

Energy Policy : An Optimal Allocation Approach

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INTRODUCTION

Any system of ideas which underlies economic policy recommendations needs to be made explicit so that its doctrinal premise may be examined and debated. Section 1 of this paper, therefore, explicitly states the philosophical under-pinning of this study. Section 2 presents the central energy problem in a general mathematical form whereas the solution of the specific energy problem for the Pakistani economy is presented in Section 3, in which policy guidelines for obtaining the desired solution have also been discussed. Finally, Section 4 briefly presents our concluding remarks.

1. GUIDING SOCIAL IDEAS

To me, as to the generations of classical, neoclassical and new neoclassical economists, individual freedom is the highest and the most fundamental human value. It implies the right to make and act on one's own decisions without interfering with others' freedom.¹ Hence I prefer a society which co-ordinates the economic and non-economic activities of its members through voluntary means such as markets or consensus.

The framework of the free market is derived from and supplements the ideal of individual freedom. This freedom of the market-place ensures an efficient allocation and maximum production for the society. Each man looking for his own economic benefits serves the economic benefits of the whole society and, on the basis of general utility, it leads to maximum happiness and minimum pain or cost of production. Like others,² I do however, recognize the need for some government intervention, especially in the case of Pigovian externalities and technical

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¹This concern for "virtue itself hath need of limits" opens the way for constraints on human actions, which one imposes in the form of laws, customs, and religious and moral codes.

²Almost two hundred years ago Adam Smith included the construction and maintenance of large public works, national defence and administration of justice as the three main duties of a sovereign. See Smith [3].

monopolies.³ The other acceptable role for the government is to provide national defence and personal security, to promote economic freedom by enforcing voluntary contracts, property rights and stable money system, and, finally, maybe to act as a private charity in order to support those who cannot look after themselves.

Freedom of the market-place and political freedom support and enhance each other. This is so because for a political decision to be freely made, the act must be severed from any connection with the process of obtaining one's livelihood.

Thus, for reasons such as freedom, incentives and efficiency, I support the market system. I also favour equality of opportunity but not absolute equality, because of its trad-off with efficiency. I do not believe in the realism of collective loyalty, altruism or coercion. Furthermore, I should like to believe that much of the inequality of income and wealth reflects inequalities in marginal product and opportunities which can be efficiently corrected within the free market economy framework. Eradication of poverty is only possible through efficient allocation.

2. THE ENERGY PROBLEM

Let us look at the nature of the problem, which requires some sort of policy to resolve it. The energy problem is usually defined as a demand-supply gap. However, little thought is necessary to realize that in a free-market framework, where prices respond promptly to a gap between the quantity demanded and the quantity supplied, shortages or surpluses are momentary. If the quantity supplied falls short of the quantity demanded at current prices, prices will rise until an equilibrium is attained between the desired levels of consumption and production. In these circumstances, price itself is the only measure of inadequacy or scarcity of supplies. Thus the energy shortage gap turns out to be imaginary rather than real in a free-market economy. Seen in this perspective, the energy problem is not one of running out of energy or of its permanent shortage, but one of ensuring a reasonable unit price.

Thus the existence or persistence of an energy shortage gap only indicates that the price system is not functioning as it should, and this usually happens when a government decides to intervene either to regulate price or to act as a monopoly supplier.⁴

The energy sector of the Pakistan economy could hardly be described as operating in a free-market situation. The government intervention is commonplace and takes two forms: (a) regulation of the prices of oil and gas, and (b) monopolistic

³Strictly I prefer private monopolies to State monopolies on three grounds: (a) I do not like the power of the government; (b) rapid technical changes make technical monopolies' life limited; (c) private monopolies remain more efficient because of the fear of potential competition.

⁴In such a situation, it is obvious that the best policy will be to promote the free-market mechanism and to deregulate the price system.

or semi-monopolistic supply of power and coal. Hence it is little wonder that the "shortage" problem is of permanent nature at least in some of the markets.⁵ In view of this ownership and management structure and bureaucratic preference for controls; the energy problem must be viewed in terms of bringing the energy markets into equilibrium by increasing the supplies. The energy planner in Pakistan, in seeking the solution to the energy imbalance, also has to face the following sub-problems and policy issues:

- (i) Problem of industrial and trade priorities;
- (ii) Financial and foreign-exchange planning;
- (iii) Pricing policies;
- (iv) Exploration and depletion problems;
- (v) Conservation and environmental issues; and
- (vi) Research and development policies.

