International Energy Markets

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Understanding Pricing, Policies and Profits

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To my mother, the first great love of my life,
and to all of those who followed.

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Acknowledgments

The technical, political, and economic challenges of global energy industries and markets are fascinating!

My work has given me the privilege and joy of traveling all over the globe while observing, applying economic reasoning, and teaching about these industries. This book has evolved out of these experiences and my desire to share the fascination of these industries with my readers.

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1 Introduction

Energy economists want to get the price right. Politicians can't define obscene energy prices but know them when they see them. Energy traders believe that everything has a price and they know it, but if you outlaw price only outlaws will know it.

—Modified from Unknown Author

Whether you are an energy economist, a politician, an energy trader, or an energy consumer, energy and its price are of interest to you. Energy in all its forms can help us live easier and more comfortable lives. In the 1950s, it was touted that nuclear power would introduce an era when energy would be a non-scarce resource, and we would have "power too cheap to meter." (Today, we would call that a bear market with perpetually decreasing prices.) Alas, this prediction has not yet come to pass. Energy is still a limited natural resource that is occasionally scarce, with prices rising in a bull market. But whether the market is running with the bulls or hibernating with the bears, we must understand and use our energy resources wisely.

Since economics is the science of optimization under scarcity, it is a valuable tool to help us do so. Thus, the major goal of this text is to develop the economic fundamentals and technical and institutional knowledge needed to implement sound economic, business, and government policy decisions relating to energy industries.

Energy originates with the four fundamental forces of physics:

- Gravity, which holds the universe together.

- Electromagnetism, which is the attraction between oppositely charged particles and repulsion between like-charged particles. The electromagnetic force is transmitted by photons, which sometimes act like packets and sometimes like waves. From longest to shortest wavelengths, electromagnetic waves are radio, micro, infrared, light, ultraviolet, X-rays, and gamma rays. The shorter the wavelength, the higher the energy carried per photon. The electromagnetic force holds the atom together and is responsible for chemical reactions.

- Weak nuclear force, which governs radioactive decay. During radioactive decay, neutrons break into protons, electrons, and antineutrinos. The weak nuclear force is transmitted by vector bosons with positive, negative, and neutral charges

- Strong nuclear force, which holds the nucleus of the atom together. Energy is liberated when this force is broken by separating elements heavier than iron (fission). When this force is exploited to fuse together elements lighter than iron (fusion), energy is also liberated. However, separating lighter elements or fusing heavier elements than iron requires an input rather than a release of energy.

These four forces generate commercial energy in six familiar forms.

1. **Mechanical energy** is associated with motion. Falling water resulting from gravity can turn a grinder, wind resulting from temperature differentials can turn a wind turbine, and human and animal power can be used to move objects fueled by the chemical reaction of food.

2. **Chemical energy** is released when molecular bonds are broken or changed as in the combustion of fossil fuels—coal, oil, and natural gas. Such chemical energy may be turned into mechanical energy as in the internal combustion engine.

3. **Thermal energy** is the heat in the vibrations of molecules. It results from friction and may also be a product of the chemical energy of combustion. Geothermal energy, which is heat from within the Earth, may be heat stored from the formation of Earth supplemented with heating from pressure and radioactive decay.

4. **Radiant energy** is light and all forms of electromagnetic radiation. Solar energy is a critical source of radiant energy, and infrared is a radiant source of heat.

5. **Nuclear energy** from fusion and fission results from the strong nuclear force. It is changed to mechanical and other forms of energy in nuclear submarines, the explosions of nuclear weapons, and in nuclear power plants.

6. **Electrical energy** is movement of electrons caused by electromagnetic force. If electrons travel one way through a wire, we have direct current. If they continually reverse directions, we have the more common alternating current.

In any system, we can change energy from one form into another. For example, the mechanical energy of a stream can be turned into electricity by a hydro unit. The resulting electricity can be turned into heat and light in a home or can run a machine in a factory. With these changes, the first law of thermodynamics requires that the total amount of energy in an isolated system will always remain constant. Energy scarcity becomes a problem because of the second law of thermodynamics, which requires that when energy is converted, it is reduced in quality and its ability to do work. Thus, with each energy conversion, we have the same total amount of energy but less available energy to do work. For example, the generation of electricity produces both heat and electricity. However, the heat generated is generally at a temperature too low to be otherwise usefully captured for work. (Georgescu-Roegen, 1979) (Hinrichs, 1996).

An understanding of the economical use of energy is interdisciplinary. It involves knowledge of economics, tools of mathematical optimization, simulation, and forecasting along with institutional, engineering and technical information for energy production, transportation, transformation, and use. Hence, in this book, we will combine economics and mathematical analysis with institutional and technical information to better understand various energy markets.

