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Third World Energy Policies
Demand Management and Conservation

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Third World energy policies

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Increasing energy costs underline the need for more efficient management of energy supply and demand to maintain economic growth, especially in the resource scarce developing countries. Combining policy tools for demand management and conservation (including pricing, physical controls, technical methods, and education) yields the best results. Pricing policy takes into account the efficiency costs of energy supply required to meet economic objectives. This is then adjusted to satisfy other objectives of pricing such as social-subsidy considerations, financial viability, conservation, price stability, etc. Energy conservation programmes should be implemented only after determining whether their economic benefits exceed the corresponding costs.

Keywords: Energy; Third World; Demand management

Today's societies require increasing amounts of energy for domestic, industrial, commercial, agricultural, and transport uses. These energy needs are met by the commercial energy sources including the short-term, depletable fossil fuel supplies — petroleum, coal, and natural gas — as well as the longer-run, renewable sources such as hydroelectric, biomass, solar, geothermal, wind, and tidal power.

In 1980, world commercial energy consumption was almost 140 million barrels per day of oil equivalent. Only 20% of this was used by the developing countries although they contained over 75% of the world's population. The almost six-fold increase in the real price of oil between 1972 and 1980, and the general rise in costs of supplying all forms of energy have placed enormous financial strains on most nations. The resource scarce Third World countries will need over US$600 billion (in 1980 constant terms) for energy investments in the 1980s. To ensure that energy is economically and efficiently used, policy makers in many countries are beginning to realize that energy investment and pricing decisions should be carried out on an integrated basis, eg within the framework of a national energy master plan that addresses both supply and demand issues.

National energy planning

The broad rationale underlying national energy planning is to make the best use of energy resources to promote socio-economic development and improve standards of living. As an essential part of overall national economic planning, the principal emphasis of energy planning, is on the comprehensive and disaggregate analysis of the energy sector and its interactions within the economy. The energy planner's role might be confined to seeking the least-cost method of meeting future energy requirements, although a variety of other objectives might be included.

Energy planning requires analysis at three levels:

- links between the energy sector and the rest of the economy;
The views and opinions expressed in this paper are the author’s and do not necessarily reflect those of the Government of Sri Lanka or the World Bank. The author is grateful to Gunter Schramm, Lyndon Driscoll and an anonymous referee for helpful comments.

1Biomass consists of traditional and non-commercial fuels such as wood, vegetable residue and animal waste. These traditional fuels are particularly important in developing countries. See for example Mohan Munasinghe and Gunter Schramm, Energy Economics, Demand Management and Conservation Policy, Van Nostrand, New York, NY, USA, forthcoming 1983.


3For further details see Mohan Munasinghe, 'Integrated national energy planning (INEP) in developing countries', Natural Resources Forum, Vol. 4, 1980, pp. 359–73.

4For example reducing dependence on foreign sources, supplying basic energy needs of the poor, reducing the trade and foreign exchange deficit, priority development of special regions or sectors of the economy, raising sufficient revenues to finance energy sector development (at least partially), ensuring continuity of supply and price stability, preservation of the environment.

5Demand management includes all means of influencing and controlling the magnitude and pattern of energy consumption. Supply management includes identification and optimal exploitation of all energy resources, investment planning, transformation, refining and distribution of energy and so on.

6For example load shedding and rotating power cuts in the electricity subsector and reducing the supply of petrol or banning the use of cars during some periods.

7For example electricity generation, transmission and distribution, oil and gas wells and pipelines, coal mines, forests.

The policy tools available for energy planning and management include pricing, physical controls, technical methods (including research and development), and education and propaganda. Since these tools are interrelated, their use should be well coordinated. Price is most effective in the medium- and long-term. In terms of economic efficiency, price indicates the consumer’s willingness-to-pay and use-value of energy to the supplier; while to the consumers, it signals the present and future opportunity costs of supply based on various energy sources.

Physical controls are most effective in the short-run when there are unforeseen shortages of energy. All methods of physically limiting consumption are included in this category. Technical means include, on the supply side, the cheapest means of producing a given form of energy, the best fuel mix, research and development of substitute fuels such as wood-alcohol for petrol; and on the demand side, introducing higher efficiency energy conversion devices such as better wood burning stoves etc. Education and propaganda include, on the supply side, efforts to make people aware of external dis-economies such as pollution, and supportive of re-afforestation schemes to preserve the environment; and on the demand side public education for energy conservation.

Objectives and integrated pricing framework

Pricing and investment decisions should be closely related. However, energy supply systems usually require large capital investments with long lead- and life-times. Once the investment decision is made (usually on the basis of the conventional least-cost method of meeting demand by sub-sector, with due regard for interfuel substitution possibilities) there is a lock-in effect with respect to supply. Therefore prices should be related to the long-term planning horizon. On the demand side, energy conversion devices (eg cars, gas cookers, electric appliances, machines and so on) are expensive relative to average income and have relatively long life-times, thus limiting the ability of consumers to respond to changes in relative fuel prices in the short run.
Economic efficiency
The objectives of energy pricing are closely related to the goals of energy planning, but are more specific. The economic growth objective requires that pricing policy should promote economically efficient allocation of resources both within the energy sector and when integrated with the economy in general. This implies, generally, that energy use would be at optimal levels, with the price (or consumer's willingness-to-pay) for the marginal unit of energy used reflecting the incremental resource cost of supply to the national economy. Relative fuel prices should also influence the pattern of consumption in the direction of the optimal or least-cost mix of energy sources required to meet future demand. Distortions and constraints in the economy necessitate the use of shadow prices and economic second-best adjustments.

