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ENERGY PRICING SEMINAR

SOFIA, BULGARIA

December 3-5, 1991

Sponsored By:

U.S. Agency for International Development
Emerency Energy Program in Eastern and Central Europe

Conducted by:

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BULGARIA ENERGY PRICING SEMINAR

AGENDA
December 3-5, 1991

December 3	**INTERNATIONAL OIL PRICE FORMATION AND INFORMATION**
9:00 - 10:30	The World Oil Market -- Dr. Edward Krapels
10:45 - 11:00	Oil Price Information Sources -- Dr. Krapels
11:15 - 12:15	Presentation and Demonstration
	▪ Mr. Michael Peace, Reuters
Lunch	
2:00 - 4:00	Short and Medium-Term Oil Price Analysis & Forecasting
	(1) Fundamental Supply/Demand Approach - Dr. Krapels (2) "Technical" and Chartists
4:15 - 6:00	Other Energy Sources -- Dr. Krapels

December 4	**STRUCTURE AND COMPETITIVENESS IN ENERGY AND OIL MARKETS**
9:00 - 12:30	Internal Energy Market Structure and Competitiveness -- Dr. Donald Hertzmark
Lunch	
2:30 - 5:00	Trends in the Structure of the International Oil Industry -- Dr. Krapels

- production
- refining
- import/export
- marketing
- vertical integration

December 5	**REGULATING ENERGY PRICES: ALTERNATIVE APPROACHES**
9:00 - 10:30	Regulating Electricity Prices -- Dr. Hertzmark
10:45 - 12:00	Natural Gas Supply/Demand Outlook and European Gas -- Dr. Benjamin Schlesinger
Lunch	
1:00 - 3:00	Regulating Natural Gas Prices -- Dr. Schlesinger
3:30 - 5:30	U.S., European, Japanese and Developing Country Experiences in Regulating Oil Markets -- Dr. Krapels

SPEAKERS

Dr. Edward Krapels

Dr. Krapels is President of Energy Security Analysis, Inc. in Washington, D.C. He is a world-renown authority on the structure, operation, and dynamics of international petroleum markets and has extensive experience with energy/petroleum pricing systems in industrialized nations, as well as developing countries in Africa, Asia, and Latin America. Dr. Krapels specializes in assessing petroleum product consumption patterns by various sectors, evaluating cost structures, transport and distribution systems, and tax and subsidy regimes. He has designed appropriate product pricing structures, assessed the potential for interfuel substitution, and recommended methodologies and institutional requirements for implementing pricing systems. Dr. Krapels has developed and implemented energy pricing models as well as provided in-country training to local professionals in their use.

Dr. Krapels has conducted numerous consulting projects for private and public sector clients and has served as a consultant to the World Bank and the U.S. Agency for International Development (USAID) on petroleum product pricing efforts in developing countries. Most recently he has served as Team Leader for International Resources Group in conducting energy pricing work in Bulgaria.

Dr. Donald Hertzmark

Dr. Hertzmark is an independent consultant with extensive experience in natural resource and development economics, energy and petroleum economics, energy pricing, project financial and economic evaluation, and international trade and macroeconomic analysis. He specializes in pricing and tariff economics, energy market analyses, and economic and financial feasibility studies for energy projects and programs. Dr. Hertzmark's energy pricing experience has involved extensive work developing and implementing models, including training in the design, operation, and maintenance of these modeling tools. He has worked on pricing projects involving a wide variety of fuel sources including petroleum, natural gas, coal, and electricity. Dr. Hertzmark has experience in numerous developing countries including the Ivory Coast, Morocco, India, Indonesia, Thailand, Pakistan, the Philippines, and Turkey. During the past year, he has been working for USAID on energy pricing issues in Hungary, Poland, and Bulgaria.

Dr. Benjamin Schlesinger

Dr. Schlesinger is President of Benjamin Schlesinger and Associates, a Washington-based consulting firm specializing in all phases of natural gas markets. He has detailed knowledge of engineering and technical issues related to exploration, development, transmission, and distribution. Dr. Schlesinger's expertise includes regulatory, financial, and economic analysis as well as corporate strategic planning, legal, accounting and management/organizational issues. He assists clients in developing and restructuring

natural gas purchasing strategies and analyzing new gas marketing mechanisms and programs. Dr. Schlesinger has conducted numerous international natural gas studies including extensive work in Europe: Austria, Belgium, Holland, Germany, and the United Kingdom. Recently, he assisted International Resources Group in conducting a natural gas pricing seminar in Poland.

Mr. John Banks

Mr. Banks is an Associate with the Washington, D.C. consulting firm of International Resources Group. He specializes in the economic and political analysis of oil and product markets in developing and Eastern/Central European countries. His expertise covers energy pricing regimes and policies, supply and demand analysis, as well as consumption and production patterns. Mr. Banks has extensive experience working with senior energy officials in East and Central Europe, especially in identifying technical assistance needs and implementing aid programs and projects. Mr. Banks has organized and managed energy conferences and seminars in Bulgaria, Czechoslovakia, Hungary, Poland, and Romania. He currently serves as Project Manager for two components of USAID's Emergency Energy Program in Eastern and Central Europe.

ENERGY PRICING POLICIES AND REGULATIONS

BY

DR. EDWARD N. KRAPELS
PRESIDENT
ENERGY SECURITY ANALYSIS, INC.
WASHINGTON, D.C.

DECEMBER 1991

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ENERGY PRICING POLICY

1. INTRODUCTION

2. DESCRIPTION OF ALTERNATIVE PETROLEUM PRICING PROGRAMS

2.1 COMPLETE FREE MARKET
2.2. THE JAPANESE MODEL
2.3 THE FRENCH MODEL

3. GRADUAL LIQUIDATION OF CONTROLS
3.1 RELATIVE PRICE STRUCTURES IN THE ALIGNMENT PROCESS
3.2 WHOLESALE AND RETAIL MARGINS
Example 1. The bottom-up approach
Example 2. The top-down approach

4. CONCLUSIONS

Petroleum pricing policies: objectives and "first-best" strategies

OBJECTIVE

Maximize economic efficiency

POLICY

Price all petroleum products at their import of "opportunity cost"; i.e. the revenues foregone by selling oil at home rather than in the international market

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Petroleum pricing policies: objectives and "first-best" strategies

2. Assure that the energy sector can self- finance the investments needed to meet future demand

Wholesale price levels must be "X%" higher than cost; with "X" representing the discounted valued of the stream of future investments needed to meet future demand

.9'

Petroleum pricing policies: objectives and "first-best" strategies

3. Assure that all citizens have the essential minimum supply of vital fuels at an"affordable" price

Identify essential, vital and affordable; pay low-income citizens the difference between the "efficient price" (no. 1, above) and what they can afford to pay

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Petroleum pricing policies: objectives and "first-best" strategies

4. Prevent changes in energy prices from having a sudden and drastic impact on aggregate demand.

Adjust petroleum prices gradually and consistently: do not shield consumers against fundamental changes in energy values, but make adjustments as smooth as possible.

Petroleum pricing policies: objectives and "first-best" strategies

5. Ensure appropriate long-term conservation measures by energy consumers

Establish a pattern of relative petroleum prices that obtains the desired demand trends in the various petroleum-using sectors.

Petroleum pricing policies: objectives and "first-best" strategies

6. Ensure that the energy sector makes a net contribution to the fiscal requirements of the state

Retail price levels ("on top of" a rational wholesale price level) should be sufficient to raise the revenues needed to pay energy- sector related subsidies (if any) and to pay the energy sector's share of the fiscal requirements of the state.

Source: Loosely based on discussion in M. Munasinghe and G. Schramm, Energy Economics, Demand Management and Conservation Policy (New York: Van Nostrand Reinhold Co., 1983), pp. 100-48.

Principal elements of petroleum pricing programmes

1. Scope of regulations: all products or selected products

2. Company-specific or industry average costs

3. Cost data used to calculate price ceilings:
   - actual
   - adjusted actual, e.g.
     - top 10% of import costs
     - bottom 25% of import costs
   - official OPEC and flat transport rate
   - spot crude and charter prices

4. Crude cost equalization programme: yes or no

5. Frequency of adjustment:
   - specific period (e.g. quarterly or monthly)
   - trigger (e.g. when costs accumulate 5 or 10%)
   - "political" (whenever government feels it can)

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Principal elements of petroleum pricing programmes

6. Automaticity:
   - automatic, without maximum limits
   - automatic, with maximum limits

7. Maintenance of floor prices: yes or no

8. Distribution of price changes across products
   - based on the costs of production
   - deliberately targeted variable distribution
   - based on spot or other market prices
   - based on pre-control price pattern

9. Controls on product imports:
   - no controls
   - imports carefully licensed, but non-refiners are allowed to import
   - refiners only can import

10. Stockpile obligation

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EFFECTS OF PRODUCT PRICE DECONTROL PROGRAMS

Programme	Effects
1. Decontrol prices only price;	1.No major change in area EAFG collected by refiner
2. Decontrol product imports only	2.No change in price (by definition); area EAFG may be transferred from refiners to product importers
3. Decontrol prices and area product imports. consumers;	3.Price falls from F to E; EAFG collected by large drop in refiner revenues

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PROPOSITIONS REGARDING EFFICIENT ENERGY PRICE REGULATIONS

Proposition 1

The more the influence over the policy process is balanced between supply-oriented and demand-oriented groups, the higher the potential for the implementation of an efficient pricing program.

