PN-AAY-919
ISN 53747

ORNL-6391

ornl

OAK RIDGE
NATIONAL
LABORATORY

MARTIN MARIETTA

Energy Price Reform in Developing Countries: Issues and Options

Lawrence J. Hill

OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
NTIS price codes--Printed Copy: A06, Microfiche A01

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

ORNL-6391

Energy Division

ENERGY PRICE REFORM IN DEVELOPING COUNTRIES: ISSUES AND OPTIONS

Lawrence J. Hill

Energy and Economic Analysis Section

Date Published: August 1987

Prepared for

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
under Interagency Agreement No. DOE 1637-1637-A1

Prepared by
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
Operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under Contract No. DE-AC05-84OR21400

CONTENTS

LIST OF FIGURES iv

LIST OF TABLES iv

ABSTRACT v

EXECUTIVE SUMMARY S-1

1. INTRODUCTION 1-1

2. AN OVERVIEW OF PRICING ISSUES IN DEVELOPING COUNTRIES 2-1

2.1. Introduction 2-1
2.2. Statistical Overview: End-Use Consumption 2-2
2.3. Organizational Arrangements in the Commercial Energy Sector 2-11
2.3.1. The Electric Power Sector 2-11
2.3.2. The Petroleum Sector 2-15
2.4. Energy Pricing Problems 2-17

3. IMPLEMENTATION OF ENERGY PRICE REFORM 3-1

3.1. Introduction 3-1
3.2. Price Reform 3-2
3.3. Demand- and Supply-Side Management 3-9
3.3.1. Demand-Side Measures 3-10
3.3.2. Supply-Side Measures 3-14
3.4. Organizational Reform 3-17

4. CONCLUSION 4-1

REFERENCES R-1

APPENDIX A: CONCEPTUAL FOUNDATIONS OF ENERGY PRICING: A CANDIDATE SET OF TARGET PRICES A-1

A.1. Introduction A-1
A.2. Determination of Target Prices A-1

APPENDIX B: TECHNICAL ISSUES IN DETERMINING TARGET PRICES B-1

B.1. Introduction B-1
B.2. Computing Ramsey Prices B-1
B.3. Taxes and Subsidies B-8
B.4. Downstream Effects B-12
B.5. The Concept of Cost B-13

LIST OF FIGURES

Number	Title	Page
B.1	Demand and Cost Curves, Ramsey Pricing Example	B-3

LIST OF TABLES

Number	Title	Page
2.1	Total End-Use Energy Consumption, Amount and Percentage Composition of Noncommercial and Commercial, Select Developing Countries	2-3
2.2	Total End-Use Commercial Energy Consumption, Amount and Percentage Composition by Fuel Type, Select Developing Countries	2-7
2.3	Energy Pricing Problems, Electricity and Petroleum Products, Select Developing Countries	2-19
2.4	Ratio of Domestic to International Petroleum Prices, In Total and by Product Type, Select Developing Countries, 1973 and 1983	2-25
B.1	Calculation of Ramsey Prices, Net Revenue Constraint . . .	B-6
B.2	Calculation of Ramsey Prices, Tax Case	B-10
B.3	Calculation of Ramsey Prices, Subsidy Case	B-11

ABSTRACT

ENERGY PRICE REFORM IN DEVELOPING COUNTRIES: ISSUES AND OPTIONS

Lawrence J. Hill

This report discusses options for resolving energy pricing problems in developing countries. Based on (1) a review of the organizational arrangements and commercial energy pricing problems in 37 countries assisted by the U.S. Agency for International Development, (2) economic efficiency criteria, and (3) economic and sociopolitical realities in developing economies, a general program of commercial energy price reform was outlined.

Concisely, energy price reform in developing economies is more likely to occur if it takes shape as a balanced, politically realistic set of simultaneous and related actions. The key feature of a reform program is that, because of political considerations, downstream adjustment problems, and income distribution concerns, changes in energy prices to cost-based levels should be a gradual process. Additionally, the adverse effects of changing to cost-based commercial energy prices can be mitigated by implementing measures to (1) reduce the cost of supplying energy, (2) increase the efficiency of energy use, and (3) change organizational arrangements in the commercial energy sector.

EXECUTIVE SUMMARY

ENERGY PRICE REFORM IN DEVELOPING COUNTRIES: ISSUES AND OPTIONS

Lawrence J. Hill

One of the most significant energy problems in developing countries is that energy prices very seldom reflect the true cost of providing energy. In most cases, commercial energy prices in developing economies are not determined by market forces but are set by governments and administered through parastatal energy enterprises. These enterprises are typically expected both to subsidize an array of energy services and to maintain financial viability. In addition, the sale of energy--particularly petroleum products--is an important source of tax revenue in many developing countries.

Most development assistance agencies, including the U.S. Agency for International Development (AID), the International Monetary Fund, and the World Bank, have identified energy price reform as a high priority goal for assisted countries. Increasingly, progress with energy price reform is being considered as a condition for lending. Developing countries, on the other hand, tend to view energy pricing as an important policy tool for a variety of national objectives and, perhaps more important, tend to believe that energy price reform causes political instability. In other words, price increases can lead to protests, civil disorders, and even changes in government. As a result, any policy dialogue on energy price reform an unusually delicate process, in which progress with the dialogue depends as much on pragmatic issues of <u>how</u> to implement price reform as on <u>where</u> price reform should be headed.

This report presents a range of options for commercial energy price reform in developing countries, with policy dialogue in mind. Looking toward the implementation challenge, the options are cast in a broader framework of energy planning and economic reform. Three characteristics of the energy sector in developing countries suggest this approach: (1) constraints are placed on energy-supplying parastatals; (2) the differences between current energy prices and current costs are large in many instances; and (3) energy is an important component of development planning. Specifically, it is argued that energy price reform per se should be considered as only one of three related and simultaneous reforms in the energy sector of developing economies. The reforms include:

1. Price reform.
2. Demand- and supply-side management.
3. Organizational reform.

Each component is discussed in turn.

First, with regard to commercial energy price reform, it is usually ill-advised to change prices to cost-based levels instantaneously. Both the political infeasibility of such a move and the potentially severe downstream economic adjustments induced by the change suggest that price reform should ordinarily be a gradual process. Therefore, the following components of energy price reform are proposed:

1. Determination of an optimal set of target prices.
2. Determination of a time frame for adjustment.
3. Determination of an index for adjusting prices over time.

4. Periodic evaluation and adjustment of target prices as conditions change.

The recommended approach for calculating an optimal set of target prices incorporates the constraints placed on energy institutions in developing economies. One of the primary constraints is the requirement that parastatals maintain financial solvency. The maintenance of solvency becomes increasingly urgent in a world characterized by decreasing availability of credit for replacement or expansion of the energy supply system. Another important constraint in many developing countries is the requirement that, as a matter of policy, some energy products be subsidized for income distribution, energy substitution, or energy promotional purposes.

An approach that lends itself well to determining target prices under these constraints is break-even pricing. Under this approach, target prices are calculated on the basis of generating a prespecified amount of net revenues to cover the fixed costs of the firm and any additional amount necessary for improvement, replacement, or expansion of plant and equipment on the system. If, as a matter of policy, an energy service is to be taxed or subsidized, the break-even approach can consistently incorporate those taxes or subsidies in the determination of target prices.

After a target set of prices is computed, the time period over which current prices will be adjusted to target levels must be determined. Important considerations under this component of price reform include the difference between current and target prices and potential downstream adjustment problems induced by adjusting energy prices. The

rate of inflation in the general economy is a good candidate to serve as the reference point for setting the index to adjust prices from current to target levels. Depending on the period of time over which prices are to be adjusted, a predetermined percentage in excess of the inflation rate can serve as the index.

The computation of target prices necessarily involves determining the marginal cost of providing energy by class of service. Normally, the applicable cost is the financial cost experienced by the utility, but in many developing countries this is not the least possible cost of providing energy. In a broader energy planning context, a price reform could be undertaken in conjunction with additional measures to reduce the cost of providing energy and, therefore, its target price. Improved maintenance procedures and more efficient load dispatch, for example, can lower the target, cost-based prices in the electricity sector. Similarly, the impact of adjusting to cost-based energy prices could be mitigated through demand-side conservation measures. If the efficiency of the consumer's use of energy--especially in the transportation, commercial, and industrial sectors--could be improved, then the adverse impact of phasing in cost-based energy prices could be mitigated.

The final component of the energy planning process associated with pricing reform is organizational reform in the energy sector. In many developing economies, centralized control of the energy sector is a serious obstacle to attaining pricing efficiency. It may be beneficial in many cases to decentralize and/or privatize portions of the energy sector. Three possibilities for organizational changes are examples of such reforms.

First, in the electricity sector, many parastatals serve both densely populated urban grids and remote rural areas. The rural areas are typically characterized by higher-cost supply sources such as small-scale diesel units. In many instances, the price of electricity in rural areas does not reflect its higher supply cost because of government policy promoting electricity use in rural areas. This practice places a severe strain on the financial resources of the parastatal. As part of the energy price reform effort, it may be beneficial in some cases to consider removing the financial and managerial responsibility for rural grids from the electric power parastatals, thereby relieving an important financial strain on the parastatals and opening up opportunities for decentralized and/or private sector initiatives to provide power in rural areas.

Second, and related to the first, the efficiency of the electric power sector in many countries can be improved by eliminating the monopoly held by state-owned utilities in producing electricity. Presently, a parastatal typically has the sole legal authority to produce, transmit, and distribute electricity for central grids in developing countries. It would be economically beneficial in many instances to allow private sector participation in the power production phase, using pre-negotiated buy-back arrangements as the basis for that participation.

Third, in the petroleum sector of many developing economies, it may be beneficial to move toward deregulation of the retail prices of petroleum products. Typically, wholesale sales of petroleum products are controlled by parastatals. However, the distribution and marketing functions are accomplished by multinational oil companies with varying

degrees of participation by host governments. In many cases, it may be possible to enhance pricing efficiency by allowing market forces (in place of government-imposed retail prices) to determine retail product prices.

1. INTRODUCTION

The purpose of this report is to discuss an array of options for commercial energy price reform in developing countries. Current energy pricing problems in developing economies are generally the manifestation of the precipitous increase in international petroleum prices in the 1970s. Both the importance of low energy prices for development and the socio-political problems associated with allowing domestic energy prices to rise rapidly to international levels led many national governments in developing economies to shield their domestic economies from the effects of price increases.

Emphasis on domestic policy concerns at the expense of strict economic criteria in setting energy prices has led to serious problems in many developing economies. Two are especially prominent. First, because of the reluctance of national governments to allow domestic energy price levels to rise to international levels, many state-owned energy institutions are in financial trouble. Second, reluctance to set cost-based prices together with the use of energy prices to promote social goals has often led to a system of relative prices which does not reflect the relative costs of providing energy. This has resulted in improper investment signals and a concomitant misallocation of resources in many developing economies.

The remainder of this report addresses options for correcting energy pricing problems in developing economies. The next chapter provides a background for the discussion by addressing the nature and extent of energy pricing problems in developing countries. Organizational ar-

rangements in the commercial energy sector and current pricing problems in 37 AID-supported countries are summarized.

Chapter 3 suggests a general program to implement commercial energy price reform. It is argued that energy price reform per se should be considered as one of three related and simultaneous reforms in the energy sector of developing economies. The other two are demand- and supply-side management and organizational reform. It is further argued that it is usually ill-advised to change energy prices to cost-based levels instantaneously because of political considerations and potentially severe downstream economic adjustment problems. Energy price reform should be a gradual process in most cases. A program to adjust current prices to cost-based levels should include (1) determination of a set of target prices; (2) determination of the length of time over which current prices will be adjusted to target levels; (3) determination of an index for adjusting prices over time; and (4) periodic evaluation and adjustment of target prices as conditions change. Some concluding comments are presented in Chapter 4.

Determination of target prices is the subject matter of Appendices A and B. In Appendix A, it is shown that an approach that lends itself well to determining target energy prices under the constraints placed on energy-supplying parastatals is break-even analysis or Ramsey pricing. Under this approach, prices are calculated on the basis of generating a prespecified amount of net revenue to cover the fixed costs of the firm and any additional amount necessary for replacement or expansion of the energy supply system. If, as a matter of policy, an energy service is to be taxed or subsidized, the break-even approach can consistently in-

corporate the taxes or subsidies in the determination of prices. Three pieces of information are required for calculating Ramsey prices: (1) the marginal cost of serving various customer classes; (2) the nature of demand by customer class; and (3) the net revenue requirements of the parastatal.

In Appendix B, technical issues associated with Ramsey pricing are discussed. The chapter includes examples of calculating Ramsey prices and a discussion of both the downstream effects of changing energy prices and the concept of cost used in calculating target prices.

2. AN OVERVIEW OF PRICING ISSUES IN DEVELOPING COUNTRIES

2.1. INTRODUCTION

The purpose of this chapter is to provide an overview of commercial energy pricing in countries assisted by the U. S. Agency for International Development (AID). The issues discussed in this chapter will serve as the foundation for both energy pricing recommendations and a price reform implementation approach which will be discussed at length in subsequent chapters.

Unfortunately, there is no comprehensive source of information on commercial energy pricing in the approximately 70 AID-supported countries. However, comprehensive studies of the energy sectors of more than 40 developing countries have been undertaken by the World Bank in concert with the United Nations Development Program (UNDP).[1] Of that number, 37 are countries assisted by AID. Those 37 studies are the basis of this overview. However, they will be supplemented by other studies of energy subsectors in developing economies where appropriate.

Because the World Bank studies were conducted over a period of six years, some of the information contained in them may be outdated. End-use energy consumption data, for example, date from as far back as 1979. More importantly, approaches to energy pricing and organizational arrangements in the energy sector may have changed as a result of either the UNDP/World Bank recommendations or other external influences. For example, recent declines in the world price of petroleum may have ameliorated some of the pricing problems in the 37 countries since the

[1]The UNDP/World Bank studies were initiated in 1980 and are ongoing at the present time.

UNDP/World Bank studies were completed. This overview does not speculate on changes that may have occurred in the energy sector of the 37 countries since completion of the studies.

There are two problems in presenting an overview of this type. First, each developing economy has a unique set of institutions in the energy sector. It would be instructive to analyze each country in detail and draw conclusions for the specific set of circumstances in each economy. The goal here, however, is less ambitious; it is to summarize general pricing problems in the energy sector of developing economies, based on rather general secondary sources. Second, not all the UNDP/World Bank studies contain the same emphases. Certain topics are discussed in detail in some studies but not in others. It is not possible, therefore, to provide a comparative assessment of all pricing issues across all countries.

The remainder of the chapter is divided into three sections. The next section provides a statistical comparison of end-use energy consumption for the 37 countries included in the overview. The remaining two sections address organizational arrangements in the energy sector and energy pricing problems, respectively. Because petroleum and electricity consumption dominate commercial energy consumption in most developing economies, the emphasis in the last two sections will be placed on those two energy subsectors.

