NATURAL RESOURCES JOURNAL

Volume 24
Issue 2 *Symposium on Strucutral Changes in Energy Demand and Supply*

Spring 1984

Introduction and Overview

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Introduction and Overview

Ten years have passed since the beginning of the so-called "energy crisis." Over the course of this decade, the world slowly and reluctantly has accepted the fact that the period of low, steadily decreasing energy prices has come to an end. This recognition has set in motion forces and trends which are bringing about fundamental readjustments in the way energy is produced, used, and combined with other factors of production and consumption. Initial short-term responses have given way to long-term adjustments, adjustments that will be mostly irreversible, regardless of the cost of energy in the future. The following collection of papers is an attempt to trace these emerging structural changes in energy demand and supply.

The world first reacted to the initial quadrupling of oil prices in 1973–74 with disbelief and outrage. It was perceived that this rise was largely the result of a political power play by the oil producer cartel which eventually would yield to political, diplomatic, and economic pressures by the main consumer nations; then historical price trends would reassert themselves. Actual oil production costs in the major production countries were only a fraction of the prices charged, and known reserves, world-wide, were still comfortably large compared to prevailing demand. Energy policies, and energy user reactions, therefore, were marked initially by temporizing, helped by governmental policies that blunted, or even totally prevented, the pass-through of higher world market prices for oil to ultimate consumers. This was generally done by either reducing existing excise taxes or import duties, controlling domestic supply prices, or by providing outright subsidies.

The gradual decline in real oil prices observable between 1974 and 1979 appeared to support an initial view that prices would tend to drift back to levels closer to the marginal costs of production. Therefore, the second oil crisis in 1979–80 was a rude shock to everyone, showing how susceptible and vulnerable the world energy market had become to outside political events. Ths second crisis, perhaps more than anything else,

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finally convinced those governments still pursuing a policy of "cheap" energy through price controls, subsidies, and regulations that those policies in fact were counterproductive and wasteful. Not all of these measures have been eliminated in every country, even now.[1] It appears, however, that most of them will be eliminated before long and realistic prices, subject only to sufficient regulation to prevent abuse, will be allowed to affect energy production and consumption decisions in the majority of countries outside of the eastern block nations.

Most discussions of the "energy crisis" tend to overlook an important factor. All energy prices have not increased in real terms, nor at the rate of petroleum product prices.

Petroleum products account for only about 46 percent of total commercial energy consumption worldwide.[2] The cost of other energy resources, coal, hydro, uranium, fuelwood, and, in many locations, natural gas, have not risen, or have risen only in response to other factors such as local scarcity (fuelwood), environmental and safety concerns (coal or atomic power plants), depletion of regionally available, low-cost resources (natural gas) or deregulation of artificially low-priced supplies (U.S. natural gas prices). As a consequence, energy costs to users overall generally have risen less than the costs of petroleum fuels, and gradual substitution toward lower-cost energy resources is modifying the impact of petroleum price increases.

Several factors, however, which were independent of petroleum price increases, also have contributed significantly to the impact of the latter and to the rise of energy prices in general. In industrialized countries, the rising concern about environmental degradation has forcefully affected energy use patterns since the late 1960s, particularly with regard to the use of contaminating fuels such as high-sulfur coal, and oil. Regulation brought about massive shifts toward the use of environmentally more acceptable fuels, such as natural gas, putting pressure on already limited supplies. In addition, the rising concern about the safety of nuclear reactors led to ever higher safety requirements which vastly increased the costs of atomic power plants, rendering them essentially noncompetitive with alternative sources of electricity. In addition, environmental concerns led to the addition of costly clean-up facilities at coal-fired installations. These, in many cases, doubled capital costs and increased operating costs as well.