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PROPOSITIONS REGARDING EFFICIENT ENERGY PRICE REGULATIONS

Proposition 2

(a) The finance ministry and the central bank bear primary responsibility for advocating an efficient overall pricing policy (i.e., requiring that if some prices are subsidized, the prices of others will be high enough to offset the revenue loss created by the subsidy); and

(b) The more the central bank accedes to multi-tier exchange rates the higher the probability that oil purchases will be transacted at the low (subsidized) exchange rate, and the more likely that overall energy pricing policy will be inefficient.

PROPOSITIONS REGARDING EFFICIENT ENERGY PRICE REGULATIONS

Proposition 3

(a) In oil-importing countries the highest priority should be placed on advising the government to align the weighted average wholesale price with international prices;

(b) Advise dealing with the prices of individual products must be given with full consideration of the political and technical context of the country in question. In the political sphere cross-subsidies may be highly effective means of income redistribution. In the technical sphere, there is no priori reason for cross-subsidies to be inefficient. They often balance other distortions, and aligning an individual product price with international prices, without taking other distortions into account, may decrease overall economic efficiency;

PROPOSITIONS REGARDING EFFICIENT ENERGY PRICE REGULATIONS

Proposition 3 (continued)

(c) In self-sufficient countries where the weighted average petroleum product price is far below international levels, emphasis should be placed on a long-term program of reform, which may take years to implement, and not on one-shot increases in prices in return for assistance on a particular development project; and

(d) In all cases high priority should be placed on the development of institutions that contribute to the emergence of the creative tension between supply-side and consumer advocates. In many developing countries the national oil company can play a vital role in this respect. Conditions placed on development assistance that denigrate the role of such national institutions are likely to be counterproductive.

PROPOSITIONS REGARDING EFFICIENT ENERGY PRICE REGULATIONS

Proposition 4

(a) Given the development of a propensity to embrace the principles of efficient petroleum pricing, regulators' ability to maintain efficient prices in the face of market fluctuations is a function of their ability to develop a technical pricing program that satisfies critical social and political objectives; and

(b) The principal elements of successful pricing programs are: pricing formulas that clearly spell out the variable that set the thresholds for price changes: a commitment to change petroleum prices, at a minimum on a quarterly basis and preferably on a monthly basis; and automatic implementation of these changes.

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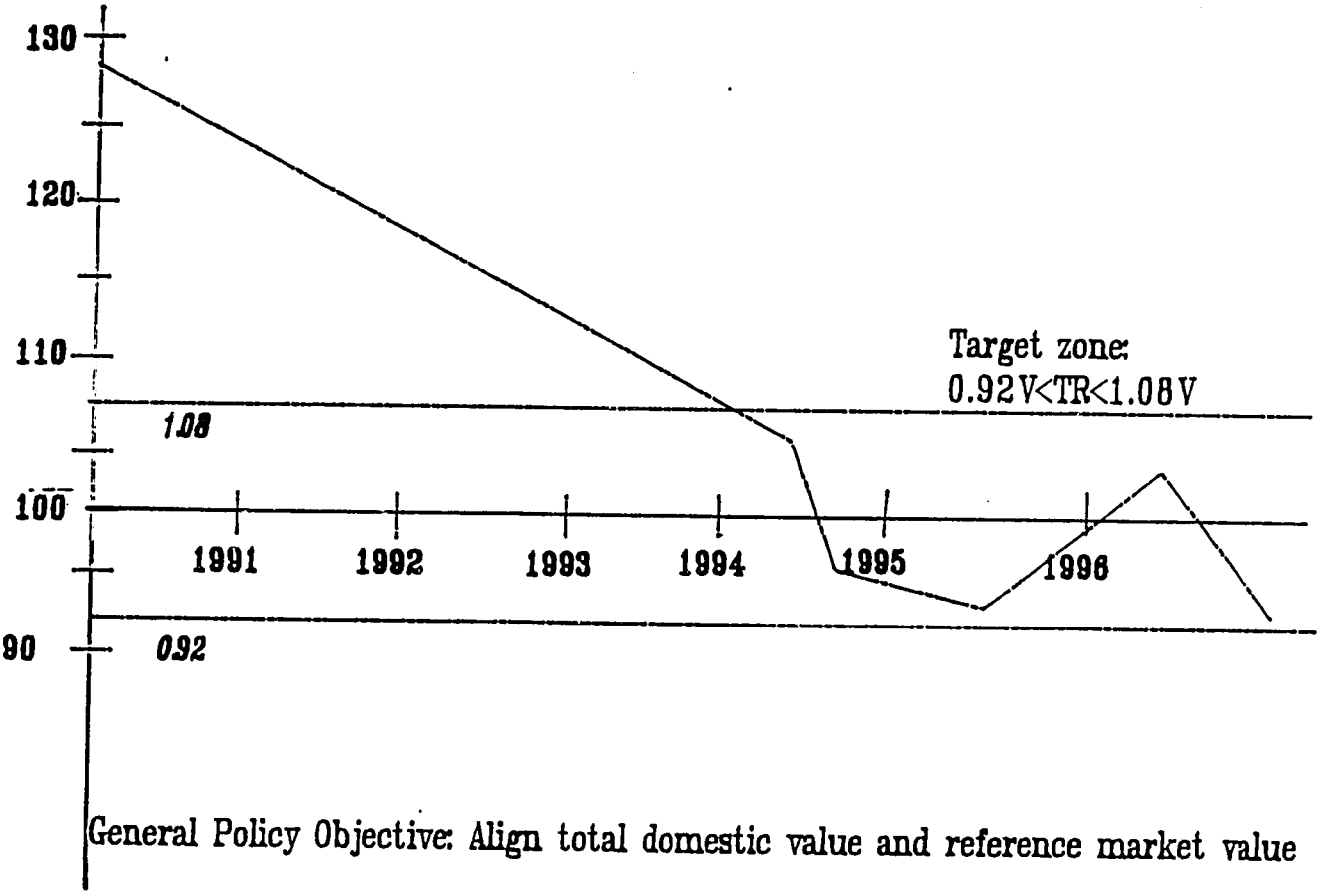
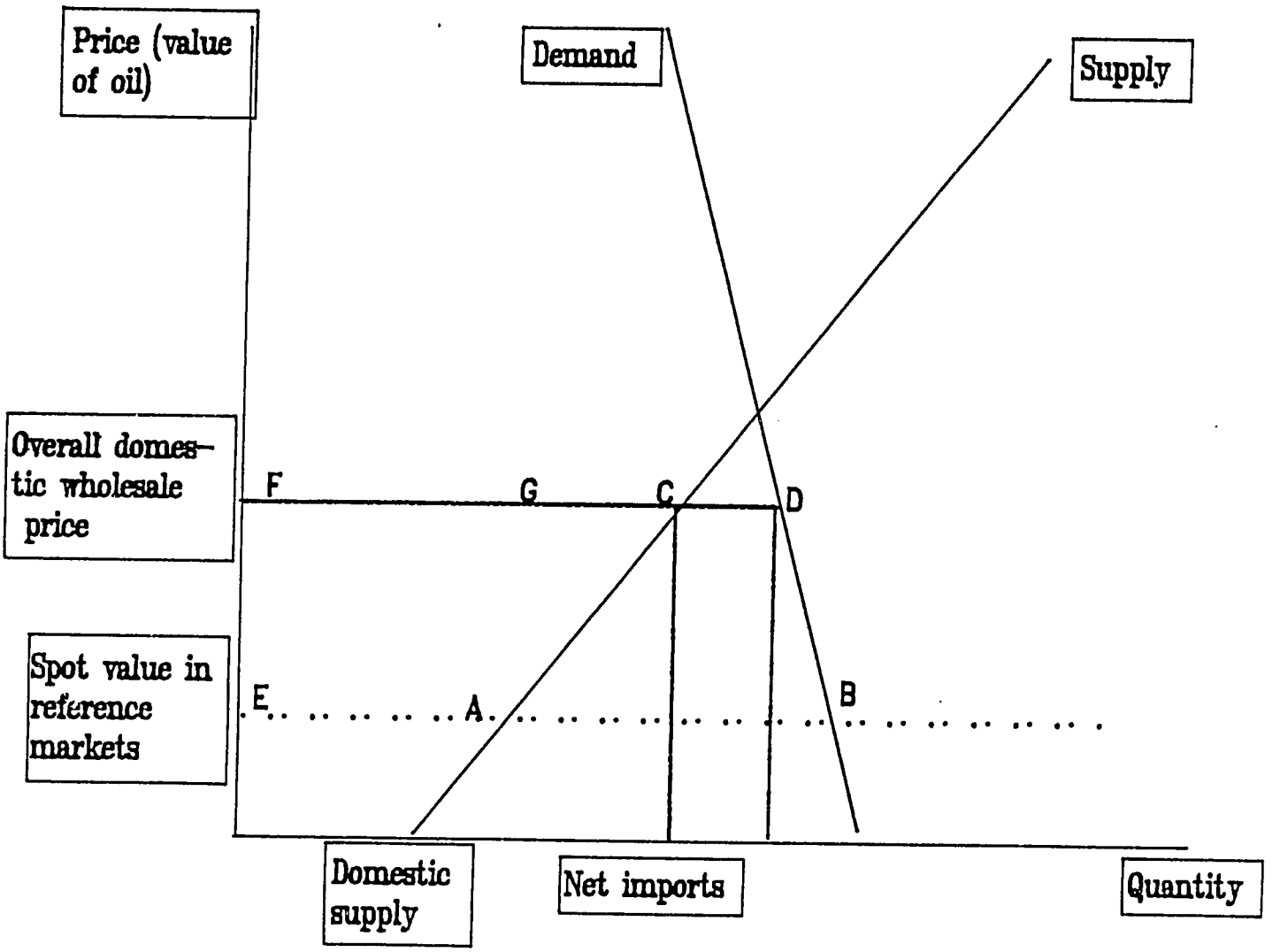
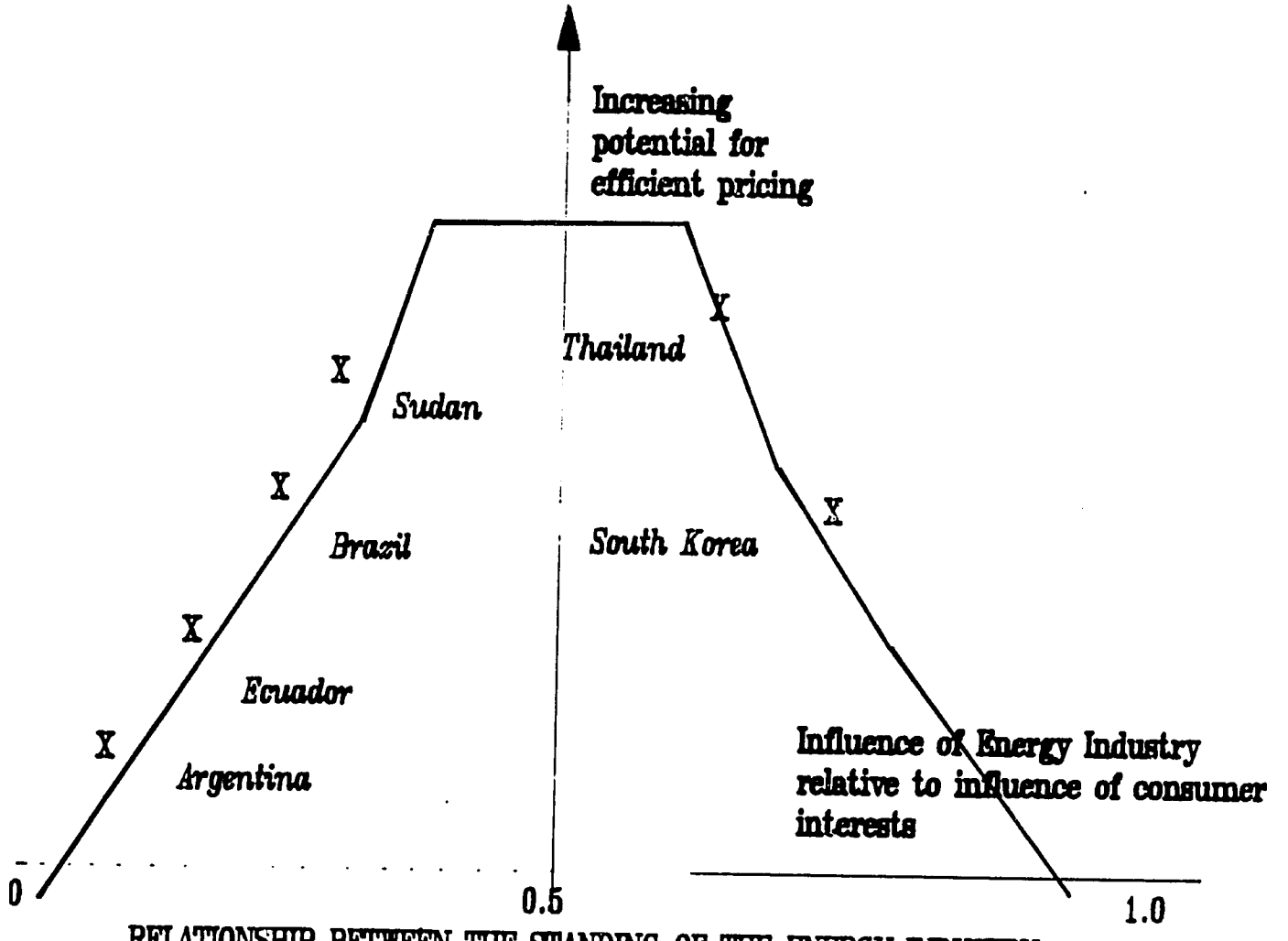