2.2. STATISTICAL OVERVIEW: END-USE CONSUMPTION

Table 2.1 provides a summary of total end-use energy consumption for 37 AID-assisted countries, divided between commercial and noncommer-

Table 2.1
Total End-Use Energy Consumption
Amount and Percentage Composition of Noncommercial and Commercial
Select Developing Countries

(Amounts in Thousands of Tonnes of Oil Equivalent)

Country (Year)	Noncommercial		Commercial		Total	
	Amount	%	Amount	%	Amount	%
Bangladesh (1979/1980	NA		2,207.0		NA	
Bolivia (1981)	891.0	41.5	1,254.0	58.5	2,145.0	100.0
Botswana (1982)	350.0	48.3	374.6	51.7	724.6	100.0
Burma (1982/1983)	7,137.0	85.8	1,181.7	14.2	8,318.7	100.0
Burundi (1980)	NA		46.4		NA	
Cape Verde (1982)	49.0	61.3	30.9	38.7	79.9	100.0
Costa Rica (1981)	569.2	39.7	863.9	60.3	1,433.1	100.0
Ecuador (1984)	1,002.0	22.2	3,512.0	77.8	4,514.0	100.0
Ethiopia (1982)	7,431.6	92.7	584.1	7.3	8,015.7	100.0
Fiji (1982)	316.4	56.9	239.6	43.1	556.0	100.0
Gambia (1982)	126.6	72.9	47.1	27.1	173.7	100.0
Guinea-Bissau (1983)	161.6	91.1	15.7	8.9	177.3	100.0
Haiti (1979)	936.7	80.8	223.0	19.2	1,159.7	100.0
Indonesia (1979/1980)	NA		22,049.4		NA	
Jamaica (1983)	117.5	7.1	1,534.3	92.9	1,651.8	100.0
Kenya (1979)	NA		1,419.0		NA	
Lesotho (1981)	NA		133.0		NA	
Liberia (1983)	630.1	68.7	287.2	31.3	917.3	100.0
Malawi (1980)	3,112.4	93.7	208.1	6.3	3,320.5	100.0
Mauritania (1983)	152.6	52.9	135.9	47.1	288.5	100.0

Table 2.1 (Continued)

Country (Year)	Noncommercial		Commercial		Total	
	Amount	%	Amount	%	Amount	%
Morocco (1981)	2,362.0	35.8	4,240.0	64.2	6,602.0	100.0
Nepal (1980/1981)	2,806.0	94.3	169.2	5.7	2,975.2	100.0
Niger (1981)	827.1	85.8	137.1	14.2	964.2	100.0
Paraguay (1982)	1,090.0	71.9	426.0	28.1	1,516.0	100.0
Peru (1981)	3,155.0	28.1	8,086.0	71.9	11,241.0	100.0
Portugal (1982)	860.0	9.6	8,134.0	90.4	8,994.0	100.0
Rwanda (1979)	946.0	93.9	61.6	6.1	1,007.6	100.0
Senegal (1981)	1,081.0	64.4	597.9	35.6	1,678.9	100.0
Sri Lanka (1980)	2,040.0	62.8	1,210.3	37.2	3,250.3	100.0
Sudan (1981)	5,055.0	82.2	1,093.0	17.8	6,148.0	100.0
Tanzania (1981)	8,300.0	92.0	725.0	8.0	9,025.0	100.0
Thailand (1983)	6,440.9	37.4	10,797.3	62.6	17,238.2	100.0
Togo (1982)	559.4	70.5	234.0	29.5	793.4	100.0
Uganda (1980)	4,222.0	94.7	234.0	5.3	4,456.0	100.0
Yemen (1982)	1,350.0	61.8	834.5	38.2	2,184.5	100.0
Zambia (1980/1981)	2,032.0	45.2	2,460.0	54.8	4,492.0	100.0
Zimbabwe (1980)	1,645.0	29.9	3,855.0	70.1	5,500.0	100.0

SOURCE: UNDP/World Bank Energy Assessments

NA-Not Available

cial energy types. The sources of information for Table 2.1 are the energy balances provided in each of the UNDP/World Bank energy sector studies. The dates in parentheses following the names of the countries are the years for which the energy balances were computed. While the information provided in Table 2.1 is somewhat outdated, it was felt that this source of information was generally more accurate and detailed than more current data on energy consumption provided in published data bases.

The classification of commercial and noncommercial end-use energy consumption in Table 2.1 is somewhat arbitrary, relying not on technical definitions of commerce but on definitions used in current practice.[2] Noncommercial energy includes wood-based fuels (firewood and charcoal), animal wastes, and various other types of biomass-based fuels (bagasse, for example), even if they are traded in formal markets. Commercial energy includes natural gas, coal (including coke and lignite), electricity, and petroleum products.

Table 2.1 suggests that the emphasis of this report--pricing practices in the commercial energy sector--addresses what is sometimes only a minor portion of total energy consumption. Commercial energy consumption accounted for more than 50 percent of total end-use consumption in only 11 of the 32 countries for which data were available (Bolivia, Botswana, Costa Rica, Ecuador, Jamaica, Morocco, Peru, Portugal, Thailand, Zambia, and Zimbabwe).[3] The percentage of total consumption ac-

---

[2]Another classification commonly used instead of noncommercial and commercial is traditional and nontraditional energy.

[3]As noted at the bottom of the table, data for noncommercial energy consumption were not available for five countries.

counted for by commercial energy was less than 10 percent in seven of the 32 countries (Ethiopia, Guinea-Bissau, Malawi, Nepal, Rwanda, Tanzania, and Uganda). At the extreme, commercial energy accounted for only 5.3 percent of Uganda's total end-use energy consumption in 1980.

Although the emphasis of this report on commercial energy is rather modest in terms of total end-use energy consumption, it is important for two reasons. First, commercial energy accounts for a large share of energy consumption for which governments actively participate in price-setting. In most cases, prices of commercial energy products in developing economies are not market-determined, but are set (or at least approved) by governments. On the other hand, prices of noncommercial energy products are typically determined in markets.[4] Second, the use of commercial energy is a major source of the foreign exchange problems that many developing economies are experiencing. This is attributable to reliance on imported, petroleum-based fuels. Although world petroleum prices have recently declined, the foreign exchange problems resulting from the two oil price shocks of the 1970s have lingered.

Table 2.2 disaggregates the commercial energy component of Table 2.1 by energy source. The table shows that petroleum and electricity dominate the commercial energy sector of the 37 countries. Petroleum consumption accounted for less than 50 percent of end-use commercial energy consumption in only four countries (Botswana, Lesotho, Zambia and Zimbabwe). In those countries, the use of coal was significant. On the

---

[4]This does not imply that there are no policy problems associated with the pricing of noncommercial energy. In many developing economies, the use of fuelwood (firewood and charcoal), for example, has led to serious deforestation problems.

Table 2.2
Total End-Use Commercial Energy Consumption
Amount and Percentage Composition by Fuel Type
Select Developing Countries

(Amounts in Thousands of Tonnes of Oil Equivalent)

Country (Year)	Natural Gas		Coal*		Electricity		Petroleum		Total
	Amount	%	Amount	%	Amount	%	Amount	%	Amount
Bangladesh (79/80)	668.0	30.3	177.0	8.0	115.0	5.2	1,247.0	56.5	2,207.0
Bolivia (1981)	54.0	4.3	0.0	0.0	124.0	9.9	1,076.0	85.8	1,254.0
Botswana (1982)	0.0	0.0	110.4	29.5	116.1	31.0	148.1	39.5	374.6
Burma (1982/1983)	157.6	13.3	21.3	1.8	88.5	7.5	914.2	77.4	1,181.6
Burundi (1980)	0.0	0.0	0.0	0.0	11.6	25.0	34.8	75.0	46.4
Cape Verde (1982)	0.0	0.0	0.0	0.0	0.9	2.9	30.0	97.1	30.9
Costa Rica (1981)	0.0	0.0	0.3	0.0	182.2	21.1	680.6	78.9	863.1
Ecuador (1984)	0.0	0.0	0.0	0.0	273.0	7.8	3,239.0	92.2	3,512.0
Ethiopia (1982)	0.0	0.0	0.0	0.0	63.5	10.9	520.6	89.1	584.1
Fiji (1982)	0.0	0.0	12.0	5.0	45.9	19.2	181.7	75.8	239.6
Gambia (1982)	0.0	0.0	0.0	0.0	2.9	6.2	44.2	93.8	47.1
Guinea-Bissau (83)	0.0	0.0	0.0	0.0	2.2	14.0	13.5	86.0	15.7

Table 2.2 (Continued)

Country (Year)	Natural Gas		Coal*		Electricity		Petroleum		Total
	Amount	%	Amount	%	Amount	%	Amount	%	Amount
Haiti (1979)	0.0	0.0	0.0	0.0	15.5	7.0	207.5	93.0	223.0
Indonesia (79/80)	3,189.6	14.5	88.0	0.4	1,330.4	6.0	17,441.3	79.1	22,049.4
Jamaica (1983)	0.0	0.0	0.0	0.0	99.6	6.5	1,434.8	93.5	1,534.4
Kenya (1979)	0.0	0.0	40.0	2.8	117.0	8.2	1,262.0	88.9	1,419.0
Lesotho (1981)	0.0	0.0	49.1	36.9	21.6	16.2	62.3	46.8	133.0
Liberia (1983)	0.0	0.0	0.0	0.0	78.8	27.4	208.4	72.6	287.2
Malawi (1980)	0.0	0.0	31.2	15.0	29.5	14.2	147.4	70.8	208.1
Mauritania (1983)	0.0	0.0	0.0	0.0	11.4	8.4	124.5	91.6	135.9
Morocco (1981)	40.0	0.9	52.0	1.2	1,171.0	27.6	2,977.0	70.2	4,240.0
Nepal (1980/1981)	0.0	0.0	48.0	28.4	13.5	8.0	107.7	63.7	169.2
Niger (1981)	0.0	0.0	0.0	0.0	21.6	15.8	115.5	84.2	137.1
Paraguay (1982)	0.0	0.0	0.0	0.0	70.0	16.4	356.0	83.6	426.0
Peru (1981)	0.0	0.0	0.0	0.0	2,274.0	28.1	5,812.0	71.9	8,086.0
Portugal (1982)	57.0	0.7	0.0	0.0	1,323.0	16.3	6,754.0	83.0	8,134.0

Table 2.2 (Continued)

Country (Year)	Natural Gas		Coal*		Electricity		Petroleum		Total
	Amount	%	Amount	%	Amount	%	Amount	%	Amount
Rwanda (1979)	0.0	0.0	0.0	0.0	16.3	26.7	44.7	73.3	61.0
Senegal (1981)	0.0	0.0	0.0	0.0	47.4	7.9	550.5	92.1	597.9
Sri Lanka (1980)	0.0	0.0	0.0	0.0	120.1	9.9	1,090.2	90.1	1,210.3
Sudan (1981)	0.0	0.0	0.0	0.0	60.0	5.5	1,033.0	94.5	1,093.0
Tanzania (1981)	0.0	0.0	2.0	0.3	59.0	8.1	664.0	91.6	725.0
Thailand (1983)	32.7	0.3	173.9	1.6	1,427.3	13.2	9,157.5	84.9	10,791.4
Togo (1982)	0.0	0.0	0.0	0.0	28.6	12.2	205.5	87.8	234.1
Uganda (1980)	0.0	0.0	0.0	0.0	21.0	9.0	213.0	91.0	234.0
Yemen (1982)	0.0	0.0	0.0	0.0	44.0	5.3	790.5	94.7	834.5
Zambia (1980/1981)	0.0	0.0	426.0	17.3	1,390.0	56.5	644.0	26.2	2,460.0
Zimbabwe (1980)	0.0	0.0	1,466.0	38.0	1,687.0	43.8	702.0	18.2	3,855.0

SOURCE: UNDP/World Bank Energy Assessments

*Includes coke and lignite.

other hand, petroleum consumption accounted for more than 80 percent of total commercial consumption in 21 of the 37 countries listed in the table. Together, petroleum and electricity accounted for more than 90 percent of total end-use commercial energy consumption in 28 of the 37 countries.

The remainder of this report will concentrate on petroleum and electricity pricing. There are two reasons for this emphasis. First, natural gas and coal are generally minor end-use consumption fuels in developing economies. Table 2.2 shows that natural gas was consumed at end-use in only seven countries (Bangladesh, Bolivia, Burma, Indonesia, Morocco, Portugal, and Thailand). It accounted for more than 10 percent of total commercial consumption in only three of the seven--Bangladesh, Burma, and Indonesia. Fifteen of the 37 countries used coal; however, it was a major source of commercial energy only in Botswana (29.5 percent), Lesotho (36.9), Nepal (28.4), and Zimbabwe (38.0).

Second, natural gas and coal are not used as extensively at end-use across individual sectors of the economy, compared with petroleum and electricity. Natural gas is used primarily in the industrial sector. Coal is used primarily for industrial purposes and, in some countries, in the transport sector as fuel for locomotives. Often, it is used for one specific industry. In Zimbabwe, for example, coal is used primarily in the copper mines.

Emphasizing petroleum and electricity does not imply that there are no pricing problems with coal and natural gas. On the contrary, a significant problem exists in determining the relative prices of coal, natural gas, and petroleum which are used for electricity production in

economies where coal and natural gas are used as inputs. Here, the problem is not determining the end-use prices of energy, but rather the intermediate or wholesale prices.

2.3. ORGANIZATIONAL ARRANGEMENTS IN THE COMMERCIAL ENERGY SECTOR

2.3.1. The Electric Power Sector

A general characteristic of the electric power sector in developing economies is the presence of state-owned or parastatal electric utilities. In smaller economies, one parastatal is typically responsible for producing, transmitting, and distributing electricity in central, densely populated urban areas. In larger economies, several parastatals serve densely populated urban areas. For example, the 1982 General Electricity Law was enacted in Peru to decentralize the electric power sector. Under provisions of the legislation, eight regional utilities will provide electricity. However, Electroperu, a state-owned enterprise, has overall responsibility for management and development in the power sector of the country [UNDP/World Bank (1984a)].

The area served by electric parastatals varies from country to country. In some countries, the state-owned utility serves the central grid only. In Yemen, for example, the Yemen General Electric Corporation provides electricity for urban consumers, while rural consumers are served by privately owned, decentralized generating systems [UNDP/World Bank (1984m)]. More typical, however, is the case in which a parastatal provides electricity to at least a portion of rural consumers in addition to serving the central grid.

A number of arrangements characterize electricity service in rural areas not served by the state-owned utility. In some instances, private autogenerators serve some of the remote areas. The arrangements vary across countries. In some countries, private firms serve remote areas in concert with providing power for manufacturing or mining operations. In other cases, non-profit private organizations are involved in providing electricity. In Nepal, for example, the United Mission to Nepal, a church-supported organization, has helped establish a private, small-scale hydroelectric power industry in remote areas of the country [Flavin (1986)].[5] Some rural areas are served by electric cooperatives. In Costa Rica, for example, cooperatives have been in existence since the early 1960s. More recently, a Rural Electrification Board was established in Bangladesh to organize and finance rural electric cooperatives in a manner similar to the Rural Electrification Administration in the United States [Deverick et al. (1986)]. In some countries, subnational governments have responsibility for rural electric service. In Sudan, for example, it is anticipated that regional governments will manage self-contained rural power systems [UNDP/World Bank (1983e)].