Since the advent of the big bang, theorized to have occurred some 13 billion years ago, energy has remained a fundamental component of the universe. Humans, who arrived only a few million years ago, have consumed only a small portion of the vast supply of energy on this small planet. Part of the ascent of humans has been the process of learning how to use ever more of this energy to satisfy basic needs, along with space conditioning, transportation, and entertainment.

In chapter 2, we begin with the history of energy use and speculate upon future global energy production and consumption.

Economists often favor markets in a capitalist economy for allocating scarce resources. They feel that market discipline helps to create efficiencies and minimize costs. The lure of profits helps to attract capital to growing markets and away from those that are shrinking. Markets spur innovation and promote new products. With competition and decentralized decision-making, capitalist economies are more flexible and personal freedom is enhanced.

In chapter 3, we analyze energy markets past and future, focusing on competitive markets in a static framework with an application to the coal industry. Principles of demand and supply help us to understand how market prices are influenced. Demand and supply elasticities, which capture responsiveness to price, are developed and used to analyze market changes and price controls. In turn, elasticities can also be used to recreate demand and supply curves.

Energy resources are often publicly owned and considered basic wealth to a society. As such they are usually taxed—sometimes quite heavily. In chapter 3, we also consider energy taxes in the context of a static model. Who pays, or the incidence of the tax, depends on how responsive demanders and suppliers are to market price. Types of taxes and information on energy tax structure are presented.

Economists who favor markets and private ownership for the allocation of goods and services sometimes agree that markets fail and that room exists for the government to step in. One such case is a decreasing-cost industry in which the greater the production, the lower the unit costs, and the bigger the producer, the lower its average costs. Such industries are considered *natural monopolies.*

For many years, the electricity industry's huge capital costs and economies of scale had marked it as a natural monopoly. In such an industry, we prefer one producer on the grounds of greater efficiency. However, one private producer when left to his own devices will be able to monopolize the industry and make monopoly profits. In chapter 4, we consider the electricity industry, summarize the various technologies for generating electricity, and discuss how government ownership or price regulation have been used to try to control monopoly profits.

Alleged problems with government ownership and regulation, along with technical changes in electricity generation, have led to the current moves toward deregulation and privatization, which are discussed in chapter 5. Classic deregulation examples in New Zealand, the United Kingdom, and Scandinavia are considered along with the problems accompanying the restructuring of regulated markets in California.

If large producers have market power and are able to set prices, they can make monopoly profits. A classic example of this market failure is the Organization of Petroleum Exporting Countries (OPEC), which we discuss in chapter 6. We include both the history of OPEC as well as models to explain OPEC behavior. Since OPEC cannot control non-OPEC production, it will be treated as a dominant firm, rather than a monopoly; however, since OPEC is not a monolith but is comprised of 11 different countries, some of their differences will be noted as well.

With deregulation, institutional arrangements or governance structures in markets are likely to evolve. Such structures include spot purchases, long-term contracts, and vertical integration. Transaction-cost economics suggests that the market structure that survives is the one that minimizes transaction costs. Market governance is determined by a number of factors including the specificity of assets in the industry. For example, a pipeline is a very specific asset transporting a particular good from one predefined place to another, whereas a semi-truck is much less specific and can transport a variety of different goods to and from a variety of places. Market governance is also influenced by the amount of uncertainty and the frequency of transactions, all of which influence transaction costs. In chapter 7, we introduce transaction cost economics and apply it to changes in the U.S. natural gas markets.

Energy production, transport, and consumption produce a variety of pollutants. Often such pollutants affect others besides the producers of the pollutants. For example, when the Exxon Valdez went aground in Prince William Sound, Alaska, spilling millions of barrels of oil, Exxon lost money but wildlife, fishermen, and others external to the producers and consumers of the product were affected negatively as well. Thus, pollutants are called negative externalities. Since the producer or private decision-maker does not take into account these costs, which are external to them, private markets will not allocate energy efficiently. Therefore governments have stepped in with laws and policies that have been undertaken in response to externalities such as pollution. A review these policies will be presented in chapter 8.

Another externality comes from public goods: A good from which people cannot be excluded (*non-excludability*) and one person's consumption does not reduce another person's consumption (*non-rivalrous*). The classic example is a lighthouse: Anyone in the vicinity can look at it, and one person looking at it does not generally restrict the ability of another to look at it. If, in making a private decision to produce such a good, an individual only takes his own satisfaction or utility into account, too little of the good will likely be produced. Further, if one cannot be excluded from consumption, each consumer will want someone else to pay for the good (*the free-rider problem*). Both effects cause a public good to be under-provided by the private market.