Looking at this list of complicated and interacting problems, it is quite clear that the free-market system is best suited to resolving them simultaneously. However, the market mechanism, guided by a conscious government policy concerning energy,⁶ might provide the best alternative providing answers to the problems faced.

The energy problem, in its general form, can be formulated as under:

a. Energy Supply Model

$$\text{Minimize } C X \quad \dots \quad \dots \quad \dots \quad (1)$$

$$\text{Subject to } A X \leq R \quad \dots \quad \dots \quad \dots \quad (2)$$

$$A_d X \geq D^* \quad \nu^* \text{ (shadow prices)} \quad \dots \quad (3)$$

$$X \geq 0$$

b. Energy Demand Model

$$D^* = F_d(P^*) \quad \dots \quad \dots \quad \dots \quad (4)$$

c. Energy Balance

$$P^* = V^* \quad \dots \quad \dots \quad \dots \quad (5)$$

⁵This is so, for example, in the power industry, where load shedding is a permanent and increasing problem, and is causing scarce resources to be diverted to the financing of small-scale generation.

⁶Strictly speaking, I do not believe that the centralized planning system can bring about results similar to those that the free-market system can. However, the theoretical possibility is undeniable.

where

C is a cost vector for the supplies activities

X is a vector of production and trade activity level

$A X \leq R$ represents resources and other non-demand constraints

$A_d X \geq D^*$ represents demand constraints

$D^* = F_d(P^*)$ represents market determined demand vector

$P^* = V^*$ shows energy markets equilibrium.

The energy problem above (i.e. 1 to 5) can also be formulated as an economic surplus maximum problem.⁷ Such a formulation not only can make the computation simple but also can provide a direct welfare interpretation of the equilibrium solution. However, it also requires that certain regularity conditions e.g. the direct demand functions, i.e. $D^* = F_d(P^*)$, are invertible and the inverse demand functions, i.e. $P_d(\cdot)$, are mathematically integrable — are satisfied. These conditions were not even approximately satisfied in our study. Hence, a specific formulation,⁸ based on the formulation 1 to 5 has been used to find an optimal solution for the energy problem. The following energy policy recommendations are based on this optimal solution and the simulation results.

3. POLICY GUIDELINES

The optimal solution simulation results and certain value judgements imply the following policies for the Pakistan energy sector.

(a) Industrial, Trade and Output Priorities

The optimal investment, trade and output activities which will satisfy the projected energy demands have been chosen on the basis of their comparative advantages. Thus, these selected options can be considered as priority options for the industrial and trade policies. The priorities have been classified in Table 1, using the following criteria:

⁷See, for instance, Pressman [1] and Uri [4] for such a formulation. Using this format, the problem can be expressed as :

$$\begin{array}{ll} \text{Maximize} & F_d(D^*) - CX \\ \text{Subject to} & A X \geq R \\ & A_d X - D^* \leq 0 \\ & X \geq 0 \end{array}$$

⁸The specific model used consists of an objective function and a set of seven constraints (viz. capacity requirements and availabilities, trade limits, maximum resources, maximum capacities and seasonal hydro considerations, etc.). In addition, simulation experiments were performed using such constraints as national self-sufficiency, national security, clean environment, etc. For full details, see Riaz [2].

Table 1
Industrial and Trade Priorities

| Industry and Option | Priority 1 | Priority 2 | Priority 3 | Priority 4 |
|-------------------------------------|-----------------|-----------------|----------------|---------------|
| (a) <i>The oil industry</i> | | | | |
| Domestic expansion | x (326 MGJ) | | | |
| Synthetic oil from coal | | | x (250 MGJ) | |
| (b) <i>The natural gas industry</i> | | | | |
| Domestic expansion | x (1975 MGJ) | | | |
| Synthetic gas from coal | | | x (150 MGJ) | |
| (c) <i>The coal industry</i> | | | | |
| Domestic expansion | x (90 MGJ) | | | |
| (d) <i>The power industry</i> | | | | |
| Hydro expansion | x (378 MGJ) | | | |
| Nuclear expansion | x (162 MGJ) | | | |
| Gas steam expansion | | x (1242 MGJ) | | |
| Gas turbine expansion | x (162 MGJ) | | | |
| Solar expansion | | | | x |
| Breeder reactor expansion | | | | x |
| Wind & wave expansion | | | | x |
| (e) <i>Conventional energy</i> | | | | |
| Bio-gas expansion | x (520 MGJ) | | | |
| Wood growing | | | | x |
| Fuels from wastes | | | | x |
| (f) <i>Trade</i> | | | | |
| Oil import | x (7013 MGJ) | | | |
| Oil export | x (380 MGJ) | | | |
| Gas export | x (2259 MGJ) | | | |
| Coal import | | | | x |

