Pricing Gas for Local Consumption

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Introduction

1. In 1955 natural gas represented one percent of total energy consumption in the Western European countries. Over the next 25 years that figure grew to 16% even as the total energy consumed in those countries more than doubled. In the developing countries today, natural gas accounts for about 5% of the total commercial energy used. At the same time, their gas reserves (excluding the OPEC member countries) are about 100 times as large as current consumption. The technical feasibility of rapid gas development in the LDCs is clear.

2. In addition, the economics of gas look much better now than they did in the European countries in 1955. It has recently been estimated that the full cost of finding and supplying gas to the consumer averages around $2.00/MMBTU, compared with a delivered cost of oil of three times that amount. Thus for a developing country with indigenous gas resources and, as is often the case, large oil import bills, the ranking of gas development is high on the list of claims for scarce public investment funds.

3. The constraints to rapid gas development in the LDCs, therefore, are not based on supply potential or economics (as the situation was perceived for Europe in the mid-fifties). Rather, they are the complex and country-specific questions of evolving a gas policy framework -- in which producer and consumer prices play a central role -- that is conducive to rapid and equitable development. In this area, unfortunately, the major gas producing countries -- the U.S., the U.K., Canada -- do not provide very useful models. This paper and the following one by Mr. Palmer attempt to outline some alternative routes.

LDC Gas Utilization Patterns

4. As noted above, there is good reason to believe that a large number of developing countries stand on the threshold of major programs of gas development. The bulk of this development will be geared not to producing gas as an export product -- either directly or indirectly -- but rather to the replacement of other fuels and feedstocks used to meet domestic demands. As shown in Figure 1, the electric power sector will remain the single largest consumer, followed by industry. The amount of gas consumed as fuel by those two sectors -- about one-third of the total -- is expected to be about as large as the total gas exported as LNG. The "chemical" or feedstock uses of gas will comprise most of the remainder, and account for about 20% of the total.

5. In comparing these figures with those of developed countries, it is important to bear in mind that the value of gas to a developing country in a particular use may be quite different from what it would be in the same use to a highly industrialized country. For example, studies undertaken in several LDCs imply that the "net-back" value of gas used as fuel

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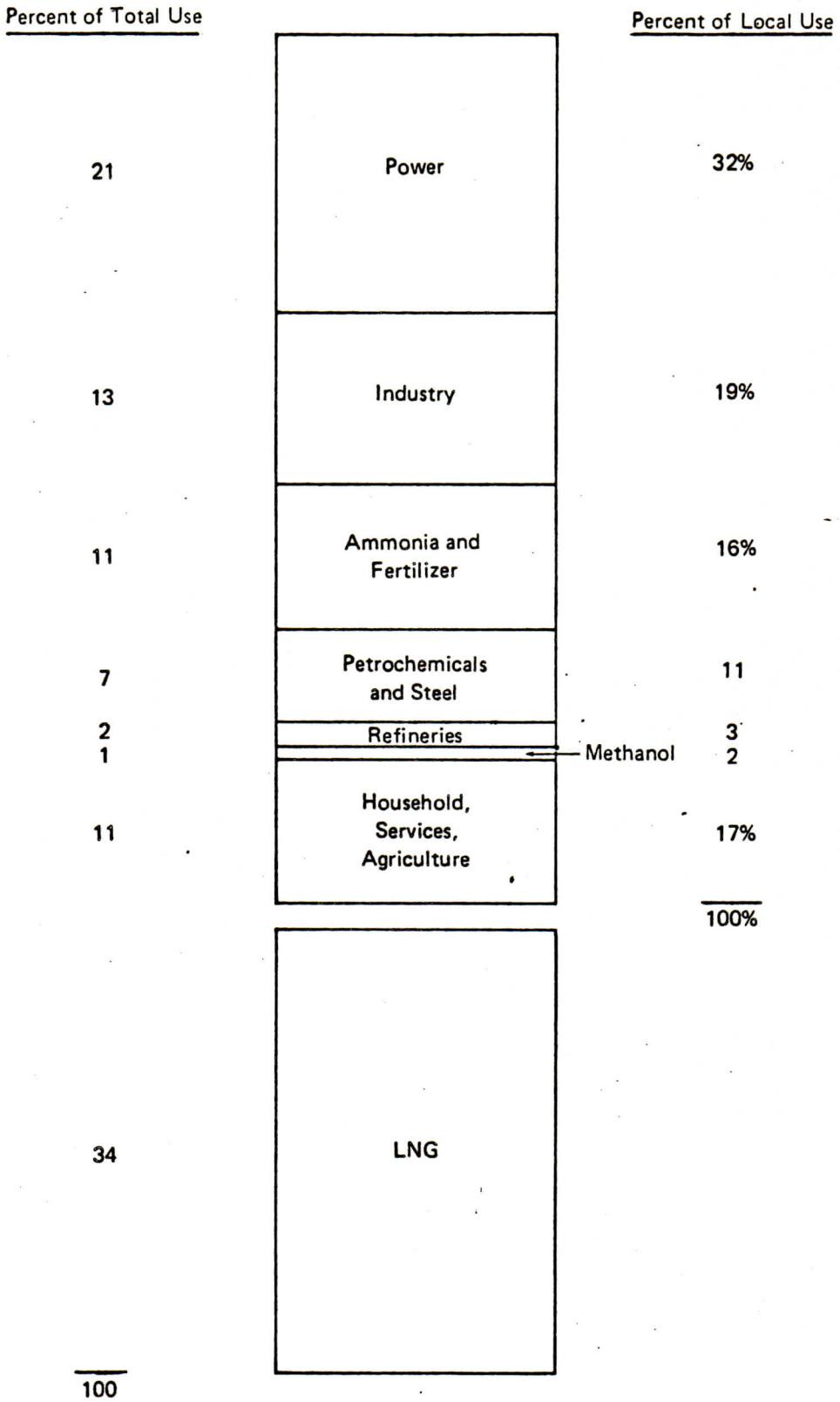
1/ Acting Economic Adviser, Energy Department, World Bank. The views expressed in this paper are those of the author and do not necessarily reflect the position of the World Bank.