For all of these reasons, the real costs of the main sources of commercial

1. See, for example, the complexities of natural gas price regulation in the United States, or the regulated domestic petroleum and natural gas pricing structures in Canada. For a detailed discussion of the latter, *see* Helliwell, MacGregor, & Plourde, *Changes in Canadian Energy Demand, Supply, and Policies, 1974–1986*, in this volume.

2. World Bank, The Energy Transition in Developing Countries, Table 1 (1983).

energy, petroleum fuels, natural gas, and electric power have risen steeply compared to historical levels or compared to the costs of other goods and services. As these increased energy costs are being passed on to energy users and as energy users begin to realize that higher energy prices are here to stay, fundamental shifts in use patterns are developing. At the same time, the potential rewards for developing energy-saving technologies have been enhanced greatly, as have been the rewards for finding additional supplies of conventional energy sources such as oil and gas. To be effective, all of these forces and new developments require time to be implemented. Energy-inefficient equipment and appliances have to be replaced. Because of cost, this is often not feasible until they approach the end of their useful lifetimes. Factories producing new, energy-saving outputs have to be equipped, new products developed and brought to market. Prospective new deposits of oil, gas, and coal have to be found, proved, and developed. Years are needed until the full impact of all of these measures affects long-term supply and demand. Today, ten years after the "energy crisis" started, these new forces are finally making themselves felt on a massive scale, but many more years will have to pass until all readjustments take place.[3]

To understand these trends and why it is so difficult to predict and model them with conventional macro-economic tools,[4] a brief review of the many interacting factors that affect and change energy consumption and production decisions over time is essential. As events during the last ten years have shown again and again, the short-run elasticity of energy demand is quite low, even in the face of rather drastic changes in the costs of supply. This applies to price increases as well as decreases. The reasons are easy to understand. First, energy is generally not consumed for its own sake but only for the services it provides. The total costs of these services, in most activities, are far greater than those for the energy component alone (e.g. the total costs of owning and operating an automobile versus the cost of gasoline and lubricants only). Hence, even sharp changes in energy costs affect the total systems costs by a much smaller margin.[5] Second, the available alternatives in the short-run are limited. Thermostats can be lowered, or pleasure driving can be reduced, but the specific fuel efficiency of a given vehicle will remain unchanged. In some locations, private transport by automobile can be replaced by

3. For a discussion of these structural adjustments in developing countries, *see* Munasinghe, *Energy Strategies for Oil Importing Developing Countries*, in this volume.

4. For an application of these tools, *see* Pindyck & Rotemberg, *Energy Price Shocks and Macroeconomic Adjustments*, in this volume and Helliwell, MacGregor, & Plourde, *supra* note 1.

5. Overall, as a percent of GNP, the costs of energy supplies range between a few to about 10% of total GNP in most countries. For individual activities or production processes, energy costs are usually but a small fraction of total costs, even today, with the exception of a few energy-intensive activities. For a description of the latter, *see* Ross, *Industrial Energy Conservation*, in this volume.

public transport. Most of the changes that can be accomplished in the short-run, however, are also short-run in nature. If and when prices change back to previous levels, most of the old habits quickly reassert themselves.[6]

Options in the medium-term are much greater and changes brought about are usually also more permanent. Broken windows can be repaired, new insulation installed, or energy-inefficient vehicles replaced. Existing plants might be retrofitted with recirculation equipment that uses waste heat, or convert their boilers and furnaces from use of gas or oil to coal.