Social—basic needs
The social objective recognizes the basic right of all citizens to be supplied with certain minimum energy needs. Given the existence of significant numbers of poor consumers and also wide disparities of income, this implies subsidized prices, at least for low income consumers.

Financial viability
The government is concerned with financial objectives relating to the viability and autonomy of the energy sector. This implies pricing policies which permit institutions (typically, government-owned) in energy subsectors to earn a fair rate of return on assets and to self-finance an acceptable portion of the investments required to develop future energy resources.

Conservation
Energy conservation is also an objective of pricing policy. While prevention of unnecessary waste is important, there are often other reasons underlying the desire to conserve certain fuels. These include the desire for greater independence from foreign sources (eg oil imports), the need to reduce the consumption of woodfuel due to deforestation and erosion problems, etc.

Other
There are a number of additional objectives, such as the need for price stability to protect consumers from large price fluctuations, the need for simplicity in pricing structures to avoid public confusion and for simplicity of metering and billing, and so on.

Finally, there are other specific objectives such as promoting regional development (eg rural electrification) or specific sectors (eg export-oriented industries), as well as other socio-political, legal and environmental constraints.

Two stage pricing policy
The objectives mentioned above are often not mutually consistent, and so a realistic integrated energy pricing structure must be flexible enough to permit trade-offs among them. To achieve this, pricing policy formulation must be carried out in two stages. In the first stage, a set of prices which strictly meets the economic efficiency objective is deter-
The latter procedure is more ad hoc with adjustments being determined by the relative importance attached to each objective.

**Shadow pricing and economic efficiency**

Shadow pricing theory has been developed mainly for use in the cost-benefit analysis of projects. However, since investment decisions in the energy sector are closely related to the pricing of energy outputs, for consistency the same shadow pricing framework should be used in both instances.

Given perfect competition the interaction of atomistic profit maximizing producers and atomistic utility maximizing consumers yield market prices which reflect the correct economic opportunity costs, and thus scarce resources will be efficiently allocated. However, in the real world, a variety of distortions lead to market prices, which may diverge substantially from their shadow prices or true economic opportunity costs. Therefore, ‘efficiency’ shadow prices must be used in investment and output pricing decisions, to ensure proper allocation of resources (see Appendix 1). Moreover, if there are large income disparities, even these efficient shadow prices must be further adjusted, especially to achieve socially equitable energy pricing policies for serving poor households. To clarify the basic concepts involved in optimal energy pricing we have analysed a relatively simple model using a two step procedure (see Appendix 2).

**Adjustments to efficient energy prices**

Once efficient energy prices have been determined, the second stage of pricing to meet social, financial, political and other constraints, must be carried out.

**Social-lifelines prices**

Socio-political or equity arguments are often advanced in favour of subsidized prices or ‘lifeline’ rates for energy, especially where the costs of energy consumption are high relative to incomes of poor households. Economic reasoning based on externality effects may also be used to support subsidies, eg cheap kerosene to reduce excessive firewood use and prevent deforestation, erosion, etc. To prevent leakages and abuse of such subsidies, energy suppliers must act as discriminating monopolists. Targeting specific consumer classes (for example, poor households), and limiting the cheap price only to a minimum block of consumption is comparatively easy to achieve for metered forms of energy like gas or electricity. Other means of discrimination may also be required such as rationing, licensing, etc.

The income distribution arguments for a subsidized energy price are illustrated in Figure 1. This shows the respective demand curves for energy (CD and FG) of low \( (I_1) \) and average \( (I_2) \) income domestic users, the social tariff \( p_s \) over the minimum consumption block \( Q \) to \( Q_{\text{min}} \), and the efficient price level \( p_e \). All tariff levels are in domestic market prices. If the actual price \( p = p_s \), then the average household will be consuming at the ‘optimal’ level \( Q_2 \), but the poor household will not be able to afford the service.
If increased benefits accruing to the poor have a high social value, then the consumer surplus portion $CDE$ should be multiplied by an appropriate 'low income social weight' ($W>1$). Thus, although in nominal domestic prices the point $A$ lies below $p_e$, the weighted consumer surplus could be greater than the shadow price of supply. The adoption of the block tariff shown in Figure 1, consisting of the lifeline rate $p_s$, followed by the full tariff $p_e$, helps to capture the consumer surplus of the poor user, with minimum effect on the optimum consumption pattern of the average consumer.

In practice, the magnitude $Q_{\text{min}}$ has to be carefully determined, to avoid subsidizing relatively well-off consumers; it should be based on acceptable criteria for identifying 'low income' groups, and reasonable estimates of their basic energy needs (eg for poor electricity consumers, in most developing countries $Q_{\text{min}}$ would be less than 50 kWh per month, whereas the corresponding value in industrialized countries might be several hundred kWh). The level of $p_s$ relative to the efficient price may be determined on the basis of the poor consumer’s income level relative to some critical consumption level.

The financial requirements of the energy sector would also be considered in determining $p_s$ and $Q_{\text{min}}$. This approach may be reinforced by an appropriate supply policy (eg subsidized house connections for electricity, special supply points for kerosene, etc).