FIGURE 1: PROJECTED DISTRIBUTION OF GAS UTILIZATION IN LDCs, 1990



in the power sector is frequently higher than that of gas used as a feedstock for ammonia/urea production. This results primarily because of three features of the respective power and fertilizer markets. First, the construction and/or conversion time required to generate power from gas is much less than that required to produce fertilizer. This means that present value (PV) comparisons of the two alternatives will show the benefits materializing sooner by using the gas for power generation. Second, the capital requirements for ammonia/urea plant construction are much larger per unit of gas consumed than they are for either gas turbine or combined cycle generating plant. In LDCs, where capital is usually at least as scarce as energy, the opportunity cost of capital is often quite high. The relatively greater capital-intensity of fertilizer production also means that returns are extremely sensitive to capacity utilization rates. A recent study by an authority on fertilizer production noted that under certain conditions, "the effect of operating at 70% rather than 90% (capacity utilization) is equivalent to having to pay an increased gas price of $2.00/MMBTU."[1/] The third reason that power often yields a higher return to gas than fertilizer in LDCs is that fertilizer is clearly a traded commodity, and its cost of production in the successful exporting countries has generally been based on very low gas input prices. This means that it is possible for many LDCs (depending on location and market size) to import urea at a price that already reflects low gas costs. The savings in ocean freight made possible by domestic production is often offset by higher site development costs in the LDCs. The increasingly competitive international market in fertilizer also introduces a large element of market risk in any LDC investment that is export-oriented. For power, on the other hand, the alternative to gas is not direct import but alternative inputs such as fuel oil, coal or hydro development. Many LDCs have already exploited their inexpensive hydro potential, and lack both indigenous coal resources and the port and railway infrastructure necessary to import coal. Thus the full value of gas as a fuel oil alternative is often realized in its use in the power sector.

6. The purpose of this discussion of gas valuation in power versus fertilizer is not to imply that the comparison will always favor power in LDCs, but merely to point out that the accepted theories regarding gas development in industrialized countries are not necessarily borne out by the studies that are now being undertaken in the developing countries. That observation is probably even more relevant in the area of gas pricing policies. The following section, therefore, begins with a few general principles before venturing into a more concrete example.

1/ William F. Sheldrick, "The Effect of Energy and Investment Costs on Total Fertilizer Production Costs," paper presented at ISMA Meeting, London, December 3, 1981, p. 6.

