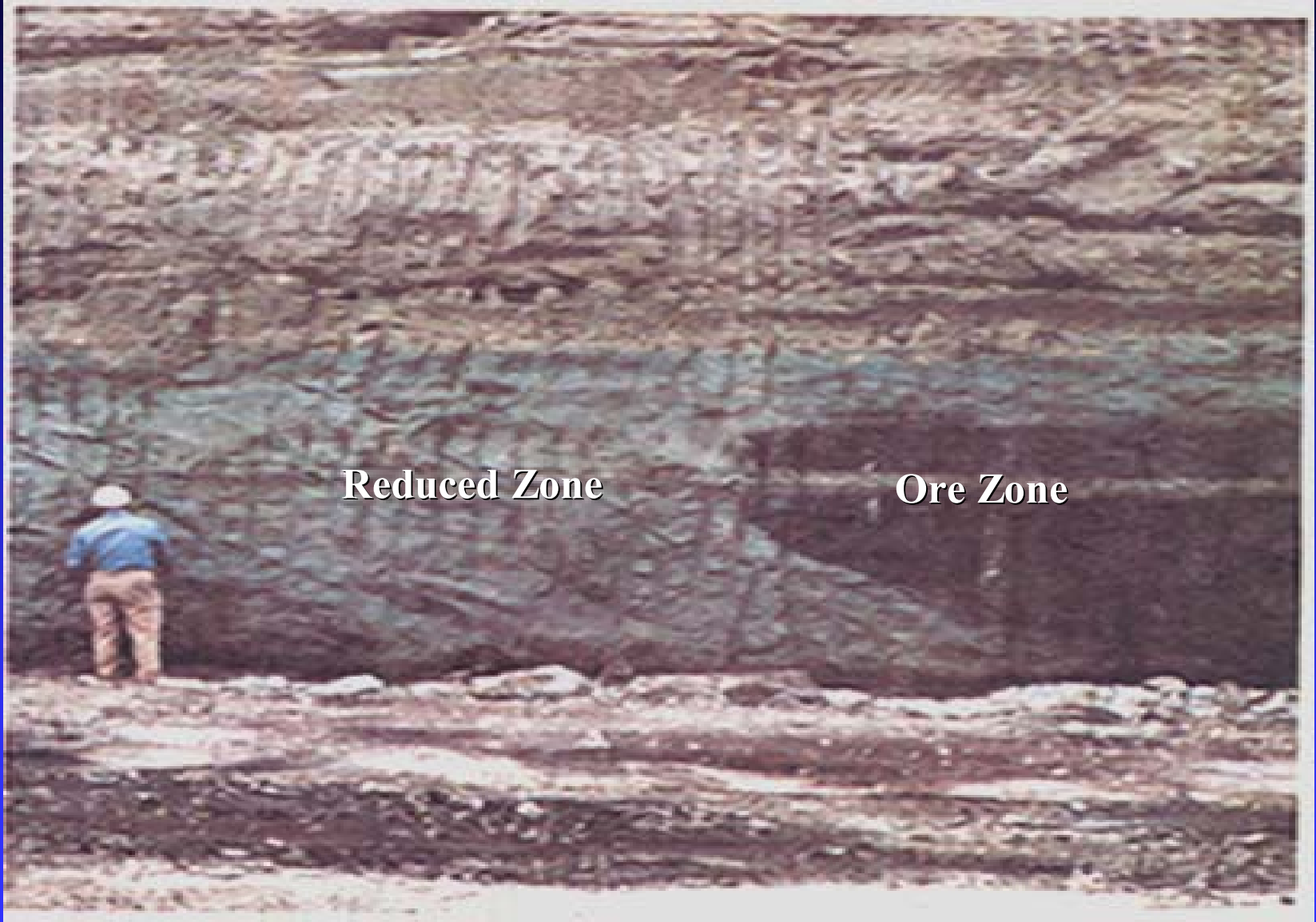
Roll-Front Exploration Guide, Wyoming



Rubin, B., 1970



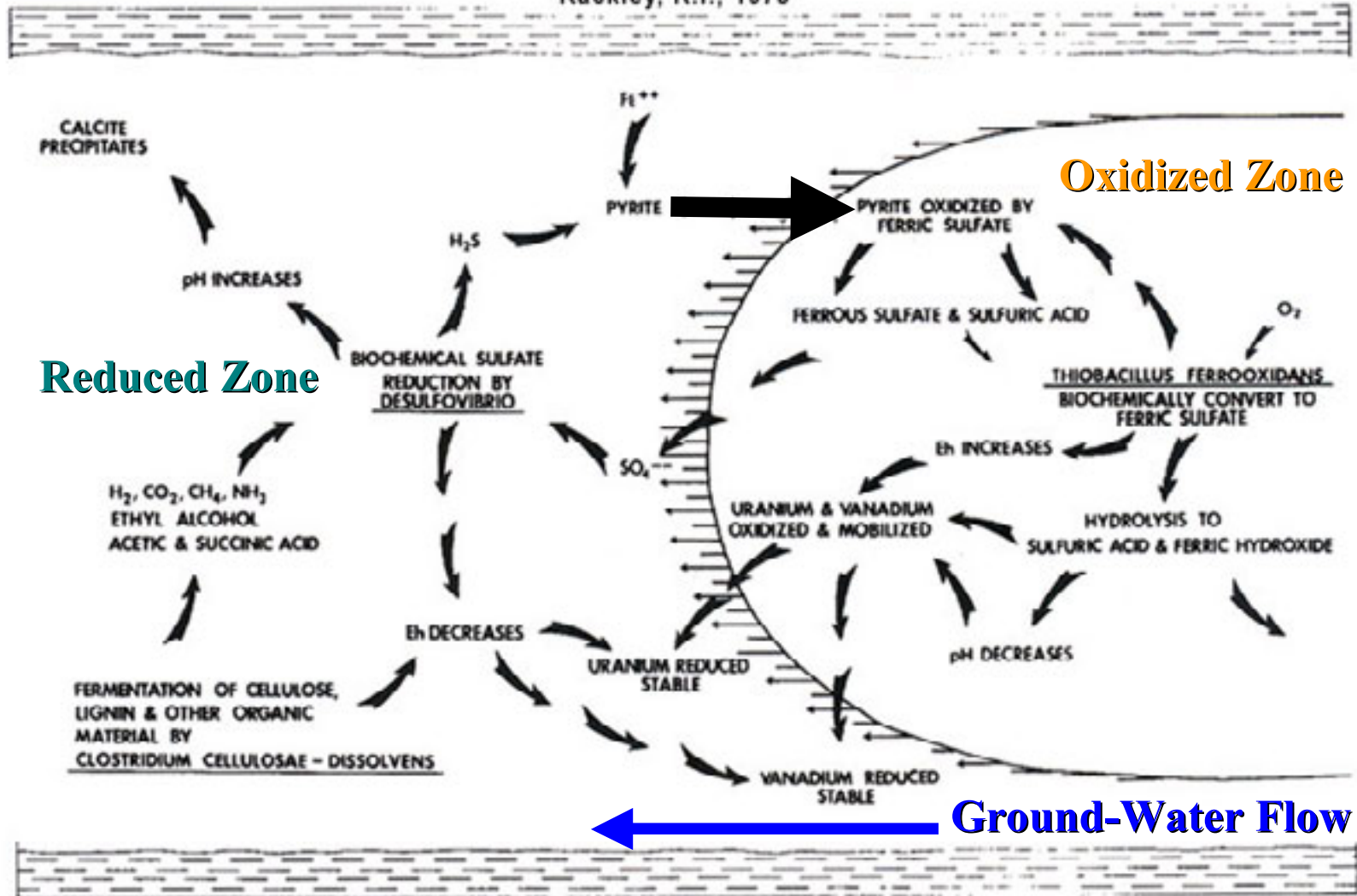
Roll Front in Mine Pit Wall, Texas (Cont'd)





