CHAPTER 7: DEPLETABLE/NONRECYCLABLE ENERGY RESOURCES

I. Introduction

A. In this chapter, we will review the use of alternative energy resources and their use. Specifically, we will look at:

1. Overview of Energy Resources
2. Natural Gas - the impact of price controls
3. Oil
   a. Price Controls and Cartels
   b. The Impact of OPEC on resource allocation
   c. Oil as a national security concern
4. Alternative Energy Resources
   a. Transition fuels: Coal, Uranium
   b. Renewable resources: Solar Power, Wind Power, Hydroelectric Power
5. Current Conservation Efforts

II. Energy Usage

A. The dependency of the U. S. energy consumption on depletable/nonrecyclable resources has grown significantly over time.

Changes in U. S. Energy Sources

![Energy Source Chart]

- Nuclear
- Oil/Gas
- Coal
- Wood/Water
B. Current Energy Usage Patterns:

1. U.S.:

![US Energy Sources Pie Chart]

2. World

![World Energy Sources Pie Chart]

C. Oil and natural gas should be transition fuels, eventually replaced by (with smooth transition)

1. other transition fuels: coal and uranium

2. renewable resources: solar power, wind power, hydroelectric power.
D. We will focus primarily upon the use of oil and natural gas. Specifically, we will be asking the question:

Given current property rights and market conditions, are these resources likely to be optimally allocated?

III. Natural Gas

A. Historical Background

1. Natural gas was discovered in the search for oil.

2. Discovered principally in Texas, Oklahoma, Louisiana, California, and West Virginia, as well subsequently in Alaska and offshore.

3. Prior to WWII, the usefulness of natural gas was limited due to transportation costs.
   a. It was not found in traditionally industrialized areas of the country.
   b. In the 1920’s and 30’s it was primarily burned off as a wasted product.

4. Following WWII, a long distance pipeline system was developed, increasing the availability of gas, allowing natural gas to become a major source of energy for the United States.
   a. Currently, Natural gas comprises about 25% of the energy consumer in the U. S.
   b. About 50% of residential homes and buildings rely upon gas for heating.

B. Question: Has natural gas been efficiently allocated in the past and is it likely to be in the future?

1. Historically, the answer to this question appears to be no.
   a. During the winter of 1974-75, serious shortages occurred in the natural gas industry, with shortages of approximately 10% of the total gas production in 1975.
   b. The likely cause of this shortage was price controls set by federal regulation.

2. The Origins of Price Controls
   a. The Natural Gas Act of 1938
      i. This act empowered the Federal Power Commission (FPC), later the Federal Energy Regulatory Commission (FERC), to regulate
the price pipeline companies could charge for gas shipped over state line (i.e., interstate).

ii. The 1938 Act did not allow the FPC to regulate well-head prices. However, the companies that owned the fields often also owned the pipelines. If they did not, this helped to encourage vertical integration.

iii. Average Cost pricing was used to determine prices, with an allowable rate of return built in.

b. The Supreme Court (1954) (Phillips vs. Wisconsin) gave the FPC powers to regulate back to the well-head.

i. Owners of the fields were perceived to have monopoly powers and to be charging too high a price.

However, the evidence does not support this conclusion.

ii. Primarily, the regulation was an attempt to shift rents from the producers to the consumers - rents from the increased cost of discovering and extracting new reserves. That is, the problem of new versus old wells arose.

iii. The pipeline owners that did not own fields were, in part, behind this regulatory push, as were final consumers.

c. Regulatory havoc ensued. The task of regulation proved cumbersome.

i. There were thousands of natural gas wells at the time and thousands of individual producers.

ii. In early years, FPC was overwhelmed.

- Between 1955 and 1960, over 3500 producers applied for rate increases. Only 10 of these applications were processed.
- Finally, the FPC decided upon "area rates", with differences between "old" and "new" gas.

C. Question: What are the consequences of price controls?

1. Short Run

a. Static analysis: the shortage is \( q_d - q_s \).
b. Average Cost Pricing: new gas vs. old gas, rent distribution

c. The lack of intrastate regulation caused wide disparities between states (i.e., those with natural gas reserves and those without).

   i. higher price within the production state

   ii. producers commit reserve addition to intrastate, instead of interstate markets

   iii. shortage becomes more intensified in states relying on pipeline

2. Long Run:
a. inter-temporal Misallocation

i. Price lower at the beginning, and jumps at the end

ii. Price control has impacts even when $p_c$ is not binding, if the price control is effective permanently

- Even if $p_c > p_0$, MUC decreases as price control is imposed
- Total MC=MEC+MUC, thus $S_1$ is lower than $S_0$; more is produced at a lower price initially
• As stock decreases, MEC increases and eventually shortage happens: at $S_3$, shortage is $q_2 - q_3$.

iii. In summary, two impacts of the price-control policy

• Demand will increase due to lower prices
• Supply will decrease (current reserves will decline) as long as the price controls are permanent.

