Energy History - 1975 to Present

SAND2007-5540P

Energy History: 1975 to Present

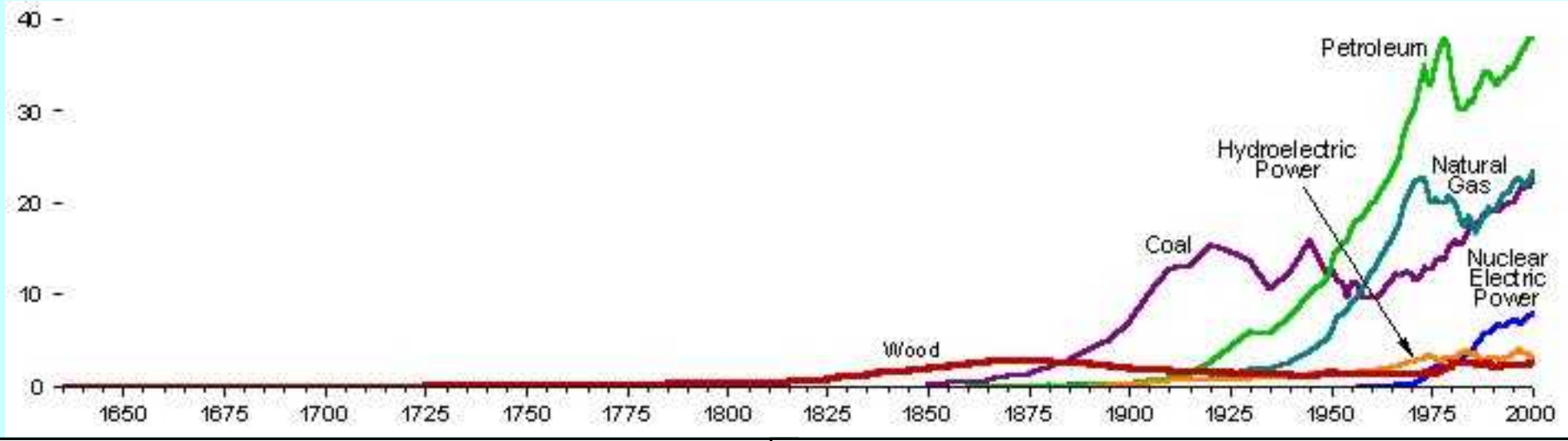
- Snapshot of the energy trends since the Arab Oil Embargo (early to mid 1970's)
- The History of the Period and the Role of Government
  - Deregulation, environmental laws
- The Search for Alternatives
  - Efficiency
  - Renewables – Projected in the late 1970s to be 20% of electricity by 2000
  - Alternative Fuels
  - Nuclear – Projected in the late 1970s to be 50% of electricity by 2000
- The diversification and long term effects of increasing supply and lower costs for traditional energy sources
- Development of a complex interdependent energy system

Energy History: 1975 to Present

Some Significant Events

- Arab Oil Embargo
- Browns Ferry nuclear accident
- Three Mile Island
- Iranian Revolution
- Chernobyl
- Gulf War
- Organizational and Safety Failures in Japanese Nuclear industry

Snapshot of the energy trends since 1975



- Complex, Interconnected, Interdependent System Evolves
- Deregulated to Regulated to Deregulated
- Transitions extended with attempts for regulatory control with unexpected consequence
- Never really deregulated
- Energy in Many Forms becomes a Commodity

- Nuclear Stalemate Continues
- Return of Coal
- Natural Gas extends into Electrical Generation
- Increased reliance on electricity
- U.S. no longer controls its oil supply
- Growth of Competing Economies

Energy History: 1975 to Present

1970's

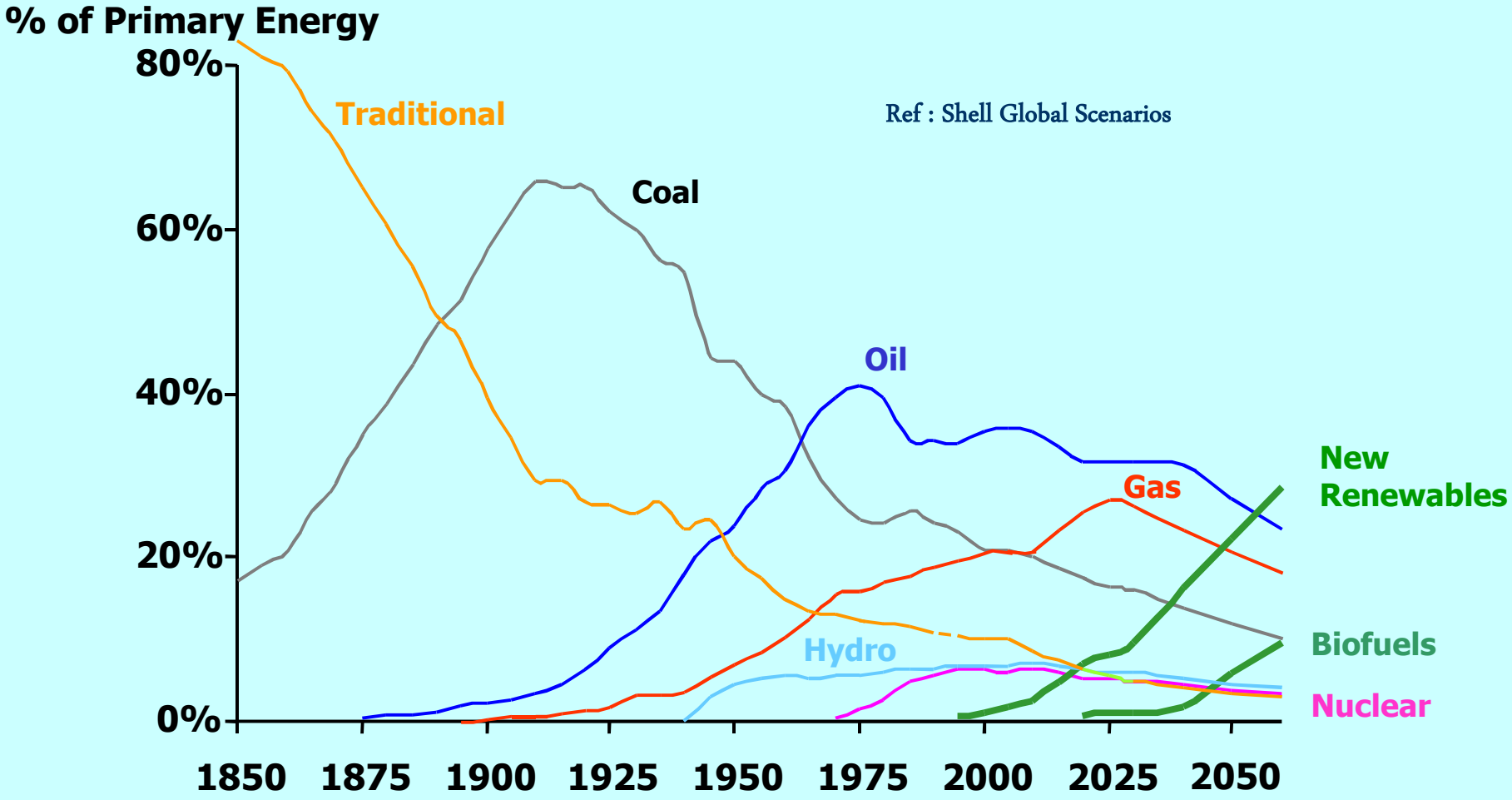
- Clean Air Act
- National Environmental Policy Act of 1969
- EPA formed
- Water and Environmental Quality Act
- Clean Air Act expanded
- Clean Water Act
- Energy Policy Act established Strategic Petroleum Reserve and increased automobile efficiency amongst other goals
- DOE formed
- Public Utilities Regulatory Act (PURPA) ends utility monopoly over generation
- Power Plant and Industrial Fuel Use Act limits use of natural gas in electric generation (repealed in 1987)

Energy History: 1975 to Present

1980
Pacific Northwest Electric Power Planning and Conservation Act establishes regional regulation and planning
Citizens Power, first power marketer in North America

1990
ISO New England forms, first ISO
California opens deregulated electricity market
Foreign acquisition of US power: Scottish Power buys Pacificorp, Nation (UK)
Grid purchases New England Electric System
FERC issues Order 2000, promoting regional transmission

Peaks in Energy Supplies- Possibilities?



