SIMULATION OF GOVERNMENT POLICY

James A. Calloway

ABSTRACT

Government policy, and sometimes the lack of it, can alter the basic structure of the U.S. economic system. This paper describes the development of a policy evaluation model and its use to simulate proposed energy and environmental policy effect on the national economy. The model and its components are described together with the analytical and validation processes used.

INTRODUCTION

Government policy has a dramatic influence on the state of the national economy whether it deals with the money system directly through Federal Reserve policy or indirectly through such avenues as environmental policy. Even the lack of positive government action has a definite bearing on the economic behavior of business and industry as evidenced by the recent inability of policy makers to enact a comprehensive national energy program. This paper deals with the analysis of resource-allocation-policy and the evolutionary development of an energy-policy evaluation simulation model.

Shubik (6) defines simulation as "the operation of a model--a representation of the system--amenable to manipulations which would be impossible, too expensive or impractical to perform on the entity it portrays." The impracticability certainly applies to our national economy, although this is exactly what we do when we enact legislation without knowledge of its probable economic impact.

Our economic system is extremely flexible, and in many instances, capable of withstanding extreme abuses. On the other hand, it represents a delicate balance of attitudes, biases, and interrelational complexities that is virtually beyond comprehension. Since any energy policy must have far-reaching national effects, we are definitely dealing with the entire economic system. Most contend that this nation's actions relative to energy policy are likely to have international implications as well. Manipulation of such a system for purposes of experimentation and, especially without a reasonable or at least partial understanding of the result, would lead to its ultimate destruction. A model or representation of the system is a must for policy analysis, since the model can be manipulated and studied without detriment to the actual system. Implication of the behavior of the actual system can be determined from the model and policy makers can proceed to develop legislation with an improved knowledge of the impact such legislation will have on the operating system.

The analyses described here involve policy evaluation models funded by the National Science Foundation and used to:

> evaluate the feasibility and national economic impact of President Ford's proposed policy of zero imports of foreign crude oil by 1985, coupled with the policies set forth by the Environmental Protection Agency leading to zero discharge of pollutants to the air and waterways.

Economic impact was to be measured in terms of the price effect on raw materials and manufactured goods associated with certain critical energy-intensive industries. Thus, the model had to account specifically for prices and quantities related to energy supplies, (fuel, electricity, etc.), raw materials, and industry end-products, as well as the quantity, composition, and origin of all pollutants produced by the industries.

The decision to build a policy model was an easy one; the decision as to what type of model to build was not. In fact, the decision process was evolutionary and a final determination took several months and several unsatisfactory turns.

The nature of energy and energy-related policies, such as environmental policy, is such that the future is not expected to be represented by the past and historical data are generally insufficient to forecast the costs of imposing newly legislated environmental policy. Furthermore, the nation had never had energy legislation or environmental legislation as such before; thus, there was no historical data to collect. Future waste treatment, resource recovery, and recycle process configurations were likely to appear for which no historical operating data existed. (This speculation has indeed been born out in recent months.) In general, normative models were required which possessed the ability to augment historical data with an appropriate synthesis of technical data into a comprehensive economic framework to evaluate how the basic structure of the industry or industries might change in response to proposed legislation. The models had to be able to adapt to changes in the operating scene which had never before been experienced.

MODEL STRUCTURE

A process model using linear programming was used to describe the critical energy production, conversion, and consumption industries. Considerations included alternative methods of production and waste treatment; input mixes of energy, water, capital, and raw materials; and output mixes of end-products, by-products, and waste discharges. This model was comprised of the following industries identified by their Standard Industrial Code (SIC): electric power, petroleum refining, natural gas processing, and the basic chemicals industries such as organic and inorganic chemicals, fertilizers, plastics and polyesters, cyclics and intermediates, alkalies and chlorine, and synthetic rubber.

Development of the model was based on a three tier structure: individual plant models, combinations of plant models into industry models, and combinations of industry models into an integrated industry model. Each production process was modeled specifically in terms of its resource requirements (fuel, raw materials, capital) and the resulting outputs (primary products, secondary products, pollutants) as illustrated in Figure 1. Further, alternative production and waste treatment processes were provided to allow changes in production configuration affected by technological innovations, improved efficiencies, and capital equipment investment and retirement decisions. Thus, the model was able to adapt to changes in the industrial operating environment perpetrated by proposed energy policy, environmental policy, technological progress, or any combination of the three. Upon specification of the supplies of natural resources, environmental policy, and final demand for the model's 48 produced outputs, the linear programming model efficiently allocated the available resources to satisfy the specified production requirements.

VALIDATION

Since it was intended that the policy evaluation model represent physical and economic structure likely to exist in the future, model validation presented an interesting problem. This problem was met through formulation of a panel of experts (industry, academic, and government) to provide critical analysis of model development, technological accuracy, and analytical results. The panel was formed at the outset and used in an advisory as well as analytical capacity. Membership was modified periodically as the need for expertise changed.