A Strategy for Gas Development in the LDCs

7. From the perspective of the developing country, the return expected from the large amount of capital required to embark upon a successful gas development program must compare favorably to the returns that could be expected from investing that capital in other large projects such as irrigation to improve agricultural productivity. In many cases, the latter sort of "more traditional" project is perceived to be less risky than setting out to create a new market for an untapped domestic resource. The appropriate strategy for gas development should have as its objective the maximization of net benefits to the country from the development and use of its exhaustible gas resources. The evaluation of those net benefits should incorporate techniques for measuring risks and rewarding flexibility.

8. Such an objective has three important dimensions, each of which implies certain pricing principles. First, there must be incentive to promote efficient use of the gas. Gas prices must be neither so high as to inhibit consumption (especially where the users must incur some cost to switch from other fuels), nor so low as to encourage wasteful use. Secondly, there must be adequate incentive to explore for and produce the gas. Particularly in cases where the government may be able to attract foreign capital to assist in gas development, the provision of an appropriate pricing and contractual framework is essential.[1/] Finally, the growth rates of both supply and demand for gas should be rapid and matched up to the level when full development has been reached. As discussed below, the basic principle that facilitates the achievement of all three objectives is that both consumer and producer prices should be set near the marginal opportunity cost of the gas with excess producers' or consumers' surplus captured through profit taxation. In practice, of course, this approach is complicated by uncertainties affecting reserve size and the growth rate of the market. Before taking up those concerns, however, we focus on the problem of determining the opportunity cost of gas under assumed conditions of known (or predictable) supply and demand.

The Determination of Opportunity Costs

9. The opportunity cost for gas, or any other commodity, can be thought of as the price that will equate demand and supply. If the good is internationally traded, then the relevant import supply and export demand functions must be included in the calculations.

10. An example of this situation is shown in Figure 2. If the good were not traded, its opportunity cost to the country would be P_{nt} and the appropriate quantity to produce would be Q_{nt}. Once there is an international market in the good, however, the relevant demand and supply

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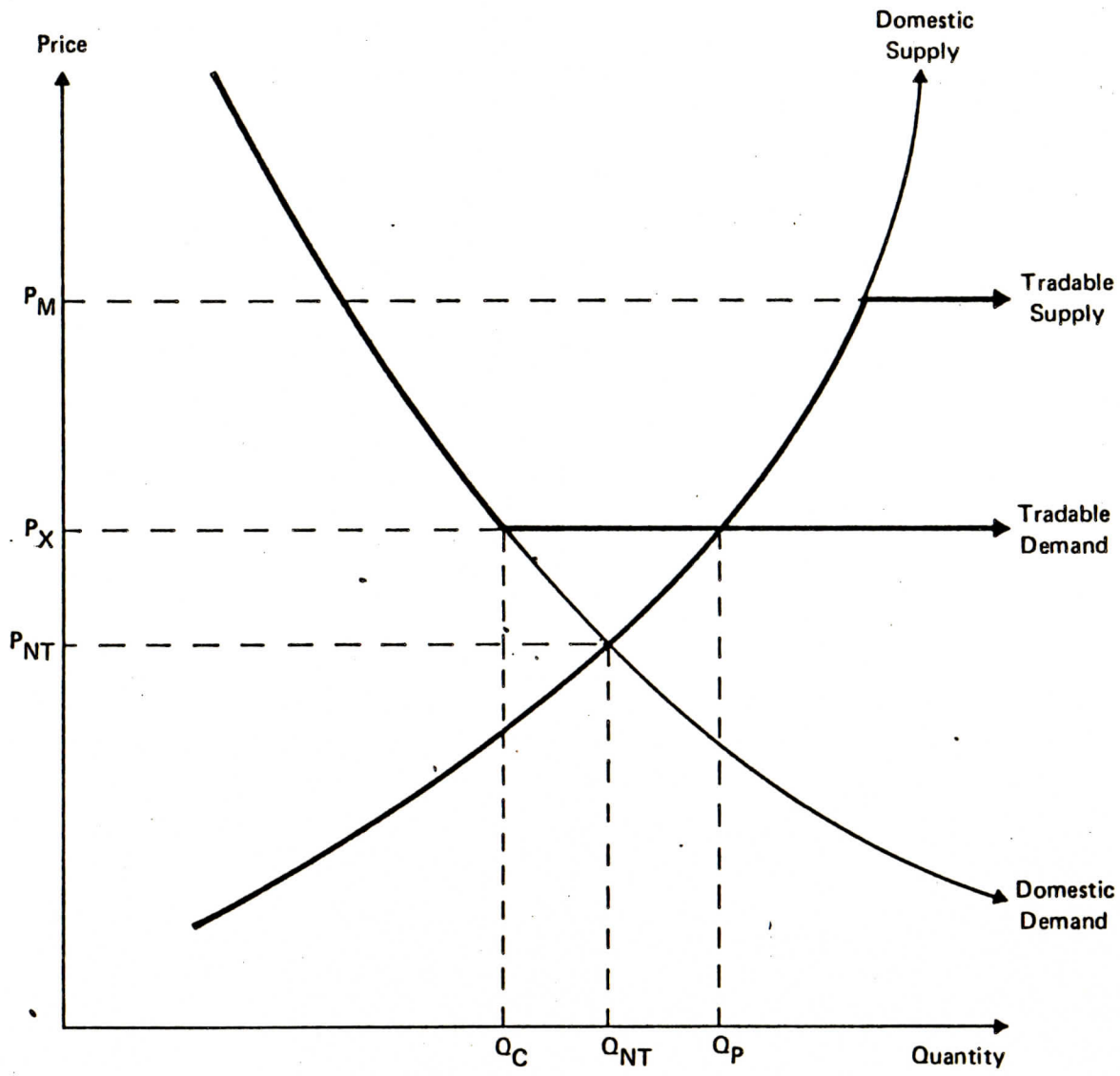
1/ This topic is taken up in the following paper by Mr. Palmer.