Generally, electricity prices for customers served by the parastatals are not market-determined, but are set by the government and administered through the parastatal enterprises. Although the degree of

---

[5]Along this same line, the feasibility of private power production has attracted the interest of international assistance agencies. One organizational arrangement would allow local, private firms--possibly with the financial and technical aid of foreign corporations--to construct power plants and sell electricity to parastatals in developing countries. Much of the interest in this type of arrangement was generated by the growth of private power projects in the United States as a direct result of provisions of the Public Utility Regulatory Policies Act of 1978.

autonomy of these enterprises varies from country to country, final ratemaking or approval rests outside the parastatal. That is, energy tariffs proposed by the enterprise typically are subject to review and approval by government agencies in a manner similar to public utility regulation in the United States. In Paraguay, for example, the management of the electricity sector is under the sole jurisdiction of the Administracion Nacional de Electricidad, an independent public utility with complete financial independence. However, any proposed tariff changes must be submitted for approval to the National Council on Economic Coordination through the Ministry of Public Works and Communications [UNDP/World Bank (1984k)].

Another general characteristic of the electricity sector in developing economies is the requirement in principle that state-owned electric utilities maintain financial solvency. They are generally required to be financially self-sufficient. The financial requirement has been a source of many of the problems of the parastatals. Many electric parastatals have incurred large financial losses over the past several years, leaving the utilities with a lack of (1) working capital for routine operating and maintenance activities and (2) internally generated funds for debt service and power system improvement and expansion.

A number of factors have contributed to the strained financial condition of the parastatals. One of the most significant has been the reluctance of national governments to allow electricity rates to be raised to cost-based levels. As discussed below, parastatals are required either to subsidize some customer classes or to simply keep electricity rates low for socio-political reasons. Another contributing factor has

historically been inadequate management of the electric supply system. Management problems range from inefficient use of the supply system to the inability to stop theft on the transmission and distribution systems. Finally, many parastatals have difficulties in collecting payment for providing electricity. In many cases, the biggest offenders are government departments.

Financial considerations become even more important in an environment in which capital requirements for electricity expansion are increasing and international sources of capital for replacement and/or expansion of electricity supply systems are becoming increasingly scarce. Heron (1985), for example, estimated that, given an annual electricity demand growth rate of six percent, the required increase in generating capacity in the developing world would be 285,000 megawatts over the 1986-1995 period, estimated to cost $522 billion (1985 U.S. dollars).[6] Assuming that one-third of the total investment will be derived from foreign exchange, the amount of local currency required to accommodate the assumed growth in demand is $350 billion. The implications of this estimate are clear. The local currency requirement must be raised through internal funding from electric power sales, or electric power systems in developing economies will have a shortage of capacity unless general revenues of the government are used for power system capital expansion.

---

[6]The investment figure does not include interest during construction. The assumptions underlying this estimate include capacity costs of $1830/kilowatt ($1280/kilowatt for generating plant and $550/kilowatt for transmission and distribution facilities) and a generation mix of 51 percent thermal, 36 percent hydroelectric, 12 percent nuclear, and one percent geothermal.

2.3.2. The Petroleum Sector

Organizational arrangements in the petroleum sector of developing economies generally depend upon the size of the petroleum market and the resource base of the economy. In countries that have refining capacity,[7] a state-owned petroleum corporation typically has responsibility for securing crude oil, refining it, and selling products to distributors. Refineries are either wholly owned by the government or co-owned with private firms. In Senegal, for example, the lone refinery is owned by the government (a 10 percent share) and seven private oil companies [UNDP/World Bank (1983d)]. In Sudan, the refinery is equally owned by the government and a multinational oil company [UNDP/World Bank (1983e)].

Refining operations, like electric power parastatals, are typically required to be financially self-sufficient. In most cases, refineries are allowed to earn a prespecified profit margin. In Paraguay, for example, the ex-refinery price level is set to allow a profit of seven percent of costs. Automatic price adjustments are allowed when costs exceed revenues by two percent--after the seven percent profit margin is considered [UNDP/World Bank (1984k)]. In Senegal, ex-refinery prices are set on a cost-plus basis. The refinery is allowed a 12 percent return on capital employed [UNDP/World Bank (1983d)].

Distribution and marketing of refined petroleum products generally involve both the state and subsidiaries of multinational oil companies. A number of organizational arrangements exist. In some cases, multina-

---

[7]Of the 37 countries included in this overview, 23 have refining capacity. Petroleum refining is discussed further in the next section.

tional firms are the primary marketers, with little participation by the state. In Tanzania, for example, five companies market petroleum products. Two of the companies are 50 percent-owned by the state petroleum corporation [UNDP/World Bank (19841)]. In Rwanda, seven oil companies import petroleum products. One of the companies is partially owned by the state [UNDP/World Bank (1982f)].

In other cases, the state--through its parastatal petroleum corporation--exercises more control. In Sudan, for example, the market shares of four petroleum marketing companies are determined by their allocations of petroleum from the General Petroleum Corporation, a state-owned petroleum enterprise [UNDP/World Bank (1983e)]. In Niger, the state-owned petroleum corporation has a monopoly on importing petroleum products except for fuel oil. Five marketing companies are supplied by the parastatal [UNDP/World Bank (1984f)].

The most common characteristic of the petroleum subsector in developing economies is the existence of government price control. In most cases, the government sets the price level for all products, allowing marketers to both cover costs and earn a prespecified profit. In a few cases, the prices of only a select number of products are controlled. The remainder are determined in the market. In Botswana, for example, the prices of gasoline, diesel, and kerosene are set by the government. All other products are priced independently by petroleum marketers [UNDP/World Bank (1984j)]. Similarly, the prices for premium and regular gasoline, kerosene, and auto diesel in Uganda are set by the government, but the prices of fuel oil, jet fuel, and lubricants are deter-

mined by the marketing companies in consultation with the government [UNDP/World Bank (1983f)].

2.4. ENERGY PRICING PROBLEMS

Energy prices can serve six major purposes or functions in an economy. First, energy prices can be set to ensure the financial solvency of energy supply institutions. Second, prices can be set to promote efficient resource allocation. Third, prices can be set to redistribute income. Fourth, energy prices can be used as a source of revenue for the government. Fifth, prices can be set to promote the consumption of specific energy products by targeted consumer groups. Sixth, energy prices can be set to promote other political or social goals--to simply keep the cost of energy low, for example.

Strictly on the basis of economic efficiency criteria, the first two functions are the most important. The first refers to the level of energy prices. The price level is related to the total earnings of the firm. If there are problems with the level of prices, then revenues generated by energy parastatals from the sale of all energy services are not sufficient to cover all costs of operation (including capital costs) as well as internal financing for replacement and/or expansion of the energy supply system. A problem with the price level means that a parastatal is experiencing financial difficulty.

The second function refers to the structure of individual energy prices. Problems with the structure of prices indicate that the relative prices of energy products do not reflect their relative costs of production. In this case, the price signals provided to energy users are distorted. Therefore, investment decisions of energy users are not

based on the relative costs of providing energy, resulting in a misallocation of resources.

Table 2.3 provides a summary of electricity and petroleum product pricing problems identified by the UNDP/World Bank in studies of 37 AID-assisted countries.[8] The problems are broadly categorized as pertaining to the two basic components of setting economically "correct" commercial energy prices: the rate level and the rate structure.

Table 2.3 shows that 30 of the 37 countries were experiencing problems with the level of electricity tariffs at the time of assessment. For the petroleum sector, the level of prices was identified as a problem in 20 of the 37 countries. The primary reason for the relative severity of price level problems in the electricity sector in comparison with the petroleum sector is that 14 of the countries lack refining capacity. For many of these countries, imported refined petroleum products are sold at cost plus a distributor's margin. Perhaps more notably, the structure of electricity prices in 32 countries and of petroleum products in 33 countries was a problem at the time of assessment.

Table 2.3 also shows that problems with both the level and structure of electricity prices were identified in 26 of the 37 countries. For the petroleum sector, the corresponding number of countries was 20. In the electricity and petroleum sectors of these countries, the parastatals were not only experiencing financial difficulty at the time of

---

[8]It must be emphasized that the problems were identified at the time of assessment. They may have been subsequently corrected as a result of either the recommendations made as part of the assessment or other external influences.

Table 2.3
Energy Pricing Problems
Electricity and Petroleum Products
Select Developing Countries

Country	Electricity		Petroleum		Petroleum Refining Capacity
	Level	Structure	Level	Structure	
Bangladesh	X	X	X	X	Yes
Bolivia	X	X	X	X	Yes
Botswana	X			X	No
Burma	X	X	X	X	Yes
Burundi		X		X	No
Cape Verde	X	X	X	X	No
Costa Rica	X	X	X	X	Yes
Ecuador	X	X	X	X	Yes
Ethiopia	X	X	X	X	Yes
Fiji	X			X	No
Gambia	X				No
Guinea-Bissau	X	X	X	X	No
Haiti		X		X	No
Indonesia	X	X	X	X	Yes
Jamaica	X	X	X	X	Yes
Kenya		X		X	Yes
Lesotho	X	X			No
Liberia	X	X	X	X	Yes[a]
Malawi		X		X	No
Mauritania	X	X		X	Yes[a]
Morocco	X	X		X	Yes

Table 2.3 (Continued)

Country	Electricity		Petroleum		Petroleum Refining Capacity
	Level	Structure	Level	Structure	
Nepal	X	X		X	No
Niger				X	No
Paraguay		X			Yes
Peru	X	X	X	X	Yes
Portugal	X	X	X	X	Yes
Rwanda	X	X			No
Senegal	X	X	X	X	Yes
Sri Lanka	X	X		X	Yes
Sudan	X	X	X	X	Yes
Tanzania	X	X		X	Yes
Thailand	X	X	X	X	Yes
Togo		X	X	X	Yes[a]
Uganda	X	X	X	X	No
Yemen	X			X	No
Zambia	X	X	X	X	Yes
Zimbabwe	X	X	X	X	Yes[a]

SOURCE: Derived from UNDP/World Bank Energy Assessments

Level-Overall price level
Structure-Relative price structure

X-Identified as problem at the time of assessment

[a]Capacity not in use at the time of assessment

the UNDP/World Bank assessment because the overall price levels were too low, but the relative prices of energy were not correct.

The severity of the pricing problems shown in Table 2.3 varies across countries. Problems with the level of prices in some countries are major. Some parastatals have been generating insufficient cash flow over a considerable period of time. Prospects for loans from international assistance agencies are in jeopardy unless the level of prices is raised, but national governments are reluctant to allow higher prices for political reasons. Other countries have been experiencing relatively minor problems with the level of prices. Although they were experiencing a positive cash flow, concerns were raised about the amount of internal generation of funds for future expansion and/or replacement of the supply system.

The severity of problems with the structure of electricity and petroleum prices also varies across countries. In some instances, the problem is a relatively minor cross-subsidization of one product by another; in other cases, problems are more severe. Energy prices not set on the basis of cost as well as large subsidies for a range of products over a period of time have severely distorted market signals for investment in all sectors of the economy. As a result of this pricing structure, capital investment decisions have been made on the basis of energy costs that do not reflect the true cost of providing energy.

Ignoring problems with the structure of energy prices for the moment, the sources of distortions to the level of electricity and petroleum prices vary across countries. In some countries, prices of all of the energy products are set below cost. In these case , the

price level is an impediment to attainment of financial solvency by the parastatal. In other words, the relative prices are correct in some cases--reflecting relative costs--but the level at which they are set is too low. In other countries, the prices for most classes of service are set at cost-based levels. The exceptions are subsidized for income distribution or for promotional reasons. The financial problem here is the same--the firm is not able to generate sufficient net revenues. In still other cases, all prices may equal the estimated cost of providing energy services, but the firm is still not able to maintain financial viability. The reason is usually attributable to inefficiency on the part of the parastatal. In other countries, the source of the problem with pricing levels is that the profit margin of the petroleum marketers is set too low.

Ignoring problems with the level of energy prices, there also exist a number of sources of structural energy pricing problems. In some countries, the problem is that relative prices for different classes of service do not represent the true relative costs of providing energy to those classes. That is, in the aggregate, the prices set for energy may allow the parastatal to be financially viable, but the prices are not set on the basis of the costs of serving different customer classes, leading to a misallocation of resources.

More often, as a matter of government policy, the prices of some energy services are subsidized. The subsidies take on many forms. Some subsidies are direct in the sense that a specific product is subsidized for income distribution purposes. For example, the price of kerosene is set at a low level in many countries to allow low-income households the

ability to purchase it. Other subsidies are indirect. In some countries, prices for electricity are uniform across urban and rural areas, not reflecting differences in the cost of supply. For petroleum products, a uniform price may exist for all regions of the country, not reflecting differences in the cost of transportation to different regions.

Another problem in some countries is a regressive tariff structure. For example, the pricing of electricity to low-voltage, residential customers is based on a declining block structure. Therefore, consumers of smaller amounts of energy are penalized relative to larger-volume users.

Generally, except where its price is deliberately kept low, energy is subject to taxation in developing economies. Although taxes vary from country to country, petroleum products are more pervasively taxed than electricity services. In many cases, the tax structure is a source of structural pricing problems. In some countries, some petroleum products are more heavily taxed than others. For example, there may be a large excise tax on gasoline with no corresponding tax on diesel fuel. The incentive provided consumers in this case is to purchase diesel-using vehicles in numbers not dictated by the relative costs of providing gasoline and diesel fuel.

Finally, the use of stabilization funds in some countries distorts the relative prices of energy services similar to inappropriately applied taxes. A stabilization fund is the result of a surcharge applied to the price of an energy service. The proceeds of the fund are typically used to subsidize some energy consumers or consumers of other important non-energy commodities. In some cases, the proceeds are used to compensate a parastatal for energy provided to government agencies.

As an indication of the pricing problems in the petroleum sector of developing economies, Table 2.4 provides a summary of a study by Julius et al. (1986) on the relationship between domestic and international prices of petroleum products for three categories of developing countries, both by fuel type and in the aggregate over the 1973-1983 period. The ratio of domestic to international prices in Table 2.4 is intended to provide an indication of the extent to which retail petroleum prices in developing countries diverge from cost-based levels. The international prices chosen for the analysis are f.o.b. Rotterdam mid-year quotations. As such, they do not reflect transport, marketing, and distribution costs.[9] Moreover, because the domestic prices used in the study are at the retail level, they reflect taxes on and subsidies of petroleum products.

Three conclusions emerge from the table. First, the ratio of overall weighted-average domestic petroleum product prices to international prices declined dramatically over the period for all country categories. Because the period under consideration in the table encompasses the two international oil price shocks of the 1970s, the countries in each of the categories apparently mitigated the impact of international petroleum price increases by lowering taxes on petroleum products.