General Policy Objective: Align total domestic value and reference market value

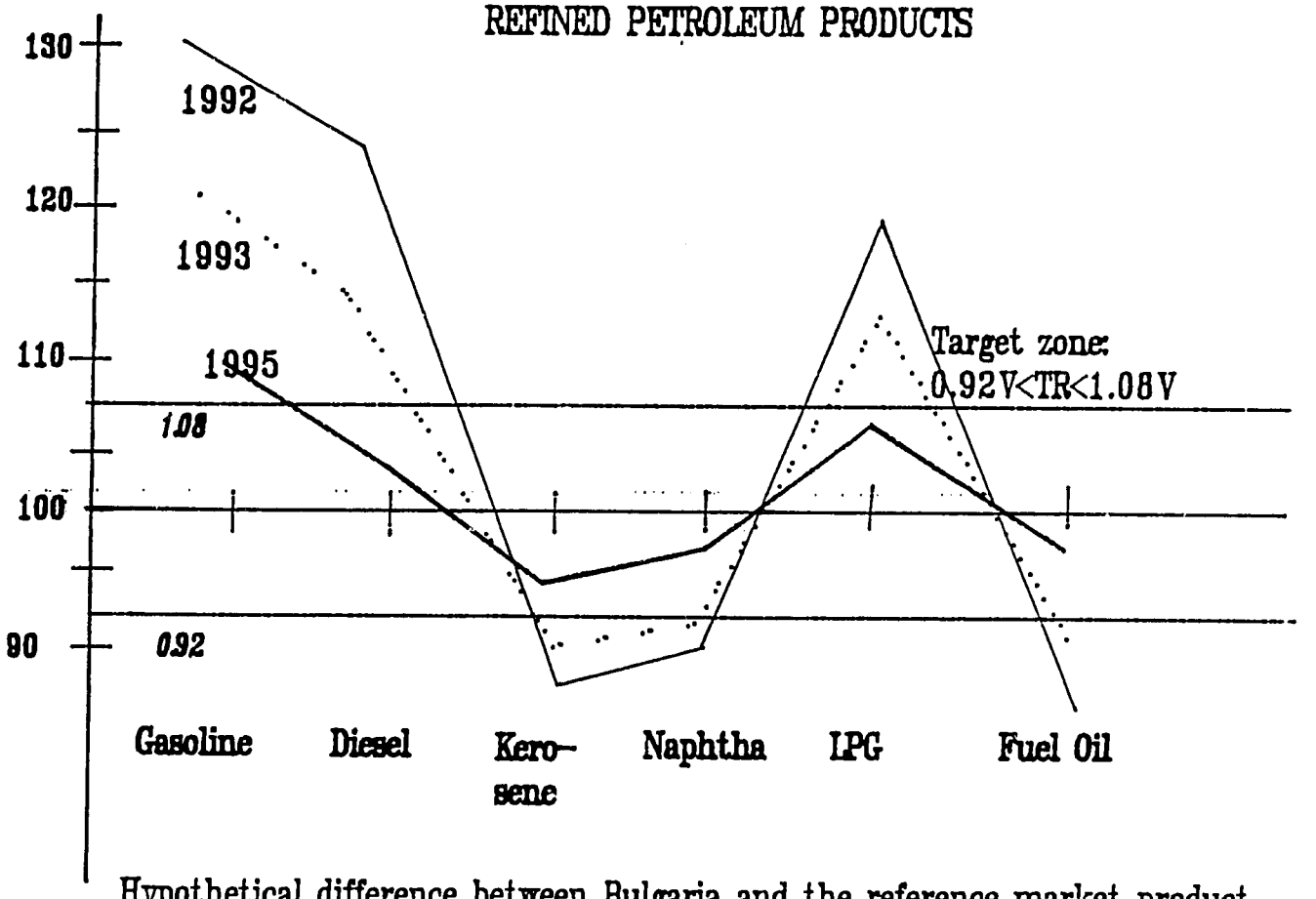
A PROTECTED MARKET FOR PETROLEUM PRODUCT IMPORTS





RELATIONSHIP BETWEEN THE STANDING OF THE ENERGY INDUSTRY THE DEGREE OF CONSUMER ORGANIZATION, AND THE POTENTIAL FOR EFFICIENT ENERGY PRICING