Notes: (a) Figures in parenthesis refer to 25 years' expansion and trade requirements.
(b) MGJ = Mega Giga Joules

- Priority 1 is given to those technologies or options which were chosen under all sets of assumptions and constraints.⁹ Hence, these meet all criteria of selection.
- Priority 2 is given to those options which were selected in the basic model as well as under some (but not all) simulation experiments.
- Priority 3 is given to those options which were ignored in the basic solution, but were, however, chosen under some alternative assumptions and constraints.
- Priority 4 is allotted to those options which are experimental at present but could become important in future.

The industrial output is inherently related with the industrial capacity and the selection of the output levels is based on the "cheap fuel now" policy. In the case of fossil fuels, it is cheaper to extract them from domestic reserves (hence the stress on domestic capacity expansion) than to import them. The optimal oil output schedules will exhaust all domestic reserves in the first five years. This is, of course, due to the bang-bang nature of the optimal solution, but such an action is neither technically feasible nor economically or nationally sensible. Thus an intelligent policy may be to produce technically maximum feasible output. The coal output requires immediate expansion. The natural gas output expansion requires to be moderated.¹⁰ The power output to meet base load is required to be met by the hydro and nuclear supplies.¹¹ The medium load can be supplied by the gas steam plants and the peak load should be met by using existing coal, oil and gas turbine plants.

In order to achieve and maintain equilibrium in the energy markets there will be need to expand domestic capacity as well as to increase the net imports of energy goods. Thus, the real energy problem facing Pakistan is to raise capital (and foreign exchange) to finance this required development of domestic resources and to pay for the rapidly increasing imports. The total capital cost of maintaining a long-run equilibrium (to 25 years) will amount to be about Rs. 174 billion in the 1980 prices. The breakdown of the energy sector's financial and foreign-exchange requirements is given in Table 2.¹² A careful observation of the figures given above will indicate the planner's problem which is to raise those large sums in a capital-short country. In the past, capital funds for the energy sector have mostly come from external sources (i.e. aid, loan or foreign investment) such as aid-giving countries and international financial bodies such as IMF and IBRD. The international financial climate

⁹For full details of these, see Riaz [2].

¹⁰This means that its wasteful use must be discouraged.

¹¹This policy implication is in direct conflict with the present practice of sharing base load by hydro and gas steam plants.

¹²With rapidly changing energy and capital goods prices, these figures could not reflect anything more than rough estimates of possible magnitudes.

Table 2
Capital and Foreign-Exchange Requirements of Long-run Equilibrium

| Requirements | 1981-85 | 1986-90 | 1991-95 | 1996-2000 | 2001-2005 |
|------------------|---------|---------|---------|-----------|-----------|
| Capital | 28.6 | 8.2 | 11.27 | 23.05 | 9.72 |
| Foreign-Exchange | 10.60 | 15.80 | 17.71 | 23.04 | 24.91 |

Source: Riaz [2].

Note: Foreign-Exchange requirements include both the cost of energy imports and the foreign-exchange component of the capital cost.

prevailing in the mid-80s is not all that conducive to aid or loan programmes. Thus, it might be well worth mentioning here that the development and exploitation of the domestic capital markets along with appropriate pricing policies in conjunction with the use of supplier's credit, leasing facilities, promotion of foreign investment and borrowing from the international money markets might be the only way to deal with this difficult situation.

(b) Pricing Policies

The methodology of this study is consistent with the principle of marginal cost pricing which ensures efficient allocation and, therefore, yields a welfare optimum.¹³

The pricing policy of the optional solution, which is reflected in the dual variables corresponding to the demand constraints, supports the long-run marginal opportunity cost pricing which is consistent with the objective of efficiency. These prices can also satisfy any revenue-raising objectives as these are greater than the average costs.