Second, and related to the first, the international price increases have led to a situation where the level of retail petroleum product prices in many developing economies is insufficient to cover costs, in-

---

[9]The authors estimate that margins up to 20 percent would have to be added to the international prices to account for international transportation and domestic costs, depending on the location and petroleum sector characteristics of individual countries.

Table 2.4
Ratio of Domestic to International Petroleum Prices
In Total and by Product Type
Select Developing Countries
1973 and 1983

Country Category/ Year	Premium Gasoline	Kerosene	Diesel	Fuel Oil	Weighted Average
Low Income[a]					
1973	2.8	2.4	2.3	1.7	2.3
1983	2.3	1.1	1.5	1.3	1.5
Middle Income[b]					
1973	3.8	3.4	3.0	3.7	3.0
1983	2.2	1.1	1.2	1.0	1.2
Oil Exporters[c]					
1973	2.8	1.3	1.4	2.5	2.0
1983	1.0	0.2	0.3	0.3	0.4

SOURCE: Summarized from Julius et al. (1986).

[a]Includes Burma, Ethiopia, Haiti, India, Pakistan, and Sri Lanka.

[b]Includes Bolivia, Brazil, Colombia, Dominican Republic, El Salvador, Greece, Kenya, South Korea, Morocco, Panama, Paraguay, Philippines, Portugal, Thailand, Turkey, and Yugoslavia.

[c]Includes Ecuador, Egypt, Indonesia, Malaysia, Mexico, Peru, Tunisia, and Venezuela.

dicating that petroleum consumers are subsidized from general revenues of the government. Comparing country categories, the level of petroleum prices in low income countries was nearly 300 percent greater than that of oil exporters and 25 percent greater than that of middle income countries in 1983. For oil exporters, there is every indication that each petroleum product type is subsidized--an across-the-board subsidy of petroleum consumers.

Third, the relative prices of petroleum products in developing countries are distorted through taxes and subsidies. The data in Table 2.4 suggest that premium gasoline is more heavily taxed than the other product types and kerosene is generally subsidized relative to other product types.

3. IMPLEMENTATION OF ENERGY PRICE REFORM

3.1. INTRODUCTION

This chapter presents an approach to energy price reform which, it is felt, will encourage reforms in developing countries by making their implementation more feasible from the point of view of policymakers, as well as more valid from a theoretical perspective. The approach is cast in a broader framework of energy planning and economic reform for a number of reasons, including such realities in the energy sector of most developing countries as that: (1) constraints are placed on commercial energy-supplying parastatals; (2) the differences between current energy prices and current energy supply costs are large in many instances; and (3) energy is an important component of development planning. Specifically, it is argued that energy price reform per se should be considered as only one of three related and simultaneous reforms in the energy sector of developing economies. The reforms include:

1. Price reform.
2. Demand- and supply-side management.
3. Organizational reform.

Technically, of course, price reform is one aspect of demand-side management. It has been classified separately here because it is the focal point of the discussion. In the context of this report, demand-side measures other than those related to pricing, supply-side management, and organizational changes are viewed as an integral part of implementing energy price reform, because they mitigate adverse economic and sociopolitical impacts of moving to cost-based energy prices. Each

of the reform measures will serve as the basis of discussion in the following three sections of this chapter.

3.2. PRICE REFORM

Increasing emphasis on economically efficient or cost-based energy prices by international assistance agencies as a condition for lending has changed the objectives of energy pricing policies in many countries. National governments are now being forced to reevaluate their policies, placing more emphasis on economic--rather than political--criteria. However, where current prices are significantly below their cost-based levels and uses of energy products or services are significant, instantaneous adjustment to economically efficient price levels may not be feasible. Three characteristics of developing economies form the basis of this assertion: (1) a rapid increase in energy prices is politically infeasible in most cases; (2) rapid price changes may cause severe hardships for downstream energy users in the short run; and (3) income redistribution caused by the price changes may be inconsistent with national policy.

The political consequences of abrupt changes in the prices of key commodities have been documented many times in recent years. In Liberia, for example, a sudden, large increase in the price of rice in April 1979 led to street riots. As a result of the political unrest in which dozens were killed and hundreds injured, many foreign investors withdrew their capital from the economy. Political stability was restored only after the price increase was rescinded and most of the arrested demonstrators were released. Similarly, increases in the prices of cooking oil and other staples in the Dominican Republic, implemented as part of

an austerity program mandated by the International Monetary Fund, led to three days of riots and more than 50 dead in April 1984.

In Ecuador, elimination of food and gas subsidies, implemented by the government in October 1982 as part of a larger austerity program requested by the International Monetary Fund, prompted strikes and rioting. The increase in the price of gasoline, originally scheduled to be 120 percent, was lowered to 100 percent as part of the concessions made by the government to end civil rioting.

In Jamaica, rioting precipitated by increases in the price of energy in January of 1985 led to the deaths of seven people and a large drop in tourist revenue. Under the austerity program, gasoline prices were increased from $1.80 to $2.19 per gallon, kerosene from $0.74 to $0.80, and 100-pound tanks of propane from $20.10 to $23.30--all rather modest increases, from some perspectives.

Although movement to cost-based energy prices promotes economic efficiency in the long run, downstream adjustments to higher energy price levels could be particularly troublesome for many economies in the short run. An immediate change to cost-based energy prices could induce downstream <u>income</u> and <u>price</u> effects that negatively affect the short-term performance of a developing economy. Income effects arise because of the transfer of income from energy consumers to energy producers, decreasing the purchasing power of consumers for other goods and services. The reduction in income leads to decreased expenditures on non-energy goods and services. The result is a decline in the output of non-energy producers which can lead to higher levels of unemployment. Also, in-

creases in energy prices change the relative price structure in the economy, which could cause an increase in the general level of inflation.

The short-run, downstream effects of an immediate adjustment to cost-based energy prices are particularly troublesome in two sectors of developing economies. First, the typical developing economy relies to a large extent on the export of a few primary products to generate foreign exchange. In many cases, the exporting industries are among the largest users of energy in the economy. An immediate increase in energy prices to cost-based levels--and, therefore, a large increase in production costs for export-based industries--could jeopardize an important source of foreign exchange earnings for the economy by making exports less competitive in world markets. Second, the production of electricity in many developing economies relies to a large extent on petroleum-based fuels that are currently subsidized in many cases as a matter of policy. Instantaneous adjustment to cost-based prices for diesel or fuel oil could have a marked impact on the cost of producing electricity.

Besides the downstream macroeconomic consequences, an immediate adjustment to cost-based commercial energy prices could intensify income distribution problems in the economy. In most cases, it is likely that higher commercial energy prices would further increase the disparity in income across segments of the population. If the responsiveness of demand to higher commercial energy prices for upper income classes is larger than for lower-income households--that is, if demand is more price elastic--higher prices would further distort the distribution of income. Such a negative distributional impact could conflict with other national objectives.

Also, for commercial energy products or services that have noncommercial energy substitutes, an instantaneous increase to cost-based commercial energy prices could induce fuel-switching to noncommercial or traditional forms of energy (firewood and charcoal, for example) which the government is trying to discourage. For example, the consumption of traditional forms of energy by households may be the source of deforestation problems in the country which the government is trying to relieve by keeping commercial energy prices low.

The political considerations, downstream effects, and distributional consequences of instantaneous adjustment to cost-based rates suggest that energy price reform should ordinarily be a gradual process. A program to implement price reform over time will ameliorate the adverse economic effects of a one-time adjustment to cost-based energy prices. Therefore, the following process for energy price reform is suggested:

1. Determination of an optimal set of target prices.
2. Determination of a time frame for adjustment.
3. Determination of an index for adjusting prices over time.
4. Periodic evaluation and adjustment of target prices as conditions change.

Because of financial, subsidy, and fiscal considerations, the approach to determining a target set of prices cannot be reduced to a formula. That is, the price of various types of energy products or services cannot simply be matched with the cost of providing them. Policy dialogue on energy price reform must take into consideration the balancing of economic objectives of energy prices--allocative efficiency and financial cost coverage--with a number of other fiscal or social consi-

derations. This is the major challenge confronting those who prescribe energy price reform programs in developing economies.

Besides economic efficiency criteria, the approach to calculating an optimal set of target prices should take into consideration the constraints placed on energy-supplying institutions in developing economies. One of the primary constraints is the requirement that parastatals maintain financial solvency. The maintenance of solvency becomes increasingly urgent in a world characterized by decreasing availability of capital for replacement and/or expansion of the energy supply system.

Another important constraint in many developing countries is the requirement that, as a matter of policy, some energy products be subsidized for income distribution, energy substitution, or energy promotional purposes. Also, taxation of energy--particularly petroleum products--is both an important source of revenue in many developing countries and a prominent source of distortions in relative energy prices. Therefore, tax issues must be considered in determining target prices.

While it may be possible to devise a comprehensive tax program with less emphasis on energy taxation in a given country, pragmatic considerations--such as the relative ease and certainty of using energy sales for revenue generation--may override considerations of fiscal efficiency. Similarly, a recommendation to eliminate a subsidy to an

industry or firm may not be acceptable if the industry or firm is an important source of foreign exchange earnings.[1]

Depending on the nature of the energy pricing distortion, the adjustment in the price of some classes of energy services may be downward, rather than upward. This could result from either eliminating the cross-subsidization of one energy type by another or reducing an inordinately high tax on an energy service in the current pricing structure.

After a target set of prices is computed, the time period over which current prices will be adjusted to target levels must be determined. Important economic considerations under this aspect of price reform include the difference between current and target prices and potential downstream adjustment and income distribution problems induced by adjusting energy prices. From political and economic standpoints, the relative price of energy to the prices of other commodities in the economy cannot generally be changed suddenly without unacceptable consequences in most cases.

A good candidate to serve as the reference point for setting the index for adjusting energy prices from current to target levels is the general rate of inflation in the economy. There are two good reasons

[1]An approach that lends itself well to determining optimal target prices under all of these potential constraints is called break-even analysis. Under this approach, target prices are calculated on the basis of generating a prespecified amount of net revenues to cover the fixed costs of the firm and any additional amount necessary for replacement or expansion of the energy supply system. If an energy service is to be taxed or subsidized, the break-even approach can consistently incorporate taxes and subsidies in the determination of target prices. Also, calculating optimal prices under this approach is not limited to uniform tariffs. If distinct types of service within a given customer class can be differentiated, multi-part tariffs can be determined. A background on energy pricing and an in-depth discussion of break-even analysis occupies the discussion in Appendices A and B.

for using the inflation rate as the adjustment index. First, from a practical standpoint, it is a macroeconomic index that is readily available for all developing economies. Second, the relative impacts of higher energy prices are somewhat reduced if energy price increases are aligned with price increases in the overall economy. Depending on the period of time over which prices are to be adjusted, increasing current prices to target levels based on a predetermined percentage in excess of the inflation rate is a good approach to phasing in energy price reform over a period of years.

It may be well-advised to phase in energy price reform over a period greater than ten years, contingent on country-specific circumstances. For example, if the general level of energy prices is presently one-half the cost-based level, it would take seven years to adjust prices to cost-based levels with a ten percent real increase per year. The problems of civil unrest sometimes associated with price increases suggest that the period of adjustment in some countries may have to be longer.

Gradual introduction of cost-based energy prices is not without precedent in both the industrialized and developing world. In the United States, for example, legislation enacted in 1978 to decontrol the wellhead price of much of the country's natural gas provided for a phase-in of price increases. Total decontrol was to be accomplished in 1985, seven years after the process of decontrol was initiated. Increases in the wellhead price of natural gas were tied to (assumed) increases in the price of petroleum. The purpose of the seven-year adjustment period was to smooth the transition from relatively low,

government-controlled wellhead prices to higher, market-determined price levels.

This suggested, time-phased reform process is complicated by the fact that the set of target energy prices may have to be changed during the adjustment period. For example, price volatility in international petroleum markets--not totally reflected in the index used to adjust energy prices to cost-based levels--may require adjustments of target prices. Adjustments of energy prices to such external changes would be called for, however, regardless of the strategy for implementing a price reform.

One possibility for mitigating the impact of oil price changes during the adjustment period is to use the energy tax system. That is, appropriate adjustments to the taxes placed on energy could absorb the impact on energy prices if energy supply costs fluctuate during the adjustment period. For example, during periods when the petroleum import price is declining, taxes could be increased to maintain price levels. During periods when the petroleum import price is increasing, taxes could be reduced to maintain price levels.[2]

3.3. DEMAND- AND SUPPLY-SIDE MANAGEMENT

To this point, the discussion has addressed only one aspect of demand-side management--estimating and adjusting to cost-based energy prices. However, in a broader energy planning context, price reform should be undertaken in conjunction with additional measures to reduce

---

[2]As discussed in the preceding chapter, there is an indication that many developing countries reduced excise taxes on petroleum products to shield consumers from at least a portion of the increases in international petroleum prices during the 1970s.

both the cost of using energy and the cost of supplying it, thus mitigating the magnitude of the impacts that must be absorbed by energy consumers.

3.3.1. Demand-Side Measures

First, the impact of adjusting to cost-based energy prices could be mitigated through demand-side conservation measures. By improving the efficiency of the consumer's use of energy, the economic impact of phasing in higher energy prices could be moderated, because the consumer would be able to realize the same energy services by purchasing less energy. To illustrate the magnitude of potential energy conservation savings, the results of a comprehensive study of the transport, industrial, government, power, and agriculture sectors in Pakistan showed that $1.5 billion in energy cost savings (15.2 percent of 1984 consumption) could be realized over the 1984 to 1993 period with an investment of $0.5 billion [Bever and Ahmad (1986)]. The net savings in foreign exchange was estimated to be more than $0.35 billion. The largest potential savings are in the industrial sector--46.6 percent of 1984 consumption.

In the developing country context, a large portion of potential commercial energy savings through conservation measures is likely to be in the commercial, industrial, and transport sectors. This is not to imply that there is no potential for conservation-induced energy savings in the residential sector. However, in the majority of countries, a large portion of the residential-sector savings is likely to be attributable to the conversion of noncommercial energy sources--wood to charcoal, for example--and more efficient use of noncommercial energy in the household--improved wood and charcoal stoves, for example. A major ex-

ception occurs in countries--particularly in Asia--with an expanding middle class. For these countries, there is a large potential for commercial energy conservation in households (more efficient air conditioners, for example).

In the commercial sector, the largest potential savings is in the use of air conditioning in buildings. More efficient air-conditioners, insulation, and temperature control measures could directly reduce the consumption of electricity and, through the impact on the load of electric power parastatals, reduce the use of imported petroleum products. In Niger, for example, the World Bank [UNDP/World Bank (1984f)] estimated that in 1982 replacing air conditioners in current use with a 30 percent more efficient type (similar to ones used in Middle Eastern countries) would have reduced peak electricity demand by three megawatts. The estimated energy supply savings was $2.5 million.