Is Peak Oil Production Coming Soon

Hubbert's Peak : The Impending World Oil Shortage by Kenneth S. Deffeyes Out of Gas: The End of the Age of Oil by David Goodstein

The Oil Factor: How Oil Controls the Economy and Your Financial Future by Donna Leeb, Stephen Leeb

The End of Oil : On the Edge of a Perilous New World by Paul Roberts

The Coming Oil Crisis by C. J. Campbell

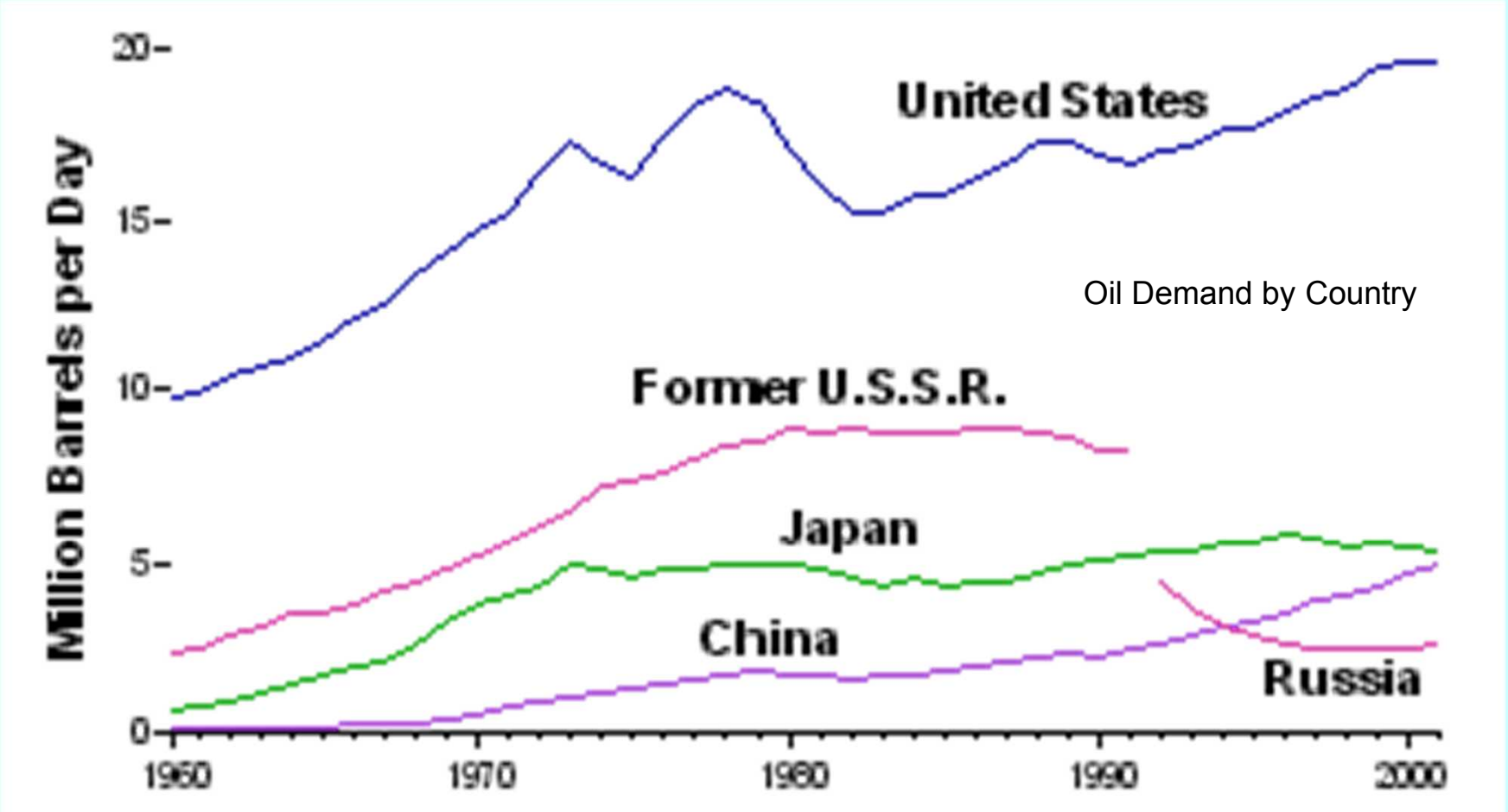
The Color of Oil : The History, the Money and the Politics of the World's Biggest Business by Michael Economides, et al

Resource Wars: The New Landscape of Global Conflict With a New Introduction by the Author by Michael T. Klare (Rate it)

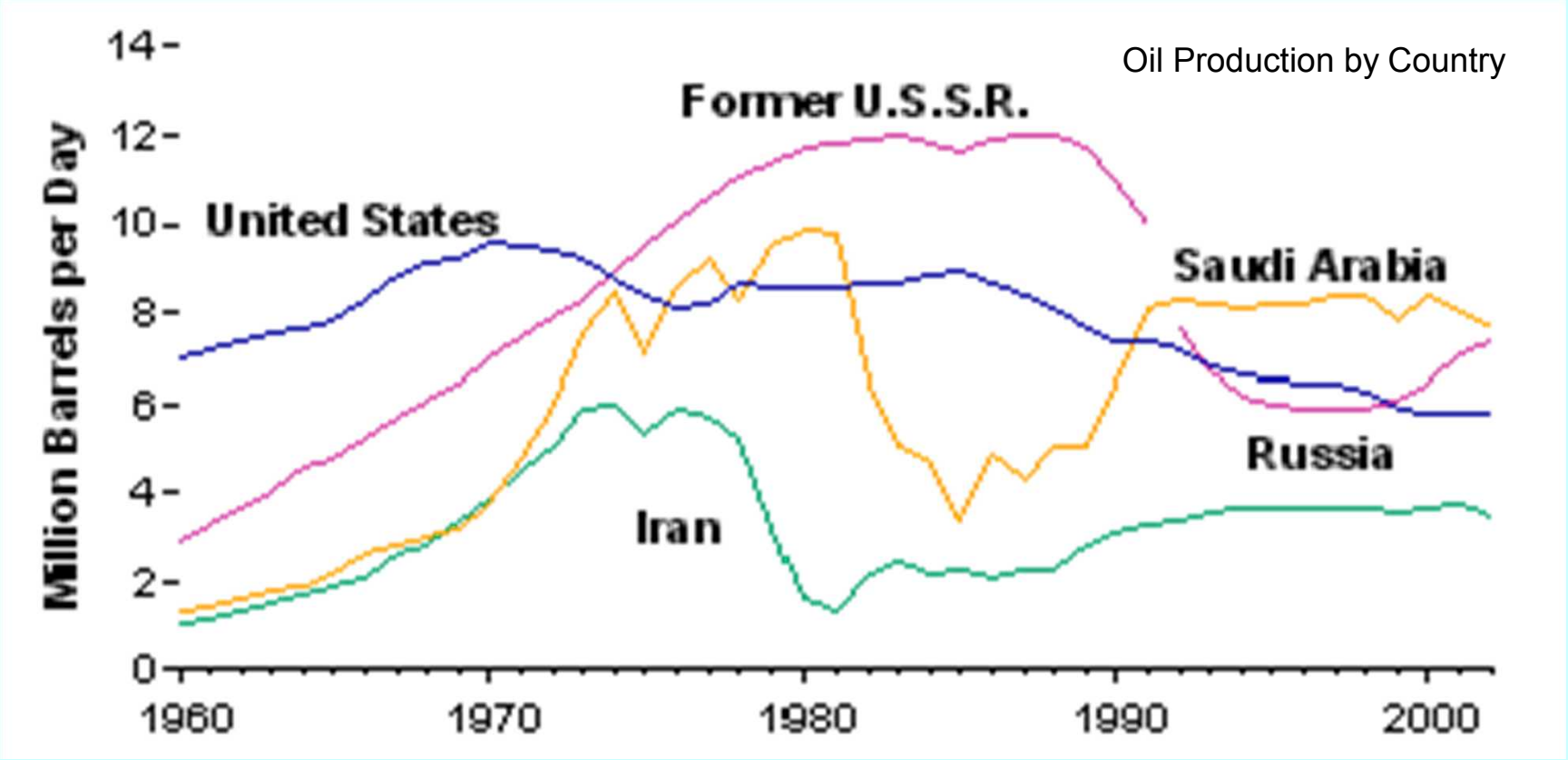
Russia 2010: And What It Means for the World by Daniel Yergin, et al

