

America's Energy Future: Do We Need National Legislation to Get There?

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Outline of Talk

- US Energy Industry History
- Current Trends in US Energy Industry
- Dimensions of US Energy Market
 - Information collection and dissemination
 - Energy Transportation Network
 - Natural Gas, Electricity and Oil
 - Environmental Concerns
 - Strategic Energy Issues
- Is legislation necessary to achieve these goals?
- Bonus topic: Myth versus Reality in Governor Schwarzenegger's Energy Policy

1 BTU = heat required to change the temperature of one pound of water one degree Fahrenheit at sea level

Consumption by Source

Figure 5. Energy Consumption by Source, 1635-2001

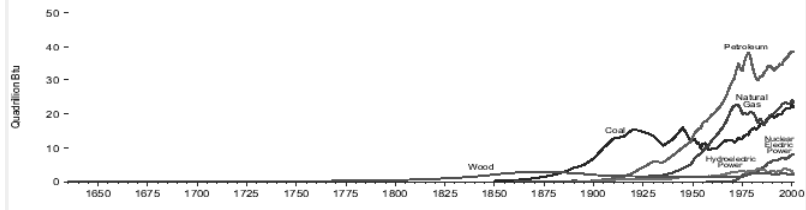


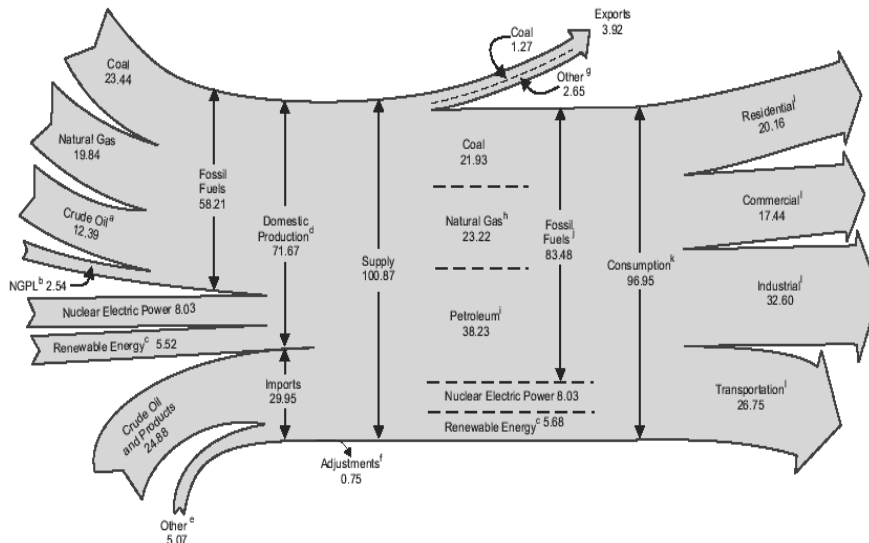
Figure 2. Energy Consumption per Person



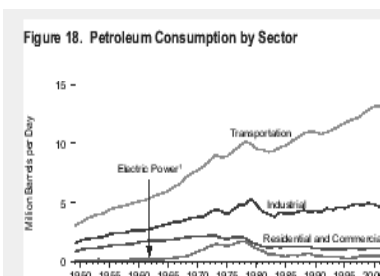
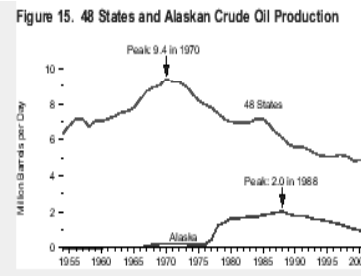
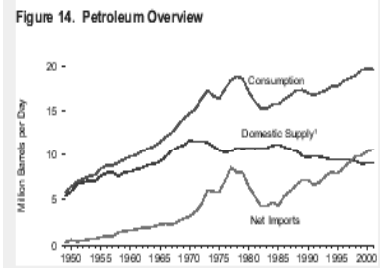
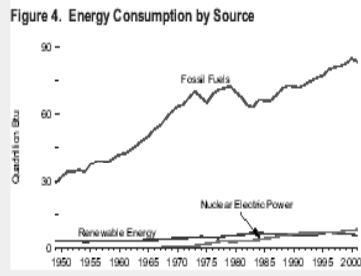
Figure 3. Energy Use per Dollar of Gross Domestic Product