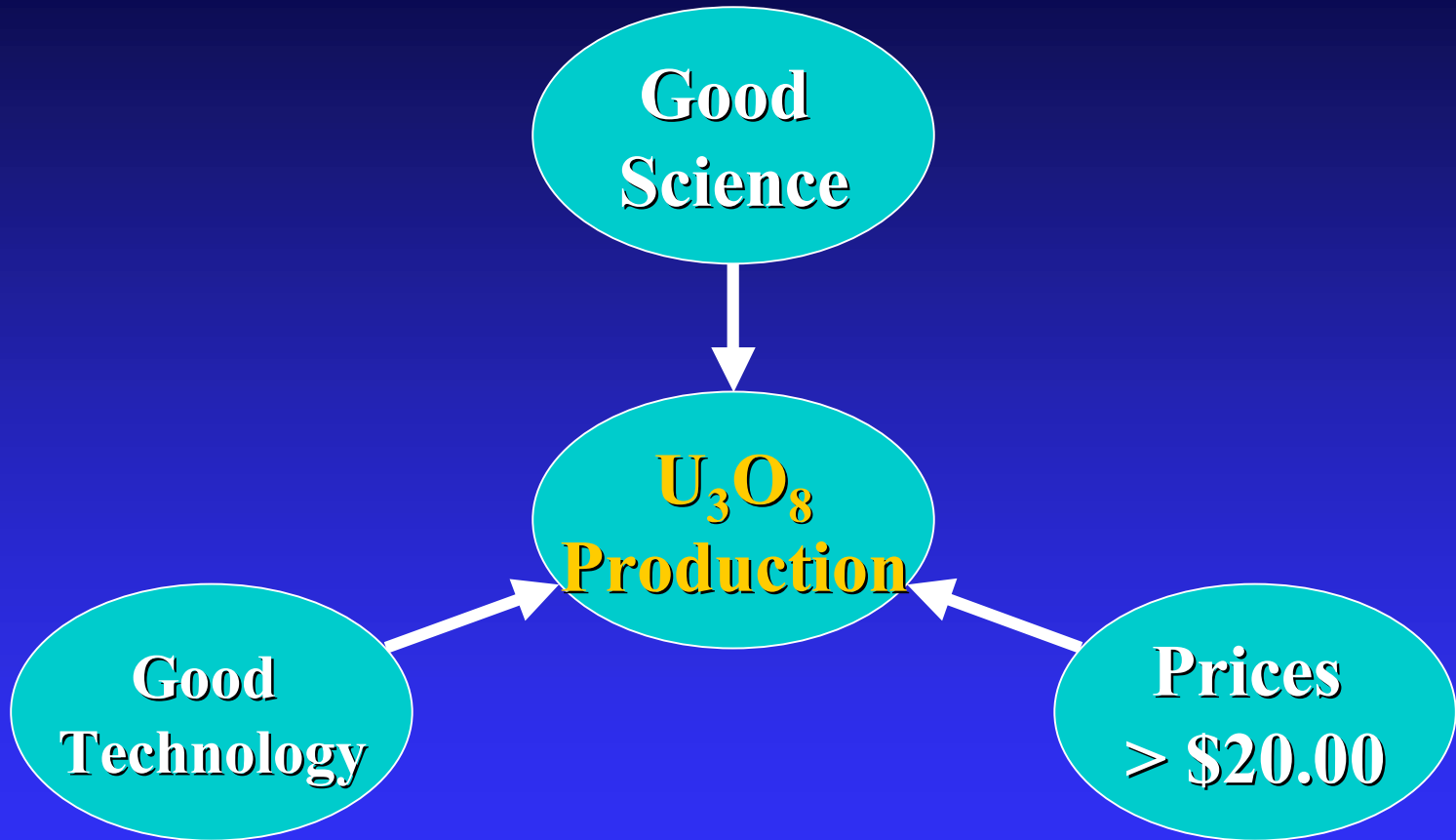
Roll-Front Biogeochemical Cell, Wyoming

Environment of Wyoming Tertiary Uranium Deposits
Rackley, R.I., 1975



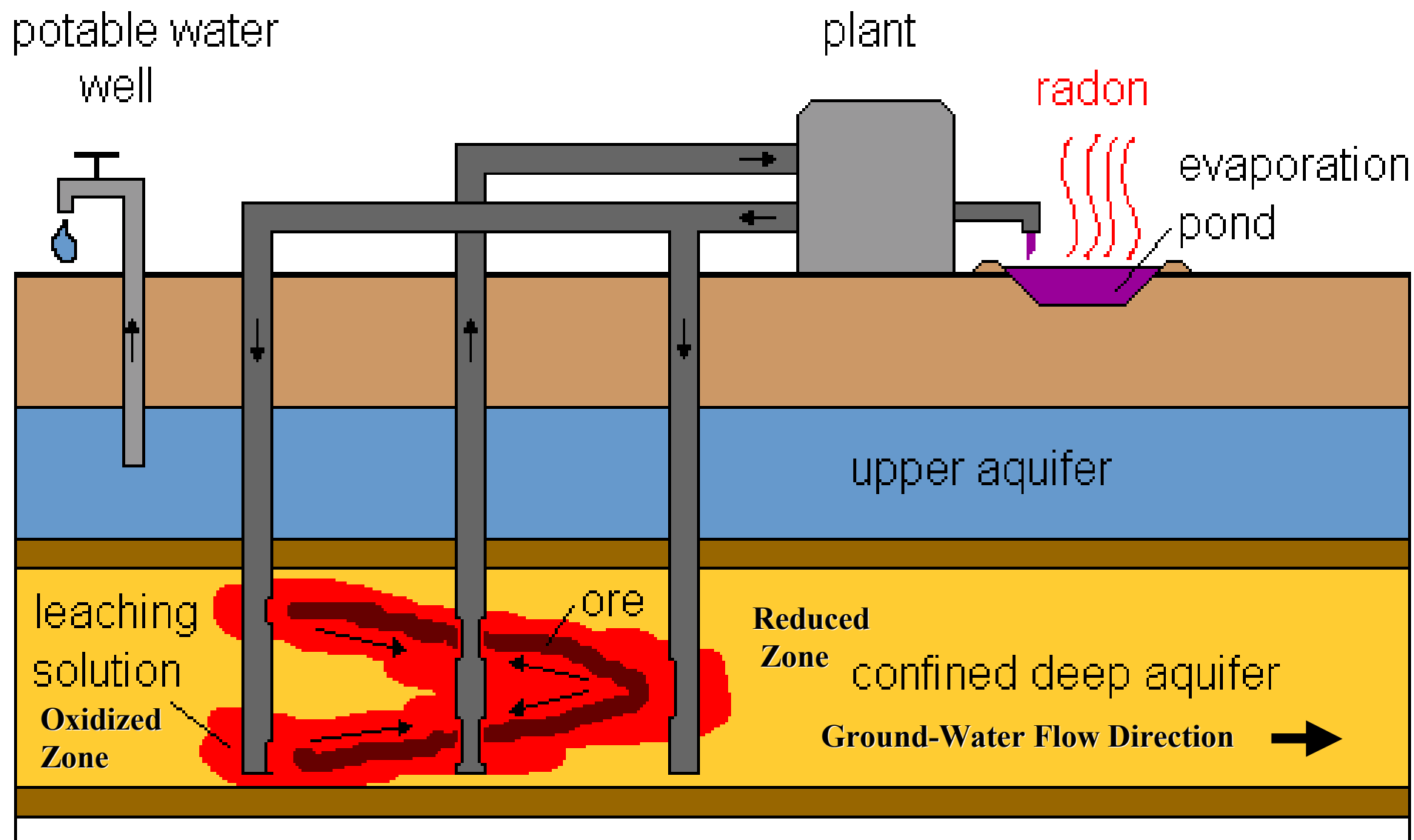


Uranium Production

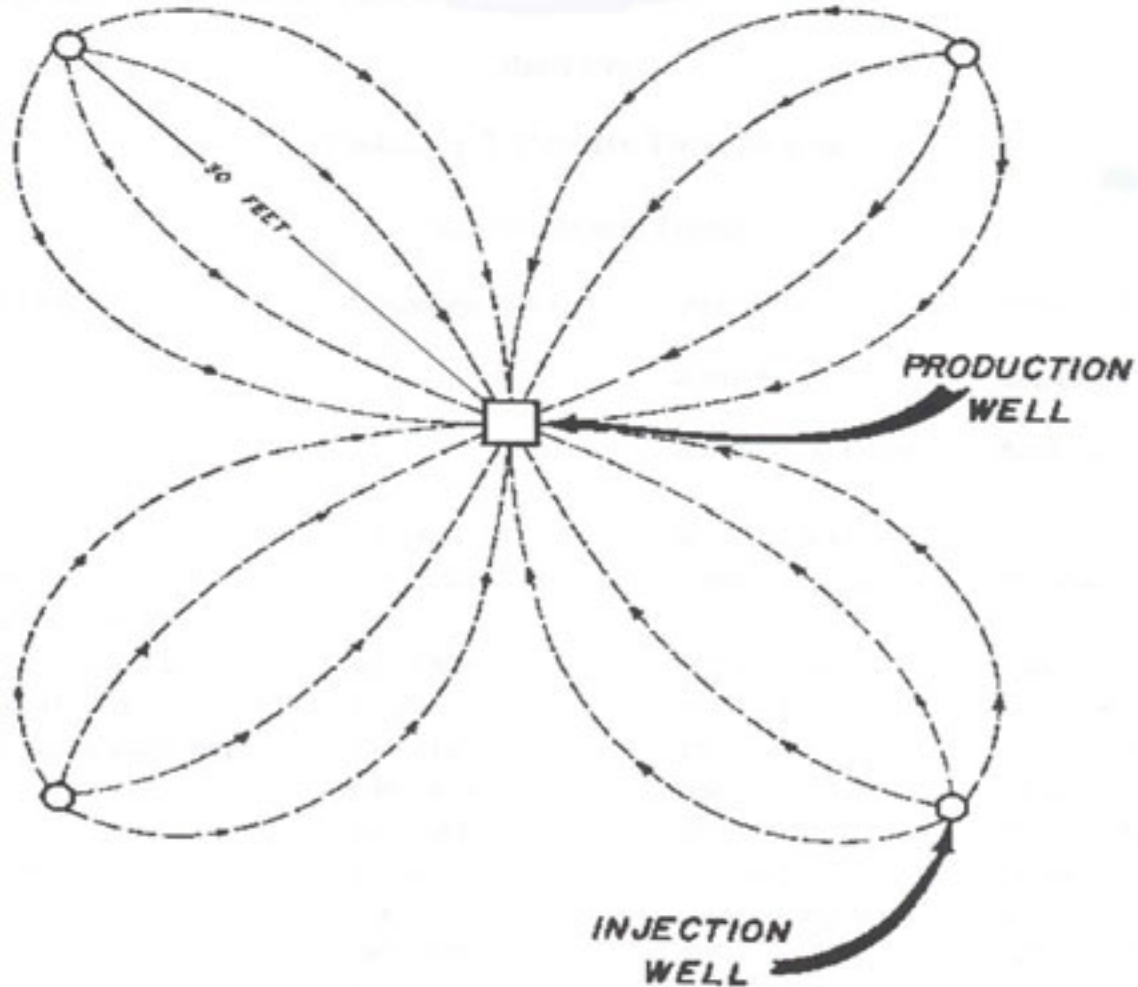




Uranium Production: In Situ Leaching



Uranium Production: In Situ Leaching