Out of Gas: The End of the Age of Oil by David Goodstein

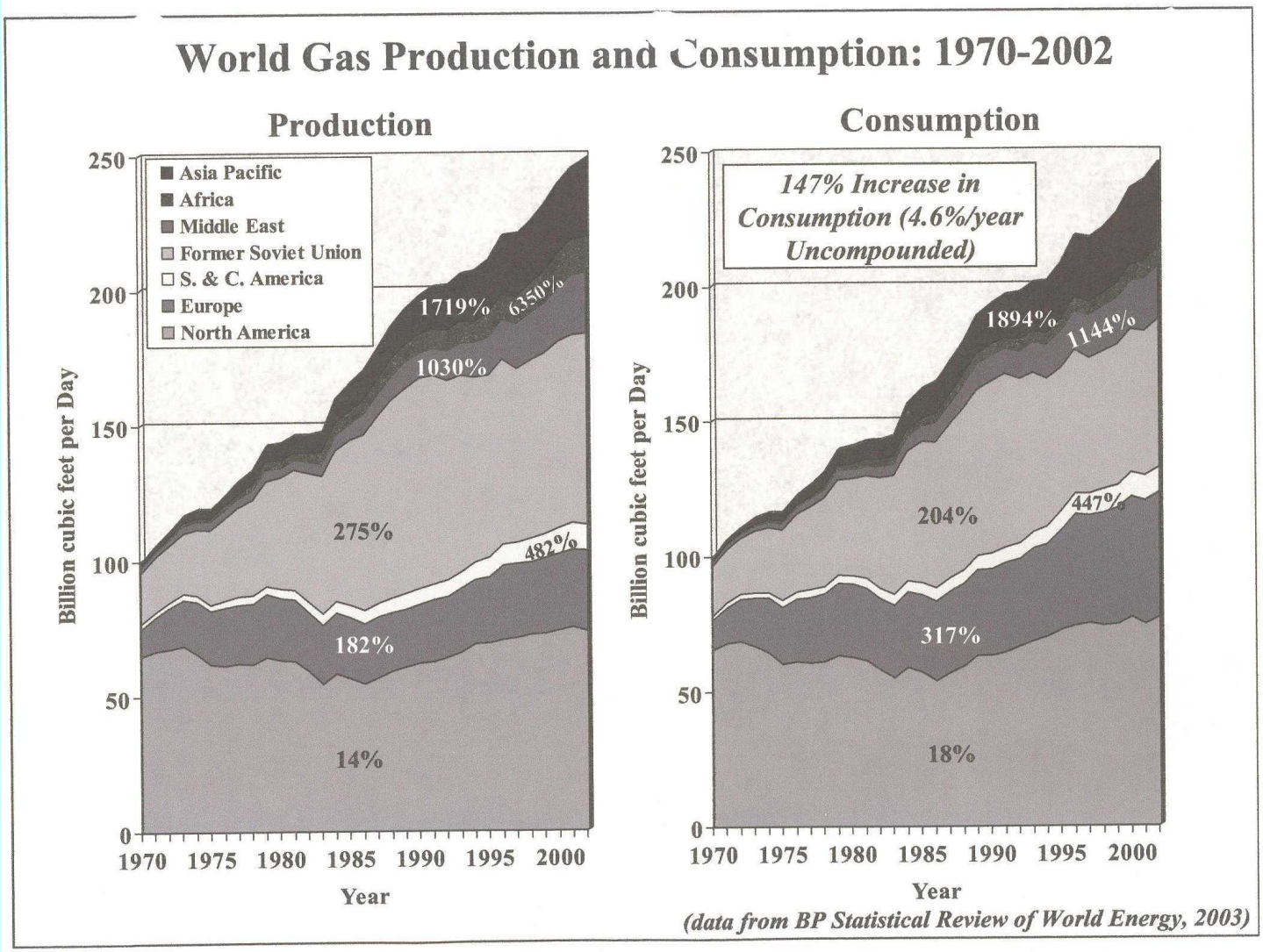
Energy History: 1975 to Present
Trend in Oil Demand