GRADUAL PRICE REFORM OF THE ENTIRE COMPLEX OF REFINED PETROLEUM PRODUCTS



Hypothetical difference between Bulgaria and the reference market product prices under the "French" regulatory program

NATURAL GAS TOPICS

- Overall supply and demand
- Economic policies
- Gas transportation and delivery
- Gas rates
- Environmental advantages
- Conclusions and discussion

ISSUES IN DESIGNING GAS RATES

- Overall economics
- Capital structure of gas industry
- Costs of service
- Goals and criteria
- Rate structure
- Special characteristics
- Administration

GOALS AND CRITERIA FOR GAS RATES

- Efficiency
- Equity
- Employment
- Ease of administration
- Environmental quality

RATE DESIGN ALTERNATIVES

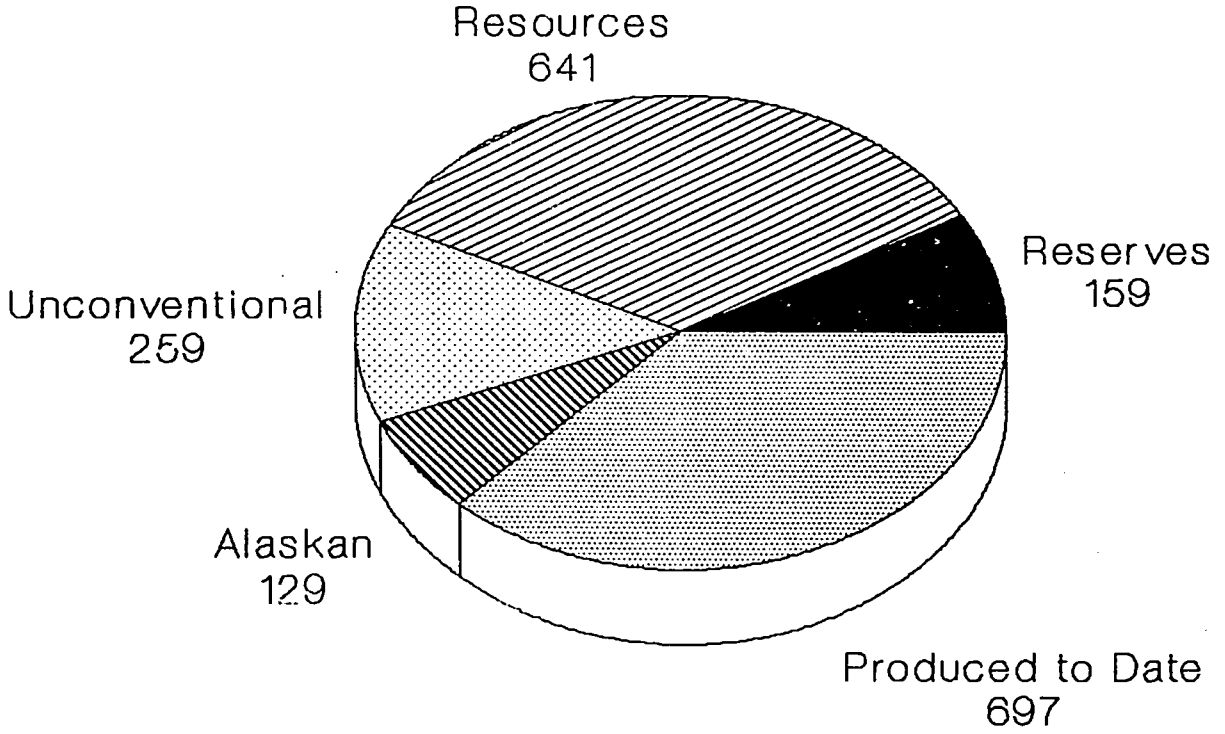
- Fixed and variable components
  - All variable
  - All fixed
  - Combination

- Flat prices versus block rates

ENVIRONMENTAL ADVANTAGES

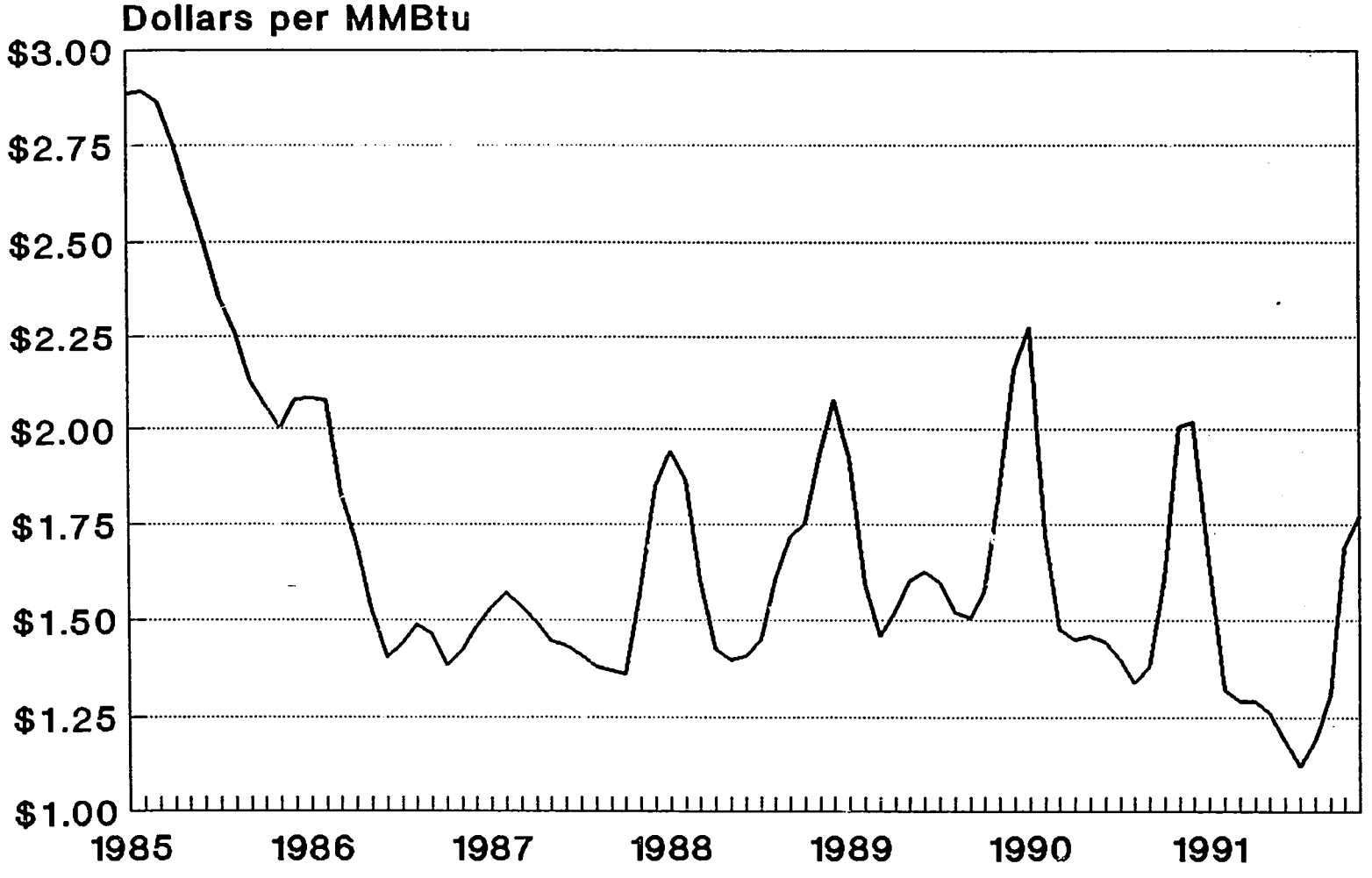
- Air emissions
- Water quality
- Toxic materials
- Land use

THE U.S. HAS 1,188 TCF OF NATURAL GAS
(Trillions of Cubic Feet, Tcf)