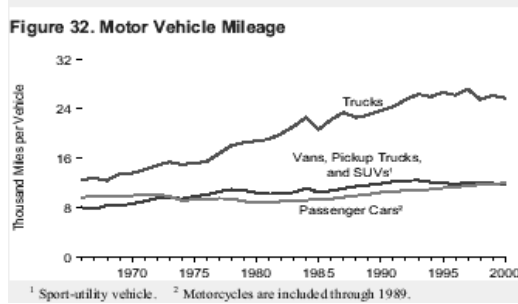
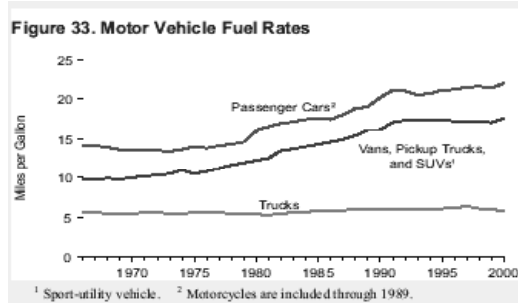
Energy Measured in Quadrillion BTU



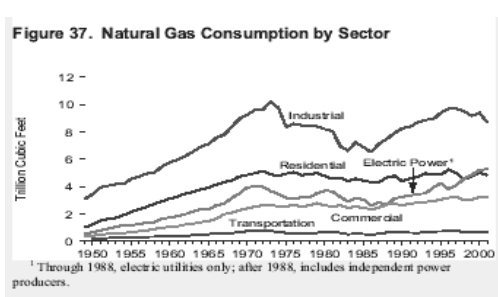
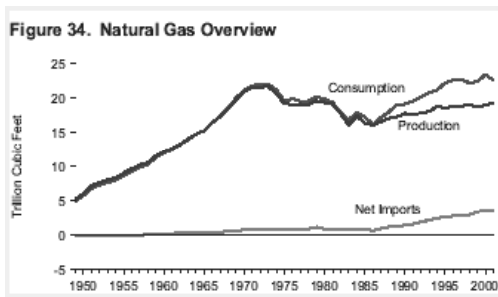
Petroleum Sector



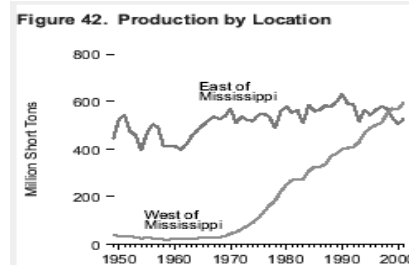
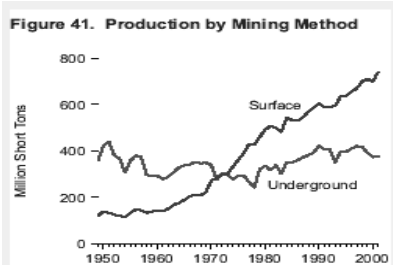
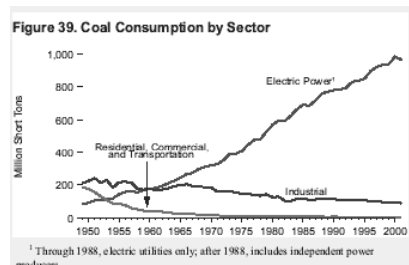
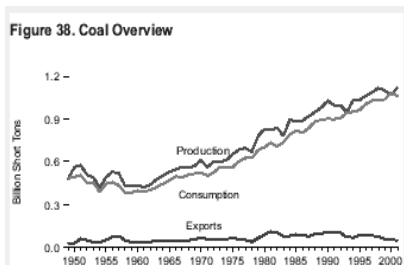
Transportation Sector