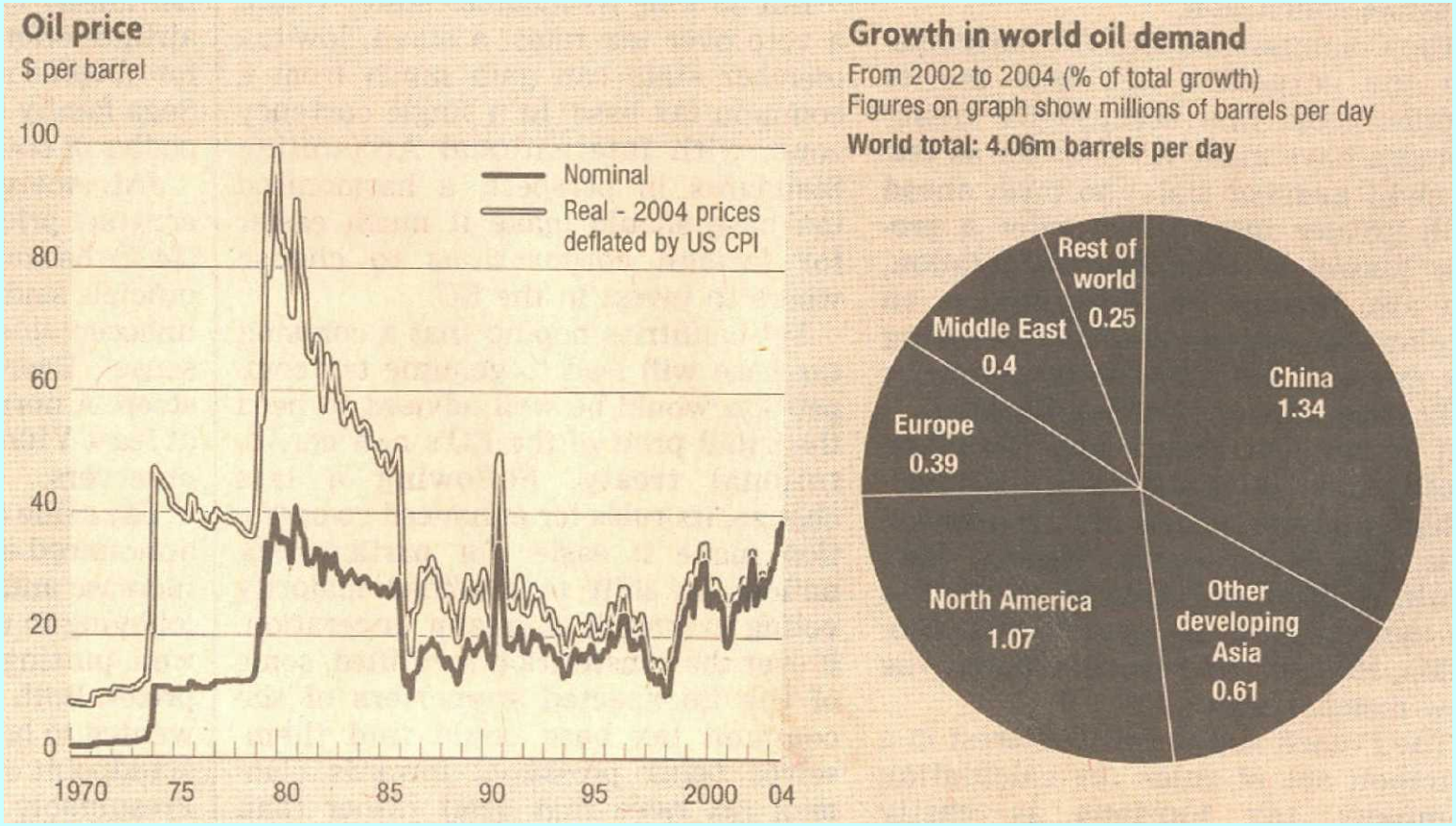
Trends in Oil Production



Natural Gas Production and Consumption 1970 to Present



Deregulated Environment: Cost as a Conservation Driver



Oil Production Trends

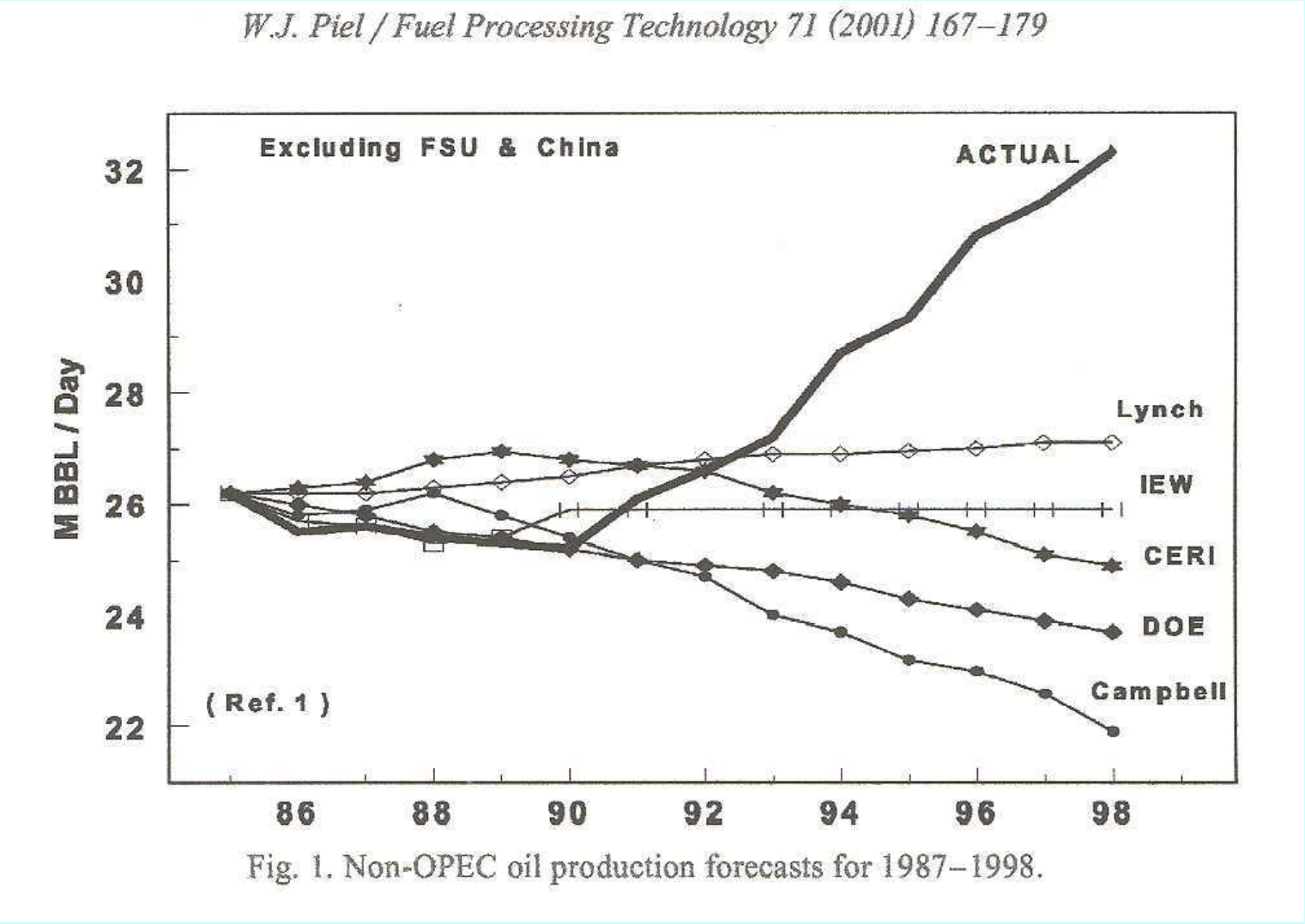
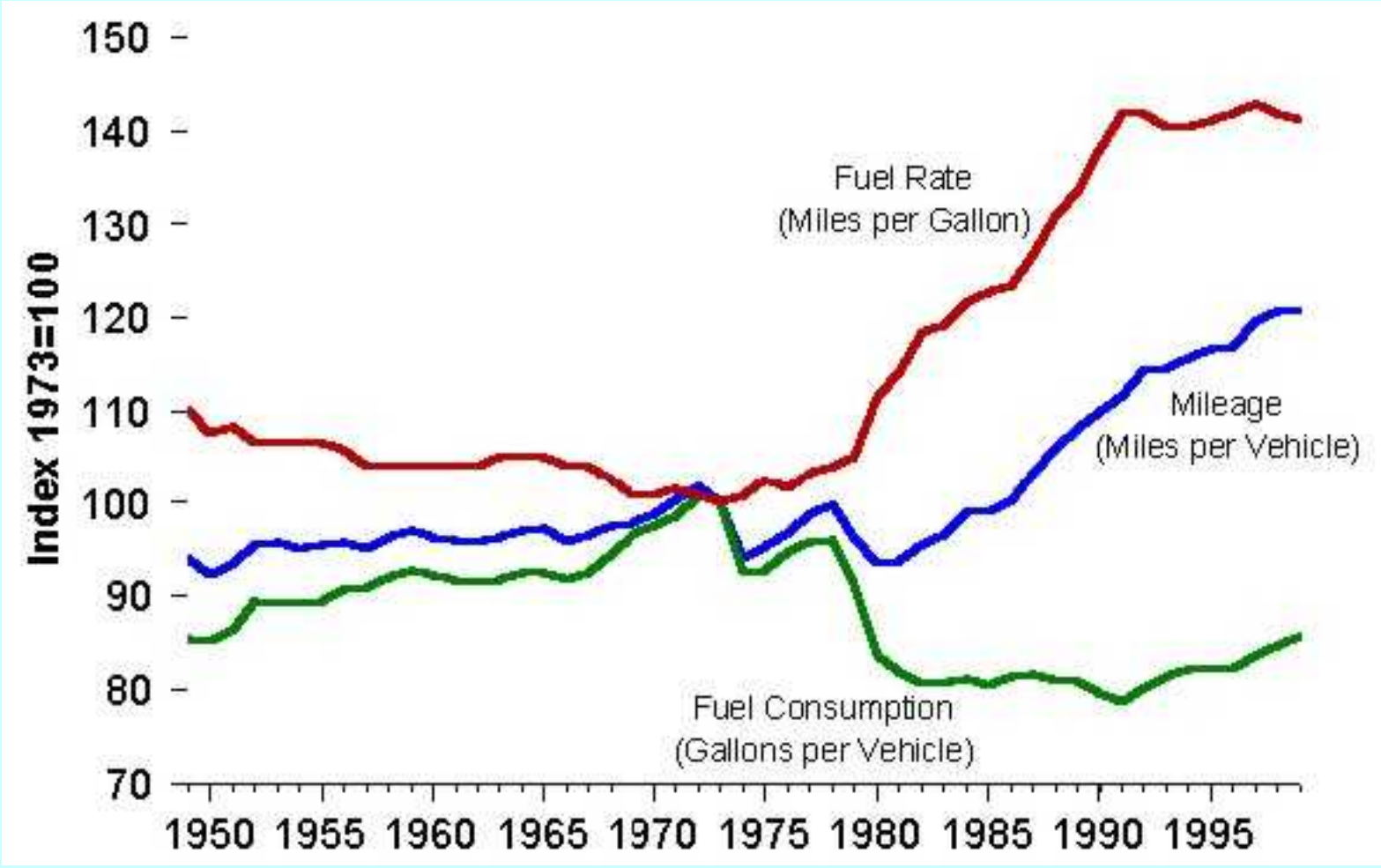


Fig. 1. Non-OPEC oil production forecasts for 1987–1998.

Fuel consumption 1945-Present

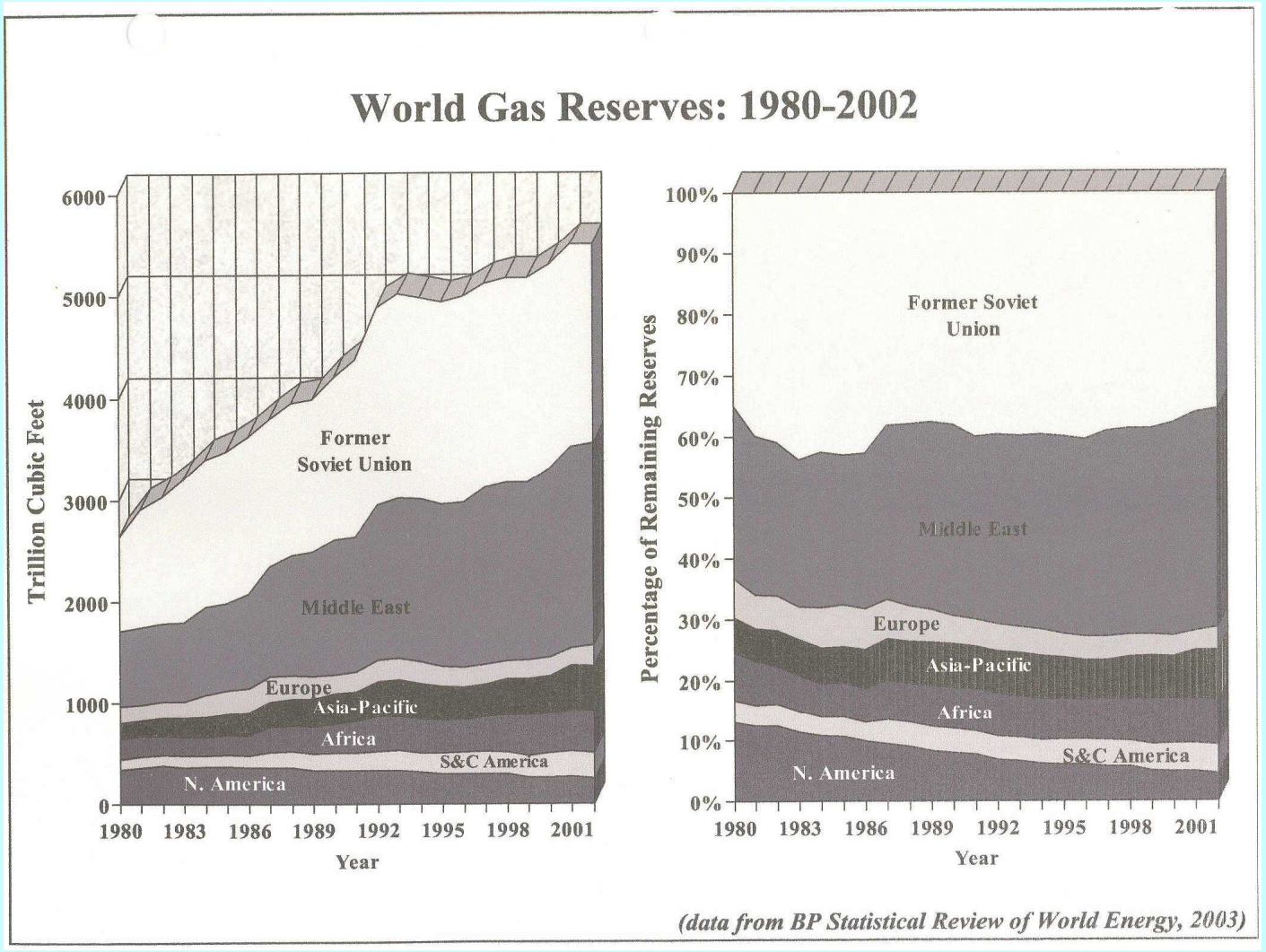


U.S. Sources of Oil Imports

Total Imports of Petroleum (Top 15 Countries)
(Thousand Barrels per Day)