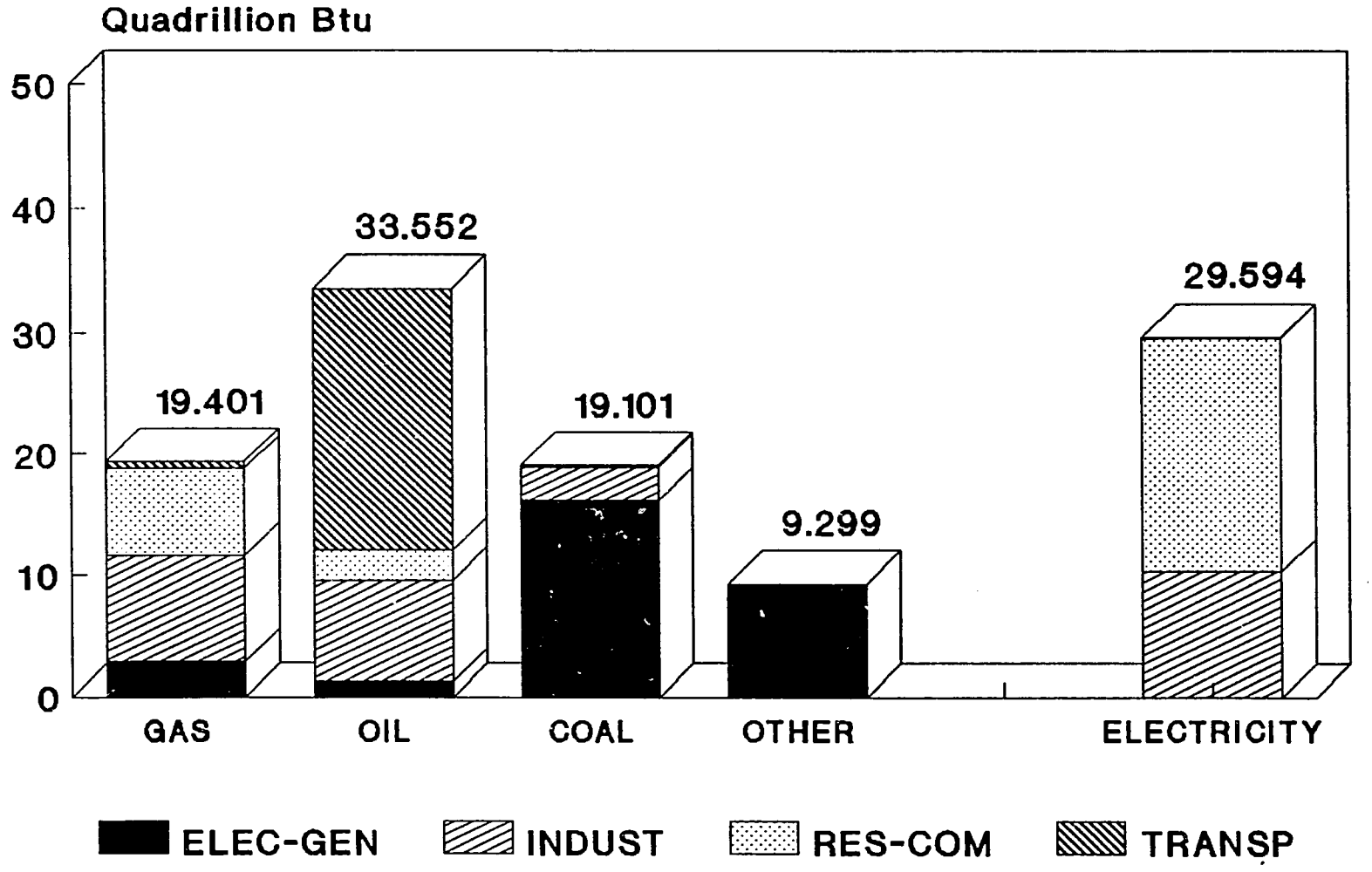
Sources: BSA, Inc., from U.S. Department of Energy, May 1988

LOUISIANA GULF ONSHORE WELLHEAD SPOT
January 1985 - November 1991



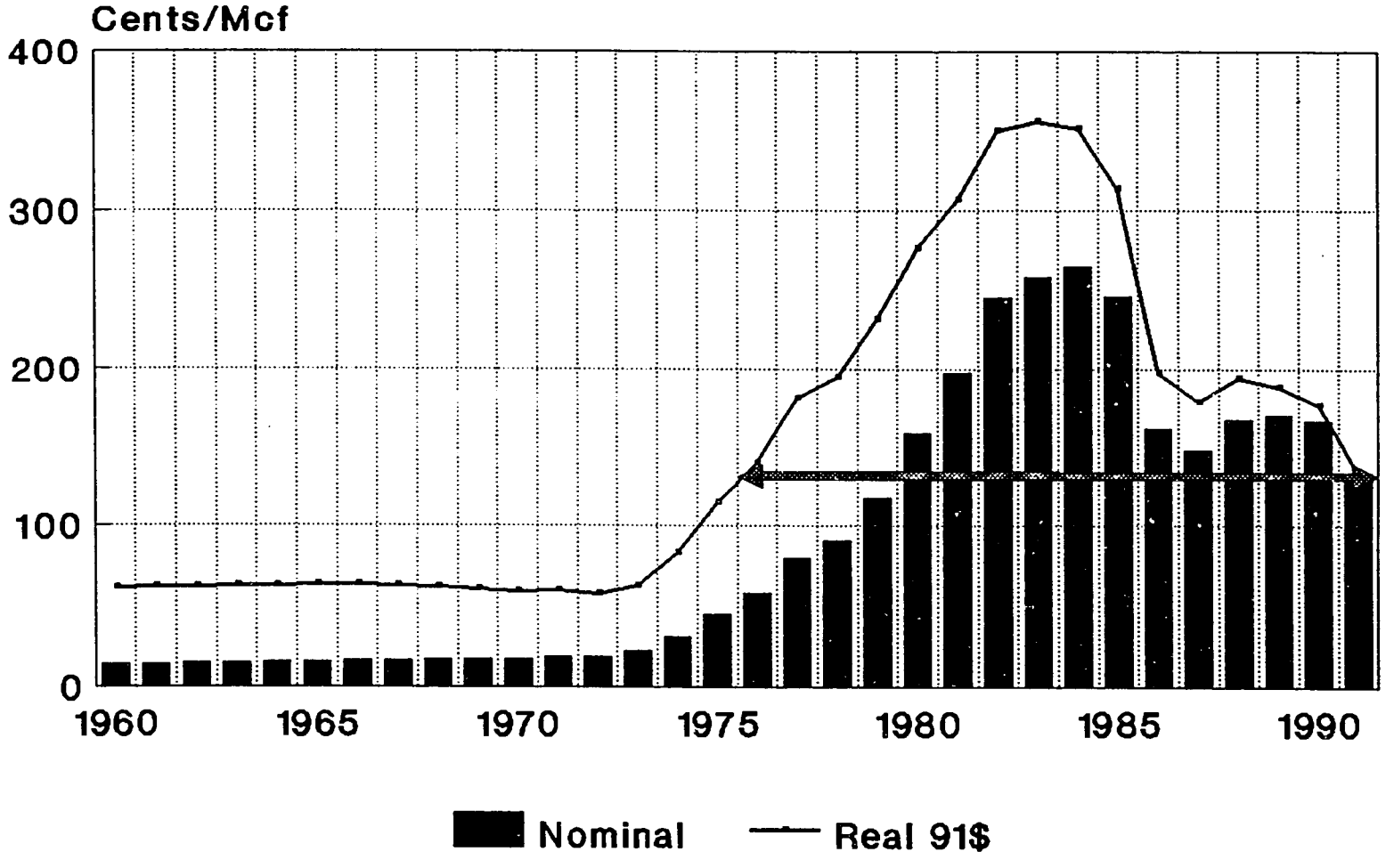
Sources: BSA, Inc.; Natural Gas Week

GAS PROVIDED 24% OF U.S. ENERGY IN 1990



Sources: BSA, Inc.;
EIA Monthly Energy Review, Aug. 1991

HISTORICALLY LOW 1991 GAS PRICES
(ANNUAL AVERAGE @ WELLHEAD: 1960-91)



BSA 1991: AGA pre-85; NGW afterward

GAS FUTURES HEDGING REDUCES COMMODITY PRICE RISK.

Hedgers

- Risk-sellers
- (e.g.) Producers, users
- Brokers/traders

Gas Futures Market

Speculators

- Risk-buyers
- (e.g.) Brokers, traders, outsiders

OVERALL COMPARISON OF NATURAL GAS INDUSTRIES
(Approximate 10^9 m^3)

	USA	Western Europe	USSR	Bulgaria
Annual Consumption	514	250	742	6.81
Gas Reserves	4,627	5,598	~40,000	7.00
Resources	32,460	11,080	N/A	7.45
Trunk Pipeline - km*10^3	308,350	N/A	212,900	950

GAS CONSUMPTION BY SECTOR
(Approximate 10^9 m^3)

	USA	Western Europe	Bulgaria
Residential/Commercial	194	112	---
Industrial	202	85	N/A
Electric Generation and Cogeneration	104	38	
Other*	14	15	---
Total	514	250	6.81

* Includes pipeline fuel and coal gasification gas.

ENERGY PRICING ANALYSIS FOR BULGARIA

Donald I. Hertzmark

December, 1991

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Energy prices should encourage patterns of production and use that will result in the energy production and use yielding the highest possible value to society. This objective can be translated into two general economic criteria:

1. Energy prices should cover the total costs of producing the energy resource, including the benefit to society of depleting the last unit of that energy;

2. Energy prices should lead energy users both to choose the least-cost energy source for a given application and to use energy only as long as the value of the last unit of energy consumed equals or exceeds the cost to society of supplying that unit of energy.

Principles of Efficient Energy Pricing

Energy Prices Should Be Made With The Following In Mind:

1. The cost of producing resources; and
2. Determining the value to the country of different energy resources in various end uses; and
3. Economy-wide effects of energy pricing, including those on income, prices, and foreign trade.