### Financial viability

The financial constraints most often encountered relate to meeting the revenue requirements of the sector; most often some target financial rate of return on assets, or an acceptable rate of contribution towards the future investment programme. Acceptable revenue levels have to be achieved by adjusting efficient prices.

Theoretically one can discriminate between the various consumer categories so that the greatest divergence from the marginal opportunity cost based price occurs for the consumer group with the lowest price elasticity of demand, and vice versa. This will result in the smallest deviations from the 'optimal' levels of consumption consistent with a strict efficiency pricing regime. In many countries the necessary data for the analysis of demand by consumer categories is rarely available, so rule-of-thumb methods of determining the appropriate tariff structure have to be adopted.

However, if an energy subsector exhibits increasing costs (eg marginal electricity costs greater than average costs), this constitutes a practical means of raising public revenues in a manner which is generally consistent with the economic efficiency objective, at least for the bulk of the consumers who are not subsidized, while at the same time helping to supply basic energy needs to low income groups. Similarly in the oil subsector, high prices for petrol, based on efficiency, externality and conservation arguments, may be used to cross-subsidize the 'poor-man's' fuel-kerosene, or diesel used for transport.

### Other considerations

There are additional considerations that may justify departing from a strictly efficient pricing policy. The decision to provide commercial energy such as kerosene or electricity in a remote rural area, which often entails subsidies because the beneficiaries are not able to pay the full price based on high unit costs, could be made on non-economic grounds, eg for...
general socio-political reasons such as maintaining a viable regional industrial or agricultural base, stemming rural to urban migration, or alleviating local political discontent. Similarly, uniform nationwide energy prices are a political necessity in many countries, although this policy often implies cross-subsidization eg urban consumers subsidizing those consumers in remote rural areas where distribution costs are higher. However, the full economic benefits of such a course of action may be much greater than the apparent efficiency costs which arise from any divergence between actual and efficient price levels. Again this possibility is likely to be much more significant in a developing country than in a developed one, not only because of the high cost of energy relative to incomes in the former, but also because the available administrative or fiscal machinery to redistribute incomes or achieve regional or industrial development objectives by other means is frequently ineffective.

The conservation objective (to reduce dependence on imported energy, improve the trade balance, and so on) usually runs counter to subsidy arguments. Therefore it may be necessary to restrict cheap energy to productive economic sectors which need to be protected and strengthened, while in the case of basic energy needs of households, the energy price could be sharply increased for consumption beyond appropriate minimum levels.\textsuperscript{19} In other cases conservation and subsidized energy prices may be consistent. For example, cheap kerosene might be required, especially in rural areas, to reduce excessive woodfuel consumption, thus preventing deforestation and erosion.

Finally, owing to the practical difficulties of metering, price discrimination, and billing, and the need to avoid confusing consumers, the pricing structure may have to be simplified, thus limiting the number of customer categories, consumption blocks, etc. Electricity and gas offer the greatest possibilities for structuring. The degree of sophistication of metering depends on the net benefits of metering, problems of installation and maintenance, and so on. However, for liquid fuels like kerosene, subsidized or discriminating pricing would usually require schemes involving rationing and coupons, and could lead to leakage and abuses.

**Energy conservation**

Using both price and non-price policy tools, demand management techniques help establish economically efficient or optimal patterns and levels of energy consumption. This may involve reducing the consumption of some forms of energy and increasing the use of others that are cheaper or more suitable. Energy conservation is an important element of demand management and involves measures that specifically seek a deliberate reduction in the use of energy below some level that would otherwise prevail. Such reduction involves elimination of outright waste, reduction of energy using activity, substitution of one form of energy for another, or substitution of other productive factors like capital and labour for energy.

**Conservation economics**

Some conservation is achieved simply by reducing or eliminating certain energy-using activities. Forgoing Sunday pleasure driving, using lower thermostat settings and shutting off appliances and lighting fixtures when not directly needed are typical examples. Other conservation measures may require the substitution by either capital or labour. Examples are...
re-using heat in industrial processing, the energy-saving reductions in the weight of vehicles by better engineering or lighter materials, or the use of improved insulation.

The substitution of some form of costly, or scarce energy resource by some other that is more readily available is an important conservation measure. Examples are the use of coal instead of fuel oil in heat processes, the use of natural gas instead of petroleum products for power plants where gas is plentiful compared to oil, or the use of gasohol instead of petrol for transport. In a physical sense, (as measured by Btu consumed) such substitution may not 'save' energy. In an economic sense, however, such substitution may be quite sensible, given the economic scarcity values of the alternative fuels.

The pursuit of energy conservation as a goal raises the issue of up to what point the reduction of energy consumption is socially beneficial or desirable. Common sense indicates that 'wasteful' energy use should be discouraged, but there is a limit beyond which conservation becomes too costly in terms of foregoing other resources or useful outputs, thereby causing more harm than good. The principle objective of a given policy should be the maximization of the welfare of a society over time.20

Economic criterion

In simple terms, the adoption of a given conservation measure is economically justified if \( \Delta B > \Delta C_1 + \Delta C_2 \), where \( \Delta B \), \( \Delta C_1 \), and \( \Delta C_2 \) are the economic values of marginal energy saving benefits, marginal additional input costs and marginal reductions in consumption benefits respectively.