Country	May-04	Apr-04	YTD 2004	May-03	Jan - May 2003
CANADA	2,063	2,044	2,092	2,015	1,993
MEXICO	1,714	1,577	1,619	1,556	1,562
VENEZUELA	1,569	1,539	1,547	1,737	1,147
SAUDI ARABIA	1,519	1,175	1,415	2,305	1,918
NIGERIA	1,197	1,073	1,143	958	820
IRAQ	674	769	657	128	622
ALGERIA	477	380	416	377	317
UNITED KINGDOM	433	461	385	557	462
ANGOLA	405	338	329	356	356
VIRGIN ISLANDS, U.S.	294	290	289	258	253
KUWAIT	278	328	234	217	235
NORWAY	278	169	246	303	263
ECUADOR	259	253	208	149	102
COLOMBIA	202	153	174	162	203
RUSSIA	200	311	172	208	209

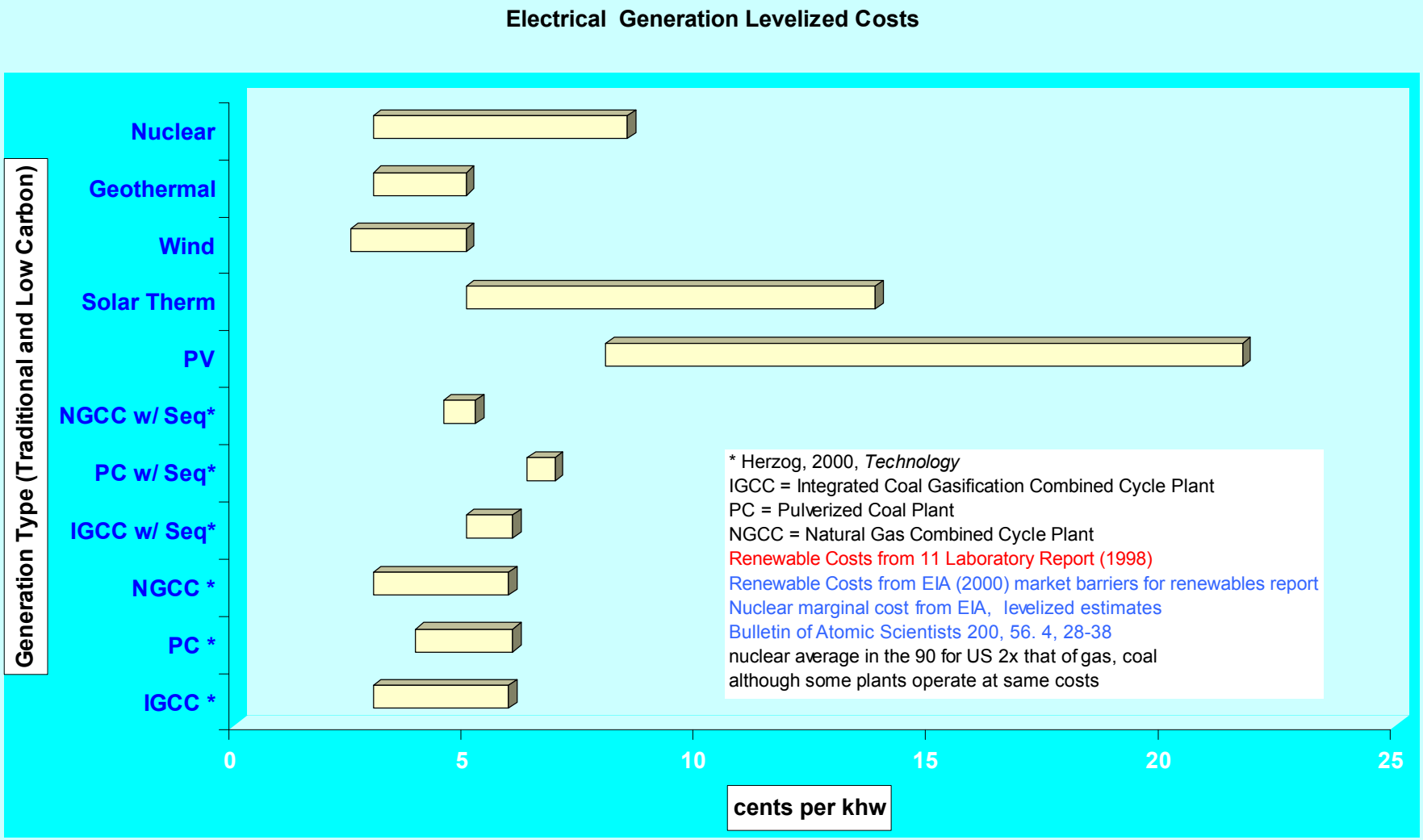
Natural Gas Reserves



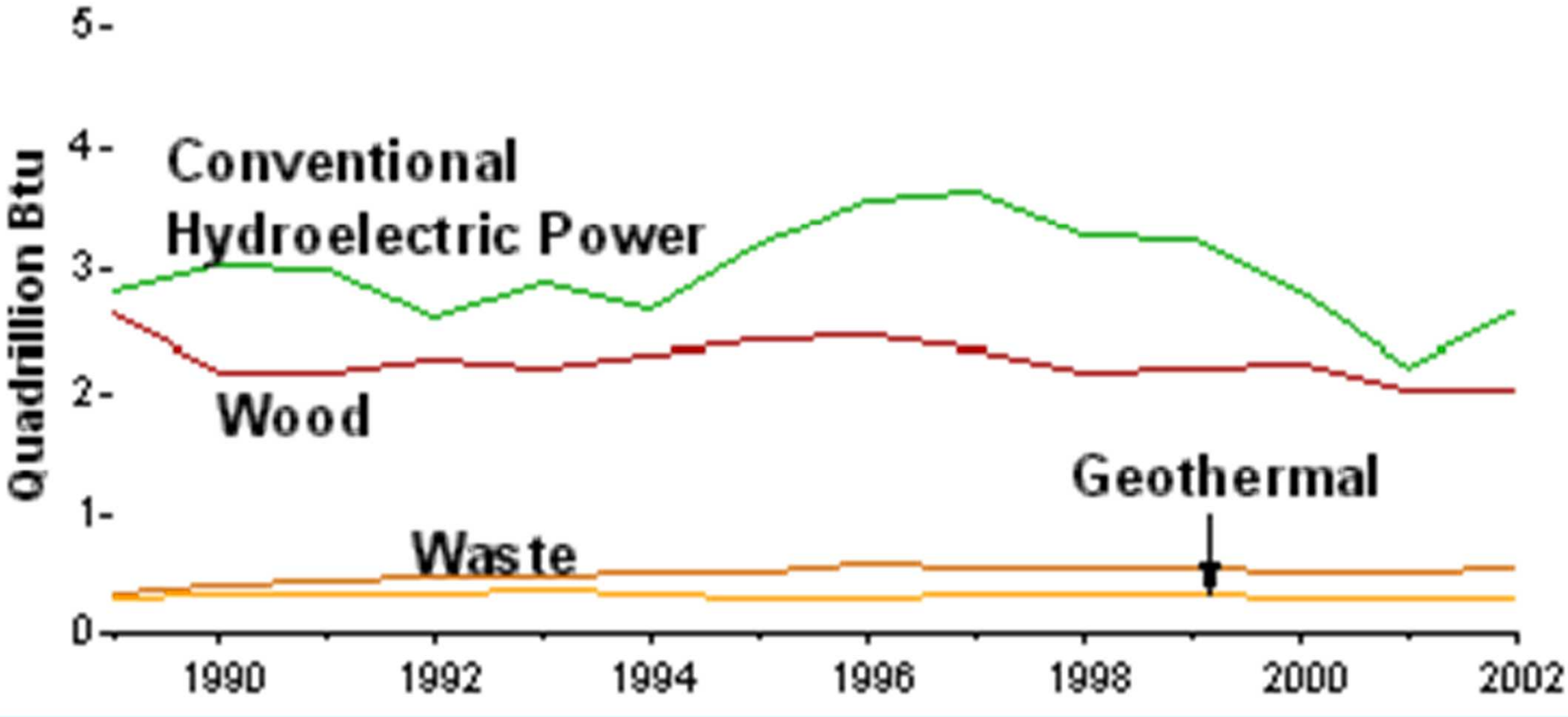
Electric Power Generation Costs Drive Capital Improvements