In A Free Market, the Following Relationships Will Hold:

- Price = Long Run Marginal Cost
- P = Marginal benefit of the last unit sold

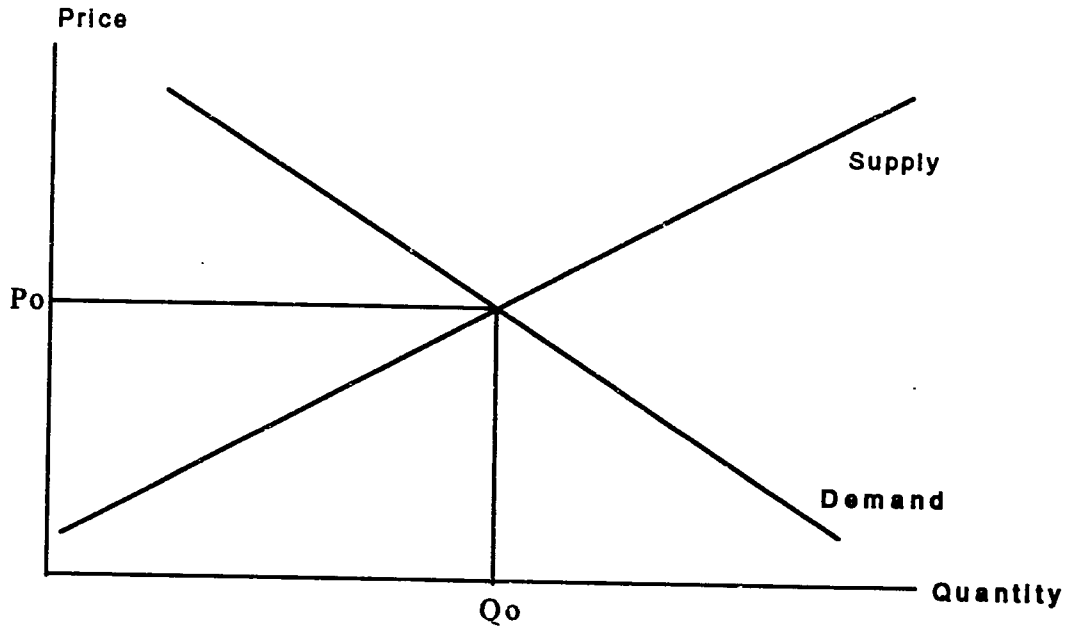


Figure 1: Supply and Demand Equilibrium

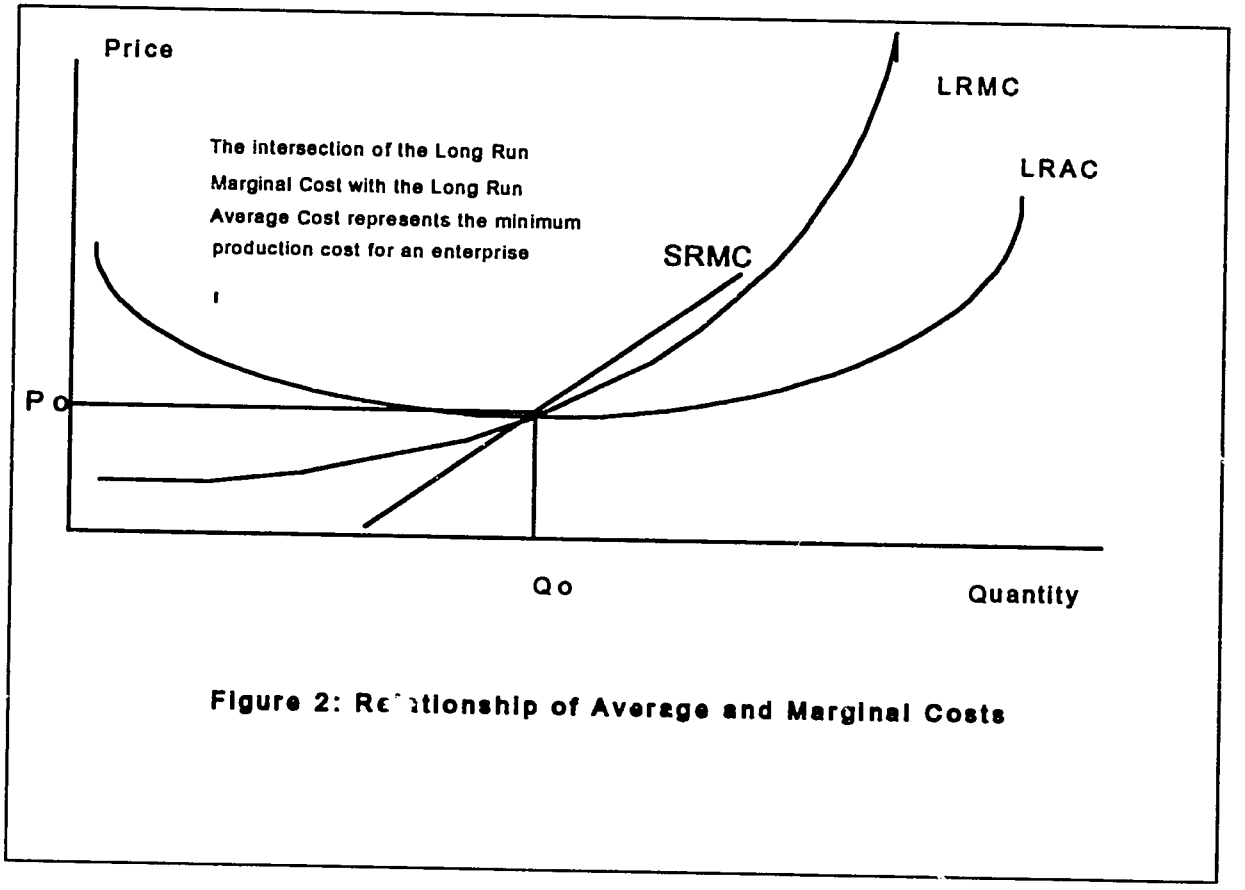


Figure 2: Relationship of Average and Marginal Costs

Complicating The Theoretical Model

- LRMC often is difficult to estimate since it involves imperfect information about not only present but future technology and costs;

- Marginal benefit or marginal value to consumers is a concept which economists, despite many attempts, have not been able to translate into directly measurable terms;

- Energy production often results in costs to society which are not included in LRMC calculations because they are not borne by the producer. These are:

  ✓ Depletion costs for nonrenewable resources; and

  ✓ Environmental externalities such as pollution.

Estimating the Cost of Supply

Alternatives to the Long Run Marginal Cost

- Use Short Run Marginal Costs;
- Use Average Incremental Costs;
- Use "Standard" Costs.

On the Demand side, the Netback Value is used as a proxy for the Marginal Benefit measure.

Estimating Short Run Marginal Cost: Key Considerations

1. Decreases in the quality and/or reliability of service, possibly remedied by resort to backup generation;

2. Lack of adequate reserve margin; and

3. Value of unserved energy.

The SRMC has two parts, and energy component and a capacity component. The energy component is easily measured, provided the input energy prices reflect the value to users. The capacity cost is represented as:

$$MCC = (OC-£) * (LOLP), \qquad (1)$$

Where:

- ✓ MCC is marginal capacity cost;
- ✓ OC is the cost of unserved energy;
- ✓ £ is the operating cost for the marginal capacity addition; and
- ✓ LOLP is the loss of load probability.

If the MCC is greater than the right-hand-side of (1), then the system is under capacity and payment of a capacity credit is justified up to the value of that term.

Average Incremental Cost

This formula for estimating future costs is often used by the World Bank. It can be represented as:

$$AIC_0 = \frac{SUM^T_{j=1}\ [I_j + (R_j - R_o)]/(1 + i)^j}{SUM^T_{j=1}\ [Q_j - Q_o]/(1 + i)^j} \qquad (2)$$

where

I_j = capital cost in year j

R_j = operating and maintenance cost in year j

R_0 = operating and maintenance costs in year 0

O_j = output of energy source in year j

O_0 = output of energy source in year 0

i = discount rate

T = time horizon of the analysis.
Year 0 is the initial point

The AIC can be used to estimate the cost of supply for "Standard" technologies.

Depletion Allowance

The Depletion Allowance (DV) of a resource accounts for its value in the future when extraction or production will be higher in cost due to the depletion of current reserves. The DV can be estimated, provided one has some idea of the future price of the resource.

i.e.,

$$DV_n = \frac{\text{Economic Price of Backstop Fuel in year of economic depletion}}{(1 + 1)^{T-n}} \quad (3)$$

Netback Values

The netback value represents the maximum value that an energy resource can attain. As such, it represents a price ceiling. That is,

$NB_x \geq AIC_x + DV_x$, i.e., $NB_x \geq$ economic supply $cost_x$

The formula for estimating the netback value is:

$$NB_{coal} = \frac{P_e - I_{coal}/unit}{Cons_{coal}/unit,} \qquad (5)$$

where P_e is the Price of the electricity purchased from the generator.

The netback Value can also be estimated using the production or generation cost of a competing fuel, this is called the opportunity cost approach.

i.e.,

$$NB_{oil} = \frac{[I_{oil}/unit - I_{oil}/unit + F_{oil}/unit]}{Cons_{coal}/unit} \quad (4)$$

for a case where an oil-fired electric generating station is replaced by a coal-fired one.

where

I_{coal} = investment and operating costs required to use coal.

I_{oil} = investment and operating costs required to use oil.