This condition should be achieved over the life expectancy of the activity,21 implying use of expected lifetime costs, not just presently prevailing cost relationships. For example, if energy costs are expected to increase relative to other input costs or the value of output over time, greater substitution by non-energy inputs (ie higher levels of energy conservation) is called for. If we introduce the time element the conservation criterion becomes:

\[
\sum_{t=1}^{n} b_t \left( \frac{1}{1+r} \right)^t > \sum_{t=1}^{n} (c_{1,t} + c_{2,t}) \left( \frac{1}{1+r} \right)^t
\]

where \( b_t \), \( c_{1,t} \), and \( c_{2,t} \) are the respective annual energy savings, additional input costs and losses in consumption benefits in year \( t \) and \( r \) is the discount rate, all defined in terms of appropriate shadow prices.

Application of the criterion

Let us consider a particular end use for energy such as home lighting, and assume there is a choice of two distinct types of light bulbs, incandescent and fluorescent. For simplicity, we begin by assuming that both have the same economic cost, same lifetime, and provide light output of the same quality. If the fluorescent bulb uses less electrical energy than the incandescent one, then replacing the latter by the former is a conservation measure that results in an unambiguous improvement in economic as well as technical efficiency. In this case, using fluorescent bulb instead of incandescent lamps reduces the economic resources expended to provide the desired output, ie lighting. Electrical energy has been conserved, with no change in other economic costs and benefits.

Next, assume that the fluorescent bulb is more costly to install. There is a trade-off between the higher capital cost of the fluorescent lamp and the
greater consumption of kWh by the incandescent bulb. The relevant data to determine whether substitution of incandescent by fluorescent bulbs is economically justified are summarized in Table 1. At this stage we distinguish between the economic value (or opportunity cost or shadow price, as discussed earlier) of a good or service, and its market price. The former is relevant to decision making from a national perspective and the latter is more appropriate from a consumer's viewpoint.

The national cost (based on economic values) of using the incandescent and fluorescent bulbs over their two year lifetimes are respectively:

\[
EC_I = 10.5 + 16 + 16/(1 + r) \\
EC_F = 32 + 4.4 + 4.4/(1 + r)
\]

Assuming an economic discount rate of \( r = 0.1 \), we find \( EC_I = 41.0 > EC_F = 40.4 \).

We have compared the energy cost saving of \((16 - 4.4) = 11.6\) dineros per year for two years against the increase in capital costs \((32 - 10.5) = 21.5\) dineros. We find that \((16 - 4.4) + (16 - 4.4)/(1 + r) > (32 - 10.5)\). Therefore using fluorescent lightbulbs, with their associated reduction in energy consumption, will improve economic as well as technical efficiency.

Note, however, that if we use \( r = 0.2 \), \( EC_I = 39.8 < EC_F = 40.1 \); and the conservation measure is no longer beneficial. This reduction in the relative value of conservation will always occur with increases in the discount rate, because increases in initial investment costs are traded off against the future cost-savings realized by conservation. This finding has important policy implications. Energy users who confront high opportunity costs of capital (eg those in many developing countries) will find costly capital-intensive energy conservation measures relatively less attractive than users who have access to low-cost sources of capital. This means that economically 'optimal' conservation measures may differ significantly among different countries.

**Market imperfections and private consumers**

So far the analysis has been based on the national viewpoint, using values for all inputs and outputs (including those for energy) reflecting economic opportunity or shadow costs. However, market prices may differ from shadow values because market imperfections, particularly in the pricing and availability of energy, abound in most countries.

To illustrate the effects of these divergences, let us return to the simple light-bulb example. The private costs (based on market prices) of using incandescent or fluorescent lighting respectively are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Incandescent bulb</th>
<th>Fluorescent bulb</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operation cost</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economic value</td>
<td>10.5</td>
<td>32</td>
</tr>
<tr>
<td>Market price</td>
<td>18</td>
<td>36</td>
</tr>
<tr>
<td><strong>Physical energy consumption</strong></td>
<td>40</td>
<td>11</td>
</tr>
<tr>
<td>Value of energy consumption</td>
<td>16</td>
<td>4.4</td>
</tr>
<tr>
<td>Economic value</td>
<td>16</td>
<td>4.4</td>
</tr>
<tr>
<td>Market price</td>
<td>12</td>
<td>3.3</td>
</tr>
</tbody>
</table>

22 As discussed earlier, the term economic value is used synonymously with opportunity costs or efficiency shadow prices, and these may differ from actual market prices.
23 Legal barriers, capital rationing or lack of credit facilities, inappropriate foreign exchange rates, price controls, externalities and many other factors interfere in the normal functioning of the energy market. Other complications arise from a lack of knowledge of available alternatives as well as future costs and prices, and the lock-in effects of long-lived facilities and equipment. All of these factors tend to distort rational choice patterns, with the result that private energy use and conservation patterns diverge substantially from those found to be optimal from a rational viewpoint (ie based on economic efficiency criteria).
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\[ PC_I = 18 + 12 + 12/(1 + r) \]
\[ PC_F = 36 + 3.3 + 3.3/(1 + r) \]

At a discount rate of \( r = 0.1 \) (e.g., the market interest rate based on private bank rates): \( PC_I = 40.9 < PC_F = 42.3 \). This means that a rational consumer would prefer to use incandescent light bulbs, because this is the cheaper option. At any higher discount rate the advantages of the incandescent system over the fluorescent one increases further. Thus, since market prices diverge from real economic costs, consumers would make economically inefficient energy-use decisions.