Two differences between this allocation and the efficient one:

• The time of transition to a substitute is earlier with price controls
• The transition is abrupt, with prices suddenly jumping to a higher level.

iv. Question: Why would the government do this?

Consider the impact of these controls on the current time period.

• Question: What impact would these changes have on TNB?
\[
\Delta CS = ABCE = ABDE + BCD
\]
\[
\Delta PS = -ABDE + DCHG
\]
\[
\Delta TNB = \Delta CS + \Delta PS
= BCD + DCHG
> 0
\]

- Politically attractive: current voters gain
- **Question: What is the problem with this solution?**

  Answer: It ignores future generations.

v. **Substitution Bias**

- The use of average cost pricing led to the use of expensive blending agents (e.g., liquid and synthetic gas) to fill the gaps created by shortages.
  - This increased the reliance upon imports, at a time when official policy was to discourage imports.
  - It also led to a reliance upon expensive energy substitutes that could be blended with gas and away from substitutes which could not be blended (solar power, etc.) Conversions to natural gas continued due to artificially low prices, further increasing the demand for gas.

- The low price of natural gas leads to additional investment in equipment that relies on natural gas. However, the market for the equipment will dry up when the gas is not available.

vi. **Inter-temporal guessing**

- Up until now, we have assumed that the price-controls are permanent.

- The additional uncertainty regarding price controls leads to additional uncertainty and inefficiency.

b. **Real Impact:**

i. Early in the 1970’s, residential customers were getting all the gas they wanted, but gas companies were refusing to sign new contracts with industrial customers.
ii. OPEC oil embargo and subsequent oil price shocks.

iii. By mid-1970’s gas supplies to existing customers were curtailed. All curtailments were occurring in the interstate markets.

iv. Between 1976 and 1979, gas was being cut off during the peak period (winter) and schools were being shut down. Recall, we also have oil crisis during this period.

v. Public outcries for change in regulatory process. This did lead to some changes
   - Rationing was instituted, which has its own problems.
   - FPC raised prices for new contracts, allowing for "new new" gas. The price for new new gas was set at intrastate market level. Retained vintages for gas and average cost pricing.


This act allowed for the eventual phase out of some price controls

a. The House wanted broader control

b. The Senate wanted decontrol

c. Compromise

   i. Only 3 out of 30 categories of gas were decontrolled. Creates substitution bias:

      Deep-wells deregulated, while some other types of wells were not. This encouraged the move to deep wells. In 1977 there were 50 deep-wells. This rose to 350 by 1980.

   ii. All old contracts, Alaskan and offshore gas would still be regulated, even after 1985.

   iii. Movement away from average cost pricing

   iv. Institution of the intrastate gas price control until decontrol was completed.

d. This was not a complete fix, but a temporary one.

   i. Eventually supplies could again be short.
ii. Recession of 1981 saved the day to some extent, along with the oil glut that followed and continues today.

e. On July 27, 1989, Bush signed a bill removing in stages all of the remaining controls on natural gas. By January 1993, no sources of natural gas were subject to price controls.

IV. Oil

Major issue: cartel and price control

A. History

1. Phase 1: The emergence of the majors.

a. Prior to WWI, there were 4 international firms:

i. Standard Oil

ii. Shell Oil

iii. Nobel

iv. Rothschild

The last two firms were Russian and died out with the Russian Revolution.

b. During WWI, Anglo-Persian emerged (later renamed British Petroleum).

c. During the 1920’s and 30’s, four more international firms emerged:

i. Gulf

ii. Texaco

iii. Standard Oil of California

iv. Mobil

d. These international oil companies formed what was know as the "seven sisters" of the oil industry, alluding to the extensive collusion that took place between these firms.

e. During the early period, the majors, with the help of their governments (e.g., the U. S. State Department), established concessions with countries later found to have substantial oil reserves. Both parties benefited.

i. The Host Countries gained
• Capital and technical expertise to develop their resources. The majors were taking a risk. While the first Saudi wells were drilled in 1934, the first successful wells were not found until 1938 and the size of the Saudi reserves were not appreciated until after WWII.