Technology Type	2001 $/Installed kW
Combustion Turbine	$360
Advanced Combustion Turbine	$500
Combined Cycle Gas Turbine	$480-$500
Advanced CCGT	$600-$650
Pulverized Coal	$1,200
Atmospheric Fluidized Bed Combustion Coal	$1,100-$1,200
Integrated Gassification Combined Cycle (coal-gas)	$1,400-$1,500
Wind	$1,000-$1,500
Bio Mass	$1,000-$1,500
Geothermal	$2,250-$2,750
Nuclear	**$2,000-$2,400**

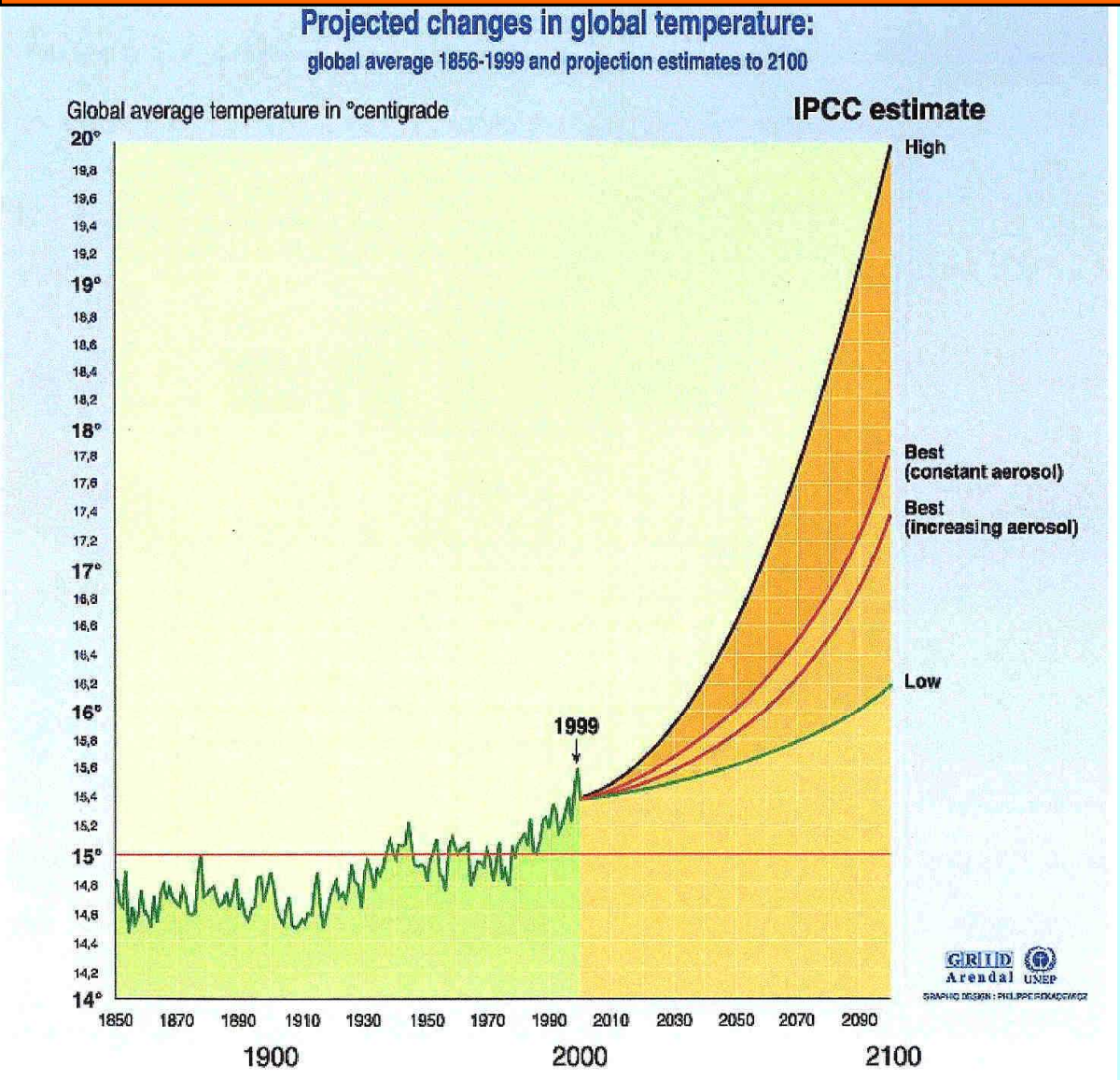
Electrical Power Trends: 1975 to Present



What Has Happened to Renewables?



Electric Power Generation Challenge*: CO2*



Technical Problem:

- Anthropogenic C02: 6Gt/year
- By 2100 CO2 emissions may reach 77Gt/year
- IPCC: Sequestration may mitigate 30% of CO2 emissions by 2050
- Transition to a hydrogen economy from fossil fuels

Technical Issues

- What are the life cycle costs?
- What are the actual capacities for separation and storage?
- What technologies are needed?

Nuclear Energy: *Is Peek Production Coming Soon?*

World Nuclear Association Fact sheets Uranium resources 2004

"Although uranium mining has continued, a significant portion of reactor fuel has come not from newly extracted uranium but from inventories. Since 1985 Western uranium production has been less than reactor requirements, and by 2000 it had fallen to only half of the annual usage.

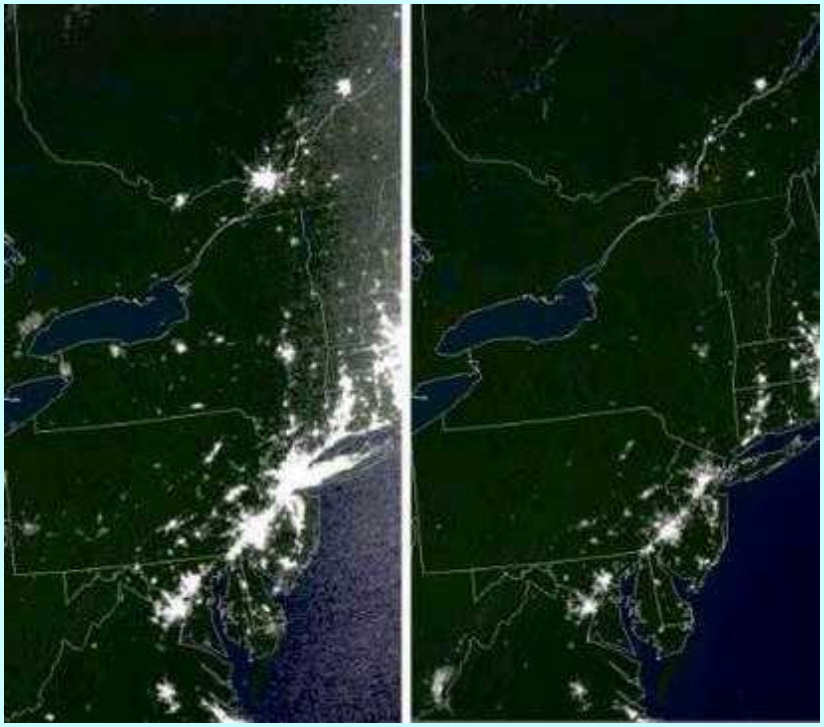
Current situation

According to the summary of uranium resources published jointly by the Nuclear Energy Agency of the OECD and the UN's International Atomic Energy Agency, known reserves of uranium from conventional sources are slightly more than 3 million tonnes. Reactor requirements are fairly steady at about 60,000 tonnes per year. Thus there is about 50 years supply of uranium known at this stage to be available. "