An enormous potential for energy conservation savings in the industrial sector of developing economies exists in both retrofit investments and fuel switching. Based on an analysis of 13 major industrial firms and the electric power parastatal in Senegal, for example, the World Bank [UNDP/World Bank (1983d)] estimated that 63,000 tonnes of oil equivalent could be saved through conservation measures. One-half of this amount could be saved with investments totaling $16 million, and with pay-back periods of three years or less. In Morocco, the World Bank [UNDP/World Bank (1984d)] estimated that an investment of $38.5 million in conservation measures would have saved industrial users of energy $16.5 million in 1981. In a comprehensive study of the industrial sector in Thailand, it was estimated that 12 percent (3.7 million

BCOE/year) of total 1982 energy use in the industrial sector could be saved through conservation measures [Desai and Nyman (1986)]. Of the total savings, one-half would be derived from industrial process improvements and the other half from housekeeping and new equipment. An additional 3.4 million BCOE/year could be saved by substituting indigenous natural gas for petroleum. In the Philippines, industrial conservation potential was estimated to be nine million barrels per year--or 18 percent of total industrial energy use in 1980 [Desai and Nyman (1986)]. Approximately 70 percent of this energy savings potential has payback periods of less than two years.[3]

In many countries, transportation accounts for a large share of petroleum product consumption. On average, the use of petroleum in the transport sector of developing countries accounts for approximately 44 percent of total petroleum use. There is both a potential for significant energy savings and a range of options for capturing those savings. The options include optimizing the use of public transport systems; improving traffic flow; fuel-switching; using the tax system to discourage certain types of vehicle use; improving vehicle efficiency through proper maintenance; improving the road infrastructure; driver training; and improving management techniques for both private firms and public transport scheduling.

In Niger, a private transport firm reduced its fuel consumption per kilometer by 22 percent over the 1977-1981 period through a program of vehicle modernization and driver training in fuel efficiency [UNDP/World

---

[3]The calculation of payback periods was made on the basis of an assumed petroleum price of $30 per barrel.

Bank (1984f)]. A program of traffic management in Kingston, Jamaica is expected to save three percent of annual fuel use [UNDP/World Bank (1985b)]. Similarly, a 1982 study of traffic flow in a small part of Bangkok showed that an automatic traffic control system could result in fuel savings of up to 20 percent [UNDP/World Bank (1985e)]. In Senegal, a study of the transport sector showed that approximately 26,000 tonnes of oil equivalent could be saved through various management and infrastructure improvements [UNDP/World Bank (1983d)]. In Costa Rica, a demonstration study showed that low-cost, quick payback measures (improved maintenance procedures and driver training) could have a significant impact on fuel use [Sabadell, Greene, and Erickson (1986)]. Improved maintenance procedures for taxi and bus fleets led to energy savings of 1.8 percent and 6.5 percent, respectively. The corresponding percentage savings resulting from driver training were 15.1 percent and 4.2 percent.

In many countries, a significant barrier to realizing energy conservation savings is the capital required for conservation investment. While pay-back periods are short and energy savings are substantial in many cases, the investment cost is prohibitive. For example, based on an audit of seven large energy-using plants in Zimbabawe, it was shown that there is a significant potential for industrial energy savings through conservation--$75.4 million annually or 51 percent of the energy demand of the plants. However, the conservation investment cost of $507 million was prohibitive [UNDP/World Bank (1982c)].

In Thailand, several measures to ease the transport problems of Bangkok and to reduce transport energy consumption have been proposed.

The proposals address improving the road infrastructure, vehicle efficiency, and management of the urban transport system. However, the estimated capital required for the total conservation program is a prohibitive $2 billion [UNDP/World Bank (1985e)].

The large capital requirements to fully realize all of the energy savings from conservation investments in some cases does not detract from the usefulness of conservation measures in the commercial energy price reform process. In most cases, relatively modest conservation investments--with short pay-back periods--will ameliorate the adverse impacts of adjusting to cost-based energy prices.

3.3.2. Supply-Side Measures

Computing target prices necessarily involves determining the marginal cost of providing energy by class of service. Normally, the applicable cost is the financial cost experienced by the firm, but in many developing countries this is not the least possible cost of providing energy.[4] An energy price reform could be undertaken as part of a broader program to reduce the costs of energy supply. This has the obvious impact of lowering the target cost-based rates determined in the first component of the suggested price reform process, making the adjustment to "correct" energy prices that much less severe.

Supply-side efficiency improvements could significantly reduce the cost of providing power in many developing countries. In many cases,

---

[4]Indeed, in many instances, a significant barrier to moving to cost-based energy prices is the perception on the part of consumers--particularly politically influential ones--that cost-based energy prices would penalize energy users by requiring them to, in effect, subsidize the inefficiencies of energy suppliers.

inefficient or redundant equipment is used. Transmission and distribution losses for electric power supply are excessive. The use of labor is often excessive and/or not properly trained or supervised. Maintenance on generating stations is often untimely or nonexistent. Load dispatching is not as economic as possible in many cases. Management and accounting systems are often sub-optimal. If properly addressed, improving these operating conditions could contribute significantly to reduction of costs on the system.[5]

Liberia provides a good example of the potential for reducing inefficiencies in electricity supply. The electric power parastatal, the Liberia Electric Corporation (LEC), was charging a uniform 15 cents per kilowatt-hour for electricity in 1983. The estimated supply cost of that power was 9.7 cents per kilowatt-hour. Still, LEC was suffering financial losses because of inadequate management of the power supply system. Unpaid accounts, theft, and power outages contributed significantly to the financial strain on the utility. If these problems were corrected, the financial strain on LEC would be alleviated, with the potential for a decrease in the end-use price of electricity [UNDP/World Bank (1984n)].

Another example is a thermal power plant rehabilitation program in Pakistan [Bever and Ahmad (1986)]. It was concluded that the operating efficiency, availability, and reliability of the thermal plants in Pakistan could be improved with an investment of $329 million. The program involves overhauls, repairs, modifications, and additions to existing

---

[5]A good discussion of potential efficiency improvements in the electricity sector of many developing economies is provided in Jhirad, Hillsman, and Sharafi (1986).

thermal plants to reduce the cost/kWh of generation in addition to organizational changes in the operation of the plants. The estimated payback period for the investment is $1\frac{1}{2}$ years.

Opportunities for significant savings also exist in both the crude oil and petroleum product supply arrangements in many developing economies. In many instances, savings can be achieved by simply changing the international arrangements for procuring crude oil and/or petroleum products. Improving the conversion efficiency of many refineries in the developing world could also be a source of significant savings. In many instances, if significant improvements are not made in refinery efficiency, shutting down refineries and importing refined products may be the most economical method of securing petroleum products. In other cases, shutting down the refinery is the only economical option, considering the cost of improvements.

In Tanzania, for example, it was estimated that a relatively modest investment in improving the operation of the refinery and changing the product mix could result in substantial savings in petroleum product supply. For 1983, the World Bank [UNDP/World Bank (19841)] estimated that, without the improvements, refinery operations would cost the Tanzanian government $1.7 million in comparison with closing the refinery and importing all refined product requirements. Similarly, in Zambia, shutting down the refinery and importing refined products may be more economical if changes are not made in operation and product configuration of the refinery [UNDP/World Bank (1983a)]. A preliminary investigation of the economics of the refinery in Ethiopia concluded that, over the next decade, it would be less costly to shut down the refinery and

obtain petroleum products from international markets unless $70 million were invested to improve refinery operations [UNDP/World Bank (1984g)].

In many instances, the configuration of current refineries does not warrant continuing refining operations even with investments in refinery improvements. In Jamaica, a preliminary assessment showed that it may be more economical to shut down the 36,000 barrel/day refinery at Kingston and import petroleum products [UNDP/World Bank (1985b)]. Similarly, in Mauritania, it was concluded that the most economical method of securing petroleum products would be to shut down the refinery and import them [UNDP/World Bank (1985a)]. Finally, there is strong evidence that refineries in some countries which have been shut down in the past should not be reopened, including refineries in Liberia [UNDP/World Bank (1984n)], Togo [UNDP/World Bank (1985c)], and Zimbabwe [UNDP/World Bank (1982c)].

3.4. ORGANIZATIONAL REFORM

To this point, addressing "correct" prices for energy has assumed that organizational arrangements in the energy sector of developing economies have not changed. Organizational arrangements include (1) the overall organization of the energy sector and its relationship to the government; (2) organization and responsibility of individual energy-supplying firms; and (3) the general approach used to allocate resources in the economy. While improvements in the first type of organizational

arrangements could be very beneficial,[6] the present discussion addresses reforms related to the latter two types.

Three organizational arrangements are examples of potential reforms in many developing economies that could be combined with an energy price reform program. The first is the centralization of urban and rural grids in the electricity sector under the financial and managerial control of one state-owned utility. Related to the first, the second arrangement is the monopolization of power production by most national governments. The third is administered prices for the distribution and marketing of refined petroleum products.

In the electricity sector of developing economies, many parastatals serve both densely populated urban grids and remote rural areas. The rural areas typically have higher-cost supply sources such as small-scale diesel units. In many instances, the price of electricity in rural areas does not reflect its higher supply cost because of government policy promoting electricity use in rural areas. Subsidies exist for rural electricity consumers either for general development purposes or to promote irrigation in agricultural areas.

Since electric power parastatals are typically required to cover costs and generate funds for investment, the subsidy to rural consumers necessarily implies that urban consumers of electricity are paying substantially higher prices than would be the case if central grids were not extended to rural areas. In countries where there is social pres-

---

[6]The overall organization of the energy economy could be improved in many ways. For example, coordination and planning might be facilitated and improved through national energy planning councils, composed of representatives from both industry and the government.

sure to keep energy prices low, the cross-subsidy is a serious impediment to the attainment of financial solvency on the part of the electric parastatal.

As part of an energy price reform, it may be beneficial in some cases to consider disassociating the financial and managerial responsibility for rural grids from the central grid. This would serve both to relieve a persistent financial strain on the parastatals and to open up opportunities for decentralized and/or private sector initiatives to provide power in rural areas.

One alternative organizational form for rural systems is the cooperative. Cooperative-type arrangements, in which groups of current or potential electricity consumers in isolated areas organize electricity supply arrangements with the aid of low-cost financing, have had a history of success in electrifying relatively isolated regions of the developed world. They have also met with some success in developing economies.

In Costa Rica, cooperatives were established in the early 1960s with the assistance of the U.S. Agency for International Development. For the most part, the decentralized provision of electricity has met with success. Besides paying off their initial loans, the cooperatives currently provide electricity to about one-half of the households in their service territories and have been a stimulant for economic growth in these areas [Flavin (1986)].

In Bangladesh, a Rural Electrification Board (REB) was established to organize potential customers into formal groups--Palli Bidyut Samity

(PBS)--in a manner similar to the Rural Electrification Administration in the United States. The goal is to organize from 80 to 99 PBS's by the year 2005. As of the end of 1985, REB had approved the organization of 33 PBSs. Funding for REB is obtained from the government of Bangladesh and international assistance agencies. Ideally, after a power system is financed and constructed by REB, the power supply system and corresponding debt would be turned over to the PBS. After a 5-year grace period, a PBS is required to pay back the loan over a 25-year period at an annual interest rate of three percent. During the 5-year grace period, annual interest of 0.75 percent is capitalized [Deverick et al. (1986)].

Another solution to electrification of remote areas in many countries is to promote private sector initiatives. A number of policy alternatives are available. Industrial autogenerators of electricity for plant uses could be provided tax or other financial incentives to create or expand small-scale grids to serve not only their own electric power needs but household and other development needs in remote areas. If market and financial incentives were present together with appropriate institutional structures (to handle distribution and revenue collection, for example), private companies could be induced to construct generation and transmission systems, possibly in concert with foreign corporations in joint venture arrangements. Other firms in the private sector could be induced to supply power with enactment of legislation similar to the Public Utility Regulatory Policies Act of 1978 in the United States. Enactment of this legislation requires existing utilities to purchase power from non-utility generators at the utility's avoided cost of power.

Related to the first type of organizational reform, the efficiency of the electric power sector in many countries can be improved by eliminating the monopoly held by state-owned utilities in producing electricity. Presently, a parastatal typically has the sole legal authority to produce, transmit, and distribute electricity for urban grids in developing countries. Recently, however, some national governments have reevaluated this policy and are now allowing private sector participation in power generation through negotiated buy-back arrangements. The arrangements allow parastatals to purchase power at ostensibly lower production costs. In Turkey, for example, plans have been made for private investors to build and operate a 960-megawatt power plant. All the power will be sold to the government under long-term contract [Stevenson (1986)]. Similarly, in Pakistan, the government has recently reevaluated its policy of not allowing private power production by soliciting proposals for the construction of generating capacity at Hub Chowki, a new industrial zone near Karachi. Under the arrangement outlined in the proposal, the government will guarantee purchase of the power with a minimum capacity factor of 50 percent [Bever and Allawalah (1986)].

Looking toward the longer term, the third candidate for organizational reform is deregulation of at least a portion of the petroleum sector to improve the capability of suppliers to set prices and improve efficiency without external intervention. In many developing economies, wholesale sales of petroleum products are controlled by the government. Control is exerted either by requiring all petroleum products to be purchased from a state-owned refinery or by requiring a state-owned petroleum corporation to be the sole importer of refined products. However,

the distribution and marketing functions are typically performed by multinational oil companies with varying degrees of participation by host governments. State control of distribution and marketing is manifested in two different ways. First, in many cases, refined products are allocated by the government. Therefore, market shares are determined by fiat. Second, retail product prices are controlled by the government. The typical approach is to allow marketers to recover all costs of operations plus a prespecified profit margin.

In many countries, it may be more efficient to allow market forces to determine retail product prices in place of government price controls. By deregulating retail prices, marketers' margins would not be determined by fiat, but would be based on the relative efficiency of firms involved in marketing products. In addition, it may be beneficial to disenfranchise the monopoly that state-owned petroleum companies generally have in either importing refined products or allocating products from state-owned refineries. As discussed in the previous section, one of the most significant problems with petroleum supply arrangements in some developing countries is inefficient petroleum procurement arrangements. Allowing private firms to secure petroleum--either from a state-owned refinery or from foreign sources--would provide a more competitive petroleum market with a greater chance for enhancements in long-run efficiency.

4. CONCLUSION

During the period of precipitous increases in the international price of petroleum in the last decade, objectives other than those based on strict economic criteria have taken precedence in the energy pricing policies of many developing countries. The discussion in Chapter 2 provided an indication of the pervasiveness of energy pricing problems in developing economies. In the electricity sector of the 37 countries under consideration, 30 countries were experiencing problems with the level of electricity tariffs and 32 with the structure of those tariffs. In the petroleum sector, the corresponding numbers of countries were 20 and 33.

Recently, policymakers in developing countries have been forced to reevaluate their energy pricing policies, placing more emphasis on economic criteria in setting energy prices. The challenge confronting those who prescribe energy price reform programs in developing economies is not only to ensure that energy prices are based on sound economic principles, but also to consider economic and sociopolitical realities as well. In most cases, these realities preclude instantaneous adjustment to "correct" energy prices.