• Revenues in the form of fixed royalty payments.

ii. The Majors gained

• Access to large geographical areas with potentially large oil reserves for a large number of years.

• Almost total control over production and pricing.

2. Phase 2: The Decline of the Power of the Majors (WWII to 1960).

a. Things changed after WWII, with

i. Increased oil demand, which led to the entrance of hundreds of smaller new entrants into the market and, consequently, the majors losing market power.

Some governments actively encouraged new entrants, including Libya.

ii. Inflation, which reduced the real value of the fixed royalty payments to the host countries.

iii. The rise of nationalism in the host countries.

iv. The uncovering of large reserves in the host countries. These countries began to realize their true wealth and potential market power. The majors had almost done too good a job of discovering oil.

b. The Collapse of the Major’s power

i. 1943-1948: Venezuela established the principle of profit sharing.

ii. 1957: American firms raised prices to thwart independents. The host countries liked this move because it increased their profits.

iii. 1959: Realizing that the increased prices were not working, the majors pushed for a reduction in oil prices. This created friction between the host countries and the majors, which in turn led to the formation of OPEC by
• Saudi Arabia
• Iran
• Iraq
• Kuwait
• Venezuela

These countries figured everyone was winning but them.

• Gas stood at $30/barrel, from which the Saudis got 20-30¢/barrel.
• Oil prices were dropping

iv. Despite the formation of OPEC, not much changed initially.

• The companies had three major advantages
  – Technical expertise
  – Control of the distribution and marketing of oil
  – The majors could work together
• In addition, there was still excess capacity in the system.


a. The boom of the 1960's increased the demand for oil

b. Other countries were using up their reserves.

c. OPEC Countries started using the threat of nationalization.

d. Arab-Israeli War (1973)

  i. The Suez Canal was closed

  ii. OPEC ceased bargaining with the oil companies

  iii. OPEC tied the supply of oil to perceived support for Arab countries in the Arab-Israeli war - cutting off oil to the U. S.
iv. OPEC countries started the nationalization process of oil reserves.

4. Phase IV: The Decline of OPEC’s Power
   
a. Iran Revolution and the Iran/Iraq war
   
   While oil price increased internal disharmony increased within OPEC.
   
b. Demand started to fall due to high oil prices and long run adjustments to oil demand began:
   
i. fuel efficient cars
   
   ii. fuel efficient houses, etc.
   
c. The recession of 1981 induced an additional reduction in the demand for oil, with prices dropping from $40/barrel to $28/barrel by 1983.
   
d. With the oil glut came a loss of power and incentives to cheat by individual countries.
   
e. OPEC remains a formidable force, controlling roughly 75% of the world’s proven oil reserves.

B. What factors made OPEC possible?

1. The price elasticity of demand

   *DEFINITION: The price elasticity of demand = the percentage change in usage that results from a 1% change in the price.*
Inelastic Demand, $\eta = 0$  

Elastic Demand, $\eta \rightarrow -\infty$

a. The price elasticity determines the change in revenues that can result from forming a cartel.

Cartel is more profitable when demand elasticity is lower

Low Elasticity of Demand, $-1 < \eta < 0$  

High Elasticity of Demand, $\eta < -1$
b. The elasticity of demand depends upon the availability of substitutes and conservation opportunities.

i. Substitutes place an upper limit on the degree to which prices can be raised by the oil cartel.

Examples:

- natural gas (cartel controls much of this as well)
- solar power (currently competitive in many parts of the country for space and water heating).
- wind power (developed extensively in the west, esp. PG&E)
- hydro-electric power (a growing part of U.S. electricity supply due to transportation improvements, i.e., wheeling).
- coal.

ii. Conservation: more important in the long run. Thus long-run elasticity of demand is typically much higher than short-run elasticity. Examples:

- storm windows
- fuel efficient cars
- water heater wraps

2. The income elasticity of demand.

a. A high income elasticity of demand improves OPEC’s position over time.

3. Non-OPEC suppliers

a. OPEC will be effective only if it controls a major portion of the oil reserves.

b. Currently only Mexico has large enough reserves to individually influence the market.

c. Other major players include Great Britain and Norway with the North Sea oil.

d. The strategy of OPEC: Salant’s (1976) competitive fringe model.
i. The fringe makes a difference if it controls as little as 1/3 of the market.

ii. The residual demand facing the Cartel has a higher demand elasticity:

![Diagram of demand and supply](image)

iii. The cartel initially sells at a lower price with the fringe than without the fringe, forcing the fringe to produce more in response to higher demand and use up its reserves. Then the Cartel can charge a much higher price.