Increasing Energy Complexity and Interdependency

Fiction

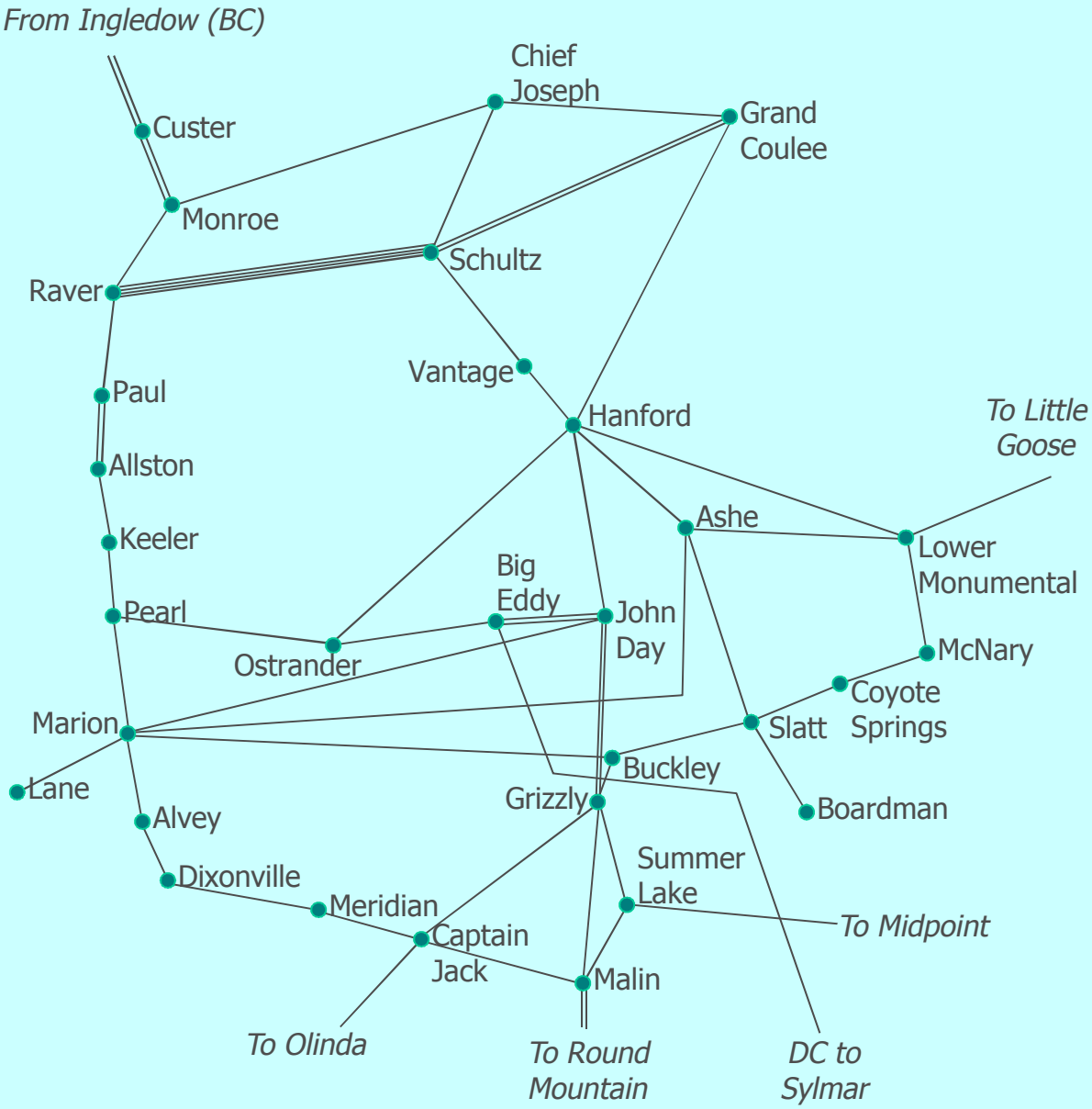
Fact

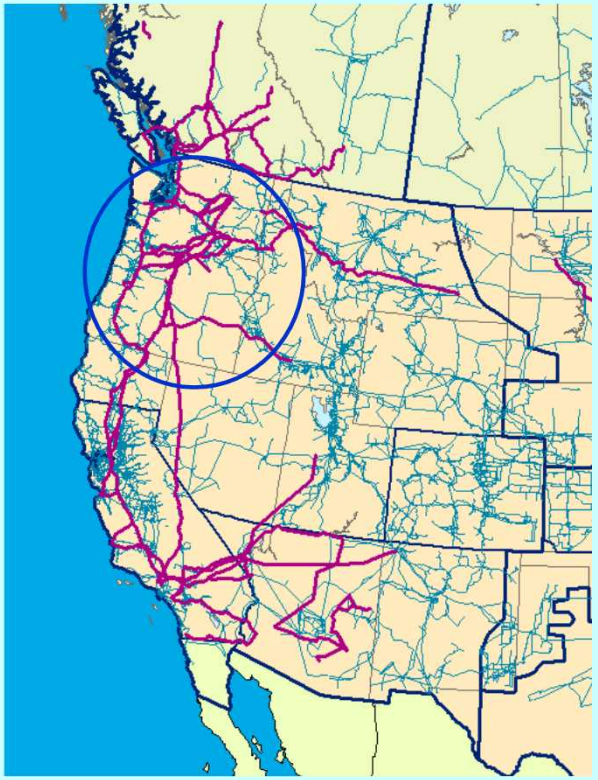


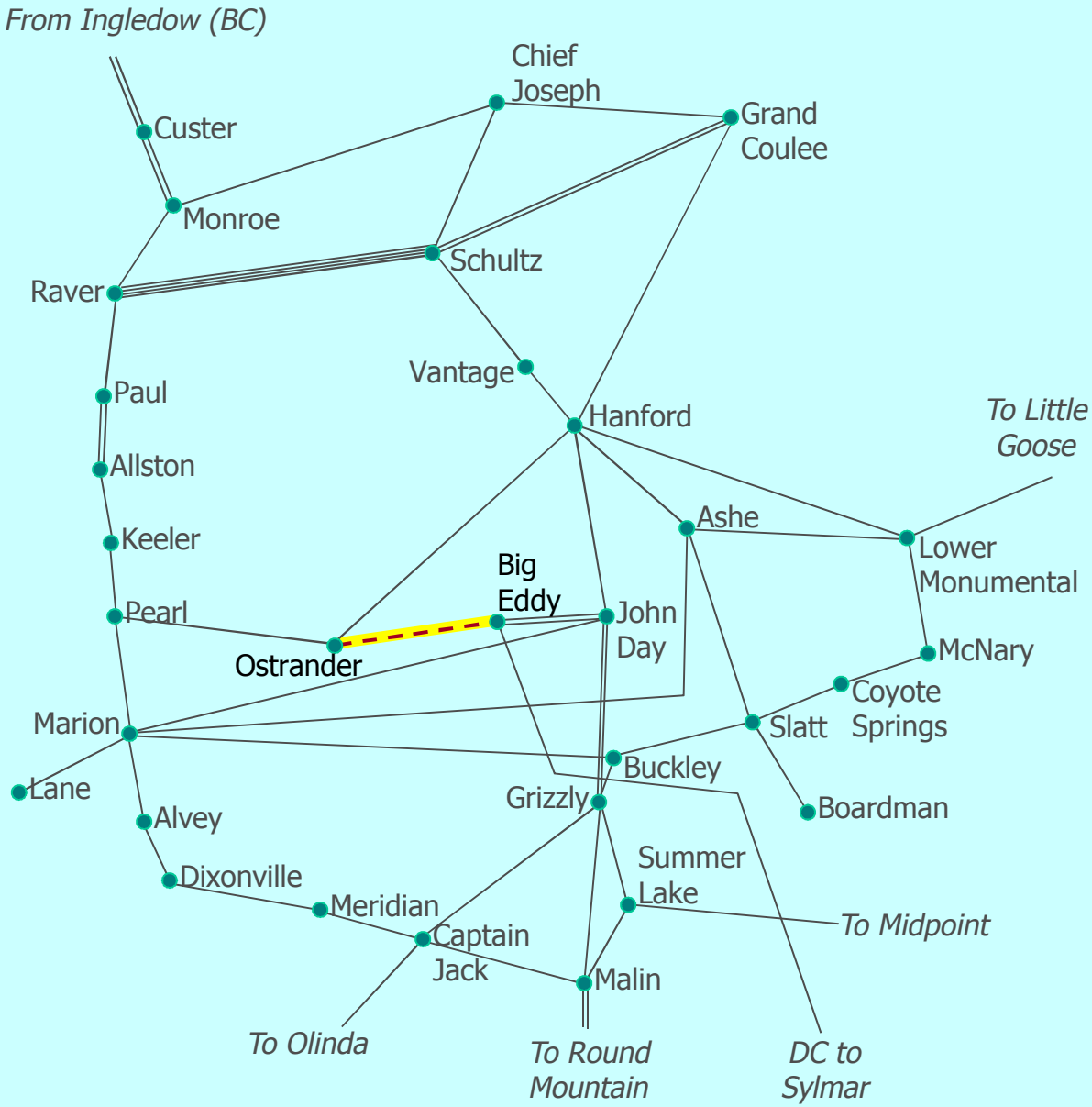
NE Energy Blackout 2003 – Fact and Fiction