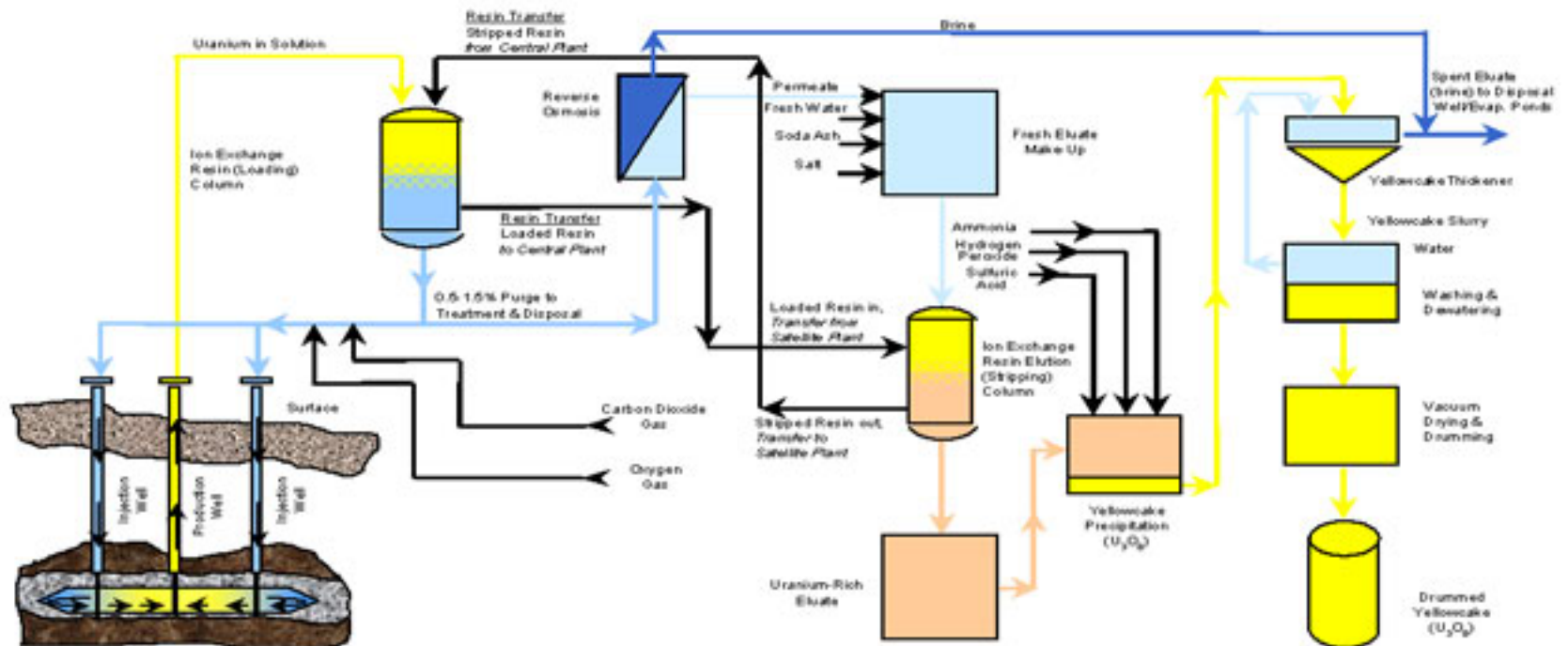
Typical 5-spot well pattern.

Uranium Production: In Situ Leaching

FLOW PROCESS SCHEMATIC

URANIUM EXTRACTION

YELLOWCAKE RECOVERY





Uranium Production: In Situ Leaching (Cont'd)

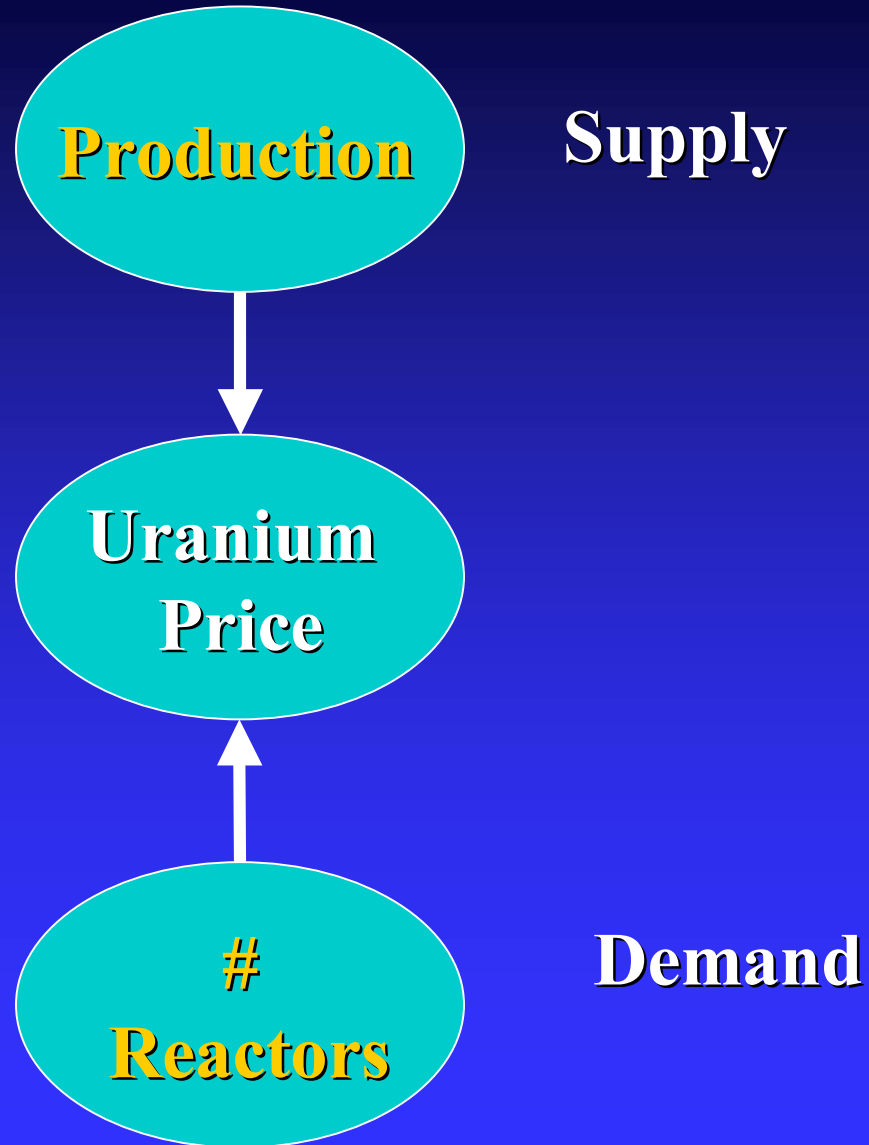
**Making Certain Assumptions,
One Full Barrel of Yellowcake (U_3O_8):**