In the long-run, substantive and generally irreversible changes are the result of actual and expected, permanently higher energy prices. Given this scenario, users place far more emphasis on energy efficiency as a criterion for investment decisions. Appliances, vehicles, industrial equipment, power plants, smelters, and refineries will be designed to reflect the new energy-price relationships. Moreover, because of the higher costs of energy, new technologies will be developed to bring about such higher efficiencies. Cars and trucks today, on average, are far more energy efficient in any price and weight class than they were only five to eight years ago. Plastic and aluminum are used instead of heavier steel. Fuel injection or diesel engines are replacing carburetors or less efficient gasoline engines. New micro-processors are used more and more to optimize fuel consumption at specific load conditions, thus reducing waste. In electric power production, for example, gas-fired, combined-cycle plants bring about fuel efficiencies as high as 60 to 70 percent compared to less than 30 percent for simple gas turbines that were popular before. Waste products such as wood waste and cooking liqueurs in pulp and paper mills or saw mills are now used to provide most, if not all, of the energy requirements of such plants (they sometimes even produce surpluses of electric power). Where liquid petroleum gas (LPG) and natural gas are available and significantly lower-priced than petroleum fuels, they are replacing gasoline or diesel as transport fuels.[7] Atomic power plants replace oil or gas-fired ones, in France, Canada, Argentina, Korea, and the Eastern Bloc nations.[8] Most of these changes are permanent. Houses and commercial buildings, built to more exacting thermal efficiency standards, will remain energy efficient regardless of the cost of energy, and greater efficiencies built into new vehicles will not disappear because the price of gasoline falls. What we see, then, is a permanent shift toward

6. *See, for example:* Lillard & Acton, *Seasonal Electricity Demand and Pricing Analysis with a Variable Response Model,* 12 BELL J. OF ECON. 71 (1981), and Wheaton, *The Long-Run Structure of Transportation and Gasoline Demand,* 13 BELL J. OF ECON. 439 (1982).

7. *See also* Schramm, *The Changing World of Natural Gas Utilization,* in this volume.

8. Although this replacement has slowed down substantially in the United States, West Germany, Sweden, Austria, or other western countries because of safety and cost considerations.

lower energy use per unit of production or consumption. These shifts, however, are not uniform over time or uniform for given activities. They are inextricably related to life expectancies of existing equipment, houses, factories, power plants, or manufacturing facilities. In declining or mature industries, such as steel production and paper, changes beyond retrofitting of existing facilities may be very slow because of existing overcapacity and disincentives to invest in new plants and equipment.[9] In other rapidly expanding activities, changes in average energy efficiencies per unit of output may be drastic indeed. In addition, governmental policies may have a major effect on the rates of change from higher to lower energy-use intensities on the one hand, or the development of new supply sources on the other.[10]

The average energy intensities per unit of average GNP will be affected by the gradual migration of energy-intensive industries to locations around the globe where energy is still cheap and plentiful because it has few alternative uses. Major candidates are electro-process industries, such as aluminum smelting, or petrochemical industries using natural gas feedstocks.[11]

On the demand side a gradual, far from uniform, but largely permanent shift toward lower energy intensities per unit of output can be seen. Some of these shifts in a given activity may be completed within a few months or years. Others may require decades. Many other factors besides energy costs affect these changes.[12] To predict these changes and their time patterns requires detailed, plant-by-plant and activity-by-activity analyses carried out at the micro-level to show what potentials exist and at what speed these potentials may be realized.[13] Short of such detailed studies,[14] the uncertainties of prediction will always remain high. For this reason, even the most sophisticated demand forecasting models will always be subject to significant margins of error, because they have to be based on past technological-economic relationships that may no longer exist in the future.

Most responses on the supply side are equally long-term and inflexible in nature. Possible short-term responses to higher or lower prices, how-

9. *See also* Ross, *supra* note 5.

10. *See* Munasinghe, *supra* note 3, and Helliwell, MacGregor & Plourde, *supra* note 1.

11. For a discussion of these effects on natural gas utilization patterns, *see* Schramm, *supra* note 7.

12. Including, for example, governmental decisions to protect high-cost, energy-inefficient industries.

13. For some activities such changes are easier to predict than others. In analyzing gas consumption for automobiles, for example, the specific fuel consumption rates can be aggregated on the basis of vehicle specifications. What is more difficult to predict, however, are scrappage rates of existing vehicles and future fleet composition (which depend on individual buyer decisions), and mileages driven.