F_{oil} = cost of fuel oil

$Cons_{oil}$ = oil consumption per KWh in tonnes or 10^6 BTU

The netback value calculation points out several key considerations, including:

- The importance of the sales price to the ability to purchase fuel;
- The importance of generation efficiency to the ability to pay for fuel;
- The relationship between the price of a fuel and competitive generation options.

Economic Rent

The economic rent is the area between the supply curve and the equilibrium market price. Any area above the equilibrium price but below the demand curve represents consumer's surplus. Figure 3 illustrates the economic rent plus consumers' surplus available to energy producers and energy consumers. The area bounded by O, P_c, C, b reflects the area in which it is in the interests of both consumers and producers to negotiate a selling or purchase price. That is, between P_p and P_c can be found a price which pays for the fuel while at the same time meeting other social or financial objectives.

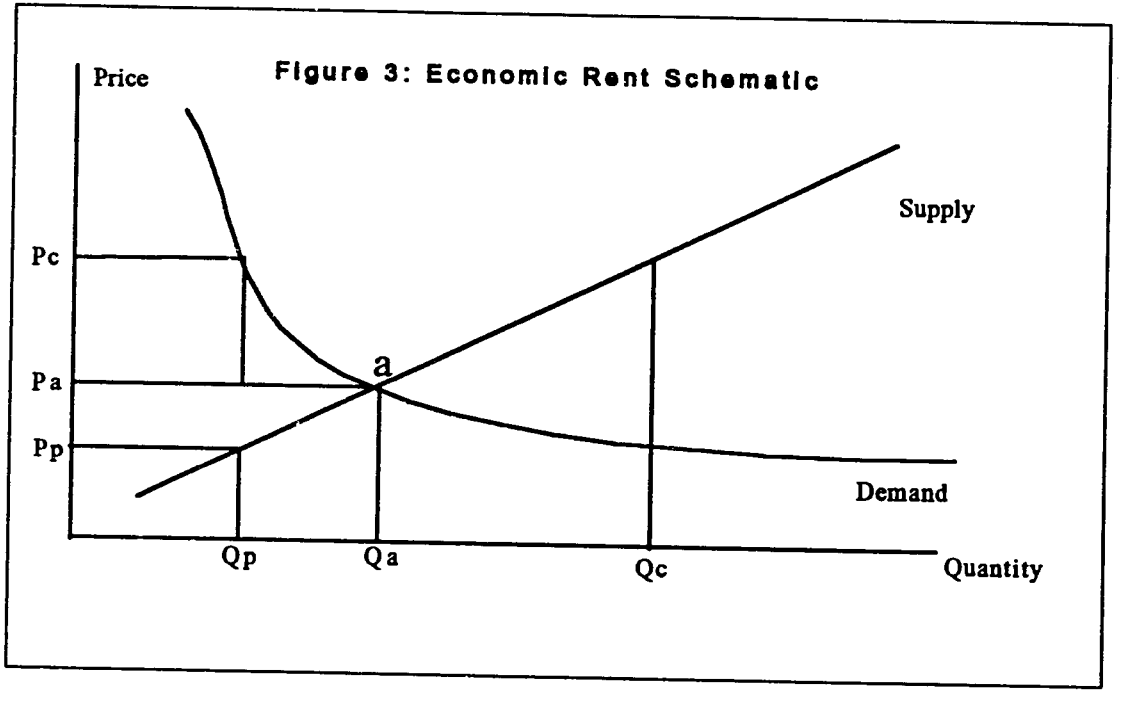


Figure 3: Economic Rent Schematic

Economic rent is the difference between the economic supply cost of a fuel and its market price (if any). Rent can be positive or negative.

A positive economic rent is a market price for a resource which is greater than is necessary to induce production of that resource.

Macroeconomic Considerations in Energy Pricing

- Imports of energy and energy using and transforming equipment will probably represent the largest single item on the balance of trade books;

  ✓ This means that the efficient use of energy is crucial to avoidance of balance of payments and trade deficits (c.f., India).

  ✓ So large are the volumes of investment in energy supply and transformation in some countries that industrial policy is, in effect, energy policy (e.g., USSR, Poland, Czechoslovakia).

- In the future much of Bulgaria's energy infrastructure will be financed from abroad without corresponding exports of that energy (except for coal). This places the burden of making the loans repayable on the efficiency of using that energy.

- If the foreign financed incremental energy is not efficiently used then the economy's additional output may not be enough to repay the loan. That is, too much energy is used for each level of output. Determining how much energy is "too much energy" and letting producers and consumers know when they are using the "right amount" is the job of microeconomic policies.

Conclusions:

- Energy pricing is not a magic bullet;
- Efficient energy prices are perhaps necessary for an efficient economy but they are not sufficient. Other conditions must be present, including:

  ✓ Free mobility of other energy and production resources;

  ✓ Prices elsewhere in the economy that reflect relative values and scarcities.

- Appropriate energy prices can be a powerful for the better in a market economy;

- Experience shows that price controls generally lead to costly and sometimes disastrous results - i.e., the risks of bad energy pricing policies are worse than the benefits of good ones.

Macroeconomic Issues in Energy Pricing

- Imports of energy still represent the largest single item on the balance of trade books for most developing countries.
- In most countries, energy is also a major source of government revenues through such venues as:
  - ✓ lease revenues from oil and gas exploration
  - ✓ production sharing or royalties from oil and gas production

- ✓ excise taxes on final sales of energy products, especially transport fuels

- At the same time, energy production and transformation remains the dominant destination for domestic investment.

  ✓ So large are the volumes of investment in energy supply and transformation in some countries that industrial policy is, in effect, energy policy.

  ✓ With most of the capital equipment coming from abroad, the energy sector represents perhaps the largest claimant on foreign exchange.

- Throughout the former CMEA countries, energy has been the greatest sink for what is now foreign exchange or hard currency, with the possible exception of weapons.

- However, the outsized role of energy in a nation's balance of trade and investment is not limited to the centrally planned economies of East Europe. For example,

  ✓ Much of Thailand's civilian foreign debt, consists of loans taken out to build the country's power generation and transmission systems.

  ✓ For India, production of energy from domestic sources is financed largely from abroad The same is true for both other countries.

- ✓ Even Indonesia, a major oil producer, finances energy investments largely from abroad Indeed, investments in the energy sector comprise more than 50% of the foreign investment and borrowing of that country.

- It is in the centrally planned economies that some of the more egregious examples of inappropriate foreign trade transactions have appeared.

  ✓ The types of transactions typical of non-functioning pricing systems encourage arbitrage. for example:

Cuba received Soviet oil for sugar at prices which underpriced the oil relative to the sugar and resold this oil at its international parity price to gain foreign exchange

E.g., if the price of oil is $20/barrel and the price of sugar is $200/tonne, then one tonne of sugar is regularly exchanged for 10 barrels of oil. However, if the price of sugar quoted in the transaction rises to $300/tonne, then Cuba can purchase 15 barrels of oil for each tonne of sugar sold to the USSR. In effect, the Soviet oil is underpriced by one third, or $7/barrel.

- ✓ This became a real problem for Cuba once the USSR pulled the plug on this trade
- ✓ A well functioning market discourages arbitrage

The Golden Rules of Energy Borrowing and Indebtedness

- Whenever energy capital is imported without corresponding exports of energy, the burden of making the loans repayable rests on the efficiency of using that energy.

- Where the incremental energy is not efficiently used then the economy's additional output may not be enough to repay the loan.

- That is, too much energy is used for each level of output. But what constitutes "too much energy." How do producers know when they are using the right amount or too much?

- This is a microeconomic issue and comprises the bulk of energy pricing work.

National Security Considerations

- Diversity of Supplies
- Reliability of Suppliers and Customers
- Vulnerability of Energy Supplies To Non-Market Forces and Threats

Decontrol Issues

Steps to promoting competition while deregulating and debureaucratizing the economy

1. Identify natural monopolies in the energy sector - for example power transmission and gas transmission

2. Note potential competition between power and gas for final users

3. Where competition naturally exists, it is wise to use the market to regulate the activities of participants, rather than relying on administrative measures

4. Identify degree and extent of competition. Try to be systematic and use a checklist. E.g.,

- ✓ Review number and types of current firms and ministries active in each sector
- ✓ Divide oil, coal, gas, and power into functional business segments
  - ► Production
  - ► Refining/Processing
  - ► Transformation (includes electric power generation plants)
  - ► Marketing
  - ► Retailing
  - ► Public Utilities (networks)

✓ Ask some questions about each business segment

- How many firms are active?
- How competitive are these firms?
- How competitive could they be?
- Uniformity of prices (price discrimination is *Prima Facie* evidence of monopoly power)
- Persistent shortages or surpluses in certain products
- Ability (or inability) to raise investment capital
- Market share of top 4 firms

- Barriers to entry or exit
- Control over key inputs or supplies (remember, every monopolist or oligopolist is a monopsonist of one or more key resources)
- How can (or should?) the barriers be lowered?

ALWAYS LOOK FOR ALTERNATIVES TO ADMINISTRATIVE AND BUREAUCRATIC MEASURES TO GUIDE THE ECONOMY

ELECTRICITY PRICING OBJECTIVES

- Encourage efficient use by consumers.
- Supply electricity at lowest cost.
- Ensure adequacy of supply.
- Promote price stability.
- Provide revenues sufficient to make the industry self-supporting.