ANALYTICAL RESULTS

Faulty Conclusions--The analysis compared total production costs for both policy conditions (no energy/environmental policy vs zero discharges and zero imports). Two subcategories were examined as well, processing costs and fuel and material

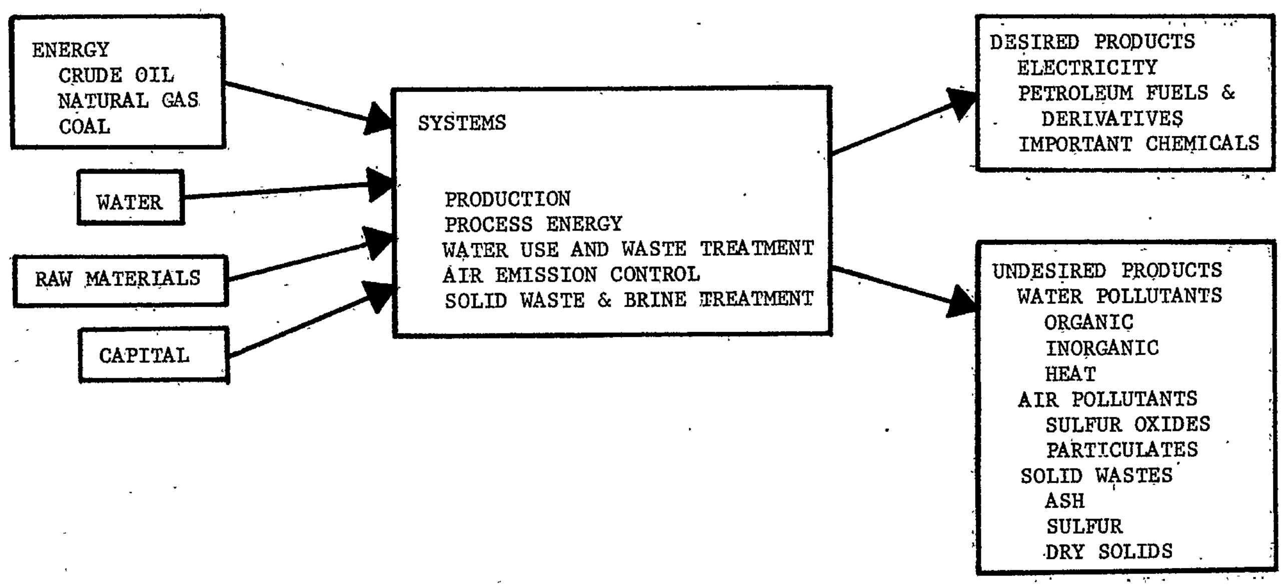

FIGURE 1 FUNDAMENTAL COMPONENTS OF REPRESENTATIVE INDUSTRY MODELS

costs. Results indicated that the objectives could be achieved at a nominal increase in total product cost of 14 percent. Processing costs increased by 40 percent while fuel costs increased by 5.7 percent (7).

Attempts at validation of the modeled results revealed a major discrepancy between the cost figures obtained from the model and those projected by industry. The evolutionary process of model development continued as we sought to determine what criteria had been omitted from the original model formulation.

Investigation indicated there was a definite shift in the production process configuration of several industries resulting from imposition of proposed environmental restrictions; that is, the cleaner fuels and non-polluting production processes were in greater demand. Furthermore, since natural gas prices were government regulated, the model did not allow a corresponding price increase as demand for clean fuels increased. Thus, the projected cost increase relative to fuels and raw materials substantially underestimated that which could reasonably be expected, especially if the market were free to determine price and supply response. We determined that, contrary to existing government policy, the price of scarce resources must be allowed to increase in conjunction with product demand. In other words, the market place must be allowed to perform its function without regulatory intervention.

The decision to make the industry model price sensitive precipitated the need for end-product demand models possessing the inherent qualities necessary to reflect the action of the market place (5). Further, resource supply models were needed to reflect possible increased supplies of resources resulting from increased prices (2) (3).

The final configuration of the model consisted of supply models for crude oil, natural gas, and coal, and demand models for critical energy end-products such as natural gas, gasoline, fuel oil, kerosene, coal, and electricity. The demand models depicted national demand in three sectors: residential and commercial, transportation, and industrial (that part of industry not accounted for by the LP industry model).

Basic estimates of economic demands were developed by the FEA (now Department of Energy) for the Project Independence Report (1). Direct and cross-price elasticities were computed for $4, $7, and $11 per barrel of crude oil. These direct and cross-price elasticities were used in the demand model to adjust the base energy requirements for different input prices.

Using 1973 as the base year, a crude oil and natural gas supply model was developed (3) which estimated total production of new crude oil and natural gas from the lower 48 states accounting for both regional economic and physical factors for eight regions of the United States. The economic feasibility of exploration investment was determined through evaluation of the net cash flow resulting from exploration, development, and production activities (4). This net present value calculation includes contributions from secondary and tertiary oil recovery as well.