1979 - OPEC accounted for 50% of world oil production

1986 - OPEC accounted for only 30% of world oil production

iv. The competitive fringe benefits from the existence of the Cartel: they do not have to cut production to enjoy the high price.

4. Compatibility of Member Interests
   a. The internal cohesion of the cartel is critical.
   b. This cohesion was highest during the Arab-Israeli war.
   c. Each member has an intrinsic economic incentive to cheat:
      i. While other members cut their production to raise the price, you can earn a high profit by producing more (cheating)
ii. But if everybody cheats, price will decrease, hurting all cartel members.

d. Without cohesion, members will be more tempted to cheat during hard times.

C. **Question:** What are the consequences of having a cartel?

1. The market will switch prematurely to inefficient energy resources.

2. Consumer Surplus will be lost.

3. There will be a significant redistribution of world income, an inefficient redistribution.

D. OPEC is not the only problem with the oil market. **Question:** What is another problem? Price ceilings

1. Price ceilings on oil started with the wage/price controls of Nixon.

   a. The rationale for these controls was inflation fighting. Nixon wanted to eliminate inflationary expectations.

   b. A second rationale for price controls was to protect consumers from monopoly power.

shortage resulted


4. What are the problems with price controls.
   a. We have the same problems as with natural gas.
   b. The OPEC problem makes this problem even worse by encouraging the U. S. to use up its own reserves.

E. Oil as a National Security Problem

1. From an economic point of view, vulnerable strategic imports have added (public) costs to society which are not reflected in the marketplace

2. Basic Case without premium (draw black part of graph)
   a. Demand = Q_r,
   b. Domestic Supply = Q_d
   c. Foreign Supply = Q_T - Q_d

3. Adding in national security consideration (draw new line)
   a. Demand = Q_r
b. Domestic Supply increases to $Q_T$

c. Foreign Supply is reduced to zero

4. Without the security issue considered, too little is produced domestically and too much is imported.

5. **Question: What happens in the event of trade embargo?**

a. In the short run only $Q_T$ is supplied at price $P_2$. Eventually domestic supply rises.

6. **Question: Is self sufficiency optimal?**

a. No. It lowers overall consumer surplus.

b. Embargoes are not certain events

c. Strategic petroleum reserves and other government actions can be used to mitigate the impact of an embargo.

d. Current consumption of domestic reserves increases the vulnerability of future generations.

7. Possible solutions:

a. Oil consumption tax: encourages conservation, but cannot achieve the efficient import/domestic production ratio.

b. Subsidization of domestic supply: achieves efficient ratio, but cannot reduce consumption.

c. Tariffs on oil imports, setting the tariff = $P_1 - P_0$.

i. The higher price will achieve efficient ratio and discourage consumption.

ii. Provide some revenues for the federal government.

iii. Transfer some of the rents from OPEC to the U. S.

V. **Transition Fuels.**

A. **Coal**

1. U. S. Reserves of Coal are 22 times greater than its reserves of oil and gas combined.

2. The environmental impacts of coal burning, however, are high.
a. Acid rain

b. Increase amounts of carbon dioxide in the air - the greenhouse effect.

B. Uranium

1. Domestic uranium reserves are 4.2 times higher than gas and oil reserves.

2. With the use of breeder reactors, uranium reserves are 252 times oil and gas reserves.

3. There are significant potential and actual environmental problems with nuclear power:
   a. Nuclear Accidents
      i. Three Mile Island (March 28, 1979)
      ii. Chernobyl’s core meltdown (April 25, 1986)
   b. Political problems - Sweden is dropping all of its nuclear plant due to political pressures - with difficult transitional problems in their future.
   c. Recent problems with Pentagon nuclear plants: CBO (1994) estimated that it may cost $1 trillion to bring the facilities into compliance.
   d. The problem of disposing of radioactive waste.
      i. Waste has an extremely long life - 1000 to 250,000 years. Thus, decisions today have impacts on many future generations.
      ii. One could tax those who consume nuclear power today in order to compensate those living near nuclear plants or disposal sites.
   e. Question: Will the market make the right decisions here?
      Probably not.

VI. Conservation and Load Management

A. Conservation has naturally occurred with the higher oil and gas prices.

B. PUC’s, chose responsibilities include regulating production, transmission, and sale of electricity, have been encouraging conservation.

C. Conservation approaches:
   a. Utilities invest in conservation, not in new plants: subsidize conservation measures
b. peak-load pricing: charge higher price at peak time (winter, or certain time of a day), at the MC of peaking units

c. internalizing environmental costs: environment tax on electricity