FIGURE 2: SUPPLY AND DEMAND FOR TRADED AND NON-TRADED GOODS



curves must take into account the import and export possibilities. If the good can be imported at a price P_m and exported at P_x (where the difference between P_m and P_x represents the freight, insurance and handling cost of trade), then the relevant demand and supply curves become the kinked ones labeled "Traded Supply" and "Traded Demand." Their intersection is at the price P_x where a quantity Q_p will be produced, Q_c will be consumed and the difference (Q_p - Q_c) will be exported. In this case, the availability of an international market means both that more should be produced and also that a higher price should be charged to domestic consumers than if there were no export market for the good. It is possible to demonstrate that the net gain to the country from producing and exporting the amount Q_p - Q_c is greater than the net loss to the country of producing and consuming only Q_{nt} at the lower price.

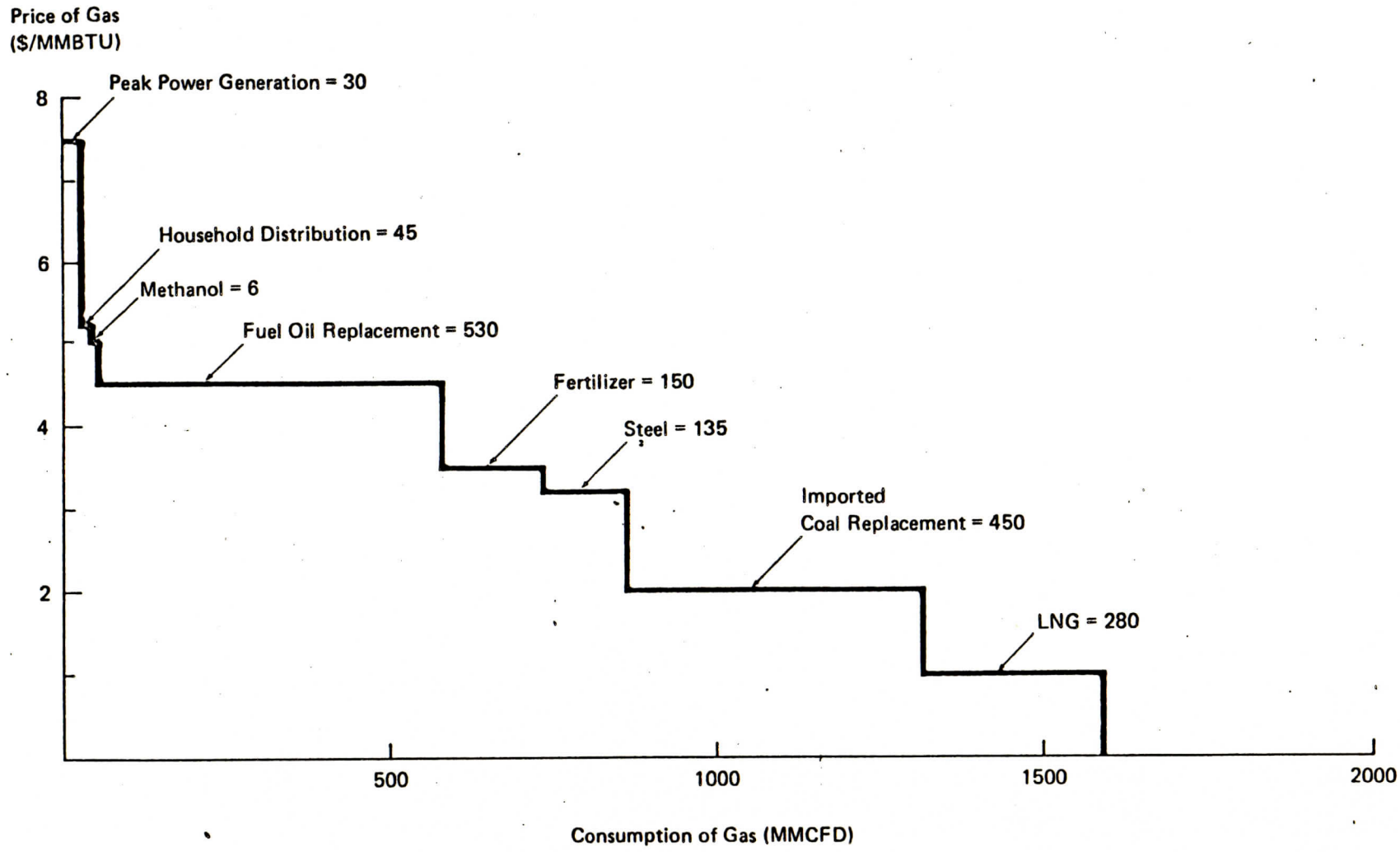
11. The main purpose of this quick review of international trade theory is simply to demonstrate the importance of the tradable/non-tradable distinction in determining opportunity costs. With gas, of course, one is generally not talking about a commodity that is directly traded by developing countries. However, the distinction is still relevant as long as the gas is used domestically to substitute for another commodity (such as fuel oil) that is tradable. Gas only becomes non-tradable, in the economic sense, when, at the margin, additional supplies that could be produced can no longer find any local markets where they would be replacing traded goods or used in the production of traded goods.

12. An example may help to clarify this point. Figure 3 shows a demand curve for gas that is derived from composite data from two studies on the net-back value of gas in various possible uses for a middle-income developing country. The length of each "step" represents the quantities of gas that could be consumed for that purpose in this country in 1990, as projected in gas marketing studies. The total height of each "step" represents the unit value of gas derived from export or import prices of the goods it is used to produce according to the formula below:

$$\text{Unit Gas Value} = \frac{\text{Sum of NPV of produciton costing gas input at zero}}{\text{Sum of PV of gas consumed}}$$

The numerator is the familiar calculation of the net present value (NPV) of the project (e.g., fertilizer, power, steel, etc.) that uses the gas over its lifetime where the cost of the gas input has been taken as zero. This will yield a total willingness-to-pay for the gas at the factory gate, which is another way to interpret the demand curve. The denominator of the fraction is perhaps a less familiar technique for deriving a unit gas value. The usual method is to divide the NPV savings due to gas by the (undiscounted) total quantity of gas consumed over the project life. This, however, <u>understates</u> the consumer willingness-to-pay because it does not take into account the time profile of the gas consumption. It