Developing country issues²⁴

In the commercial energy using sectors of developing countries, essentially the same demand management and conservation arguments apply, as for industrialized nations. However, particular policies and their implementation should be adapted in a country-specific manner.²⁵ Disseminating up-to-date information is a critical element in convincing consumers to follow desirable policies. Energy conservation in transport, which tends to be highly oil-intensive, implies changing from more to less energy consuming transport modes, increasing the technical efficiency of given modes of transport, and changing lifestyles, behaviour and patterns of urban dwelling. Similarly, energy consumption for lighting and space conditioning of buildings may be reduced by improving the conservation awareness and changing the behavioural characteristics of occupants, installing more efficient energy using equipment, and altering the architectural design practices and building materials used.

In the industrial sector, conservation efforts should focus on waste heat recovery and cogeneration, other retrofits and improvements in existing operations, major changes in manufacturing processes and production methods, and recycling and recovery of waste materials. Finally, in electric power supply, energy savings may be realized through increasing the efficiency of generation, reducing loss in transmission and distribution systems, and improving the patterns and efficiency of end use.

A recent estimate indicates²⁶ that by 1990, the developing countries can save over 4 million bbl/day oil equivalent or about 15% of total commercial energy consumption if effective conservation policies are adopted in the four key sectors outlined, although this will not be easy. Thus, inappropriate pricing of energy resources is not the only reason for inefficient energy conservation decisions. In many developing countries the lack of foreign exchange resources forces governments to maintain strict import controls. Thus, it is often impossible for large energy users to import new, more energy-efficient equipment to replace the existing, even though they are usually able to secure their share of high-cost imported fuel supplies to keep their existing fuel-inefficient equipment operating. In countries in which fuel prices are subsidized at the same time, there is little incentive for such equipment owners to press for appropriate changes in import policies.

Conservation issues unique to the developing countries arise in the case of households that depend on traditional fuel resources such as firewood, charcoal and dung. They often employ primitive cooking appliances like open fires that are highly inefficient, using only about 5% of the inherent heat energy of the fuel. Heavy population pressures, dwindling firewood

²⁴For more details see Munasinghe and Schramm, op cit, Ref 1.
²⁶World Bank, op cit, Ref 2.
resources resulting in sharply increased costs of fuelwood gathering as well as increased soil erosion, reduced availability of crop residues from new short-term, high yield crop varieties, all combine to make this one of the foremost and serious energy problems in the majority of developing countries.

The use of simple cooking stoves constructed of locally available materials at out-of-pocket costs barely exceeding $5 to $10 could improve energy efficiency by a factor of 4 to 5 in laboratory tests and perhaps by a factor of 2 or better in actual day-to-day household use.

**Price and non-price policy interactions and complications**

In addition to appropriate pricing there are a wide variety of direct and indirect policy measures that can be taken to bring about desirable levels of energy conservation. Among them are direct regulation of energy uses, regulation of the use of energy consuming equipment and appliances, mandatory standards, mandatory information requirements about energy consumption rates, taxes and subsidies, appropriate infrastructure investments for energy saving facilities (e.g., better roads, railroads, marine shipping facilities), education and propaganda, and others.

To analyse some of the effects of such conservation-oriented policies let us first return to the lightbulb example. As we have found, existing market prices have made it more attractive for users to opt for the incandescent lightbulb system. To resolve this difference between optimal economic and private market choices, the first option policy makers might consider could be to raise the market price of electricity from 0.3 dineros per kWh to its economic value of 0.4 dineros per kWh. We now have:

\[
P_{C_t} = 48.5 > P_{C_F} = 44.4
\]

and rational electricity consumers will make the correct decision in favour of fluorescent lighting. In addition, setting the electricity price equal to its marginal opportunity cost will also establish electricity consumption for non-lighting purposes at optimal levels.

Suppose that public resistance or other social pressures make it impossible to raise electricity prices. Let the economic value of an incandescent bulb be its cost of production or producer price, while the imposition of a government tax of 7.5 dineros determines the market price. Similarly, assume that an import duty of 4.0 dineros represents the difference in the CIF import cost (32 dineros) and the market price of fluorescent bulbs. Instead of raising electricity prices, an alternative policy option might be to raise the tax on incandescent lightbulbs to 9.5 dineros, making the market price 20 dineros. In this case, \( P_{C_t} = 42.9 > P_{C_F} = 42.3 \), which encourages the desirable consumer decision. Reducing the duty on fluorescent bulbs to 2 dineros and lowering the retail price to 34 dineros would also yield a favourable result, since now: \( P_{C_t} = 40.9 > P_{C_F} = 40.3 \).

Some combination of the tax increase and lowering of duty could also be used from a strictly economic viewpoint, and ignoring effects outside the lightbulb market, reducing the import duty would be preferable to raising the producer tax because the former action reduces the divergence between market price and economic opportunity cost of fluorescent bulbs whereas the latter has the opposite effect and increases the market distortion in the price of incandescent lightbulbs.

Next, assume that the tax on incandescent lightbulbs cannot be increased because the legislation affects a much larger class of related products. Similarly, suppose that the import duty on fluorescent bulbs
cannot be reduced because it would undercut the price of a high-cost local producer and drive him out of business. In this instance, some final options left to the energy policy maker might be to legislate that all incandescent light bulbs be replaced by fluorescent ones, or to give a direct cash subsidy to consumers who adopt the measure, or to mount a major public education and propaganda campaign to bring about the required change.