National Gas Sector



Coal Sector



Electricity Sector

Figure 44. Major Sources of Net Generation

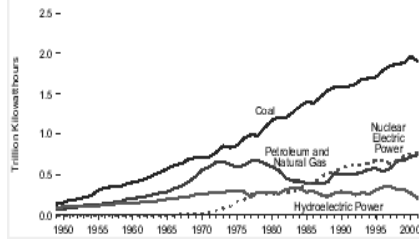


Figure 47. Retail Sales by Sector

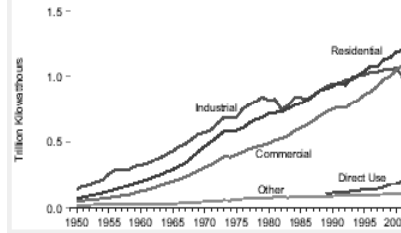


Figure 51. Nuclear's Share of Electricity

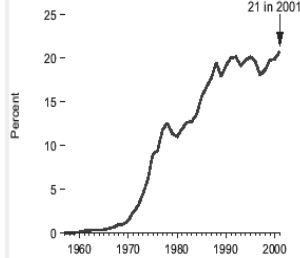
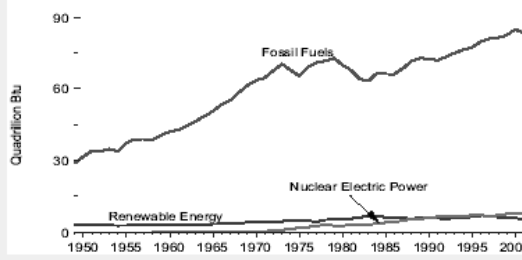


Figure 4. Energy Consumption by Source



International Energy Sector

Figure 62. Leading Crude Oil Producers

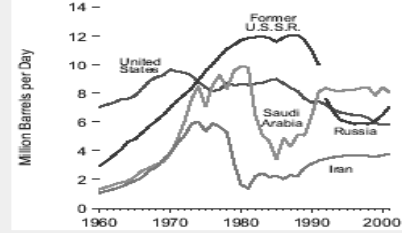


Figure 59. World Primary Energy Production by Source

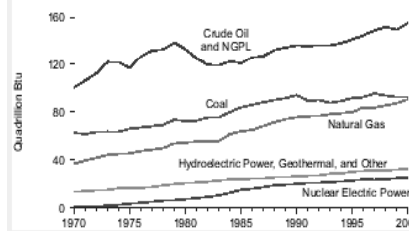


Figure 60. World Primary Energy Production by Region

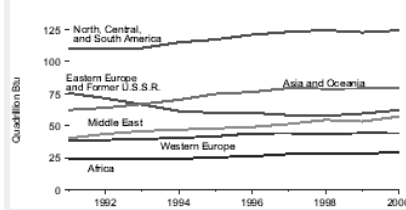
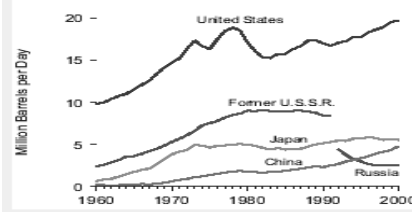
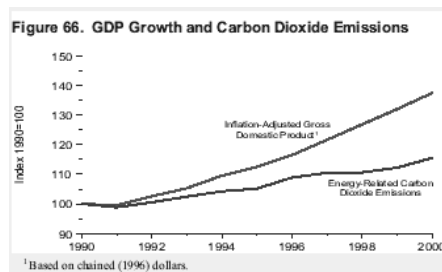
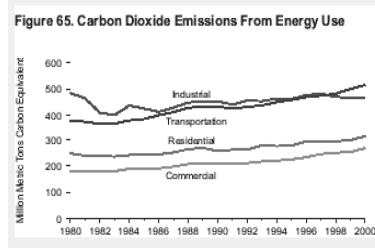
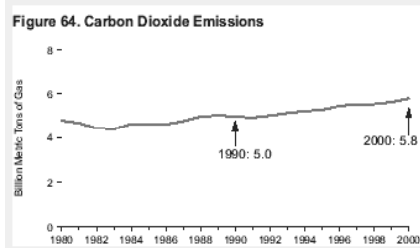