FIGURE 3: 1990 GAS DEMAND



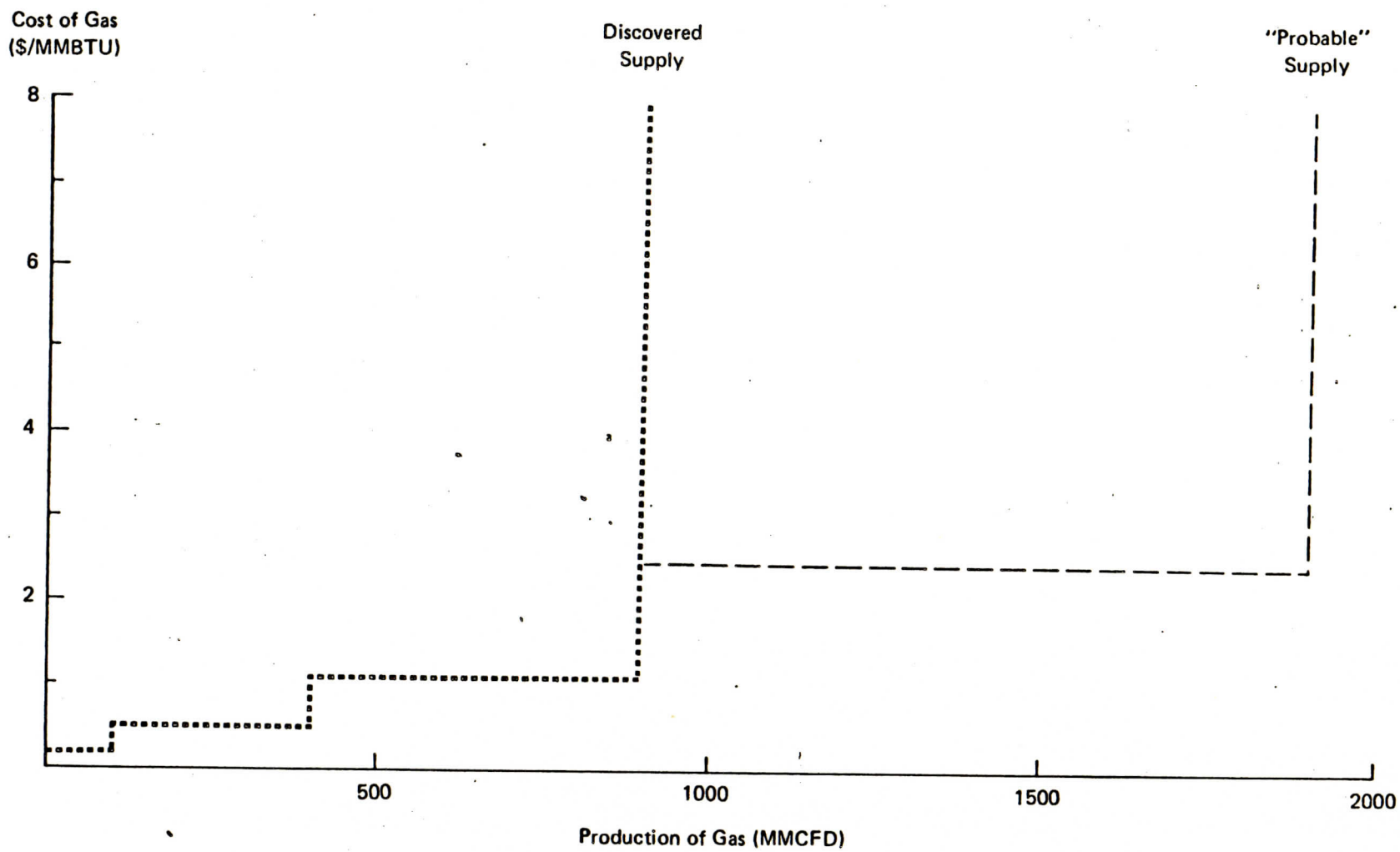
is possible to show that, if the social rate of time preference is equal to the opportunity cost of capital (as it would be on the equilibrium growth path of an economy), then the consumer willingness-to-pay for gas would be equal to the unit gas value as defined in the equation above.

13. For this particular country the highest value uses of gas are for peak power generation (where it essentially replaces diesel oil), domestic distribution (where it replaces LPG and kerosene) and methanol. The total amount of gas that can be consumed for those purposes, however, represents less than 5% of the potential market even excluding LNG. The fuel oil and coal that can be replaced in the power and industrial sectors clearly constitute the bulk of the market. Production of fertilizer and steel based on gas is sized to replace all imports of those commodities and generate a surplus for potential exports until around the year 2000 when domestic demands are projected to be large enough to absorb the full output. The LNG net-back value is based on a two million ton per year facility which was judged to be the maximum amount for which the country could reasonably expect to find a buyer. For these reasons, if we were to visualize how the curve in Figure 3 would shift over time, certain "steps" would grow longer (e.g., those based on domestic demand such as household distribution and fuel oil replacement) while others (e.g., fertilizer, LNG) would probably remain unchanged.