**Complications**

If the useful lifetimes of technological alternatives are different, then economic comparisons become somewhat more complicated. This would be the case in our earlier example if the lifetime of incandescent bulbs were to be only one year while that of fluorescent lamps might be three years. Two alternative approaches could be used to overcome this difficulty. In the first, the investment costs of each alternative would have to be annuitized over its lifetime at the appropriate discount rate and the associated energy consumption and other recurrent costs for one year would be added on. Then the total costs for each option would be compared. The second method would compare the full costs of each alternative over a much longer period, say 20 years, including the costs of periodic replacement of worn-out equipment. The two methods should give consistent results, assuming the same values are used for parameters such as the discount rate.

Another difficulty associated with changes in the benefits of consumption arises if either the quality of the end-product of energy use is different for the two alternatives. Consider a comparison of electric versus kerosene lamps for lighting. In addition to the differences in equipment and fuel costs, the cost-benefit assessment of the two options should also include a term to recognize that electricity is likely to provide lighting of a superior quality. While the quantification, in monetary terms, of this qualitative superiority will be difficult, one measure might be the willingness-to-pay of the consumers for the different forms of lighting, usually represented by the area under the relevant demand curve.

Specific conservation measures such as rationing have a quality effect that must be taken into account. For example, with the physical rationing of petrol, the cost, or welfare loss to the consumer due to the reduction in the miles he can travel in his car must be added to the cost of implementing the rationing scheme and then compared with the benefits of reduced petrol supply. Once again, the willingness-to-pay of petrol users would be the appropriate measure of the foregone consumption benefit. However in the long-run petrol consumption could also be reduced by the introduction of a more fuel efficient car engine without perhaps requiring a reduction in the miles travelled. This shows that a reduction in energy consumption does not always imply a reduction in consumption benefits. A major focus of the appropriateness of conservation policies should be the service derived from the energy use.

Finally, the costs and benefits associated with externalities should be included in the economic cost-benefit comparison of alternatives. For example, improvements in technical efficiency or fuel substitution measures may give rise to pollution, as in the case of conversions from oil burning to coal-fired electric power plants. These additional ‘external’ costs should be explicitly evaluated in the analysis.
Summary

As energy costs rise, more efficient planning and management of energy supply and demand is essential to meet multiple national objectives including the maintenance of economic growth and welfare, especially in the resource scarce developing countries. The policy tools available for managing energy demand and reducing wasteful use are pricing, physical controls, technical methods, and education and propaganda. Coordinated use of these instruments provides the best results. The policy analysis should be disaggregated as far as possible by energy source, type of consumption, etc.

Energy pricing policy is more effective in the medium and long-run, and is usually implemented in two stages. First, the strict efficiency costs of energy supply are estimated to satisfy the objective of efficient allocation of economic resources. Next, those strict efficiency costs are systematically adjusted to yield a realistic set of prices that also meet other pricing objectives such as meeting the basic needs of poor consumers by subsidizing energy, ensuring the financial viability of energy producing institutions, maintaining price stability, and so on.

Non-price policy measures such as direct controls are useful to deal with short-run crises, but are also more likely to disrupt the economy. A package of price and non-price policies may be used to implement energy conservation measures and eliminate wastage. An energy policy maker should carry out the following analysis to evaluate any given conservation measure before adopting and implementing it. First, using economic opportunity costs consistent with the national viewpoint, it should be established whether the benefits of such an action exceed the costs. If this is the case, then the same test should be repeated, using market prices relevant to the appropriate consumer group, to establish whether a rational consumer would adopt the conservation measure. If this is not the case, changes in energy prices, taxes or import duties on equipment, subsidies to consumers, legislation, and other policy options may have to be used to implement the conservation technique. In general, price changes that reduce the divergence between market prices and opportunity costs should be preferred. However, care should be exercised to ensure that these policy actions do not have adverse repercussions in other energy as well as non-energy markets.

Appendix 1

Relevant issues in shadow pricing

To derive a consistent set of economic opportunity costs or shadow prices for goods and services, a common yardstick or numeraire to measure value is necessary. A most appropriate numeraire in many instances is a unit of uncommitted public income at border prices. Essentially, this unit is the same as freely disposable foreign exchange available to the government, but expressed in terms of units of local currency converted at the official exchange rate. The discussion below is developed in relation to this particular yardstick of value. The border-priced numeraire is particularly relevant for the foreign exchange-scarce developing countries because it represents the set of opportunities available to a country to purchase goods and services on the international market.

Applying shadow prices

The estimation and use of shadow prices is facilitated by dividing economic resources into tradable and non-tradable items. The values of directly imported or exported goods and services are already known in border
prices, that is, their foreign exchange costs converted at the official exchange rate. Locally purchased items whose values are known only in terms of domestic market prices, however, must be converted to border prices, by multiplying the former prices by appropriate conversion factors (CF). Therefore, tradables and non-tradables are treated differently.

The most important tradable inputs used in the energy sector are capital goods and petroleum-based fuels. Some countries may have other fuels available, such as natural gas or coal deposits. If no clear-cut export market exists for these indigenous energy resources, then they cannot be treated like tradables. In addition, if there is no alternative domestic use for the fuels, an appropriate economic value is the MSC of production, that is, of extracting gas or coal plus a markup for the discounted value of future consumption foregone, or 'user cost'. If another high value use exists for this fuel, the opportunity cost of not using the resource in the alternative use should be considered the economic value of the fuel.