The long-run marginal opportunity cost of oil, gas and coal is the import price of those goods. The long-run marginal opportunity cost of electricity correspond to the marginal cost of nuclear supplies. The prices as indicated by the dual variables are:

Rs 340 per barrel of crude oil

Rs 549 per MCF of natural gas

Rs 1260 per ton of coal

Rs 0.36 per kWh for base load

Rs 1.40 per kWh for median load

Rs 7.83 per kWh for peak load

¹³The marginal cost of pricing rule has been criticized because of its inability to take into account increasing returns to scale and other factors contributing to market failure.

These prices will lead to a significant increase in the prices of energy goods, which might go against the government objectives of narrow social justice,¹⁴ cheap energy for industry and private domestic consumption. However, the proposed prices are consistent with the declared financial objectives and in addition will provide incentives which are sadly missing in the present pricing policies.¹⁵

(c) Depletion and Exploration Policies

The optional depletion policies reflected in the optional solution are :

- (i) rapid depletion of domestic oil and gas resources;
- (ii) steady depletion of coal reserves;
- (iii) rapid development of hydro and nuclear resources; and
- (iv) delayed development of solar resources.

These policies are not unexpected. The long-run equilibrium is desired for 25 years, total cost is being minimized, and the present is preferred to the future. Hence, the combination of all these factors promotes rapid domestic depletion policy. However, it must be noted that time horizon, objective function and discount factors are all subjective choices. A change in any of these factors will have an impact on the rate of exploitation of the domestic resources. But, given the present framework, which is based on the principle of comparative advantage, nothing short of an active exploration and depletion policy will serve the best interest of the country.

(d) Environment Policy

Environmental safety has become a major debating point and a public policy issue in most of the advanced industrial countries. Some of those countries have passed clean air and water acts to safeguard community health against industrial waste.

The pollution problem addressed in the study related to the sulphur emission only, and it was conducted as a part of sensitivity analysis. Sulphur is emitted in petroleum-refining as well as power-generating plants. The costs of the cleaning process were internalized to the pollution-creating plants. As a result, the cost of long-run equilibrium went up by Rs. 10 billion. Would the society care to spend this sort of money?

(e) Conservation Policy

The energy conservation policy is desirable only in the face of waste. Otherwise it can lead to lower production, lower living standards and, possibly, lower welfare.

¹⁴In my opinion, these objectives can be served better through alternative measures such as income and export subsidies etc.

¹⁵See Riaz [2] for a detailed discussion of pricing policies.

In Pakistan, energy waste is almost insignificant and, hence, a (forced) conservation policy would lead to a substantial loss of national welfare either through lower output or through loss of utility. Thus, even if energy conservation is possible, its desirability is not obvious. However, this does not mean that the conservation of individual fuels cannot be beneficial. Therefore, it may be possible to develop and implement a fuel-specific (such as oil) policy which will be beneficial for the country. I prefer voluntary methods of conservation (i.e. price adjustment) compared to the non-voluntary methods such as load shedding, rationing, etc. But I am ready to admit that in the short-run probably non-price methods are essential in order to restore equilibrium.

(f) Research and Development Policy

The analytical framework of this study does not incorporate any aspect of research and development, and, therefore, any discussion of this subject will have to be subjective.

A strong research and development programme is essential for national freedom and economic growth. Such a programme can help in making the country less dependent on imported technology. Yet, Pakistan has no research traditions, and, therefore, research, at least to begin with, should be concentrated where some initial experience has been obtained such as nuclear energy. In addition, policy-oriented research which will not cost much and is easy to establish could be useful in determining national limitations and options.

4. CONCLUSIONS

In concluding, it is important to restate that one single, most important policy measure will be the creation of free energy markets. This will require the dismantling of all monopolies and price controls. Failing this, the adoption of the policies which are consistent with the long-run equilibrium might be the second best choice.

It is also important to note that the "ends and means" discussion developed above is based on a stated social philosophy of liberalism and a methodology which has its roots in that philosophy. It is, however, only one point of view and it is important that it should be compared with and debated against its alternatives which prefer "welfare" and "equality" to freedom. This is the only way to develop a national consensus.

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**Comments on
"Energy Policy: An Optimal Allocation Approach"**

Dr Riaz has been pursuing the all-important problem of formulating an optimal energy policy for Pakistan for the past seven years. The subject certainly merits the attention of the top Pakistani economists and it would be very useful if others were to follow Dr Riaz's lead. There has been some work on energy systems at the Pakistan Atomic Energy Commission but that does not tackle the economics of energy. Their recommendations should be of the utmost significance for policy-makers and policy-implementers.