14. Turning now to the gas supply picture, Figure 4 illustrates a stepped cost function where the length of each step is an amount of sustained production that could be delivered for the incremental cost plotted on the vertical axis. The first (lowest) step in this function shows an amount of 100 MMCFD of on-shore, associated gas available at an incremental cost of $0.20/MMBTU. The second and third steps show production of non-associated gas from on-shore and off-shore fields, respectively, at progressively higher costs. The sum of these three steps gives the country's projected 1990 gas supply based on today's proven reserves. The dashed line, drawn as the fourth step, shows that the full cost of finding and producing an additional 1000 MMCFD from reserves presently classified as "probable" is estimated at $2.50/MMBTU.

15. The supply curve shown in Figure 4 is a simplified picture which abstracts from at least two important complications. First, it represents deliverable rather than potential supply, and therefore incorporates considerations of appropriate field depletion rates and possible infrastructure constraints. In actual practice, the steps of the curve would be less abrupt since it is usually possible to increase production somewhat through added compression or temporarily faster depletion. A second, and more important, qualification is that the costs shown in the curve do not include any component to represent the opportunity cost to the country

FIGURE 4: 1990 GAS SUPPLY



of consuming its finite gas resources now rather than in the future. Estimating, and accounting for, this "depletion premium" or user cost is a complex but critical task in countries where gas is likely to be in excess supply for a relatively short period.[1/]

16. Having discussed the derivation of both demand and supply curves, we are now in a position to superimpose the two in order to determine the opportunity cost of gas to this economy. Figure 5 shows the result. Based on potential production from proven reserves, 1990 gas availability would be sufficient to meet all of the uses down to and including steel production and about one-tenth of the coal substitution. This would indicate that the opportunity cost of gas would be derived from its value as a coal replacement, equivalent to about $2.00/MMBTU.

17. At that value, the "probable" reserves would not be developed since the cost of that gas would be higher than the equivalent cost of coal while all of the higher valued uses for gas were already being served. If we visualize these curves in 1995 or the year 2000, however, rightward shifts in the demand function would make it profitable to develop the "probable" reserves. In that case, the opportunity cost of gas would be equivalent to their development cost and no coal substitution would take place.

Constraints to Opportunity Cost Pricing

18. While the economic advantages of opportunity cost pricing are clear, and I have tried to demonstrate that it is not an impossible empirical task to derive such prices, it must be admitted that few gas-consuming countries follow this approach in setting their prices. There are at least two arguments against this approach, which are examined below.

19. First, pricing at the marginal opportunity cost means that some producers and some consumers will be reaping large benefits. In Figure 5, for example, if gas is priced at $2.00/MMBTU then the power utility and, to a lesser extent, the fertilizer producers will be in a position to make large profits. Whether they will actually be able to do so will depend on how competitive their respective industries are, and/or whether their output prices are regulated by government. Even in monopolistic industries, however, a profit tax is an efficient and practical device to return any large gains to the rest of the economy through the public sector.

20. A second objection to opportunity cost pricing in some countries is that the prices of competing fuels may be subsidized (or, more rarely, taxed) at levels which would encourage uneconomic fuel choices. For example, if fuel oil were subsidized and sold at a price equivalent to $1.50/MMBTU, then pricing gas at its opportunity cost of $2.00/MMBTU in