The most important non-tradable primary factor inputs are labour and land. Consider a typical case of unskilled labour in a labour surplus country — for example, rural workers employed for dam construction. The forgone output of workers used in the electric power sector is the dominant component of the efficiency shadow wage rate (ESWR). Complications arise because the original rural income earned may not reflect the marginal product of agricultural labour and, furthermore, for every new job created, more than one rural worker may give up former employment. Allowance must also be made for the seasonality of employment.

\[
\text{ESWR} = a.m. + c.u.
\]

where \(m\) and \(u\) are the forgone marginal output and overhead costs of labour in market prices, and \(a\) and \(c\) are corresponding conversion factors to convert these values into border prices. In most developing countries the labour conversion factor (LCF) or ratio of ESWR to the market wage rate ranges from 0.5 to 1 for unskilled labour, and is close to 1 for skilled workers.

The appropriate shadow value placed on land depends on its location. Usually, the market price of urban land is a good indicator of its economic value in domestic prices, and the application of an appropriate conversion factor, such as the SCF (see below), to this domestic price will yield the border-priced cost of urban land inputs. Rural land that can be used in agriculture may be valued at its opportunity cost, the net benefit of foregone agricultural output. The marginal cost of other rural land is usually assumed to be negligible, unless there is a specific reason to the contrary. Examples might be the flooding of virgin jungle because of a hydroelectric dam that would involve the loss of valuable timber, or spoilage of a recreational area that has commercial potential.

The shadow price of capital is usually reflected in the discount rate which is defined as the rate of decline in the value of the numerator over time. Although there has been much discussion concerning the choice of an appropriate discount rate, in practice the opportunity cost of capital (OCC) may be used in the pure efficiency price regime. The OCC is defined as the expected value of the annual stream of consumption (in border prices) net of replacement, which is yielded by the investment of one unit of public income at the margin. In the developing countries, usually 12% > OCC > 8%.

The standard conversion factor (SCF) may be used with non-tradables that are not important enough to merit individual attention or lack sufficient data. The SCF is equal to the official exchange rate (OER) divided by the more familiar shadow exchange rate (SER), appropriately defined. Converting domestic market priced values into border price equivalents by applying the SCF to the value, is conceptually the inverse of the traditional practice of multiplying foreign currency costs by the SER (instead of the OER), to convert to the domestic price equivalent. The standard conversion factor is usually less than unity in most Third World countries. It may be approximated by the ratio of the OER to the free trade exchange rate (FTER), when the country is moving toward a freer trade regime:

\[
\text{SCF} = \frac{\text{OER}}{\text{FTER}} = \frac{eX + nM}{e(1 - t_m) + nM(1 + t_m)}
\]

Where \(X = \text{fob value of exports}; M = \text{cif value of imports}; e = \text{elasticity of export supply}; n = \text{elasticity of import demand}; t_m = \text{average tax on exports (negative for subsidy)}; \) and \(t_m = \text{average tax rate on imports}.

Usually the estimation of shadow prices on a rigorous basis is a long and complex task. Therefore, the energy sector analyst is best advised to use whatever shadow prices have already been calculated. Alternatively, the analyst would estimate a few important items such as the standard conversion factor, opportunity cost of capital, and shadow wage rate. When the data are not precise enough, sensitivity studies may be made over a range of values of such key national parameters.

\[1\text{For a review of practical energy pricing rules, especially with respect to nonrenewable energy sources see Mohan Munasinghe, An integrated framework for energy pricing in developing countries, } \text{The Energy Journal, Vol 3, July 1980, pp 1–30.}\]

**Appendix 2**

**Modelling optimal energy prices**

First, the marginal opportunity cost (MOC) or shadow price of supply must be determined. Second, this value has to be further adjusted to compensate for demand side effects rising from distortions in the prices of other goods, including other energy substitutes. Suppose that the marginal opportunity cost of supply in a given energy
sub-sector is the curve $\text{MOC}(Q)$ shown in Figure A1.3. For a typical non-traded item like electricity, MOC which is generally upward sloping is calculated by first shadow pricing the inputs to the power sector and then estimating both the level and structure of marginal supply costs (MSC) based on a long-run system expansion programme. For tradable items like crude oil and for fuels which are substitutes for tradables at the margin, the international or border prices of the tradables (i.e. cif price of imports of fob price of exports, with adjustments for internal transport and handling costs) are appropriate indicators of MOC. For most Third World countries, such import or export MOC curves will generally be flat or perfectly elastic. Other fuels such as coal and natural gas could be treated either way depending on whether they are tradables or non-traded.

The MOC of non-renewable, non-traded energy sources will generally include a ‘user cost’ or economic rent component, in addition to the marginal costs of production. The economic value of traditional fuels are the most difficult to determine because in many cases there is no established market. However, as discussed later, they may be valued indirectly on the basis of the savings on alternative fuels such as kerosene, the opportunity costs of labour for gathering firewood, and/or the external costs of deforestation and erosion. Thus, for a non-traded form of energy, MOC is the opportunity cost of inputs used to produce it plus a user cost where relevant, while for a tradeable fuel or a substitute, MOC represents the marginal foreign exchange cost of imports or the marginal export earnings foregone. In each case, MOC measures the shadow priced economic value of alternative output foregone, because of increased consumption of a given form of energy. After identifying the correct supply curve, we next examine demand-side effects, especially second best corrections which capture interactions between different energy sub-sectors. This second step is just as important as the first one, and therefore it will be examined in some detail.