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

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



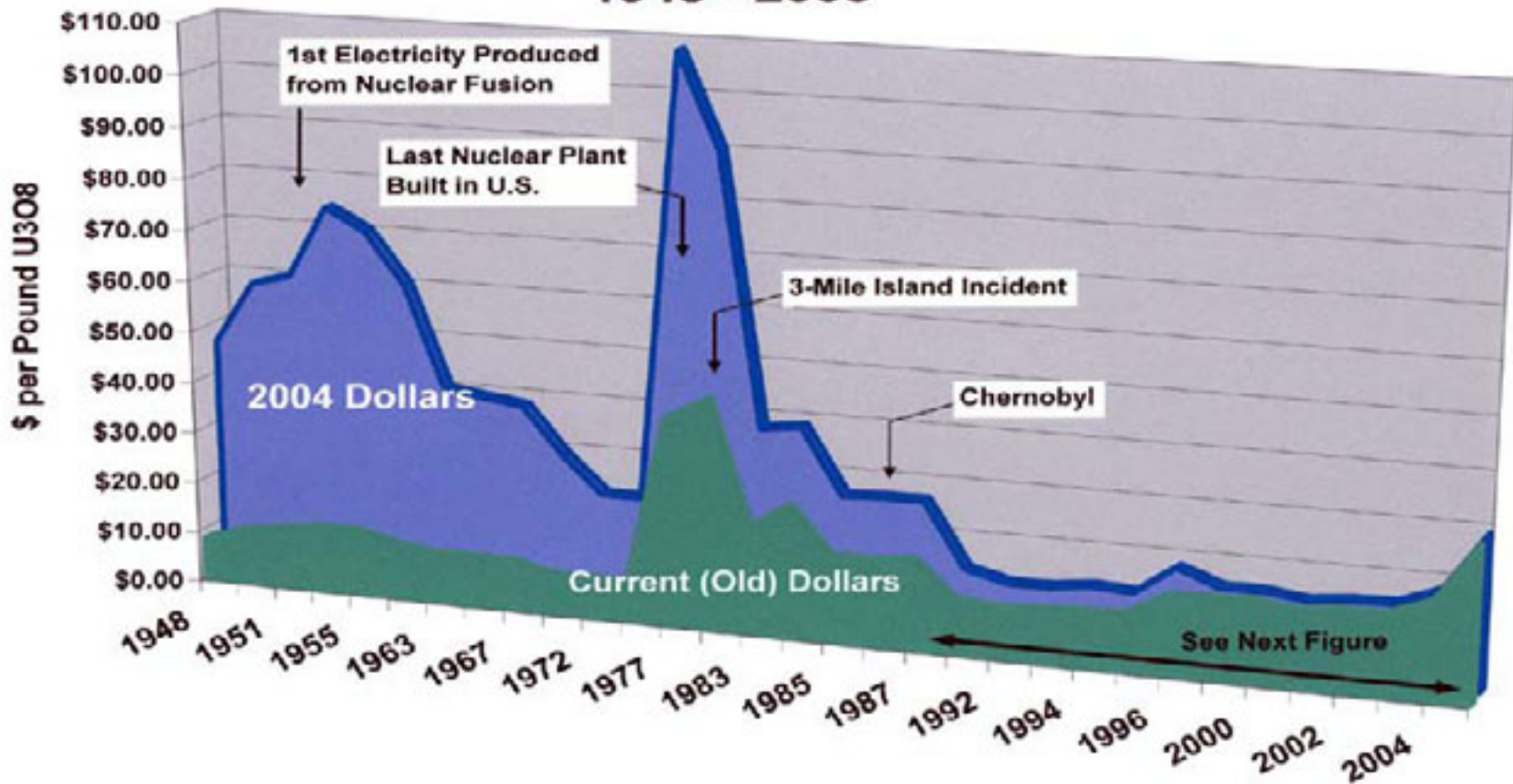
Uranium Prices





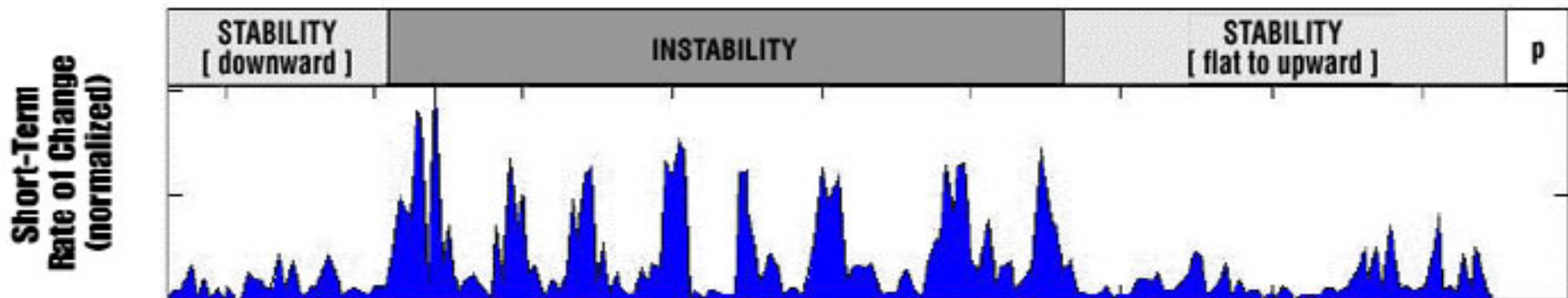
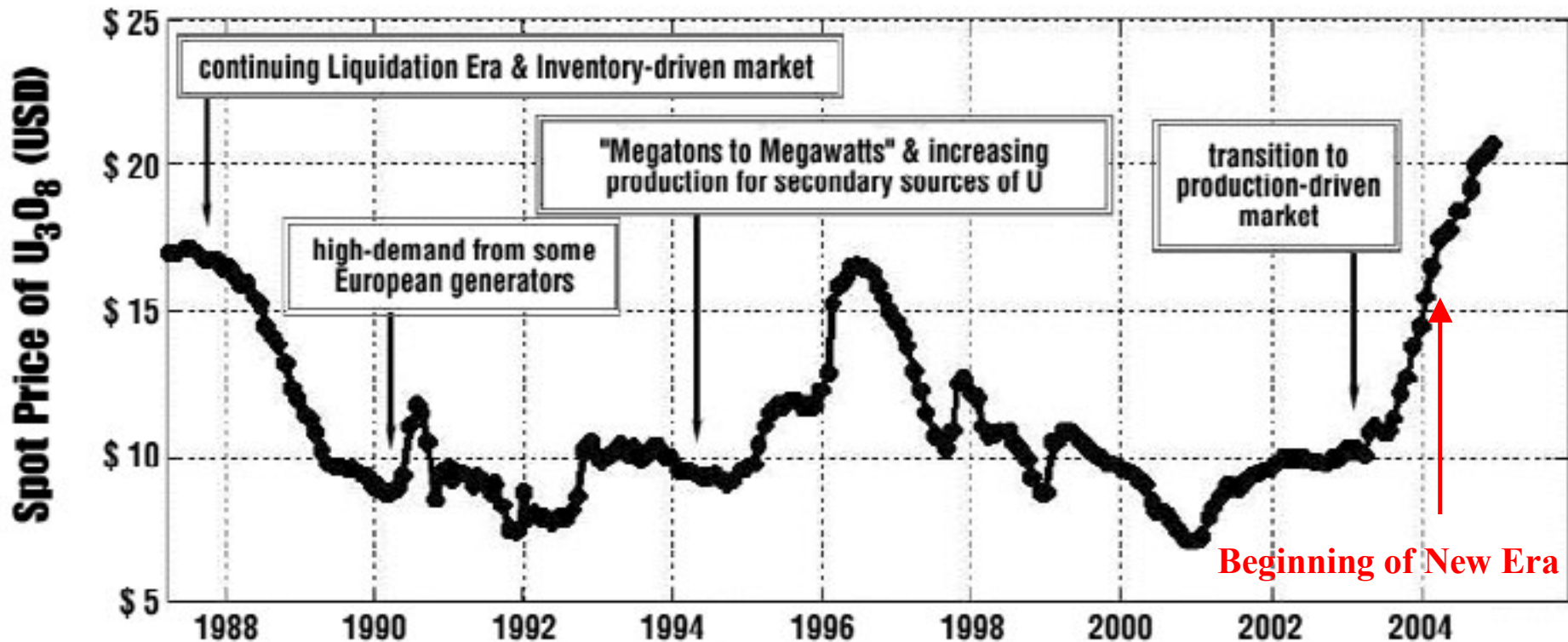
Uranium Prices (Cont'd)

Spot-Price History of U_3O_8 1948 - 2005





Uranium Prices (Cont'd)





Uranium Production

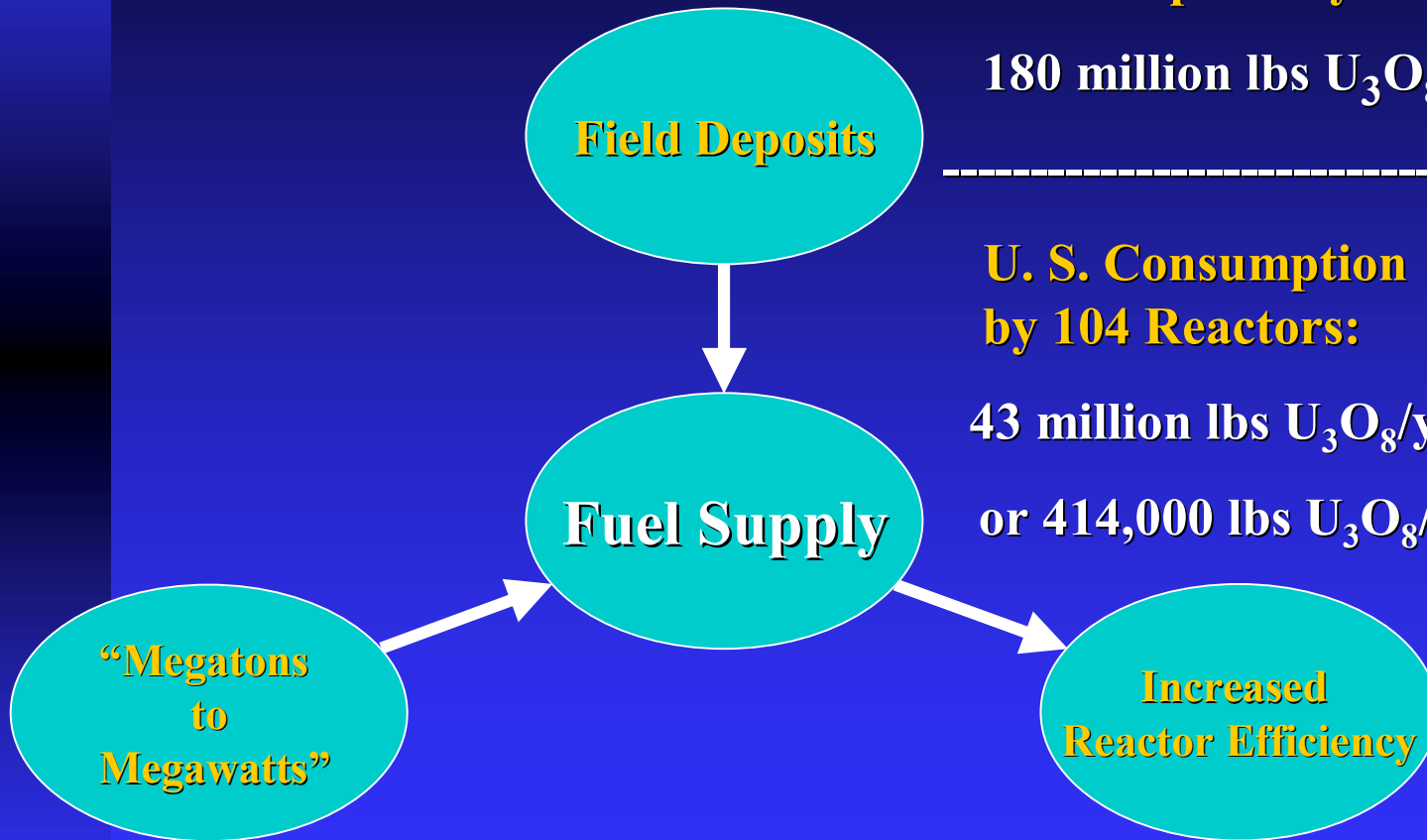
**Present Worldwide
Consumption by 435 Reactors:**