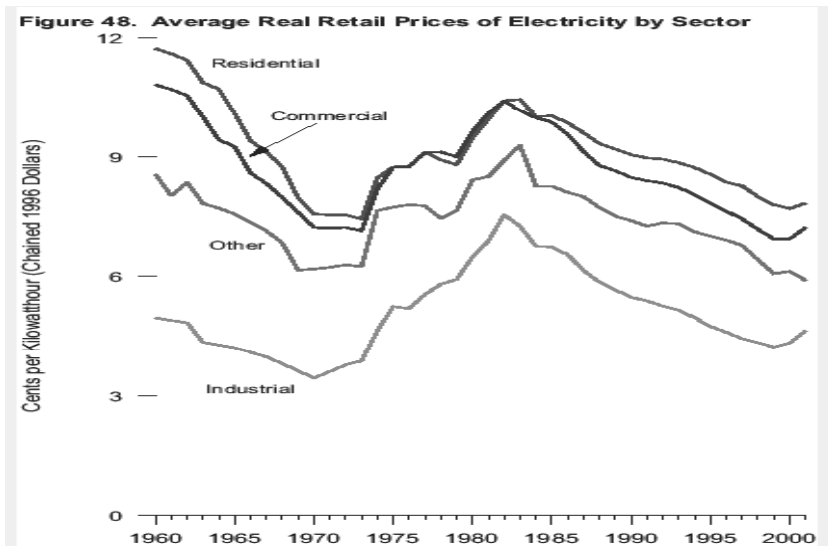
Figure 63. Leading Petroleum Consumers

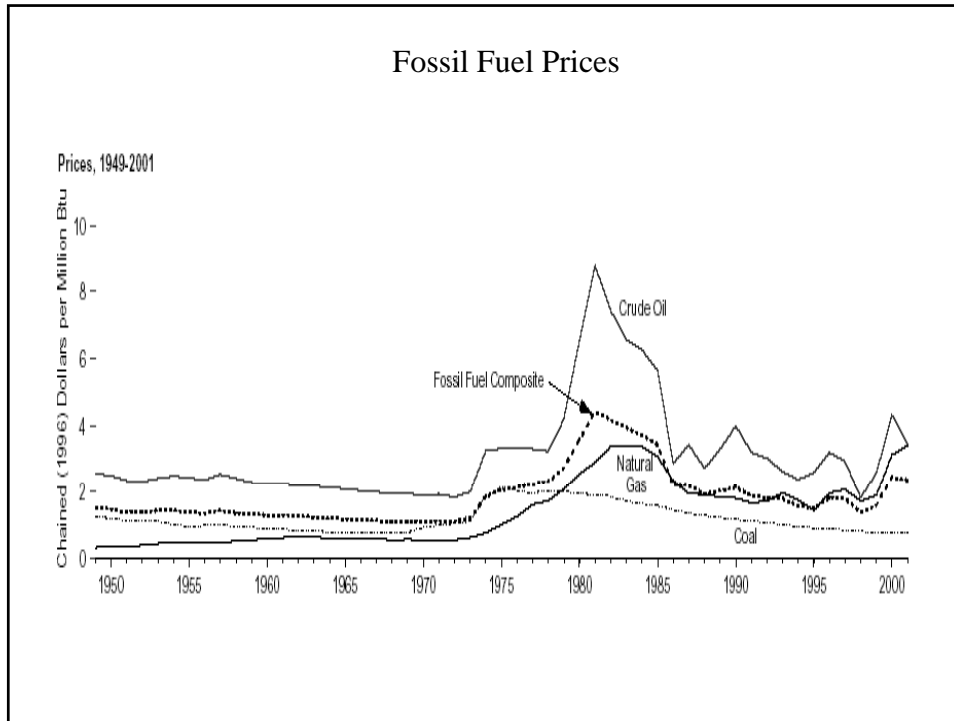


Carbon Dioxide Emissions



Electricity Prices





Does US need an Explicit Energy Policy?