14. For two examples of such evaluations, *see* Ross, supra note 5.

ever, may well reinforce price swings. When petroleum prices rise rapidly, it pays owners of existing stocks to speculate on further price increases, making it attractive to hold existing stocks or even add to them, rather than sell. The opposite is the case when prices are falling and existing stocks are dumped on the market, forcing prices down further. These attempts at reaping windfall profits or preventing windfall losses have amplified price fluctuations to a significant degree in the past,[15] and are likely to do so again in the future.

In the long-run, higher prices induce the search for additional resources, because it is now more profitable to do so. This search is not only intensified in traditional areas of production, but it is expanded into high-cost regions, for example, in off-shore locations, or in the Arctic. In addition, potential resources which before were considered marginal, such as oil from secondary or tertiary recovery, heavy oils, tarsands, or oil from shales, become economically attractive and may induce investments which, once made, are usually irreversible.[16] Ultimately, these new activities yield fruit and higher supplies are forthcoming, even though the time from initial exploration or development to production may span many years. New supplies augment existing ones and start taking over market shares of existing producers, thereby moderating prices. Because of the high capital intensities of most of these activities (in oil and gas developments, initial capital costs usually amount to 80 to 90 percent of the total life-cycle costs of a deposit), new producers usually have little choice but to produce in order to recapture at least part of their heavy financial outlays, making them quite inflexible in terms of production decisions even in the face of falling prices.

In summary, at present and for quite a number of years to come, this gradual adjustment process is propelled by a myriad of independent decision makers, leading to reduced energy consumption on the one hand and abundant energy supplies through increased exploration and development activities on the other. By their very nature, these trends are slow in developing but even slower to stop once they have been set in motion.[17] On the demand side, they generally represent a permanent shift from higher to lower energy intensities per unit of output. The implementation of these shifts generally follows an S-shaped path, accelerating as more and more users adopt new technologies, install new equipment, or change consumption patterns, but slowing down as the change-overs reach saturation.

15. *See* Adelman, *Coping with Supply Insecurity*, 3 THE ENERGY J. 6 ff (April 1982).

16. Except for those whose operating costs turn out to be well above market values for the output. The aborted Exxon oil shale venture in Colorado or the two costly, now cancelled, Algerian LNG import schemes to the United Staes are examples of such misinvestments that were based on unrealistic price expectations.

17. *See* Ross, supra note 5.

Because of these response patterns, the rates of change themselves are not stable, and estimated elasticities based on observations of changes over any given time interval or across similar activities in different locations are also not stable. Any macro-econometric analysis, therefore, ultimately must be underpinned by micro-activity studies, because it is really at the micro-level where the actual changes are taking place. These changes and their rates are the consequence of many outside factors besides the cost of energy, so their analysis must take into account governmental policies, dissemination of knowledge, capital and resource availabilities, and growth or decay rates of the underlying, energy-using activities.

Effects on the supply side usually are slower in coming. Eventually, they lead to an augmentation of existing supplies from new, but usually higher-cost sources. These new supplies encroach on market shares of existing suppliers who already are faced with a shrinking market,[18] ultimately affecting prices in a downward direction.

The Papers in Brief

The collection of papers contained in this volume attempts to capture the essence of these long-term adjustment processes and to measure their magnitude, direction, and timing. They have been designed to address these issues within a worldwide context. Given the complexities of the task at hand, however, they necessarily have to be selective in terms of both geographic and topical coverage. They use both macro- and micro-approaches, showing how both types of analysis are inextricably interrelated and complimentary to each other.

Pindyck and Rotemberg analyze the macro-economic effects of both sudden and gradual energy price increases for variables such as national and personal income, inflation, unemployment, and investment. Using a complex, highly sophisticated mathematical model, they trace the dynamics of these changes and derive conclusions about appropriate economic and energy policies to minimize the adverse impacts of energy price increases. They show how energy prices can affect macro-economic variables through a variety of different channels and outline a number of policies that could be used to minimize the adverse effects.