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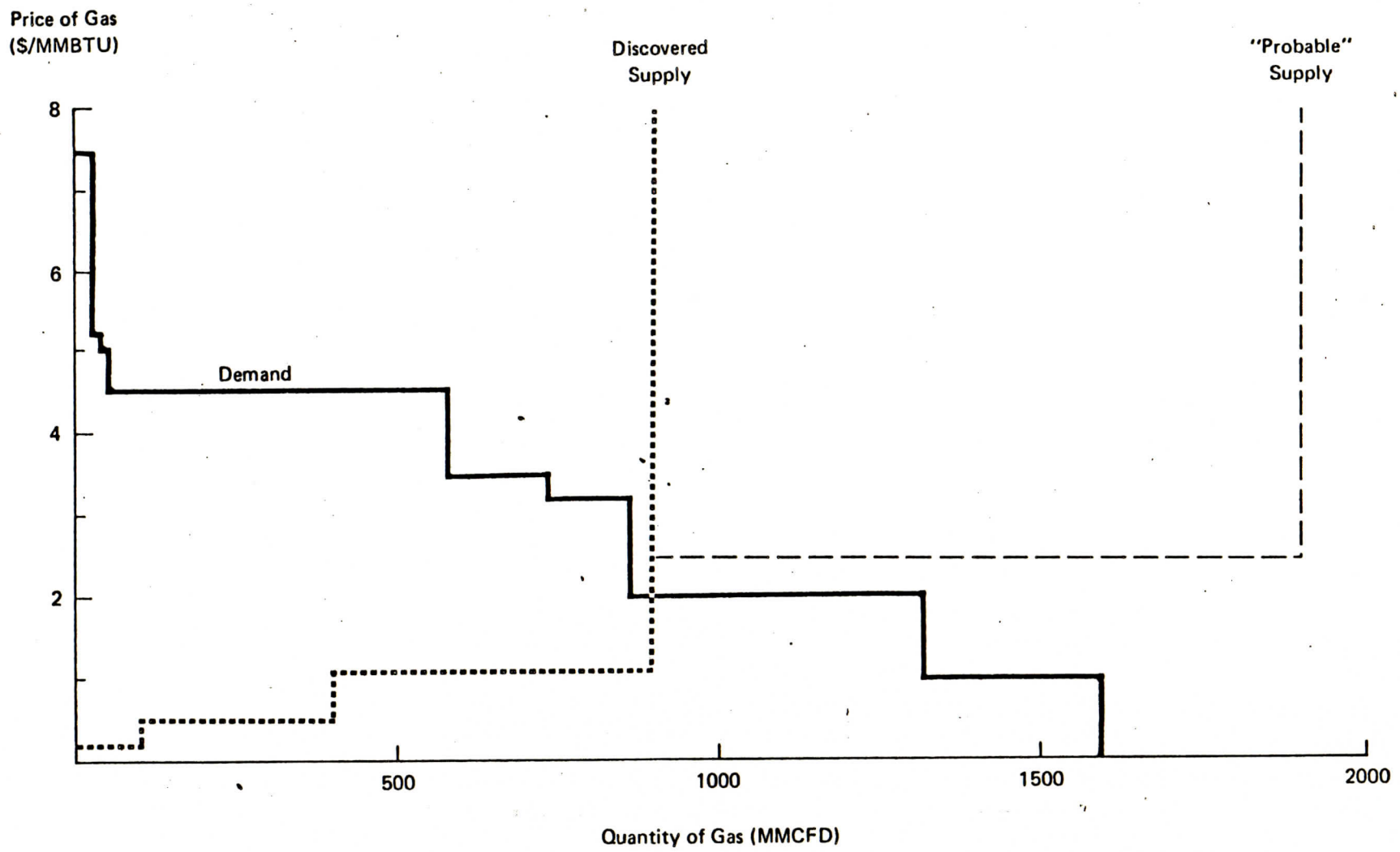
1/ Work that has been carried out in this area at the World Bank indicates that because of the high opportunity cost of capital in LDCs, the depletion premium at the beginning of a period of 10-15 years of supply surplus may still amount to 50-60% of the fuel oil equivalent price.

FIGURE 5: 1990 OPPORTUNITY COST OF GAS



the case shown in Figure 5 would discourage fuel oil users from shifting to gas. Clearly, the best solution to this problem would be to remove the fuel oil subsidy but, if that is not immediately possible, the government may consider de-linking the producer and consumer prices of gas in order to permit the consumer price to be competitive with that of fuel oil while retaining the producer's incentive to explore and produce gas.

Conclusion

21. In sum, the realization of the potential for gas development in the LDCs will depend critically on the institution of appropriate gas pricing policies. In this area the models from industrialized countries are not necessarily appropriate, both because the relative returns from gas use are likely to be different in the developing countries, and because the gas pricing policies of the major industrialized countries are more a function of their own historical structures than of the underlying economics of gas in today's energy environment. For these reasons, it is important to reopen the question of the appropriate principles for domestic gas pricing and to attempt to apply those principles in a practical way in countries where the gas market is about to blossom.

22. Our rather limited experience to date indicates that the actual derivation of the opportunity cost of gas varies widely across countries depending on their particular demand characteristics and supply endowments. This has two important implications for further work in this area. First, it means that it is important to apply a consistent economic methodology to pricing questions in developing countries rather than relying on the "accepted wisdom" of experience gained in the industrialized countries. And second, gas pricing recommendations for any particular country must be based on careful, empirical work that takes into account the physical and economic circumstances of that country.