- Since late 2000, energy bill has been under consideration in Congress
- US does not have an explicit policy to promote production of most goods
- What makes energy special?
 - Fossil fuel deposits must be discovered
 - Can only put producing oil well where there is oil deposit
 - Specialized transportation networks
 - Environmental concerns
 - Strategic issues

Information Collection and Dissemination

- US natural resource abundance in early 1900s traditionally viewed as gift of nature
- Stanford economic historians Paul David and Gavin Wright argue US was dominant mineral resource producer because combination of
 - American mining law
 - Geological surveys and public knowledge infrastructure
 - Mining education

Information Collection and Dissemination

- 19th century US mining law
 - Government claimed no legal title to nation's minerals
 - Open access to prospecting
 - “Prospector” uniquely American term
 - Other most other countries adopted ancient tradition where minerals were personal property of lord and ruler, who granted concessions (Australian is one exception)
 - Best example of policy was California Gold Rush
 - Mineral exploration with almost complete absence of governmental authority

Information Collection and Dissemination

- Geological surveys
 - US Geological Survey founded in 1879
 - Leading scientific bureau of post-Civil War era
 - Most productive governmental research agency of 19th century
- Mining Education in US
 - In 1864 Columbia College in New York opened the first school of mines in US
 - By 1890 more than 20 schools in US offered degrees in mining
 - By 1900 University of California was largest mining college in world
- Scientifically trained personnel combined with sophisticated knowledge and search procedures key to dominance of US industry in early 19th century

Transportation Infrastructure

- Energy industry requires specialized transportation network
 - Oil pipelines
 - Natural gas pipelines
 - Electricity transmission facilities
- Transportation networks facilitate competitive markets for all forms of energy
- Analogous to Eisenhower interstate highway system
 - In 1919 Lt. Col. Eisenhower participated US Army's first transcontinental US convoy from Washington, DC to San Francisco which took 62 days
 - During WWII Gen. Eisenhower saw advantages Germany enjoyed because of autobahn network
 - Highway system completed at cost of \$330 billion (\$ 1996)
 - Commerce facilitated by inter-state highway network
 - Easy to argue economic benefits produced many times cost of system

Transportation Infrastructure

- Wholesale energy competition stresses transportation network
- Consider the case of wholesale electricity markets
 - Entity that puts electrons on transmission network no longer controls generation facilities
 - All generation units have open access to transmission network
- Wholesale market has independent system operator (ISO) for transmission network
 - Owner of local generation financially independent of ISO
 - In both short-term and long-term, ISO cannot take advantage of economies to scope between transmission and generation that current transmission network was designed to utilize
 - Local generators have strong incentive to cause transmission constraints into their local area
 - Raise local prices for energy either (withholding capacity or bidding high prices) to cause congestion

Transportation Infrastructure

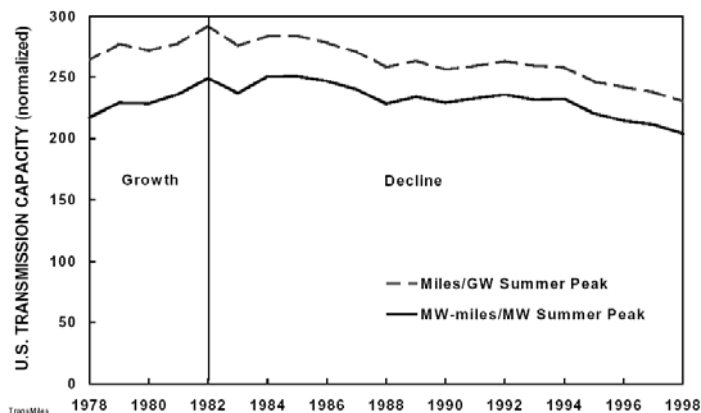


Fig. 2. U.S. transmission capacity normalized by summer peak demand from 1978 through 1998.

Transportation Infrastructure

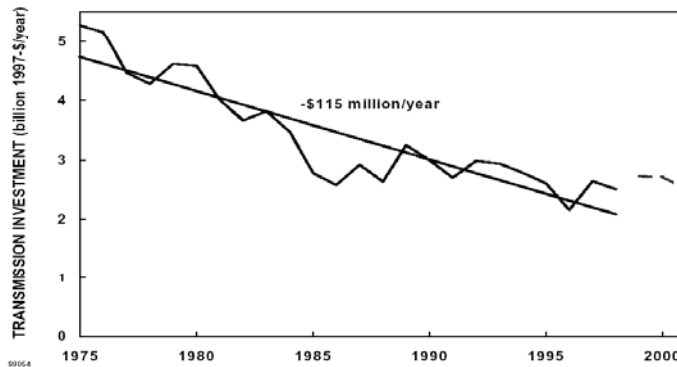


Fig. 3. Annual transmission investments from 1975 through 1998 and projections for 1999 through 2001.