In poorer countries, a significant amount of biomass is consumed to provide energy. This consumption, along with the associated land clearing and timber harvest, allegedly reduces the biodiversity on the planet, which might be considered a public good. In addition, the reduction in forest reduces the capacity of flora to absorb carbon dioxide (CO_2) while at the same time, the burning of fossil fuels (largely from industrial countries) increases the amount of CO_2 in the atmosphere. It is generally agreed that this buildup will cause global climate change, although when, where, and the exact effects of this buildup are more uncertain. Since everyone enjoys the benefits of biological diversity and lower levels of CO_2—but they are non-excludable and non-rivalrous—they have the characteristics of public goods. An analysis of the provision of such public goods as well as current policies towards global climate change will be considered in chapter 9.

Market power in the hands of either buyers or sellers leads to an inefficient allocation of resources. If there is only one buyer in a market, we refer to this market structure as *monopsony*. One buyer is able to depress the buying price and reap monopsony profits. A multinational company with exclusive rights to buy energy resources in a small developing country with a weak government would be an example of market power on the part of the buyer. With the so-called redline agreement in 1928, the multinational oil companies of the time carved up the Middle East and agreed not to compete with one another over resources, preserving their monopsony power. We develop the monopsony model in chapter 10 and apply it to Japan's purchases of liquefied natural gas (LNG) in the Asia Pacific market.

A single multinational company dealing with a strong government in an energy-rich developing country would be an example of a *bilateral monopoly*, which is a monopsonist buying from a monopolist. In such a case, the outcome is ambiguous and depends on the negotiation skills of the two players in the market. We conclude chapter 10 with pointers on negotiation along with "dirty tricks" to watch out for.

Few buyers or few sellers in a market constitute *oligopsony* and *oligopoly*, respectively. These models get more complicated as their outcome depends on the strategies of all the players in the market. We consider these market structures in the context of game theory with an application to the European natural gas market in chapter 11.

In chapters 2–11, we apply only static economic analysis to the allocation of energy resources. However, many energy sources—such as fossil fuels and uranium—are nonrenewable, depletable resources. For such a fuel, if we use the resource today it will not be available tomorrow, and dynamic analysis in which we maximize net present value of the resource is more appropriate. In chapter 12, we look at a basic two time-period model with applications to oil production and leasing.

Dynamic analysis also has applications in allocating capital costs over time. In a very capital-intensive industry such as energy, it is important to be able to allocate such costs across units of production or consumption. Capital cost allocation procedures are developed in chapter 13 and applied to the costs of electricity generation, energy transport, renewable energy production, and services from household appliances. These costs are important inputs to the many market models considered in this text, and have implications for energy supply. A case in point: Shell Oil Company expects that renewable energy sources will provide half of our energy needs by 2050. Which markets renewable sources penetrate—and how fast—will be strongly influenced by their characteristics and their costs.

If a problem can be modeled using linear equations, it is usually easy to solve—even if the model is quite large. In linear programming, we maximize or minimize a linear objective function subject to linear constraints. We apply this technique to oil refining and energy transportation in chapter 14.

In chapters 1–14, most of the analysis was done under the assumption of certainty. However, we face large uncertainties in most aspects of our lives and with uncertainty comes risk. Energy is no exception; it is a risky business. Government policies, the economy, and competition influence energy prices and costs, and all three can provide unpleasant surprises, threatening not only profits, but, in some instances, a company's very survival. Should we want to reduce risk, we have various choices, including organized futures markets with standardized contracts where parties do not know who is on the other side of the trade. With futures and options markets, discussed in chapter 15, we can lock in future prices for energy products that we want to buy or sell to reduce and manage risk.

Sometimes a player would rather provide a ceiling or a floor for the price of energy. A refinery might want to lock in a minimum price for its product and a maximum price for the crude oil it buys. To do so, it can buy or sell an option on a futures contract for these products. These standardized contracts, also discussed in chapter 15, give the buyer the right, but not the obligation, to buy or sell a futures contract depending on whether a call or put option has been purchased. If it is not profitable, the option is usually allowed to expire. However, if the option is “in the money,” usually the buyer closes out an option for a cash settlement rather than taking delivery, as with futures contracts.

Energy is produced in a technically complex industry. Uranium requires sophisticated processing; coal is gouged out of the earth with huge equipment; refineries use complicated processes utilizing catalysts to break down oil and reshape it into the products we have come to depend upon. Natural gas is transported through complicated pipeline networks with computer systems to monitor and measure its location. With the information revolution, even more technical choices influence how firms are organized and how they function. Some of these technologies and how they are being used are considered in chapter 16.

Energy is a global business with many large national, multinational, and transnational companies involved in its production and distribution. It includes not only the economics and technology considered in this text—it also has a human face. To effectively compete in this highly competitive atmosphere requires a company to understand the culture of its employees and its customers. It is also important to develop a corporate culture that is compatible with both its own mission and vision statements, as well as with the national cultures with which the company does business. Chapter 17 concludes the book by considering aspects of national and corporate culture. Topics include how power is earned and distributed, people's views of themselves relative to others and to nature, and views on uncertainty and time.