I must say that the work under discussion at present falls far short of the standard of excellence set by Dr Riaz's earlier work. He starts off with a declaration of faith in the capitalistic, free-market system and the necessity of using it for proper economic development. This point has remained controversial despite a long debate over many years. It would have sufficed for him to say that he would adopt a free-market framework in which to optimise allocation in the energy sector.

He states that "the long-run energy problem is not one of running out of energy . . . but one of ensuring a reasonable unit price". This is an odd claim. The world in general, and Pakistan in particular, *is* in the danger of running out of adequate sources of energy. In economic terms, as we run out of energy the unit cost will tend to infinity. Dr Riaz is not worried about that aspect but merely about ensuring market equilibrium. His "solution" will throw the baby out with the bath-water. He will obtain his equilibrium by raising energy costs and hence his "solution" will entail human suffering. It should be borne in mind that we can not continue to support our present population without the use of energy, for example, to run tractors, produce fertilizers, transport grain, pump water, etc. If there is a shortage of energy, regardless of equilibrium of the market we will be unable to provide food, drink, medicine and shelter for the population at present. Incidentally, I wonder why an optimal policy is required, if we are ultimately to follow Dr Riaz's recommendation of total *laissez faire*.

Before proceeding on to my main comment, I would like to say a few words about the policy implications drawn by Dr Riaz. He claims that "In the case of fossil fuels, it is cheaper to extract them from domestic reserves than to import them". This is not a generally valid statement. It must depend on the quality and quantity of the fuel reserves, and on the sort of terrain where the fuel is to be mined. The generalization may be true in England (one would not want to carry coals to Newcastle) but it may well be doubted in Pakistan. I would need much better arguments

to convince me of the recommendation that our domestic oil and gas reserves should be rapidly depleted, or that we should steadily deplete our coal reserves. Again, I would vigorously dispute that we should put our reliance on nuclear power – particularly in view of the serious hurdles being placed in its development (in Pakistan) by the United States. Also, as Dr Riaz has considered environmental hazards due to sulphur emission, he may consider the enhancement of the cost of “safe” nuclear energy. Pakistan can hardly afford the expenditure involved in the development of such hazard-free nuclear power.

My major objection is to that part of Dr Riaz’s discussion where he simply states the optimization problem and refers to an earlier work [1] for the actual procedure. On searching through that work, published in 1984, one finds it to be identical in formulation to an earlier work [2] published in this very journal in 1981. It appears that the formulation was developed in a series of discussion papers [3] in 1978-79. All that has changed since is the data and the actual numbers extrapolated. The present work merely purports to state what has been said in the latest update [1] of the 1978-79 work [3].

On looking further at what little formulation is provided, one comes across new problems. Many of the symbols, A , R , A_d , P^* are not defined though they are used in equations (2) to (4). From the context it appears that P^* is a market-determined price-vector and R is some other vector while A and A_d are some matrices. Then, while “explaining” some of the terminology involved the inequalities of equations (2) and (3) are reversed. Then in equation (6) the objective function is stated in terms of a function of the market determined demand vector, while the function was originally defined in equation (4) as a function of P^* . In equation (7), the inequality is reversed again. (Incidentally the equation in the earlier work referred to agrees with equation 2.) Then, in equation (8), a vector is subtracted from a matrix, which makes no sense whatsoever.¹ Assuming that these are all typographical errors, one could guess that the objective function should be $(D^* - CX)$ and the other equations merely repeat those on p. 4 of the original paper – unnecessary, but better than being wrong. If P^* is constant, the claim is trivially correct; otherwise it is not valid. In either case, the reformulation is better avoided. (A proper statement of the problem is given in an earlier work of the author to [1].) Even the explanatory footnotes are cryptic. Footnote 8 mention a linear model with a quadratic objective function. In what is the function quadratic? If it is quadratic, in what sense is the model linear? Nothing is explained.

Neither here, nor in the earlier works [1; 2] is the actual optimization procedure given. The validity of the analysis is not, therefore, available to be checked. A

¹Equations (6) to (8) mentioned by the discussant here were originally there in the paper presented by Dr Riaz. In the revised version of the paper, published immediately preceding these comments, they have been put, unnumbered, in Footnote 7. (Editor)

much more detailed account of the argument involved is required if anybody is to be convinced of its validity. Without that the policy recommendations are merely the author’s personal hunches. To attain some level of objective validity, much more must be presented to the reader.

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