Transportation Infrastructure

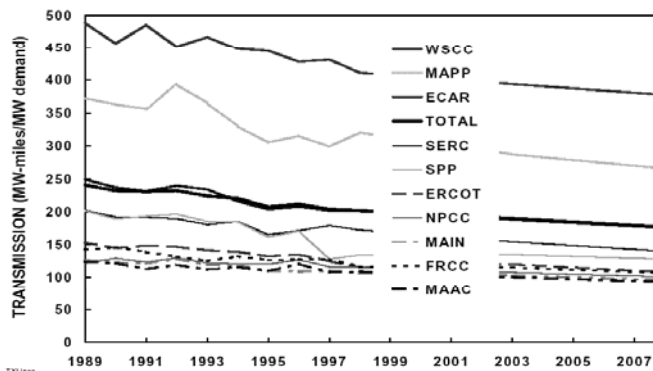


Fig. 4. U.S. transmission capacity normalized by summer peak demand from 1989 through 1998 with projections for 2003 and 2008, total and for each of the 10 regional reliability councils.

Transmission Network

- Economically reliable transmission network requires far greater inter-connection capacity than technologically reliable network
 - Economic reliability--All locations in transmission network face significant competition other independent suppliers a large fraction of the time
 - May need strong incentives to invest early on to overcome initially inadequate network for competition in generation left over from previous regime
- Consider case that “over-invest” in transmission capacity to increase prices by \$1/MWh
 - If increased capacity of transmission network results in more competitive wholesale market and average prices fall by \$2/MWh, consumers benefit from upgrade

Transmission Network

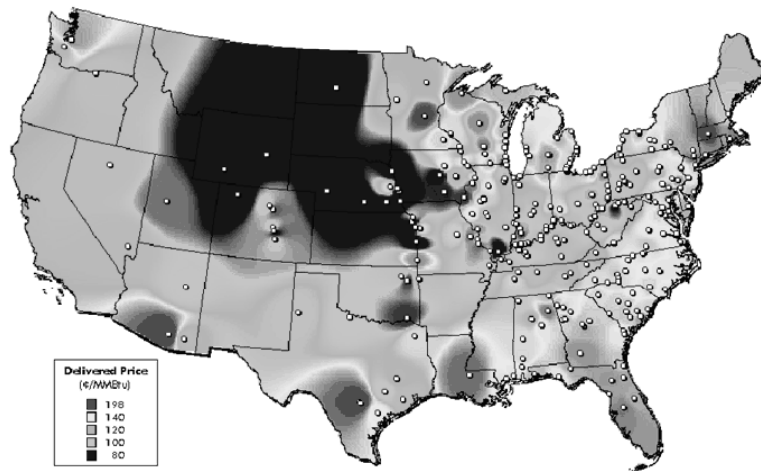
- Events in eastern US on August 14, 2003 are not surprising given patterns of investment presented above and greater stress on transmission network caused by wholesale market regime
- Similar events in natural gas and oil industries
 - Natural gas prices during winter of 2000/2001 in California
 - Prices in California averaged \$8/MMBTU higher than Henry Hub in Louisiana (on average price of Henry Hub \$5/MMBTU)
 - Oil pipeline failure in Arizona in Summer 2003 led to higher gasoline prices in California
- Transmission network can also be used to enhance size of geographic market for an energy source

Coal By Wire

- Transporting Wyoming coal as electricity rather than as coal or coal gas
- Minemouth generating facilities eliminate need to transport coal to demand centers
- Eliminates need to upgrade railway or trucking facilities
- Requires significant upgrading of high-voltage transmission lines
- Allows construction of large, standardized coal-fired facilities

Coal By Wire Versus Coal By Rail

1998 Average Spot Coal Purchase Price
For Coal-Fired Power Plants



Coal by Wire versus Coal by Rail

- If transmission of electricity from Wyoming to California is more than $(80/120) = 66\%$ efficient
 - Technological change in electricity transmission allows significantly greater than 66% of the electricity produced in Wyoming to be “delivered to” California
 - Electricity produced in Wyoming can also displace electricity generated in the intervening western states
 - Less environmental and health risk of electricity transmission versus rail transportation
- All factors imply that coal by wire lower cost than coal by rail in California and virtually all states not adjacent to Power River Basin

Is Coal by Wire Financially Viable?