Helliwell, MacGregor, and Plourde try to explain the major changes that have taken place in Canadian energy demands, supplies, and policies in the decade since 1973. They also project energy demand and supply until 1986 under alternative patterns of world oil prices and domestic Canadian energy policies. They use a macro-economic modeling approach to analyze those changes and predict future consequences. Their discussion of the effects of the policies that were pursued by the federal and

18. Shrinking, if not in absolute, then at least in relative terms.

provincial governments in their competition for shares of potential energy revenues from Canadian oil and gas production is of particular interest to governmental policy makers throughout the world. Overall, the authors conclude that the energy policies pursued in Canada have succeeded in moderating the speed of domestic energy price changes, as well as in redistributing among regions the very large windfall gains and losses accruing to Canadian producers from the major changes in world oil prices. They also show that the overall levels of national income in 1983 are very similar to what they would have been if world prices for petroleum products had been used as the benchmark prices paid by Canadian energy users. This is an important lesson for those governments still convinced that low-cost energy is essential for propelling economic growth.

G. F. Ray surveys the energy future of Western Europe, the world's largest energy-deficient region. After describing the current situation, he assesses the outlook for domestic resources and potential availability of imported supplies. He then looks at the long-term future toward the end of this century and beyond, which he feels will be a crucial period because of the approaching depletion, worldwide, of conventional petroleum resources. His paper is supported by extensive statistical data and an annex which briefly discusses the energy situation in Eastern Europe.

M. Munasinghe analyzes the impact of the past two oil price increases on the oil-importing, developing countries. He finds that their reactions were influenced strongly by developments in the industrialized world, and energy issues were inextricably linked with economic development problems. He concludes that in the short to medium-run the principal policy options for developing countries are to increase efficiency of both energy supply and consumption. Greater utilization of indigenous energy resources is the most critical and longer-term option that would permit gradual reductions in oil-import dependence. He discusses specific strategies for the oil, gas, coal, electric power, geothermal, biomass, and new energy sources subsectors, and concludes that the policy recommendations developed in his paper are valid over a reasonably wide range of future energy price scenarios.

While the first four contributions rely largely on macro-analytical approaches to derive their findings, the papers by M. Ross and G. Schramm address and evaluate the issues basically from a micro-perspective. Ross analyzes the energy requirements of U.S. industry, focusing on the sectors that dominate industrial energy use, the basic materials industries. After presenting current data on energy use, he analyzes them in terms of production levels and energy consumption per physical unit of output. Various causes of change in these components are identified, and the trends of the past decade determined. He then focuses on two specific industries—paper and steel. Taking account of demand, supply, and tech-

nological factors, he concludes that the decline or stagnation of industrial energy requirements, which has characterized the past years, is likely to continue for the next decade.

In studying his findings, it is perhaps ironic to note that the increase in petroleum prices apparently resulted in a much slower introduction of energy-saving technologies in the U.S. steel industry. High petroleum prices have accelerated the substitution of lighter materials for steel, and have brought about a down-sizing of cars, a major user of steel. The resulting decline of, and development of excess capacities in, the steel industry have reduced drastically the incentives for investments in new and more energy efficient production facilities, slowing down energy conservation.

Schramm's paper focuses on changing energy demand and supply patterns for natural gas in different regions of the world. Largely as a result of the increased search for oil, many new gas deposits have been found, most of them far from conventional gas markets. Because of the high cost of gas transport, the in-situ value of gas in many locations is low. This makes it possible to utilize gas as a systematic substitute for costly oil, in spite of higher user costs. Tracing through specific examples, Schramm shows that it is attractive economically for such gas-rich countries to bring about systematically such substitution. He concludes that, as a consequence, gas consumption patterns will differ sharply in the future between developed countries which are net gas importers at the margin, and gas-rich, but oil-poor, developing countries.