180 million lbs U_3O_8 /yr

**U. S. Consumption
by 104 Reactors:**

43 million lbs U_3O_8 /yr

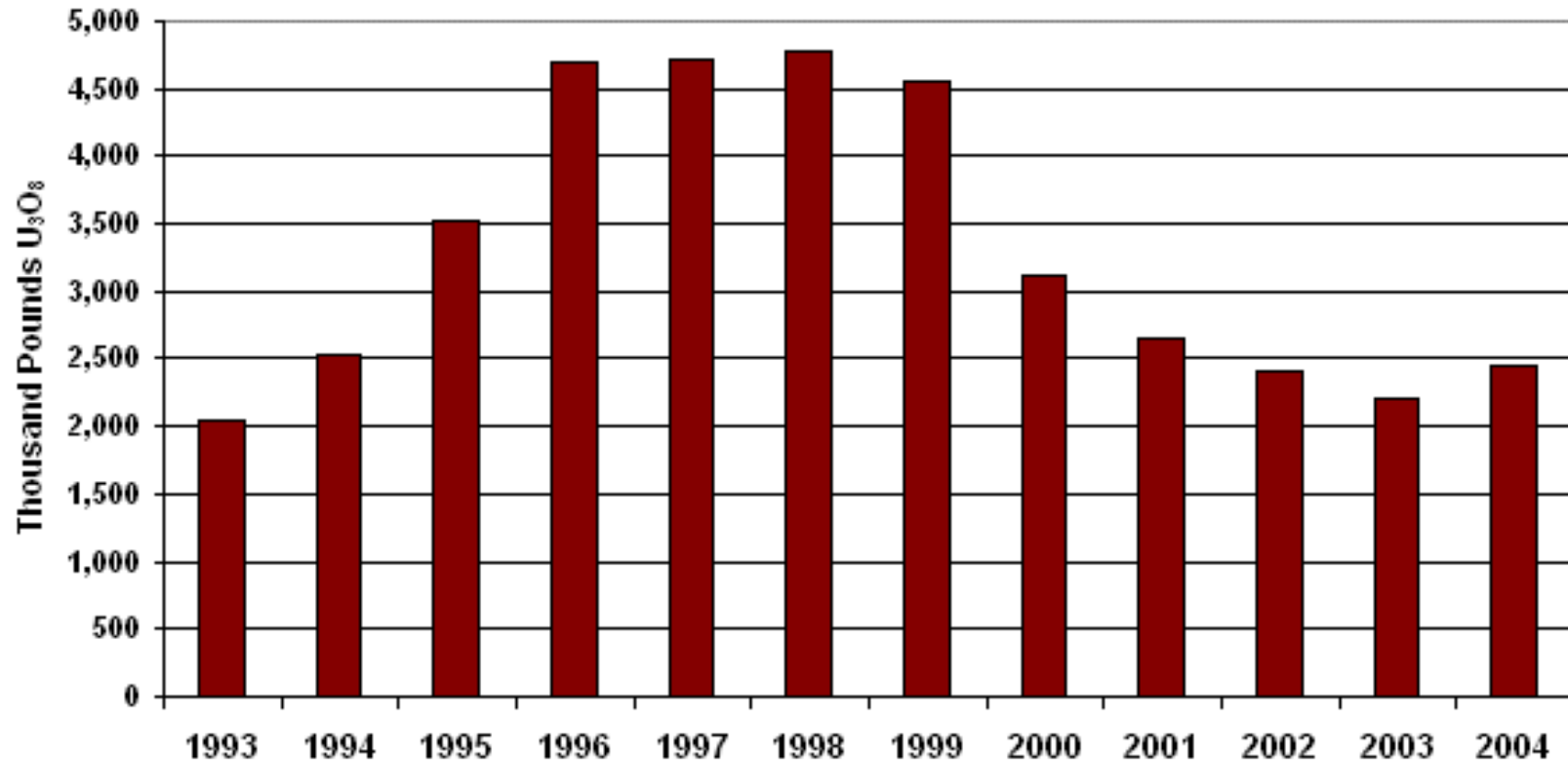
or 414,000 lbs U_3O_8 /Reactor/2-3 yrs





Uranium Production (Cont'd)

U.S. Uranium Mine Production, 1993-2004



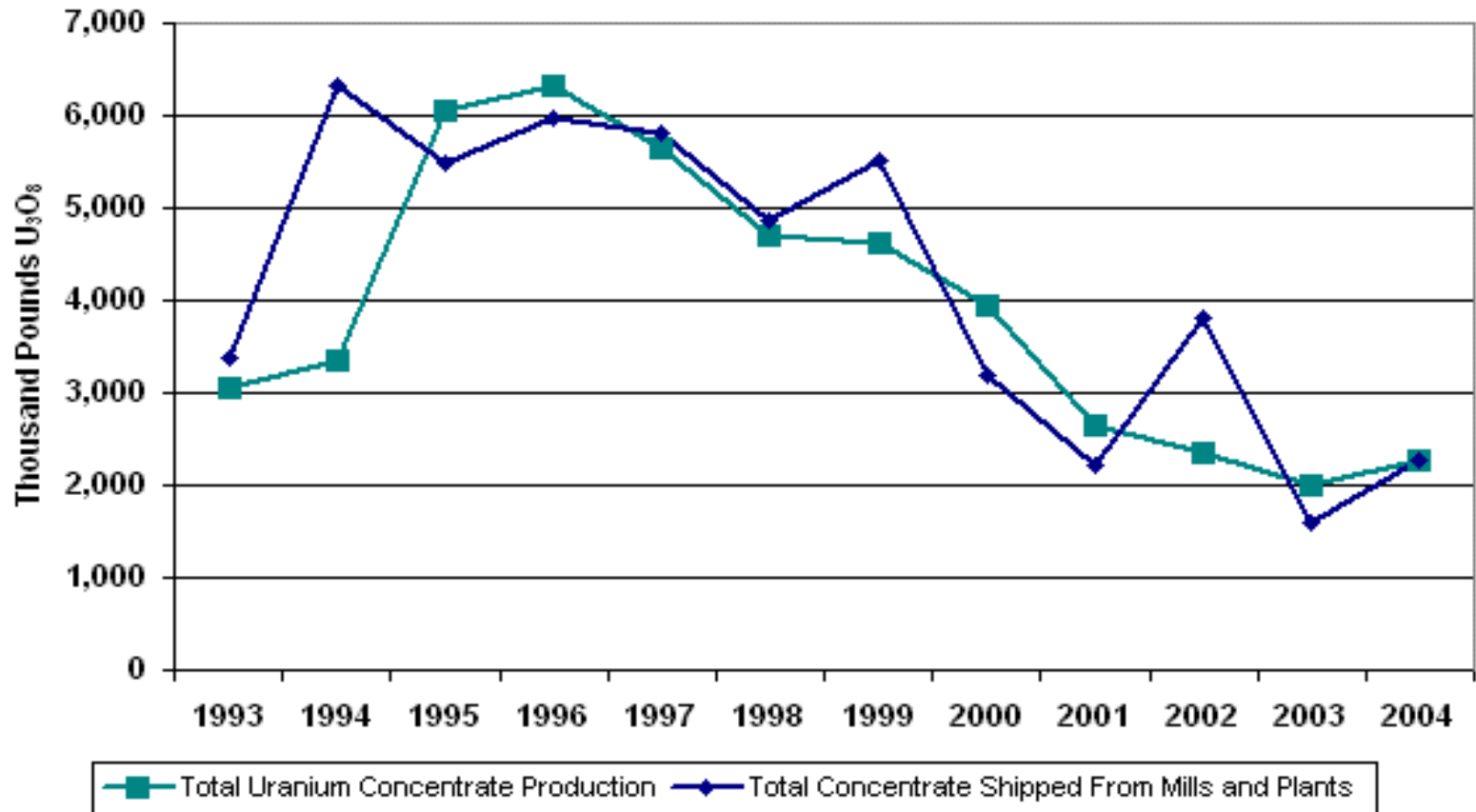
Estimate for 2003.

Sources: Energy Information Administration: 1993-2002-Uranium Industry Annual 2002 (May 2003), Table 4. 2003-2004-Form EIA-851A, "Domestic Uranium Production Report"



Uranium Production (Cont'd)

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



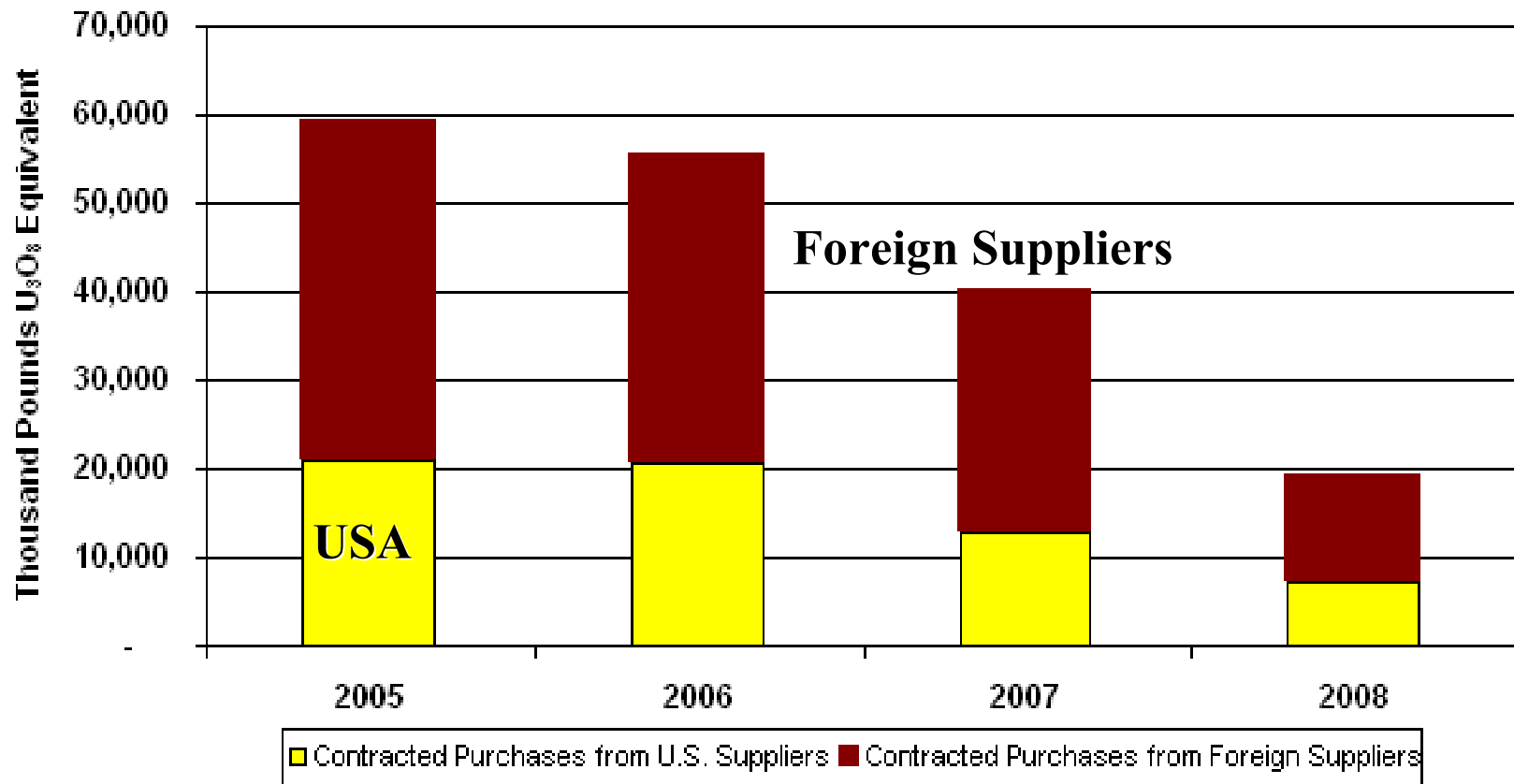
Estimate for 2002 and 2003.