Because circumstances are unique in each developing country, it is not possible to provide a "blueprint" for energy price reform. However, the discussion in this report outlined a general program for commercial energy price reform, considering the sociopolitical and economic realities that confront policymakers in developing countries. Concisely, energy price reform is more likely to occur if it takes shape as a balanced, politically realistic set of simultaneous and related actions.

The focal point of the reform program is that changes in energy prices to cost-based levels should ordinarily be a gradual process. The adverse economic and sociopolitical effects of changing to cost-based commercial energy prices can be mitigated by measures designed to both reduce the cost of supplying energy and increase the efficiency of energy use. Additionally, over the longer term, organizational changes can potentially increase the efficiency of the energy sector in many developing economies, thereby also mitigating the adverse impacts of adjusting to "correct" energy prices.

REFERENCES

Ali, Gauhar, 1986, "Pakistan: Energy Pricing Issues and Reforms," Presented at the NEA/IAEE Regional Conference on Energy Planning in South and Southeast Asia, Bangkok, Thailand, May 30-June 3.

Baumol, William J. and David F. Bradford, 1970, "Optimal Departures from Marginal Cost Pricing," American Economic Review, June.

Bennathan, Esra and A.A. Walters, 1979, Port Pricing and Investment Policy for Developing Countries, Oxford University Press, New York.

Bever, James A. and Anjum Ahmad, 1986, "Pakistan Power Sector Conservation," Presented at the Asia and Near East Workshop on Energy Conservation and Private Power Generation, Bangkok, Thailand, September 29-October 3.

Bever, James A. and Abdul Khaliq Allawalah, 1986, "Pakistan: Hub Chowki Oil-Fired Power Station," Discussion at the Asia and Near East Workshop on Energy Conservation and Private Power Generation, Bangkok, Thailand, September 29-October 3.

Brown, Stephen J. and David S. Sibley, 1986, The Theory of Public Utility Pricing, Cambridge University Press, New York.

Crew, Michael A. and Paul R. Kleindorfer, 1979, Public Utility Economics, St. Martin's Press, New York.

deLucia, Russell J. and Michael C. Lesser, 1985, Developing Country Fuel Pricing Policies I: A Discussion of Issues Associated with Retail Pricing Policies, International Development Research Centre.

deLucia, Russell J. and Michael C. Lesser, 1985, "Energy Pricing Policies in Developing Countries," Energy Policy, August.

deLucia, Russell J., 1985, Developing Country Fuel Pricing Policies II: A Discussion of Issues Associated with Wholesale Pricing Policies, International Development Research Centre.

Desai, V.V. and Kari Nyman, 1986, "Industrial Energy Conservation: Notes on Three Country Studies," Presented at the Asia and Near East Workshop on Energy Conservation and Private Power Generation, Bangkok, Thailand, September 29-October 3.

Deverick, Barbara, Mark Gellerson, John Stovall, and Robert Shelton, 1986, Rural Electrification in Bangladesh: Management, Engineering, and Financial Assessment, Oak Ridge National Laboratory, Oak Ridge, Tennessee, ORNL/TM-10042, July.

Flavin, Christopher, 1986, Electricity for a Developing World: New Directions, Worldwatch Institute, Washington, D.C., Paper 70, June.

Hak, Shahid K., 1986, "Energy Pricing in Pakistan," Presented at the NEA/IAEE Regional Conference on Energy Planning in South and Southeast Asia, Bangkok, Thailand, May 30-June 3.

Heron, A., 1985, "Financing Electric Power in Developing Countries," IAEA Bulletin, Winter.

Jhirad, David, Edward Hillsman, and Pirooz Sharafi, 1986, "Innovative Approaches to Electric Power Delivery in Developing Countries," Presented at the Asia and Near East Workshop on Energy Conservation and Private Power Generation, Bangkok, Thailand, September 29-October 3.

Johnson, M.B. and R.W. Clower, 1981, The Problem of Second Best and the Efficient Pricing of Electricity, Electric Power Research Institute, Palo Alto, California, EPRI EA-1852-SR, May.

Julius, D., 1986, "Domestic Pricing of Petroleum Products: Efficiency and Equity Impacts in Developing Countries," OPEC Review, April.

Julius, D., H. Ribe, S. Fathi, and K. Jechoutek, 1986, "Petroleum Product Pricing in Developing Countries," Paper presented at the NEA/IAEE Regional Conference on Energy Planning in South and Southeast Asia, Bangkok, Thailand, May 30-June 3.

Krapels, Edward N., 1982, Pricing Petroleum Products: Strategies of Eleven Industrial Nations, McGraw-Hill, New York.

Krapels, Edward N., 1985, "Petroleum Pricing in Developing Countries," Presented at the USAID/ORNL seminar on energy policy research, Washington, D.C., June 14.

Krapels, Edward N,.1984, Fuel for the Engine of Growth, Manuscript.

Meier, Gerald M., 1983, Pricing Policy for Development Management, World Bank, Washington, D.C.

Munasinghe, Mohan, 1980, "An Integrated Framework for Energy Pricing in Developing Countries," Energy Journal, July.

Munasinghe, Mohan, 1985, Energy Pricing and Demand Management, Westview Press, Boulder, Colorado.

Munasinghe, Mohan and Rungta, S., 1984, Costing and Pricing Electricity in Developing Countries, Manila, Philippines: Asian Development Bank.

Munasinghe, Mohan and Gunter Schramm, 1983, Energy Economics, Demand Management, and Conservation Policy, Van Nostrand Reinhold Company, New York.

Munasinghe, Mohan and J.J. Warford, 1982, Electricity Pricing, Johns Hopkins University Press, Baltimore, Maryland.

Pestano, Armando I., 1986, "Petroleum Product Pricing in the Philippines," Presented at the NEA/IAEE Regional Conference on Energy Planning in South and Southeast Asia, Bangkok, Thailand, May 30-June 3.

Ramsey, F.P., 1927, "A Contribution to the Theory of Taxation," The Economic Journal, March.

Sabadell, Alberto J., David L. Greene, and Jeffry J. Erickson, 1986, "Transportation Energy Conservation," Presented at the Asia and Near East Workshop on Energy Conservation and Private Power Generation, Bangkok, Thailand, September 29-October 3.

Saunders, Robert J. and Karl Jechoutek, 1985, "The Electric Power Sector in Developing Countries," Energy Policy, August.

Siddayao, Corazon Morales, Editor, 1985, Criteria for Energy Pricing Policy, A Collection of Papers Commissioned for the Energy Pricing Policy Workshop, Bangkok, Thailand, 8-11 May 1984, Graham and Trotman, London.

Stevenson, William, 1986, "Turkey: Tekirdag Coal-Fired Power Project--Overview and Summary," Presented at the Asia and Near East Workshop on Energy Conservation and Private Power Generation, Bangkok, Thailand, September 29-October 3.

UNDP/World Bank, 1981, Indonesia: Issues and Options in the Energy Sector, Washington, D.C., Report No. 3543-IND, November.

UNDP/World Bank, 1982a, Kenya: Issues and Options in the Energy Sector, Washington, D.C., Report No. 3800-KE, May.

UNDP/World Bank, 1982b, Sri Lanka: Issues and Options in the Energy Sector, Washington, D.C., Report No. 3792-CE, May.

UNDP/World Bank, 1982c, Zimbabwe: Issues and Options in the Energy Sector, Washington, D.C., Report No. 3765-ZIM, June.

UNDP/World Bank, 1982d, Haiti: Issues and Options in the Energy Sector, Washington, D.C., Report No. 3672-HA, June.

UNDP/World Bank, 1982e, Burundi: Issues and Options in the Energy Sector, Washington, D.C., Report No. 3778-BU, June.

UNDP/World Bank, 1982f, Rwanda: Issues and Options in the Energy Sector, Washington, D.C., Report No. 3779-RW, June.

UNDP/World Bank, 1982g, Malawi: Issues and Options in the Energy Sector, Washington, D.C., Report No. 3903-MAL, August.

UNDP/World Bank, 1982h, Bangladesh: Issues and Options in the Energy Sector, Washington, D.C., Report No. 3783-BD, October.

UNDP/World Bank, 1983a, Zambia: Issues and Options in the Energy Sector, Washington, D.C., Report No. 4110-ZA, January.

UNDP/World Bank, 1983b, Bolivia: Issues and Options in the Energy Sector, Washington, D.C., Report No. 4213-BO, April.

UNDP/World Bank, 1983c, Fiji: Issues and Options in the Energy Sector, Washington, D.C., Report No. 4462-FIJ, June.

UNDP/World Bank, 1983d, Senegal: Issues and Options in the Energy Sector, Washington, D.C., Report No. 4182-SE, July.

UNDP/World Bank, 1983e, Sudan: Issues and Options in the Energy Sector, Washington, D.C., Report No. 4511-SU, July.

UNDP/World Bank, 1983f, Uganda: Issues and Options in the Energy Sector, Washington, D.C., Report No. 4453-UG, July.

UNDP/World Bank, 1983g, Nepal: Issues and Options in the Energy Sector, Washington, D.C., Report No. 4474-NEP, August.

UNDP/World Bank, 1983h, Gambia: Issues and Options in the Energy Sector, Washington, D.C., Report No. 4743-GM, November.

UNDP/World Bank, 1984a, Peru: Issues and Options in the Energy Sector, Washington, D.C., Report No. 4677-PE, January.

UNDP/World Bank, 1984b, Costa Rica: Issues and Options in the Energy Sector, Washington, D.C., Report No. 4655-CR, January.

UNDP/World Bank, 1984c, Lesotho: Issues and Options in the Energy Sector, Washington, D.C., Report No. 4676-LSO, January.

UNDP/World Bank, 1984d, Morocco: Issues and Options in the Energy Sector, Washington, D.C., Report No. 4157-MOR, March.

UNDP/World Bank, 1984e, Portugal: Issues and Options in the Energy Sector, Washington, D.C., Report 4824-PO, April.

UNDP/World Bank, 1984f, Niger: Issues and Options in the Energy Sector, Washington, D.C., Report No. 4642-NIR, May.

UNDP/World Bank, 1984g, Ethiopia: Issues and Options in the Energy Sector, Washington, D.C., Report 4741-ET, July.

UNDP/World Bank, 1984h, Cape Verde: Issues and Options in the Energy Sector, Washington, D.C., Report No. 5073-CV, August.

UNDP/World Bank, 1984i, Guinea-Bissau: Issues and Options in the Energy Sector, Washington, D.C., Report No. 5083-GUB, August.

UNDP/World Bank, 1984j, Botswana: Issues and Options in the Energy Sector, Washington, D.C., Report No. 4998-BT, September.

UNDP/World Bank, 1984k, Paraguay: Issues and Options in the Energy Sector, Washington, D.C., Report No. 5145-PA, October.

UNDP/World Bank, 19841, Tanzania: Issues and Options in the Energy Sector, Washington, D.C., Report No. 4969-TA, November.

UNDP/World Bank, 1984m, Yemen Arab Republic: Issues and Options in the Energy Sector, Washington, D.C., Report No. 4892-YAR, December.

UNDP/World Bank, 1984n, Liberia: Issues and Options in the Energy Sector, Washington, D.C., Report No. 5279-LBR, December.

UNDP/World Bank, 1985a, Islamic Republic of Mauritania: Issues and Options in the Energy Sector, Washington, D.C., Report No. 5224-MAU, April.

UNDP/World Bank, 1985b, Jamaica: Issues and Options in the Energy Sector, Washington, D.C., Report No. 5466-JM, April.

UNDP/World Bank, 1985c, Togo: Issues and Options in the Energy Sector, Washington, D.C., Report No. 5221-TO, June.

UNDP/World Bank, 1985d, Burma: Issues and Options in the Energy Sector, Washington, D.C., Report No. 5416-BA, June.

UNDP/World Bank, 1985e, Thailand: Issues and Options in the Energy Sector, Washington, D.C., Report No. 5793-TH, September.

UNDP/World Bank, 1985f, Ecuador: Issues and Options in the Energy Sector, Washington, D.C., Report No. 5865-EC, December.

World Bank Energy Department, 1981, Energy Pricing in Developing Countries: A Review of the Literature, Washington, D.C., Energy Department Paper No. 1, September.

APPENDIX A

CONCEPTUAL FOUNDATIONS OF ENERGY PRICING: A CANDIDATE SET OF TARGET PRICES

A.1. INTRODUCTION

Chapter 3 presented a general framework for energy price reform in the context of energy planning. Computing a set of target energy prices is the first step in the suggested approach to price reform. The discussion in this appendix and Appendix B addresses the computation of target prices in detail.

This appendix develops the conceptual foundations for determining a set of target energy prices, given the constraints imposed on an energy-supplying parastatal in a developing economy. The suggested approach to calculating target prices is called welfare-optimal break-even pricing. The prices computed under this approach are a "second-best" solution for determining energy prices in a market-oriented economy. A "first-best" solution--strict adherence to marginal cost pricing--is inconsistent with requirements that energy prices be (1) at a level sufficient to maintain the financial solvency of the parastatal, (2) a source of tax revenue for the government, and (3) a means to redistribute income in the economy.

A.2. DETERMINATION OF TARGET PRICES

Under ideal conditions, economic welfare is maximized when the price of every good and service produced and consumed in an economy is equated to its marginal cost of production. Marginal cost prices are optimal and efficient because they equate the marginal resource cost of producing an additional unit of output with the marginal benefit that

consumers receive from that additional unit. Therefore, resources used in producing goods and services are attracted to their most economic use. The most economic use of resources is defined by the preferences that consumers adopt for the range of available goods and services.

Marginal cost pricing is the first-best solution for allocating resources in an economy. To illustrate this, consider a commodity that has a price-responsive demand and currently is priced above its marginal cost of production. In this circumstance, too little of the good will be produced and consumed because the additional benefit to consumers of producing one more unit of the commodity--as defined by their demand--is greater than the additional cost of producing it, signaling a desire for increased output of the commodity. A decrease in the price of the commodity to its marginal cost of production will increase production and consumption, enhancing consumers' welfare. The converse is true if the price of a commodity is set below its marginal production cost.

However, the economic welfare-optimizing properties of marginal cost pricing are based on a highly restrictive set of conditions. In real-world settings, these conditions are typically not satisfied. The most restrictive condition is that there be no impediments to marginal cost pricing in any sector of the economy. That is, the economic welfare-enhancing properties of marginal cost pricing in one sector of the economy--the electricity sector, for example--are based on the assumption that the prices of inputs purchased by that sector are also set on the basis of marginal cost.

There are numerous examples of market distortions that cause deviations from marginal cost pricing in some sectors of real-world econo-

mies. Any type of tax imposed by the government (except a lump sum tax) will cause prices to deviate from their marginal costs. Monopoly power in one or more sectors of the economy implies that prices will not equal marginal cost in these sectors. An externality that is not accounted for in the cost of production of a commodity also implies that price generally will not equal the true marginal cost of production.