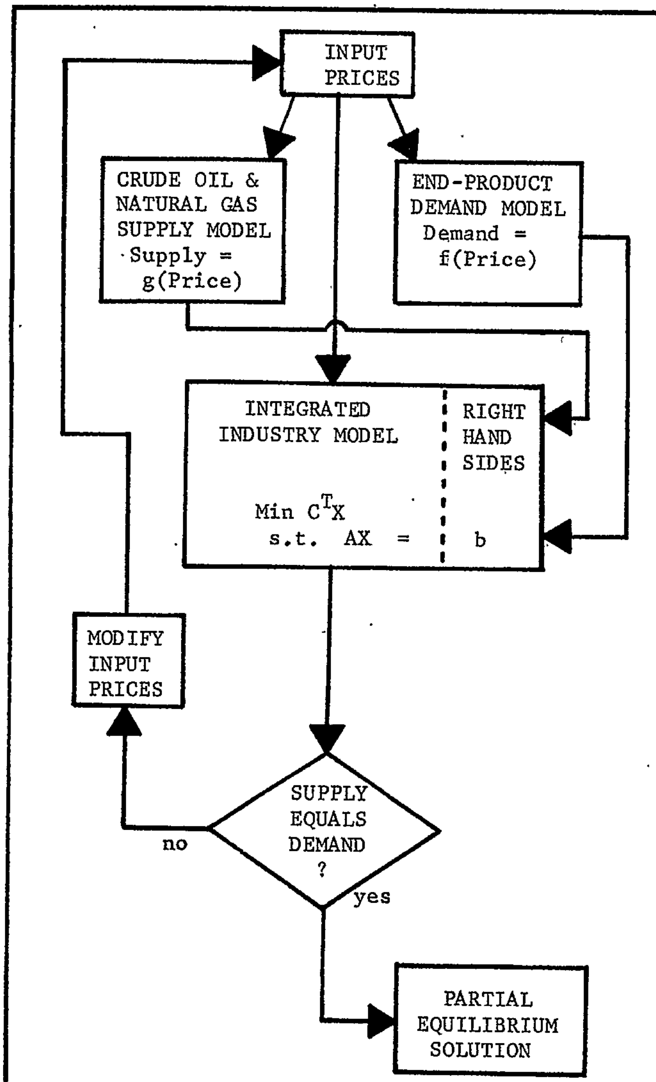

FIGURE 2 ITERATION PROCEDURE

The final simulation model used to make energy policy evaluations, represents an interactive interface of the supply, industry, and demand models as illustrated in Figure 2. The three models were operated with an iterative supply/demand equilibrating algorithm to estimate market-clearing prices and quantities of crude oil, natural gas, coal, fuel oil, and electricity for the United States. The objective of the iterative procedure was to find an industry model solution for which: 1. exeogenous final product demands were met; 2. endogenous intermediate product demands were met; and 3. supply and demand for crude oil and natural gas were balanced. Solutions were obtained for a set of 'base case' specifications (no controls) and for the scenario of interest (zero discharge/zero imports). Comparing the two partial equilibrium solutions indicated the impact of the modeled policy.

Revised Conclusions--Results from the second set of analyses indicated production cost increases of more than 50 percent. Process costs increased by 51 percent. Market clearing prices (partial equilibrium) for the major energy products were $2.48/mmbtu for oil, $2.34/mmbtu for natural gas, and $.75/mmbtu for coal. The stated objectives were accomplished to the satisfaction of the panel of critics but not without relaxing some of the restrictions on the model. Specifically, it was necessary to eliminate price regulation of natural gas and prohibit construction of new electric power plants using natural gas and oil-fired boilers.

BIBLIOGRAPHY

1. Federal Energy Administration. Project Independence Report: Project Independence. U. S. Government Printing Office, Washington, D.C., 4118-00029 (Nov., 1974).

2. Hill, Robert R., Economic Supply Models for Crude Oil and Natural Gas in Texas. Unpublished doctoral dissertation, University of Houston, May, 1975.

3. Kim, Y. Y., Economic Supply Models for Crude Oil and Natural Gas in the United States, Unpublished doctoral dissertation, University of Houston, 1978.

4. Thompson, R. G. and Y. Y. Kim, Supplies of New Crude Oil and Natural Gas in the Lower 48 States: An Economic Model. Gulf Publishing Co., Houston, Texas, 1978.

5. Lievano, Rodrigo J., Energy Use and the Environment, Unpublished doctoral dissertation, University of Houston, 1975.

6. Shubick, Martin, "Simulation of the Industry and the Firm"; American Economic Review, 1, No. 5, (Dec. 1960), p. 909.

7. Thompson, R. G., James A. Calloway, and Lillian A. Nawalanic, The Cost of Energy and a Clean Environment, Gulf Publishing Co., Houston, 1978.