Sources: Energy Information Administration: 1993-2002-Uranium Industry Annual 2002 (May 2003), Table 5. 2003-2004-Form EIA-851A, "Domestic Uranium Production Report"



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

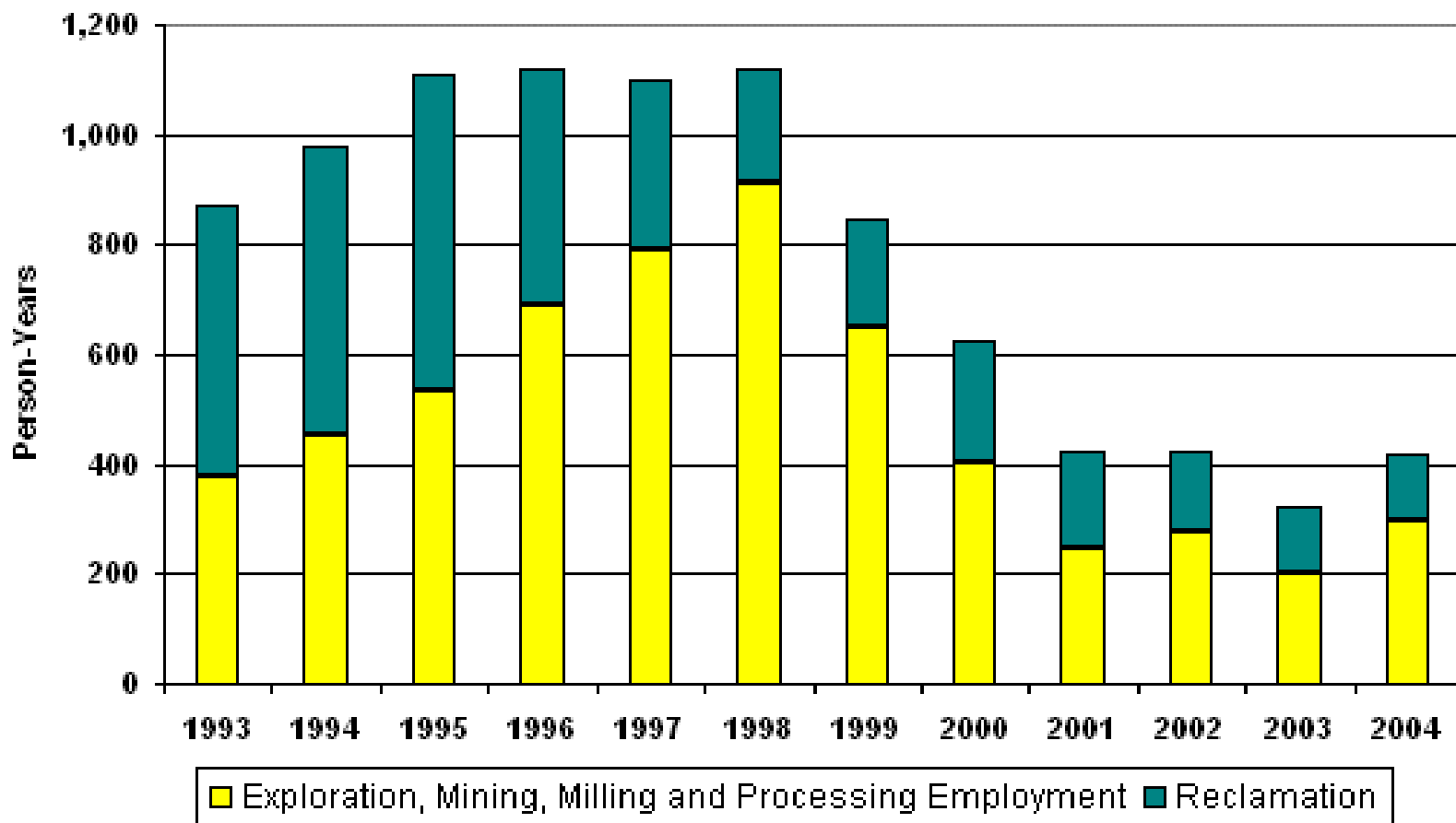


Source: Energy Information Administration, Form EIA-858 "Uranium Marketing Annual Survey" (2004).



Uranium Production (Cont'd)

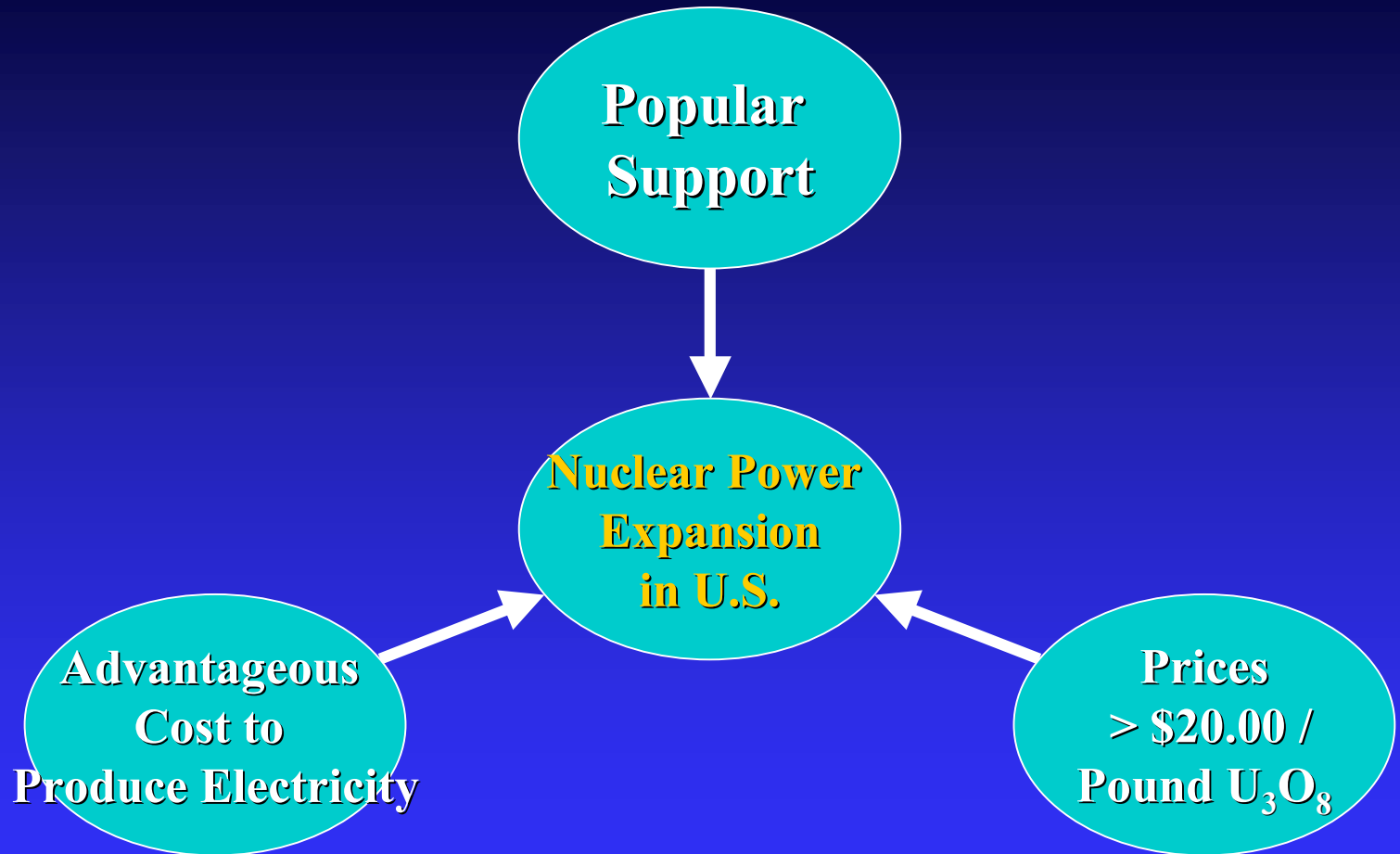
Employment in the U.S. Uranium Production Industry by Category, 1993-2004



Sources: Energy Information Administration: 1993-2002-Uranium Industry Annual 2002 (May 2003), Table 8. 2003-2004-Form EIA-851A, "Domestic Uranium Production Report"



Economics & Environmental Issues





Economics & Environmental Issues (Cont'd)