Distortions in an economy, causing prices in some sectors to deviate from marginal cost, have led to a considerable amount of research on the formulation of "second-best" pricing systems. A second-best solution is sought in cases where economic conditions do not allow first-best--or marginal cost--pricing solutions.

A special case of second-best pricing rules can be applied to sectors of an economy in which public enterprises are required to generate net revenues from operations sufficient to cover all costs of operations. In many cases, marginal cost prices will not provide the enterprise with the required net revenue to maintain financial solvency. An example is a public enterprise in the energy sector whose production is characterized by declining costs.

The second-best approach to public enterprise pricing is called quasi-optimal break-even analysis. Under this pricing system, the problem of ensuring that the public enterprise maintains its financial integrity is solved directly by specifying the amount of net revenues that the enterprise requires as a return to capital or as internally generated funds for investment purposes. It can be shown that determining prices subject to the financial constraint--a break-even constraint--is quasi-optimal. Although the first-best criterion--marginal cost pric-

ing--cannot be met, prices set in this manner are the most economically efficient second-best prices.[1]

Besides including an explicit financial constraint to ensure the solvency of public enterprises, this pricing approach is appropriate for determining efficient energy prices under other constraints in developing economies. The most prominent of these constraints is the requirement that energy be taxed to generate funds for the treasury. Since the roots of quasi-optimal breakeven analysis are in optimal taxation, the approach lends itself well to determining optimal taxes on energy, given the necessity to generate a prespecified amount of tax revenue. Also, efficient energy prices can be determined in this framework under the constraint of a government policy to subsidize one or more energy products.

To demonstrate the calculation of energy pricing by a public enterprise under a break-even constraint, consider an enterprise that produces n goods and confronts n inverse demand functions, $P_i(Q)$ (i= 1,...n), for those goods. Economic welfare, W, for the consumers of these goods can be expressed in terms of net consumers' surplus:

[1]Another solution to the problem of ensuring financial integrity is embedded or average cost, rate-of-return regulation. Under this approach, the firm is allowed to price its output at a level sufficient to generate revenues that will cover all incurred costs of operations plus a fair return on its invested capital. This type of regulation ensures that, even if the firm is in a declining cost industry, it can still maintain its financial integrity. The prices for individual commodities or services produced by the firm are based on their average or embedded cost of production. In the United States, for example, this approach is generally used in regulation of natural gas and electric utilities. It can be shown, however, that the quasi-optimal breakeven approach is more welfare-enhancing for public enterprise pricing.

$$W(Q) = \int_0^Q \sum_1^n P_i(Q)dQ_i - C(Q) \ , \tag{A.1}$$

where Q = vector of commodities produced by the firm,

P_i = price of commodity i, $i=1,\ldots n$, and

C = cost function.

The net revenue that the enterprise must generate can be expressed in terms of a profit function, π:

$$\pi(Q) = \sum_1^n Q_i P_i(Q) - C(Q) \geq \pi_0 \ . \tag{A.2}$$

Equation (A.2) is the break-even constraint for the enterprise. Total revenues must exceed the total cost of production by at least π_0, the prespecified amount of net revenues.

The first-order pricing conditions are obtained by maximizing welfare, subject to the constraint that the enterprise generates the prespecified amount of profit:

$$L(Q,\delta) = W(Q) - \delta[\sum_1^n Q_i P_i(Q) - C(Q) - \pi_0] \ . \tag{A.3}$$

By taking the partial derivative of L with respect to any commodity Q_i and rearranging terms, the first-order conditions for pricing commodity i can be expressed as follows:

$$P_i(Q) - MC_i(Q) = \delta[MR_i(Q) - MC_i(Q)] \ , \tag{A.4}$$

where MC and MR are the marginal cost and marginal revenue of commodity i, respectively.

Given that the profit constraint in equation (A.2) is binding, the first-order condition in equation (A.4) states that, under quasi-optimal pricing, the difference between the price and marginal cost of any commodity produced by the enterprise must be proportional (the multiplier δ) to the difference between its marginal revenue and marginal cost.

The relationship in equation (A.4) provides the optimal pricing structure when demands are interdependent; that is, the cross-price elasticities of demand for commodities are non-zero. If there is negligible dependency between the demands for commodities produced by the enterprise--that is, $P_i(Q) = P_i(Q_i)$--equation (A.4) reduces to the following:

$$\left[\frac{P_i - MC_i}{P_i}\right] = \left[\frac{\delta}{1+\delta}\right]\frac{1}{\varepsilon_i} \quad , \tag{A.5}$$

where ε_i is the own-price elasticity of demand for commodity i. Equation (A.5) provides the inverse elasticity rule for efficient pricing. The percentage deviation of price from marginal cost for any commodity i is inversely proportional to the own-price elasticity of demand for that commodity.

The relationship between the prices of any two commodities, i and j, can be derived from equation (A.5) as:

$$\left[\frac{P_i - MC_i}{P_i}\right] \varepsilon_i = \left[\frac{P_j - MC_j}{P_j}\right] \varepsilon_j = \alpha \ , \qquad (A.6)$$

where $\alpha = (\delta/1+\delta)$. The relationship in equation (A.6) states that, for efficient, constrained energy pricing, the percentage deviation of price from marginal cost for any two commodities produced by the enterprise--weighted by their own-price demand elasticities--should be equal to the constant α. The constant is used as the basis for setting relative prices at a level in which the enterprise generates a predetermined amount of net revenue.[2]

Equation (A.6) implies that commodities with lower price elasticities of demand--that is, relatively more price inelastic--will have higher percentage markups from marginal cost relative to other commodities. In the case where all own-price elasticities are equal, each commodity sold by the enterprise should have the same percentage mark-up from marginal cost.

Besides providing the relationship between prices of commodities produced by a public enterprise to attain a revenue target, the relationship in equation (A.6) also provides the basis for determining (1) optimal taxation of the commodities, (2) optimal pricing when the price of one of the commodities is fixed or subsidized, and (3) multipart tariffs--peak-load electricity prices, for example. These pricing considerations will be discussed in Appendix B.

---

[2]The proportionality constant α is often referred to as the Ramsey number, named for Frank Ramsey whose 1927 article on optimal taxation is the basis for computing quasi-optimal prices under this approach. The resulting prices are also called Ramsey prices.

APPENDIX B

TECHNICAL ISSUES IN DETERMINING TARGET PRICES

B.1. INTRODUCTION

Appendix A presented the conceptual foundations for computing a candidate set of target energy prices. This appendix expands on the conceptual discussion by addressing pragmatic issues that are important in actual energy pricing studies. Four topics are discussed in the appendix.

First, a set of Ramsey prices is calculated using hypothetical data. Also, data requirements for pricing studies using this approach are discussed. Second, the calculation of Ramsey prices is expanded by incorporating taxes and subsidies in the determination of efficient prices. Third, the downstream effects of a higher level of energy prices is discussed. Fourth, the concept of cost is addressed. A distinction is made between financial costs and economic costs and their applicability in determining energy prices.

B.2. COMPUTING RAMSEY PRICES

Three types of information are required to calculate Ramsey prices: (1) the demand for energy by customer class; (2) the marginal costs of serving the customer classes; and (3) the financial requirements of the public enterprise.

In most applications, the most difficult piece of information to acquire is the demand structure of the various customer classes served by the enterprise. At a minimum, the own-price elasticities for each of the customer classes must be estimated. Since a parastatal may not rou-

tinely collect information of this type, a market analysis may have to be conducted. The marginal or attributable cost[1] for each class of service usually can be obtained from the accounting records of the enterprise. Financial requirements are fixed costs or any other cash flow requirements of the parastatal. For example, many parastatals have target returns to finance replacement or expansion of their supply system.

The use of this information in calculating Ramsey prices can be illustrated with a simple example. Figure B.1 presents a graphical characterization of the demand curves for three goods sold by a public enterprise, along with their associated marginal costs of production. To simplify the analysis, it is assumed that the marginal cost of production is constant and equal for all three goods.[2] The demand curves for the three goods in Figure B.1 have the following general form:

$$Q_i = \delta_i P_i^{-\varepsilon_i} \quad , \quad i=1,2,3, \tag{B.1}$$

where Q_i = quantity demanded of i,

δ_i = scale factor of i,

P_i = price of i, and

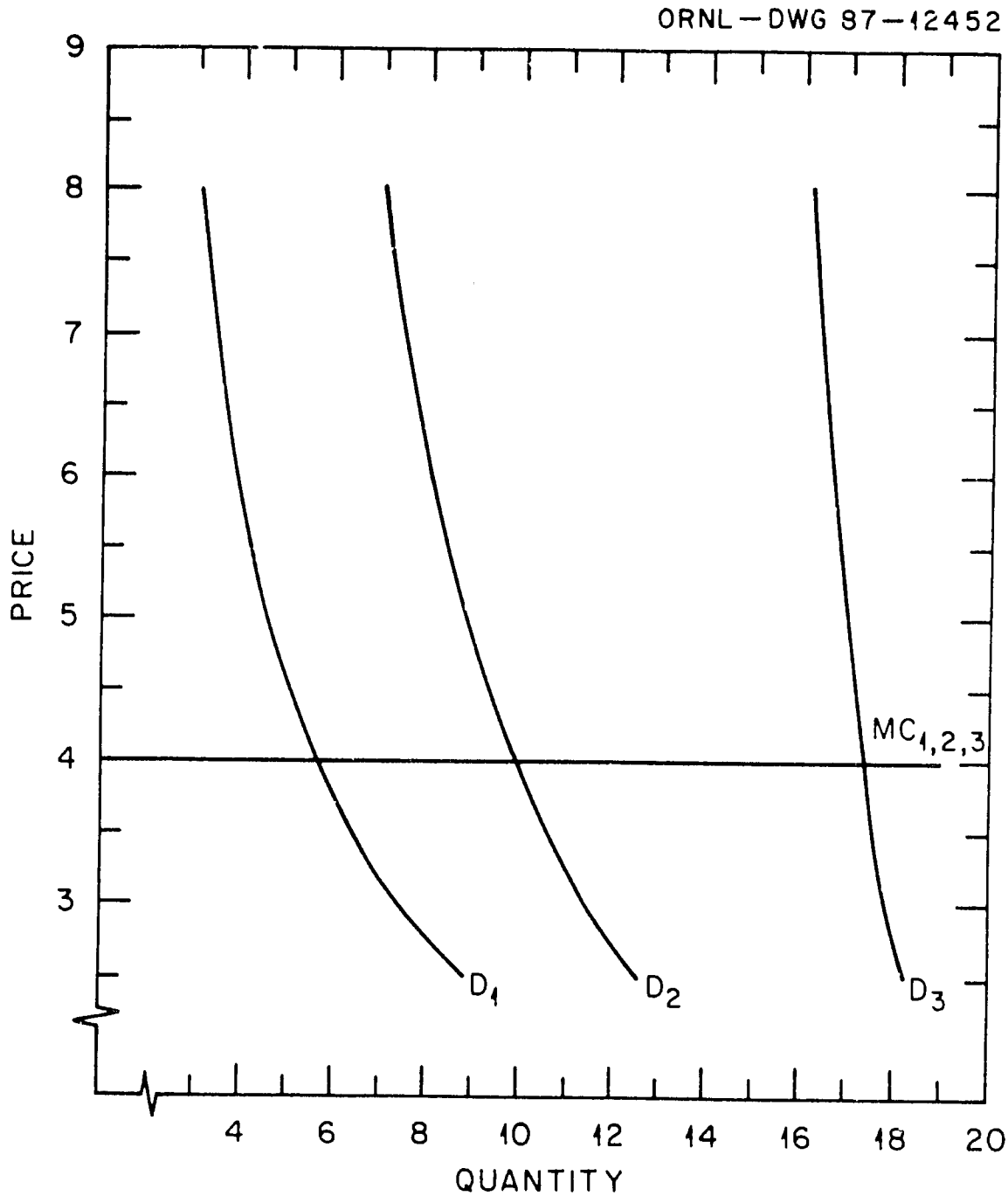
ε_i = elasticity of demand for i.

The own-price elasticity of demand for the three goods specified in equation (B.1) is constant across all output levels. Goods 1, 2, and 3 have own-price elasticities of -0.9, -0.5, and -0.1, respectively. The

[1]Attributable cost is simply the portion of total cost that can be assigned directly to a given class of service. Metering costs for residential consumers are an example of attributable costs.

[2]Constant and equal marginal costs for the three goods were assumed to simplify the analysis. Unequal and decreasing or increasing marginal cost could have been assumed at the expense of sacrificing computational simplicity.

Figure B.1
Demand and Cost Curves
Ramsey Pricing Example



scale factor, δ, is assumed to be 20 for the three goods. From the specification in equation (B.1), it is also assumed that there are no significant cross-price effects for the three commodities.[3]

Figure B.1 shows that, if price were set equal to the marginal cost of production ($4.00) for the goods, the output levels for goods 1, 2, and 3 would be 5.7, 10.0, and 17.4, respectively. Under this circumstance, the net revenues of the firm would be zero.

Assume now that, in addition to the marginal or attributable costs of production, there are also fixed costs or net revenue requirements of $25 that the firm must generate in addition to covering the attributable costs of production. Net revenue requirements, π_0, are calculated as the excess of revenues over costs:

$$\sum_{i=1}^{3} (P_i - MC_i)Q_i = \pi_0 \ , \tag{B.2}$$

where MC_i is the marginal or attributable cost of producing i.

Equation (A.6) in Appendix A showed that the first order conditions for efficient prices of n commodities sold by a public enterprise under a net revenue constraint are:

$$\left[\frac{P_i - MC_i}{P_i} \right] \varepsilon_i = \alpha \ , \quad i=1, \ldots n \ . \tag{B.3}$$

Rearranging equation (B.3), the P_i can be expressed as

---

[3]Here again, the assumption was invoked for computational simplicity.

$$P_i = \frac{\varepsilon_i MC_i}{\varepsilon_i - \alpha} \quad . \tag{B.4}$$

Substituting equations (B.1) and (B.4) into equation (B.2), the following expression is obtained:

$$\sum_{i=1}^{3} \frac{\alpha\delta_i}{\varepsilon_i} \left[\frac{\varepsilon_i MC_i}{\varepsilon_i - \alpha} \right]^{1-\varepsilon_i} = \pi_0 \quad . \tag{B.5}$$

Equation (B.5) shows that the last piece of information required to calculate efficient prices is the proportionality constant or Ramsey number, α, that will yield the desired net revenues or fixed costs, π_0.

In the current problem, where π=\$25, the calculated Ramsey number is .02481 (that is, α=.02481). Using equation (B.3), the following relationship holds for the three commodities:

$$\left[\frac{4.11-4.00}{4.00}\right] .9 = \left[\frac{4.21-4.00}{4.00}\right] .5 = \left[\frac{5.32-4.00}{4.00}\right] .1 = .02481 \quad . \tag{B.6}$$

The relationship in equation (B.6) shows that the percentage deviation of the quasi-optimal price from marginal cost--weighted by the price elasticity of demand--is equal to the Ramsey number (α=.02481) for all three commodities. The Ramsey number was computed from equation (B.5) to generate \$25 in net revenues for the firm.