August 10, 1996 WSCC Outage

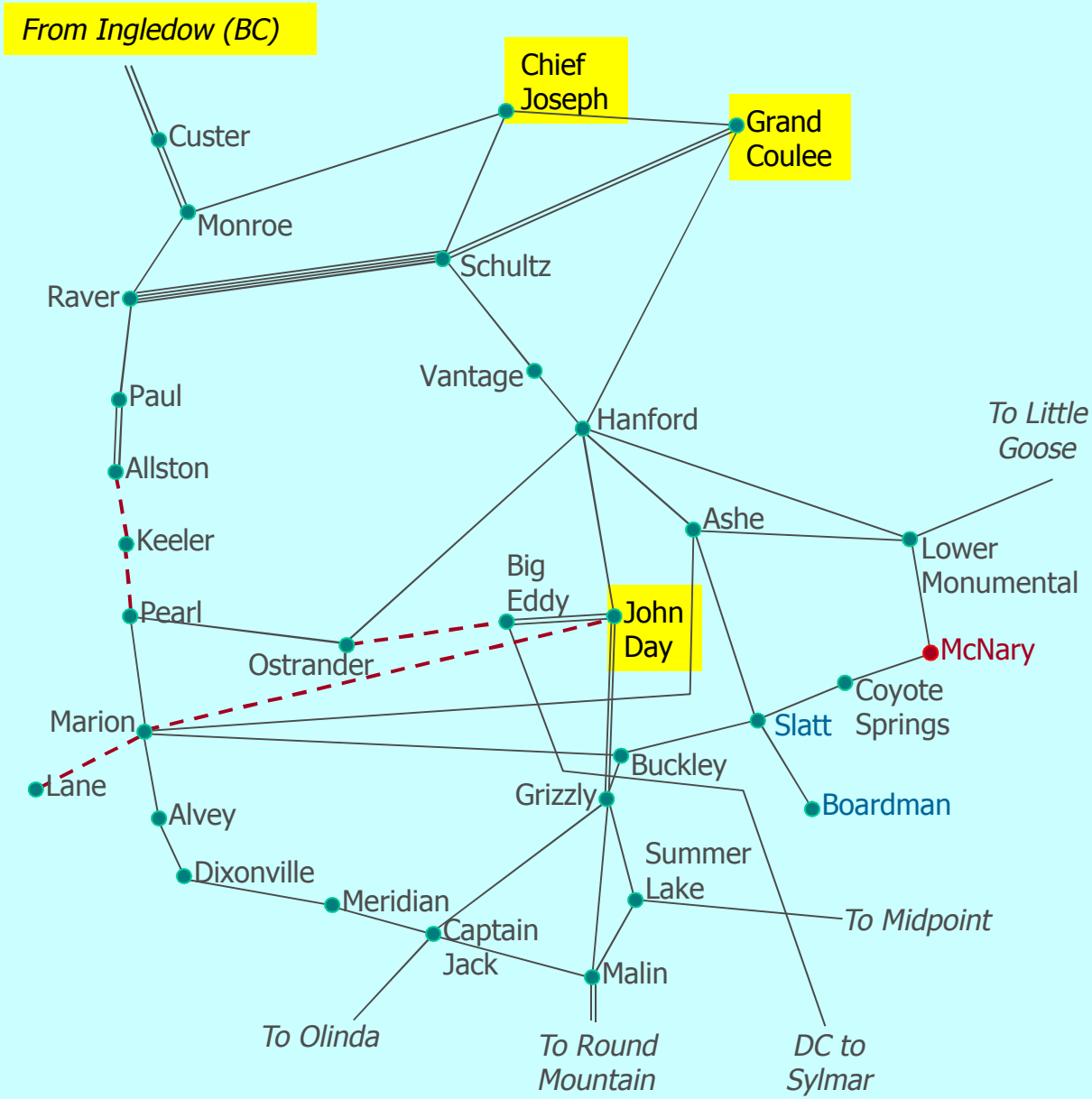
Kevin Stamber





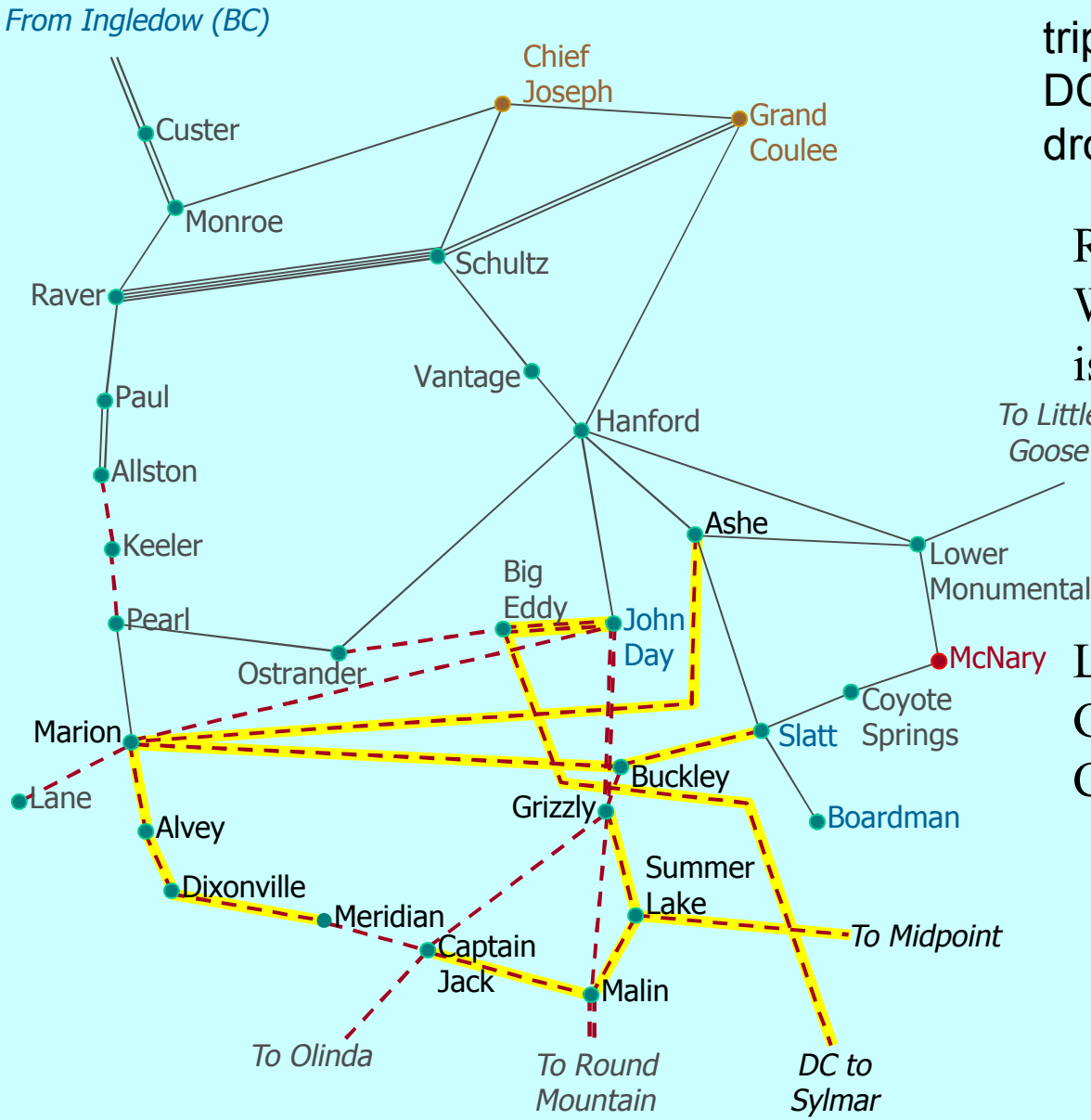


1401 PST
Big Eddy – Ostrander
Tree contact



1547:40 – 1549 PST
McNary generators trip
- 2 @1547:40 PST
- 4 @1547:44 PST
- 1 @1547:49 PST
- 1 @1547:57 PST
- 1 @1548:12 PST
- 2 @1548:47 PST
- 2 @1549:00 PST

1548 PST
Generation Responses
- Chief Joseph
- Grand Coulee
- John Day
- BC Imports



1548:54 PST
All Oregon lines of COI tripped
DC Intertie Power Level drops to zero

Result:
WSCC separates into four islands
- So CA, AZNMSNV
- No CA
- AB
- PNW/BC

Load lost: 30,489 MW
Generation lost: 27,269 MW
Customers affected: 7.49 M

Emerging Issues

- When will oil production peak?
- When will natural gas production peak?
- How will technology, public and economic policy change this peak?
- How will the world move away from the dependence on fossil fuels?
  - By when
  - By policy
  - By economics
- What needs to be done to truly integrate renewables?
- What needs to be done to truly integrate nuclear power?
- How do you optimize for emerging energy systems?

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