In Figure A1, the market priced demand curve for the form of energy under consideration is given by the curve $PD(Q)$, which is the willingness-to-pay (WTP) of consumers. Consider a small increment of consumption $\Delta Q$ at the market price level $p$. Since MOC is shadow priced, $PD$ must also be transformed into a shadow priced curve before comparing it with MOC. This is done by taking the increment of expenditure $p.\Delta Q$ and asking the question: ‘what is the shadow priced marginal cost of resources used up elsewhere in the economy if the amount $p.\Delta Q$ (in market prices) was devoted to alternative consumption (and/or investment)?’

Suppose that the shadow cost of this alternative pattern of expenditure is $b(p.\Delta Q)$, where $b$ is called a conversion factor (see Appendix 1). Then the transformed $PD$ curve which represents the shadow costs of alternative consumption forgone is given by $b. PD(Q)$; where in Figure A1, it is assumed that $b<1$. The optimal consumption level is $Q_{\text{opt}}$, where the MOC and $b. PD$ curves cross, or equivalently where a new pseudo-supply curve $\text{MOC}/b$, and the market demand curve $PD$ intersect. The optimal or efficient selling price to be charged to consumers (because they react only along the market demand curve $PD$, rather than the shadow priced curve $b. PD$) will be: $p_b = \text{MOC}/b$, at the actual market clearing point $B$. At this level of consumption, the shadow costs and benefits of marginal consumption are equal ie $\text{MOC} = b. PD$. Since $b$ depends on user specific consumption patterns, different values of the efficient price $p_b$ may be derived for various consumer categories, all based on the same value of MOC. We clarify the foregoing by considering several specific practical examples.

First, suppose that all the expenditure $(p.\Delta Q)$ is used to purchase a substitute fuel, i.e complete substitution. Then the conversion factor $b$ is the relative distortion or ratio of the shadow price to market price of this other fuel. Therefore $p_b = \text{MOC}/b$, represents a specific second-best adjustment to the MOC of the first fuel, to compensate for the fixed distortion in the price of the substitute fuel. Next, consider a less specific case in which the amount $(p.\Delta Q)$ is used to buy an average basket of goods. If the consumer is a residential one, $b$ would be the ratio of the shadow price to the market price of the household’s market basket (here, $b$ is also called the consumption conversion factor). The most general case would be when the consumer was unspecified, or detailed information on consumer categories was unavailable, so that $b$ would be the ratio of the official exchange rate $(OER)$ to the shadow exchange rate $(SER)$, also called the standard conversion factor $(SCF)$. This represents a global second-best correction for the divergence between market and shadow prices averaged throughout the economy.

From a practical viewpoint, an optimal pricing procedure which begins with MOC is easier to implement because supply costs are generally well defined (from technological-economic considerations), whereas data on the demand curve are relatively poor. The same model is modified in the next to establish socially equitable subsidization of prices for low income consumers.

$Q$ actually represents a disaggregated energy type, eg a particular oil product like petrol or electricity consumed during the peak period.

For a detailed discussion of the procedures used in the electric power subsector see Mohan Munasinghe, ‘Principles of modern electricity pricing’ Proceedings of the IEEE, Vol 69, March 1981, pp 932–48. In this sub-sector MSC is also called the long-run marginal cost (LRMC).

We note that the use of border prices does not require the assumption of free trade, but implies that the numerator or unit of value for shadow pricing is essentially uncommitted foreign exchange (but converted into local currency at the official exchange rate). For details see Lyn Squire and Herman Van der Tak, Economic Analysis of Projects, Johns Hopkins University Press, Baltimore, MD, USA, 1975.

A non-traded item is generally characterized by a domestic supply price that lies above the cif price of imports, but below the cif price of exports.

Figure A1. Efficient pricing with shadow prices.
Third World energy policies


For example, suppose the border price of imported diesel is 4 Pesos per litre (i.e. US$0.20 per litre, converted at the OER, of 20 Pesos per US$). Let the appropriate SER which reflects the average level of import duties and export subsidies be 25 Pesos per US$. Therefore $SCF = OER/SER = 0.8$, and the appropriate strictly efficient selling price of diesel: $Pe = 4/0.8 = 5$ Pesos per litre.

Note that with the foreign exchange numeraire, conversion of domestic price values into shadow price equivalents by application of the $SCF$ to the former, is conceptually the inverse of the traditional practice of multiplying foreign currency costs by the SER (instead of the OER) to convert to the domestic price equivalent.

For example, suppose the border price of imported kerosene. Suppose that the (subsidized) domestic market price of kerosene is set at 50% of its import (border) price, for socio-political reasons. Then $b = 2$, and the efficient selling price of electricity $Pe = MOC\_EL/2$ (ignoring differences in quality of the two fuels, capital costs of conversion equipment such as lightbulbs, kerosene lamps, partial substitution effects etc: a more refined analysis of substitution possibilities would have to incorporate these additional considerations). It would be misleading however to then use circular reasoning and attempt to justify the subsidized kerosene price on the basis of comparison with the newly calculated low price of electricity. We note that all these energy sector subsidies must be carefully targeted to avoid leakages and abuses.

Note that with the foreign exchange numeraire, conversion of domestic price values into shadow price equivalents by application of the $SCF$ to the former, is conceptually the inverse of the traditional practice of multiplying foreign currency costs by the SER (instead of the OER) to convert to the domestic price equivalent.


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