Land Needed by Wind or Solar Energy to Match Annual Nuclear Energy Production*



Solar Cells

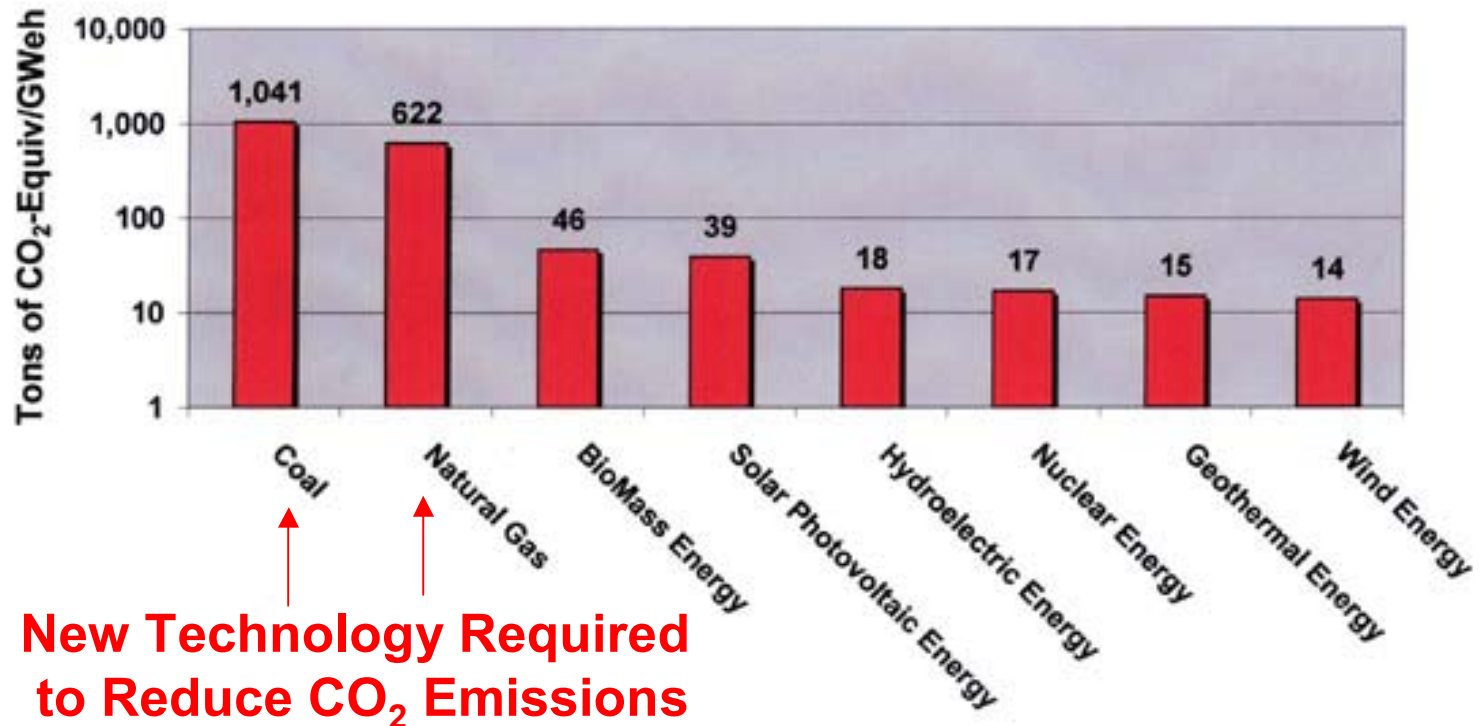


* 768 billion kilowatt-hours



Economics & Environmental Issues (Cont'd)

CO₂ Generated After Producing
One GigaWatt-Hour of Electricity By Indicated
Energy Source (U.S. EIA)



**New Technology Required
to Reduce CO₂ Emissions**



Nuclear Power Plant Safety

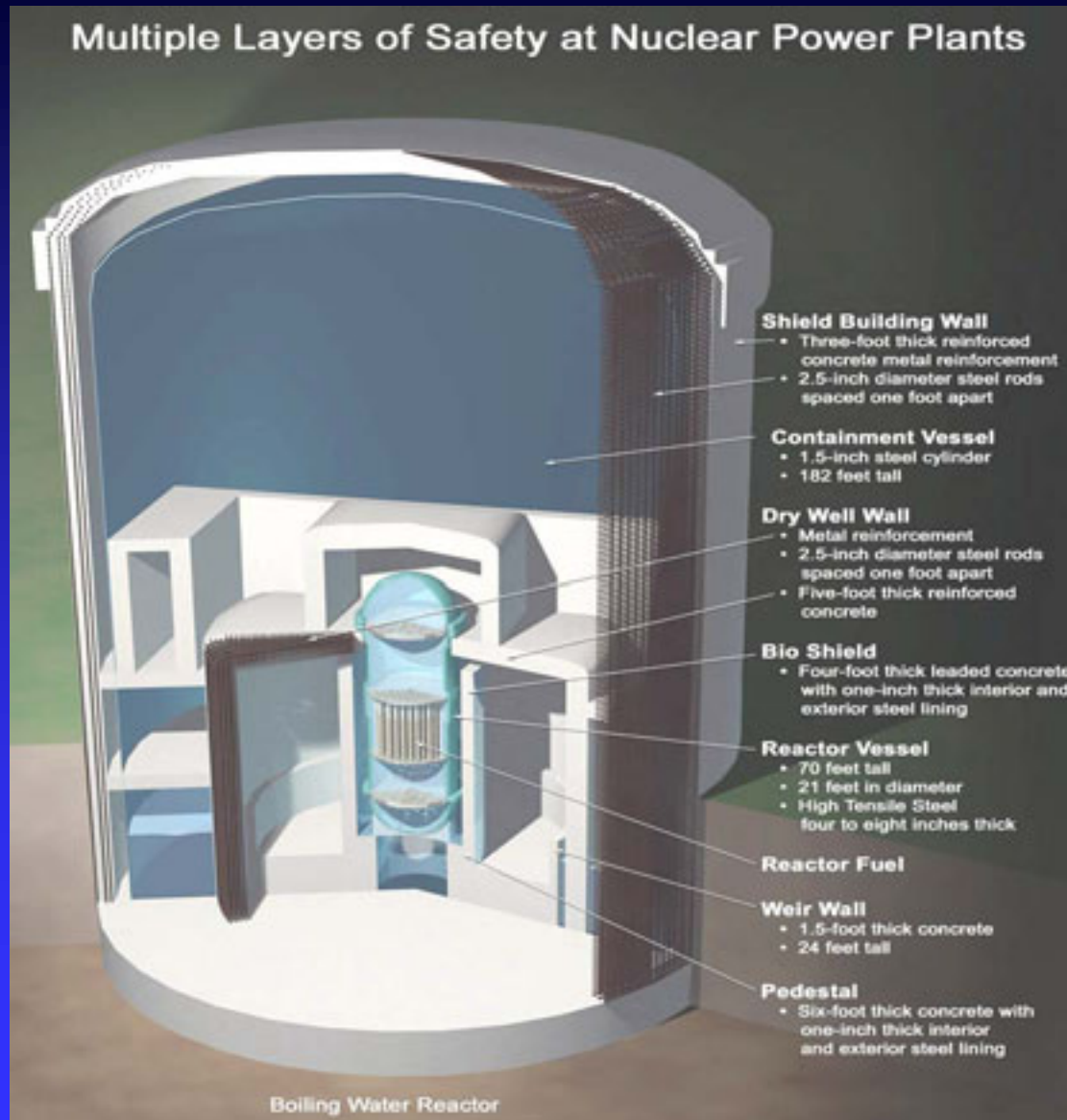
Over Past
40 Years:

1) Outstanding
Safety Record

2) Improved
Technology

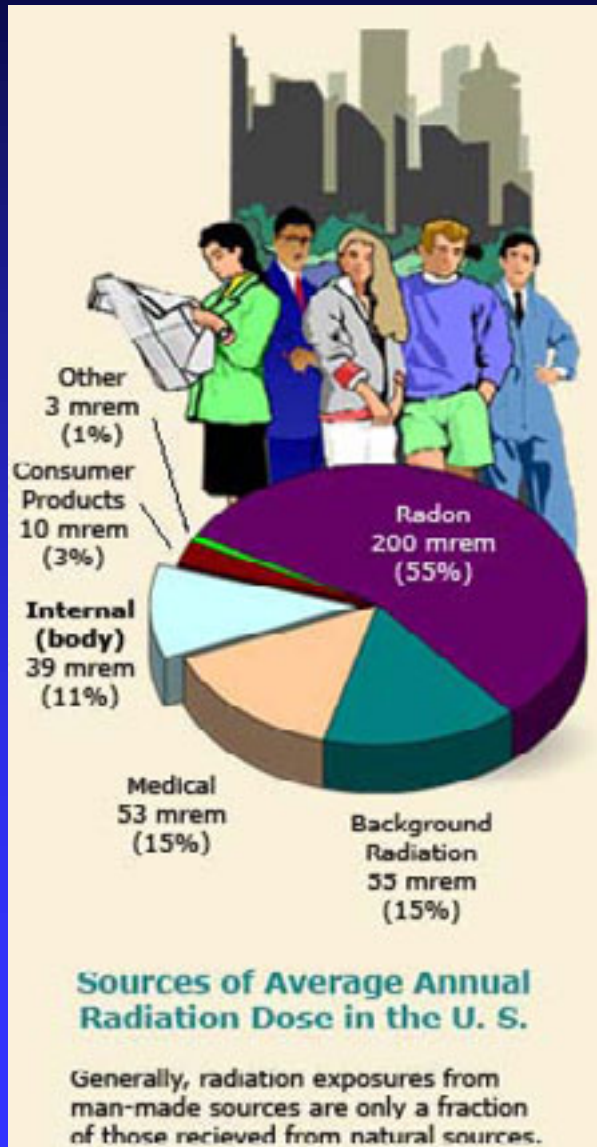
3) Improved
Operations
Management

4) Improved
Construction
Cost
Management





Nuclear Waste Transportation & Storage: Fear of Nuclear Waste ?