- Average residential prices in California are currently more than 13 cents/kwh
 - Implicit average wholesale price in this retail rate is approximately 8.5 cents/kwh
 - This price is designed to recover total generation costs and repay state’s accumulated debt

Costs of Producing Electricity From New Plants in 2005 (1996 cents/KWh)		
	Conventional Pulverized Coal	Advanced Combined Cycle
Capital	2.66	0.75
O&M	0.69	0.28
Fuel	0.69	2.07
Total	4.03	3.10
Heat Rate BTU/KWh	9,396	6,812
Fuel Price \$/MMBTU	\$0.75	\$3.00

At current natural gas price of \$5/MMBTU, average total cost of CCGT facility is 4.5 cents/kwh

Financial Viability

- Good News for Coal by Wire
 - Fuel costs are less than 1/3 of natural gas-fired fuel costs at \$3/MMBTU natural gas
 - Few substitute uses for Western US steam coal relative to those for natural gas
- Bad News for Coal by Wire
 - Higher capital costs for coal-fired facilities
 - Almost 3 times higher
 - Increased environmental concern associated with coal
 - SO₂ emissions and coal ash disposal
 - Natural gas produces water, NO_x and other particulates
 - Higher O&M costs associated with coal-fired plant operation

Environmental Concerns

- Fossil fuel consumptions results in
 - Carbon dioxide emissions
 - Coal consumption produces
 - SO₂ emissions and coal ash disposal
 - Natural gas consumption produces
 - NO_x and other particulates
- Cost to reclaim lands after resource deposit is exhausted
- Paying full cost (including environmental cost) of producing and consuming fossil fuel

Environmental Concerns

- Markets can be used to value environmental amenities
 - EPA NOx and SOx trading program
 - South Coast Air Quality Management District (SCAQMD) NOx and SOx trading program
- Emissions permit prices can be used to cost environmental amenities
- Summer 2000 in California experience with SCAQMD market
 - Suspended for power plants effective February 2001
- Lesson from California--environmental markets under stress are difficult to maintain

Environmental Concerns

- Renewable resources have hidden costs and benefits that are often not accurately accounted for
 - Wind is a very intermittent energy source
 - Roughly 25% of the potential energy from a wind facility is actually produced as compared to up to 90% of potential energy from coal-fired facility
 - Wind supply does not respond to higher electricity prices
 - Wind facilities not produce more electricity when prices are higher
 - Higher electricity prices can be used to purchase and burn more expensive fossil fuels
- These properties can increase the cost of producing more electricity from renewable sources

Strategic Concerns

- “US must reduce its dependence on foreign energy sources”
 - This logic was used to establish a strategic petroleum reserve to be called upon in national emergencies
- What is difference between the above statement and--“US must reduce it dependence on foreign clothing sources”
 - Both oil and clothing are essential to survival
 - Both oil and clothing can be stored
 - Organization for clothing-exporting countries (OCEC) could organize to withhold clothing from US in exchange for political concessions
 - Organization for Petroleum-exporting countries (OPEC) could organize to withhold oil from US in exchange for political concessions
 - OCEC needs export sales
 - OPEC needs export sales
- A tightly integrated world-trading system may be less prone to political conflicts than one with autonomous countries
- I buy what Safeway sells, but Safeway never buys what I sell
 - One-sided trading relationships characteristic of gains from specialization
 - Those who are most productive at a specific task only perform that task, to the benefit of entire economy

US Energy Policy

- Continued need for information provision on state of resource stocks
 - Maintain US Geological Survey, State Surveys, Energy Information Administration
- Enhance transportation network
 - Federal authority to site interstate electricity transmission networks (difficult federal/state issue)
 - Need for more storage facilities (state-level decision)
 - Need for intra-state transmission facilities (state-level)
- Environmental concerns
 - Methods for incorporating environmental costs
 - Maintain Environmental Protection Agency (EPA) work on these issues
- Difficult to see what additional legislation is needed to achieve these goals
 - Except Federal authority to site transmission facilities