Table B.1 summarizes the results of setting prices to generate \$25 in net revenues for the firm. An important characteristic of Ramsey pricing is the extent to which each of the goods contributes to gener-

Table B.1
Calculation of Ramsey Prices
Net Revenue Constraint

Good	ε[a]	P[b]	Q[c]	Revenues	Cost	Net
1	-.9	$4.11	5.6	$23.1	$22.4	$0.7
2	-.5	$4.21	9.7	$41.0	$39.0	$2.0
3	-.1	$5.32	16.9	$90.0	$67.7	$22.3
				$154.1	$129.1	$25.0

[a]Elasticity of demand
[b]Price
[c]Quantity

ating the prespecified amount of net revenues. In this example, the good with the lowest price elasticity of demand contributes the most to generation of the net revenues. Good 3 with a price elasticity of demand of -0.1 contributed $22.3 in comparison with good 1 which contributed only $0.7.

This result follows directly from equation (B.6), which shows that the percentage mark-up of price from marginal cost is the largest for goods with the lowest price elasticity. This characteristic of Ramsey pricing precludes the need to allocate fixed costs to various classes of service in setting rates. That is, under a typical public enterprise pricemaking procedure with multiple classes of service, fixed costs must be allocated to various customer classes. Many categories of costs cannot be allocated on the basis of sound economic principles. These

costs, therefore, are somewhat arbitrarily allocated.[4] Under Ramsey pricing, fixed costs or net revenues are allocated directly. Each customer class shares in generating fixed costs on the basis of its own-price elasticity of demand.

A number of assumptions were invoked in the example to facilitate computation. As noted above, two of the assumptions--a constant own-price elasticity of demand function with negligible cross-price effects and a constant marginal cost function--can be relaxed at the expense of sacrificing computational simplicity. In real-world settings, a number of other considerations may further complicate calculation of Ramsey prices.

In the example, it was implicitly assumed that each of the three goods had a uniform price or tariff. A uniform or one-part tariff is one in which the price does not vary with the quantity consumed. In real-world settings, it may be desirable to differentiate consumers within a given class of service on the basis of some common attributes. For example, it may be desirable to differentiate electricity consumers on the basis of peak and off-peak users. Multi-part tariffs can be incorporated in the Ramsey framework by simply defining separate demand and cost characteristics for consumers differentiated on the basis of these attributes.

---

[4]This problem is particularly acute in the typical rate-of-return regulation imposed on electric and natural gas utilities in the United States. Rates for individual customer classes are based on the embedded (or average) cost of serving those customers. While many of the costs of production are easily allocable to customer classes--metering costs, for example--others are more difficult to apportion. In many instances, arbitrary methods are chosen. A good example of these types of costs is base-load capacity costs of an electric utility which must be apportioned to various customer classes.

In real-world settings, customer classes can often be distinguished geographically. For example, a country may have one electric power parastatal serving both a central grid in a large urban area and one or more rural grids in remote areas. The cost of serving urban and rural customers may vary also. For example, production of electricity for the urban grid may rely on extensive use of relatively less expensive hydropower, while production for the rural grid may rely on relatively more expensive small-scale, diesel units. The Ramsey framework can accommodate that situation. The procedure is simply to specify more classes of service with different cost and demand functions.

B.3. TAXES AND SUBSIDIES

The discussion in Chapter 2 pointed out that excise taxes on energy products are a significant source of income for the general treasury of many developing economies. In general, petroleum products are more heavily taxed than other forms of energy. Conceptually, it may be possible to devise a set of taxes for a developing economy that places less emphasis on the taxation of energy products and services and is more welfare-enhancing than the existing array of income, sales, excise, import, and export taxes. As a practical matter, however, a global analysis of optimal taxation may not be feasible; even if it were, the recommendations may not be consistent with the government's approach to revenue generation In many instances, taxes on energy are relatively easy to administer and are relatively more enforceable than other types of taxes. Given the requirement of generating a certain amount of revenue from energy taxes in a developing economy, the most economically efficient method to distribute the tax burden among the products sold by

a public enterprise can be determined under the Ramsey pricing framework.

A similar argument holds for energy subsidies, which are widely used for income distribution and energy promotion purposes in developing economies. While it may be possible to devise a set of subsidies across the economy that are more welfare-enhancing than a kerosene subsidy, for example, political obstacles may preclude implementation. Again, Ramsey pricing provides a method to determine efficient prices, given a government's policy to subsidize one or more energy products.

The remainder of this section will explore Ramsey prices under tax and subsidy constraints. Two examples, with the same demand and cost specifications used in the preceding section, will be used to illustrate the procedure.

In the first example, it is assumed that the government wants to generate $25 in taxes for the general treasury from the sale of energy in addition to generating $25 to cover the net revenue requirements of the public enterprise. The latter assumption is the same as that used in the example of the preceding section.

Using the relationship in equation (B.5), the problem is to find the Ramsey number that generates net revenues of $50 ($\pi$=50). In this case, the calculated Ramsey number is .0408. Similar to equation (B.6), the following relationship holds:

$$\left[\frac{4.19-4.00}{4.00}\right] .9 = \left[\frac{4.36-4.00}{4.00}\right] .5 = \left[\frac{6.76-4.00}{4.00}\right] .1 = .0408 . \qquad \text{(B.7)}$$

The results are summarized in Table B.2. In this example, the contributions to the fixed costs of the firm and the tax revenues of the treasury by the three commodities are based on their relative own-price elasticities of demand. Good 3 with an elasticity of -0.1 contributes $45.6 of the $50 in net revenues, while commodity 1 with an elasticity of -0.9 contributes $1.0 of the total.

Table B.2
Calculation of Ramsey Prices
Tax Case

Good	ε[a]	P[b]	Q[c]	Revenues	Cost	Net
1	-.9	$4.19	5.5	$23.1	$22.1	$1.0
2	-.5	$4.36	9.6	$41.7	$38.3	$3.4
3	-.1	$6.76	16.5	$111.7	$66.1	$45.6
				$176.5	$126.5	$50.0

[a]Elasticity of demand
[b]Price
[c]Quantity

Suppose that, as a matter of policy, the price of commodity 3 is fixed at $3.50 per unit--a subsidy of $0.50 per unit. Further suppose that the firm wants to generate fixed costs of $25 from current operations. The problem is to derive the prices of goods 1 and 2 so as to cover both the fixed costs of the firm and the deficit incurred because of the subsidy of good 3.

Using the demand curve for good 3 ($Q_3=20P^{-.1}$), the quantity demanded at $3.50 per unit is 17.6 and, given the marginal cost of $4.00 per unit, the deficit created by the subsidy is $8.8. Using equation (B.5) for commodities 1 and 2, the problem is to find α such that $33.8

of net revenues will be generated--$25 in fixed costs and $8.8 attributable to the cross-subsidy of commodity 3. For this problem the calculated Ramsey number is .2444. Similar to equation (B.7), the following relationship holds:

$$\left[\frac{5.49-4.00}{4.00}\right] .9 = \left[\frac{7.82-4.00}{4.00}\right] .5 = .2444 \ . \qquad \text{(B.8)}$$

The results are summarized in Table B.3. As with the other examples, the contributions to generating net revenues of $33.8--fixed costs of $25 and the $8.8 subsidy of commodity 3--from commodities 1 and 2 is based on their relative own-price elasticities. Commodity 2 with a price elasticity of -0.5 contributes $27.3 of the total, while commodity 1 with a price elasticity of -0.9 contributes $6.5.

Table B.3
Calculation of Ramsey Prices
Subsidy Case

Good	ε[a]	P[b]	Q[c]	Revenues	Cost	Net
1	-.9	$5.49	4.3	$23.7	$17.3	$6.4
2	-.5	$7.82	7.1	$55.9	$28.5	$27.4
3	-.1	$3.50	17.6	$61.8	$70.6	-$8.8
				$141.4	$116.4	$25.0

[a]Elasticity of demand
[b]Price
[c]Quantity

B.4. DOWNSTREAM EFFECTS

The discussion in Appendix A showed that, given a fixed net revenue target of energy producers, break-even pricing will maximize economic welfare. However, the problem of optimal energy pricing was cast in a partial equilibrium framework. That is, the energy sector of a developing economy was analyzed apart from other sectors in the economy. Interrelationships between households and the industrial/commercial sector--and their relationship to the energy sector--were not taken into account.

If downstream effects were considered, break-even prices may not be welfare optimal in a general equilibrium sense. The potential negative downstream effects induced by break-even pricing could more than offset the enhancement to welfare in sectors where it is implemented. For example, consider an economy comprised of an energy sector, a business sector, and a household sector. If both the business sector and the household sector consume energy--and the household sector purchases the output of the business sector--the impact of break-even pricing on general welfare is indeterminate without information on its effect on production in the business sector and demand in the household sector. This problem, of course, arises in proposing any type of energy pricing system.

There are two alternatives for dealing with downstream effects. The first is to phase in break-even prices over a period of time. The adjustment over time from current to break-even prices will ameliorate adverse short-term effects of energy price changes on consumers downstream from energy producers. The full impact of higher energy prices

on an energy-intensive industrial process, for example, would not be imposed immediately, but phased in over a number of years. Also, appropriate conservation or energy substitution measures can be taken during the adjustment period.

The second alternative is to cast the commercial energy pricing problem in a general equilibrium framework. One approach would be to maximize total consumers' welfare subject to production constraints and policy tools at the disposal of the government. In this case, both optimal prices and taxes could be obtained from solution of the modeling system. However, construction of a large-scale model often is neither feasible nor advisable in the developing country context. The amount of information required to construct a system of this type is a significant obstacle. Information requirements include knowledge of both the demand functions and the nature of production relationships in all sectors of the economy. Similar limitations exist even if the modeling system was confined to major energy users in the commercial and industrial sectors of the economy.

B.5. THE CONCEPT OF COST

In any economy, the financial or market cost of inputs used for production may differ from their real or opportunity cost because of the presence of market distortions. Some prominent distortions are wage and price controls, taxes, import and export duties, an overvalued currency attributable to exchange rate management, monopoly practices, externalities that are not internalized in the cost structure of firms, and credit controls for financing investment.

In the energy sector of developing economies, distortions in the cost of inputs may be particularly severe. The "shadow" price of foreign exchange and capital--the price that measures the real resource cost of these inputs--is typically greater than the market or financial price on which state-owned energy enterprises base their ratemaking and investment decisions. Energy firms are typically among the largest users of foreign exchange and capital in developing economies.

One approach to correct for these potentially large distortions in input prices is to compute cost-based energy prices on the basis of the economic opportunity cost of the inputs used in energy production. That is, the market or financial cost of all inputs used in production could be adjusted to correct for distortions in the economy. The calculated rates would then reflect the real resource cost of using energy.

Basing energy prices on the shadow values of inputs used in energy production could, in many countries, increase the marginal cost of producing energy by two or more times the financial or market cost, causing severe downstream adjustment problems for energy users. If shadow prices of inputs are used in the energy sector exclusively, downstream users of energy would be provided with distorted relative price signals. Downstream industries, for example, would be confronted with energy priced at its real resource cost, while other inputs--capital, labor, and materials--are priced at their financial or market cost. A similar argument can be made for other users of energy. In households, the stock of energy-using appliances used to produce household services--cooking and lighting, for example--will be priced at their financial or market cost, while their power sources are priced at economic cost.

An alternative to basing energy prices on the shadow price of inputs is to address the question of market distortions directly at the macroeconomic level. The problem with an overvalued currency should not be handled in the energy sector alone, but at the national level. A fixed or managed exchange rate system that leaves a large differential between the real cost of foreign exchange and the observed market cost should be addressed directly by exchange rate reform. Similarly, differences between the real cost of capital and the market cost should be handled by policies aimed at the root of the distortion--relaxation of credit controls, for example.

There are two other arguments against using the opportunity cost of inputs in calculating commercial energy prices. First, there are significant computational problems in determining the actual resource cost of inputs used in energy production. Besides capital and foreign exchange distortions, there are taxes, import duties, and unemployed or underemployed labor, among the many other possible distortions in a given economy. Second, computing energy prices using the shadow price of inputs could significantly increase the net revenues of energy supplying parastatals. It was assumed that the break-even prices would be calculated on the basis of the marginal financial cost of producing energy to generate a prespecified amount of net revenue as both a return to capital and an internal source of funds for replacement and expansion of the supply system. If energy prices were calculated on the basis of marginal resource cost of inputs rather than marginal financial cost, it is conceivable that the marginal cost of energy could be two or more times as large as the financial cost in many developing economies. Energy prices would reflect this differential. In such a case, rates

would have to be adjusted downward to prevent the parastatal from realizing excess profits.

INTERNAL DISTRIBUTION

1. H. Perez-Blanco
2. J. Christian
3. L. M. Cochran
4. T. R. Curlee
5. W. Fulkerson
6. D. L. Greene
7. G. R. Haddee
8-23. L. J. Hill
24. E. L. Hillsman
25. M. L. Johnson
26. D. W. Jones
27. R. Lee
28. F. C Maienschein
29. S. McConathy
30. R. D. Perlack
31. C. H. Petrich
32. S. Purucker
33. G. O. Rogers
34. R. D. Roop
35. G. G. Stevenson
36. P. J. Sullivan
37. T. J. Wilbanks
38. S. B. Wright
39. Central Research Library
40. Document Reference Section
41. Laboratory Records (RC)
42-43. Laboratory Records Dept.
44. ORNL Patent Section

EXTERNAL DISTRIBUTION

45. Dr. Jaime G. Carbonell, Associate Professor of Computer Science, Carnegie-Mellon University, Pittsburgh, PA 15213

46. Mr. David J. Jhirad, Office of Energy, U.S. Agency for International Development, SA-18, Room 509, Washington, DC 20523

47. Dr. Fritz R. Kalhammer, Vice President and Head of the Energy Management and Utilization Division, Electric Power Research Institute, Post Office Box 10412, Palo Alto, CA 94303

48. Dr. Roger E. Kasperson, Professor of Government and Geography, Graduate School of Geography, Clark University, Worcester, MS 01610

49. Dr. Richard L. Perrine, Professor of Engineering and Applied Sciences, Civil Engineering Department, Engineering I, Room 2066, University of California, Los Angeles, CA 90024

50. Mr. Alberto Sabadell, Office of Energy, U.S. Agency for International Development, SA-18, Room 509, Washington, DC 20523

51. Mr. James B. Sullivan, Office of Energy, U.S. Agency for International Development, SA-18, Room 509, Washington, DC 20523

52-56. Ms. Shirley Toth, Office of Energy, U.S. Agency for International Development, SA-18, Room 509, Washington, DC 20523

57-86. Technical Information Center, Oak Ridge, TN 37831

87. Office of the Assistant Manager for Energy Research and Development, Department of Energy, Oak Ridge Operations Office,Oak Ridge, TN 37831