Over 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)

Fear

Exposure?
Drinking Water?
Hollywood
&
Press Media

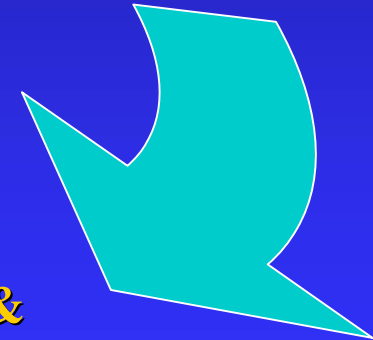
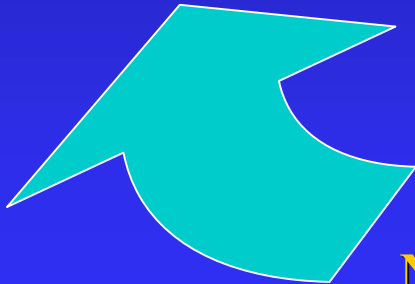


Assessment

Safety Record, Good Science
New Technology, Improved Management

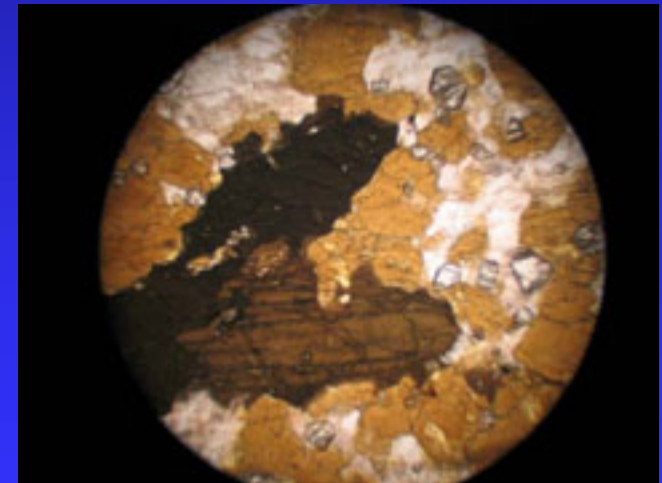
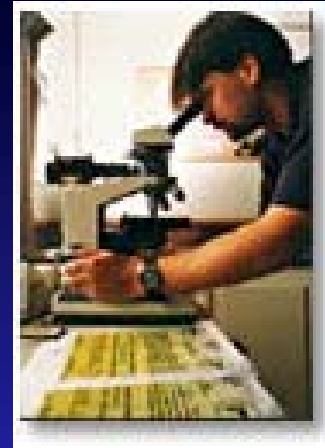
Risk

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



Drilling



Claim Locations w/ GPS



Coring & Logging



...and More Drilling



Uranium Field Work



Underground Mines



**Field Reconnaissance
& Mining Claims**



Environmental Monitoring Wells



...And there are always disagreements....

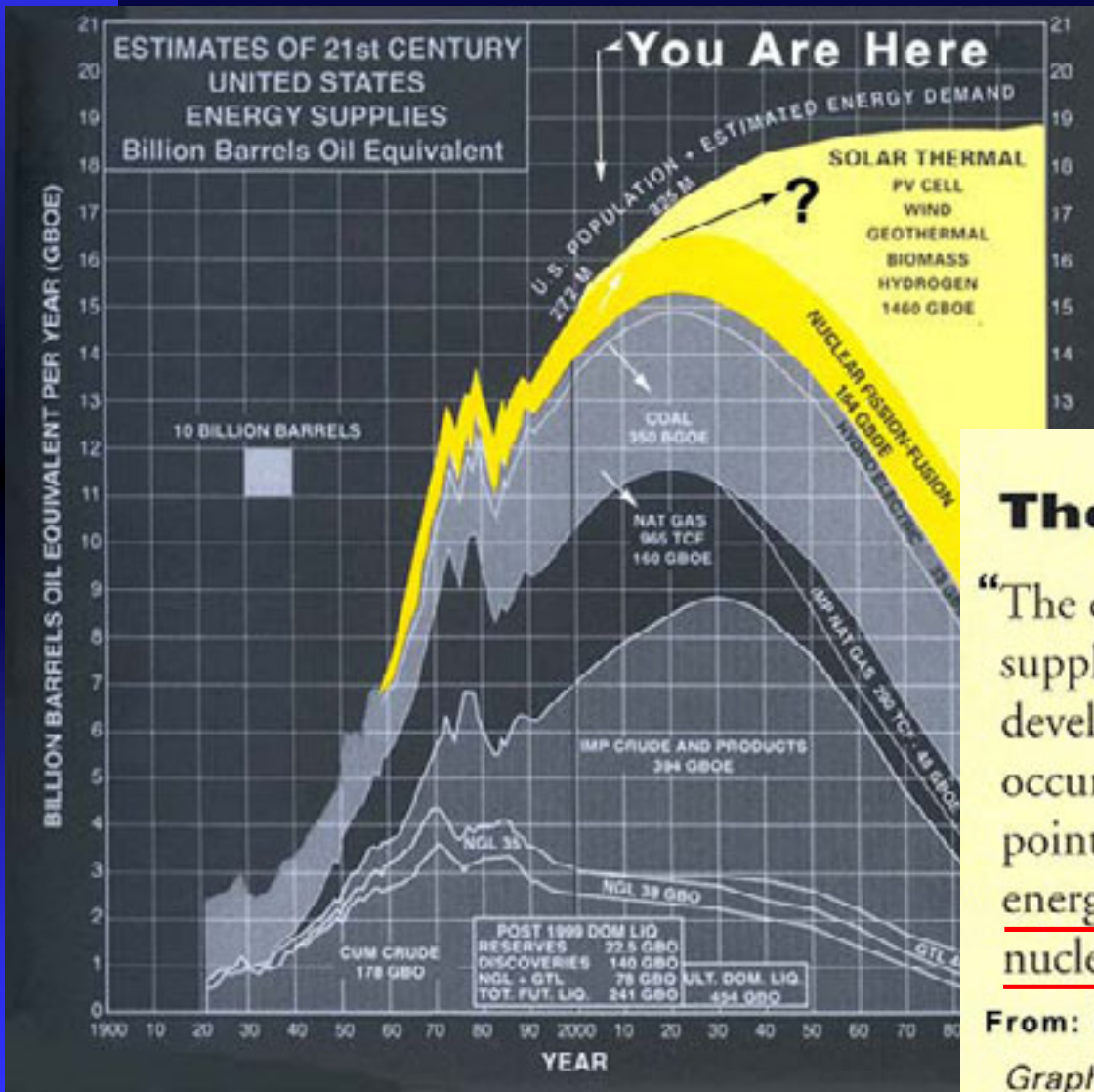


Conclusions...

Nuclear Power is One of the Answers...

Now and Later

Fission is the Bridge to Fusion



The Yellow Zone

“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)

Campbell, M. D., *et al.*, 2005, Recent Uranium Industry Developments, Exploration, Mining and Environmental Programs in the U.S. and Overseas, AAPG, Energy Minerals Div., Uranium Committee Report for 2005:
http://emd.aapg.org/technical_areas/uranium.cfm (Public Page)

**Campbell, M. D. and K. T. Biddle, 1977, Frontier Uranium Exploration in the South-Central U.S., Chapter 1: Frontier Areas and Exploration Techniques in *Geology of Alternate Energy Resources in the South-Central United States*, (M. D. Campbell (ed)), Houston Geological Society, pp. 3-44.
(<http://www.ela-iet.com/ie08000B.htm>)**

**Campbell, M. D., 1977, Introduction, in *Geology of Alternate Energy Resources in the South-Central United States*, Houston Geological Society, pp. v-xiv
(<http://www.ela-iet.com/ie08000B.htm>)**

De Voto, R. H., 1978, Uranium geology and exploration: Short course lecture notes and references: Golden, CO, Colorado School of Mines, 396 p.



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Dickinson, K. A., and J. S. Duval, 1977, South Texas Uranium: Geologic Controls, Exploration Techniques, and Potential, Chapter 2: Trend Areas and Exploration Techniques Utilization in *Geology of Alternate Energy Resources in the South-Central United States* (M. D. Campbell (ed)), Houston Geological Society, pp. 45-66. (<http://www.ela-iet.com/ie08000B.htm>)

Limerick, P. N., *et al.*, 2003, What Every Westerner Should Know About Energy, Center of the American West, University of Colorado at Boulder, Report # 4. 46 p. (http://www.centerwest.org/pdfs/CAW_EnergyFIN.pdf)

Rackley, R. I., *et al.*, 1968. Concepts and Methods of Uranium Exploration. *Wyo. Geol. Assoc. 20th Field Conf Guidebook*, pp. 115--124.

Rackley, R. I. and Johnson, R.L., 1971. The Geochemistry of Uranium Roll-Front Deposits with a Case History from the Powder River Basin. *Economic Geology*, v. 66, n. 1, pp. 202-203, (abstract).

Rackley, R. I., 1972, Environment of Wyoming Tertiary Uranium Deposits: *AAPG Bulletin*, v. 56, n. 4, pp. 755-774.



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Rackley, R. I., 1976, Origin of Western-States Type Uranium Mineralization, in *Handbook of Strata-Bound and Strataform Ore Deposits*, Chapter 3, K.H. Wolf (ed), Elsevier Sci. Pub. Company, Amsterdam, pp. 89-156.

Rubin, B., 1970. Uranium Roll-Front Zonation in the Southern Powder River Basin, Wyoming, *Wyoming Geological Assoc. Earth Science Bull.*, v. 3 n. 4: pp. 5-8.

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>