MARGINAL COST- BASED PRICES

- Encourage efficient use by consumers.
- Promote least-cost electricity service
- Support adequacy of supply.
- Provide revenues sufficient to make the industry self-supporting

PRICING OF GENERATION

- A deregulated, competitive generation sector will set prices through competitive bidding.
- If truly competitive the Gencos will bid prices close to their marginal costs of production.
- Clearly, maintaining competition among generators is critical.

LONG-TERM VS.SHORT-TERM PRICES

- Gencos can sell their full output to Transco through short-term (hour-by hour) price bids

- Alternatively, they can sell to Distcos and large customers through long-term contracts.

- Contract prices will be determined by expected future system hourly prices; however, the risk will be shifted.

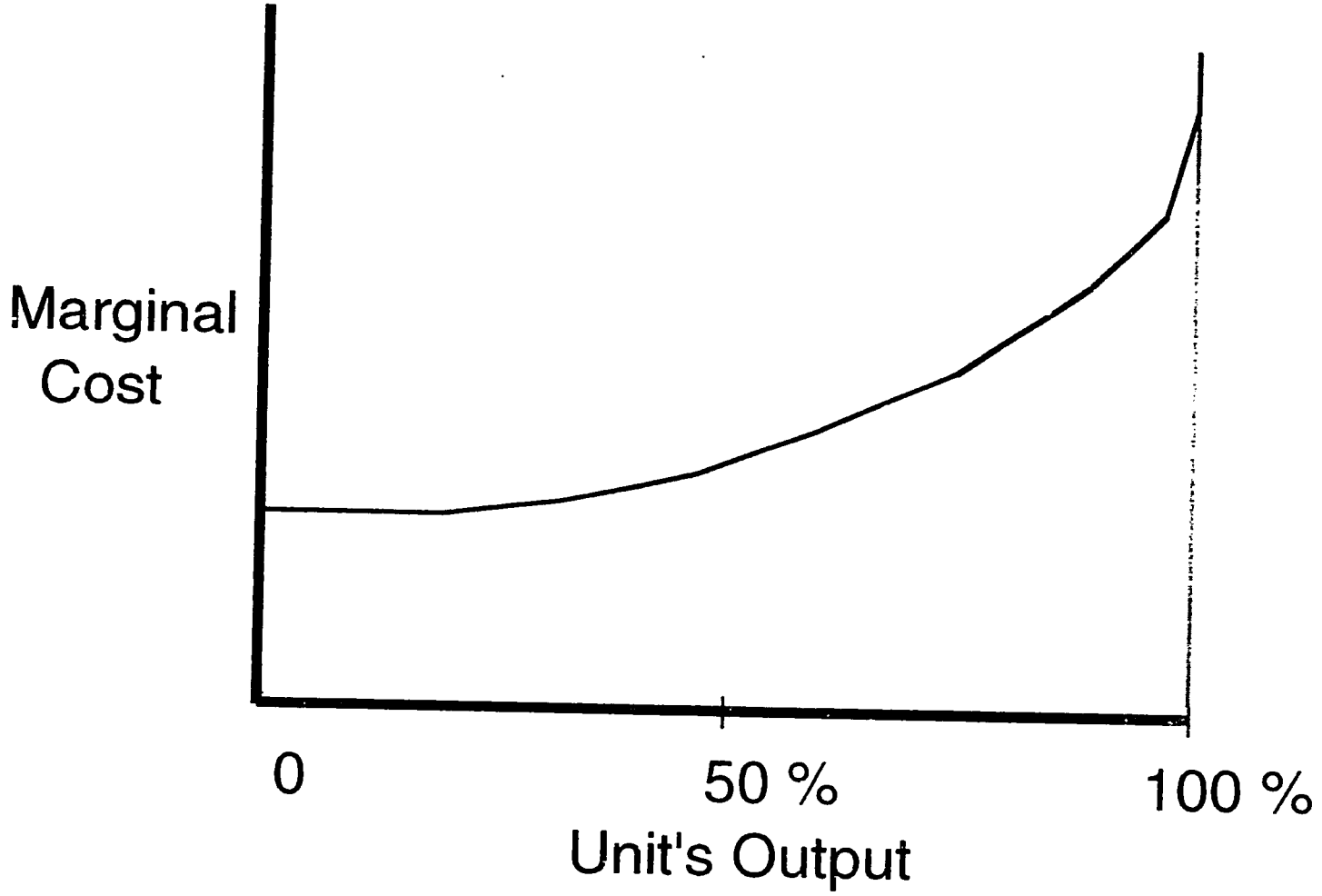
COORDINATING GENERATION OPERATIONS

- Generating plant operations must be coordinated:
  - Choosing the generating units needed to meet each day's peak demand
  - Loading the units in merit-order
  - Scheduling units for periodic maintenance.

MARGINAL COST OF GENERATION

- The power system's marginal cost of generation is determined by:
  - the marginal costs of the individual generating units
  - the available generating capacity relative to electricity demand.

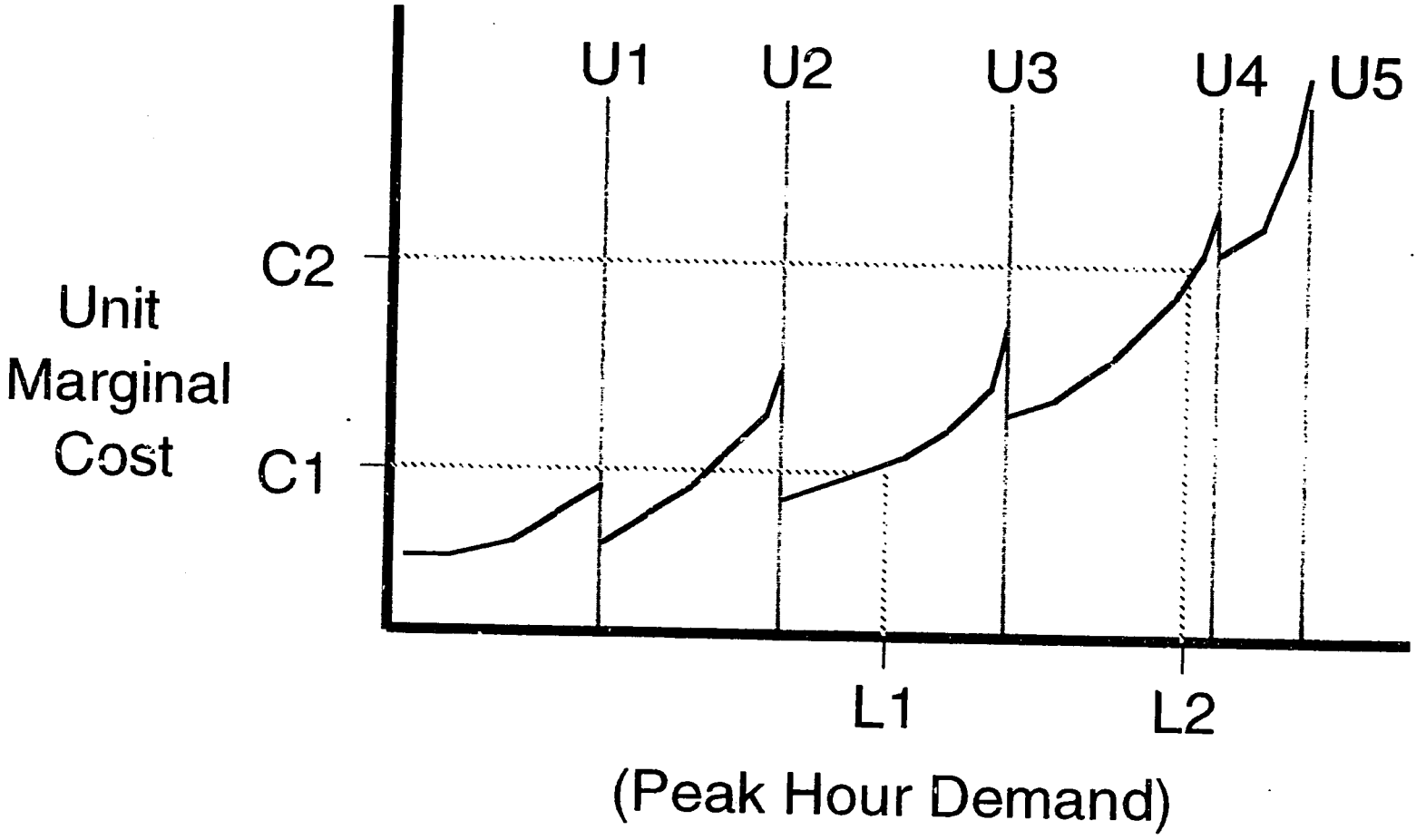
GENERATING UNIT MARGINAL COST



MERIT- ORDER DISPATCH OF UNITS

- Generating units are dispatched in "merit-order"
  - Lowest cost units are loaded first, followed by higher cost units until demand is satisfied.
  - All partially loaded units have the same marginal cost.

EXAMPLE: MERIT- ORDER DISPATCH



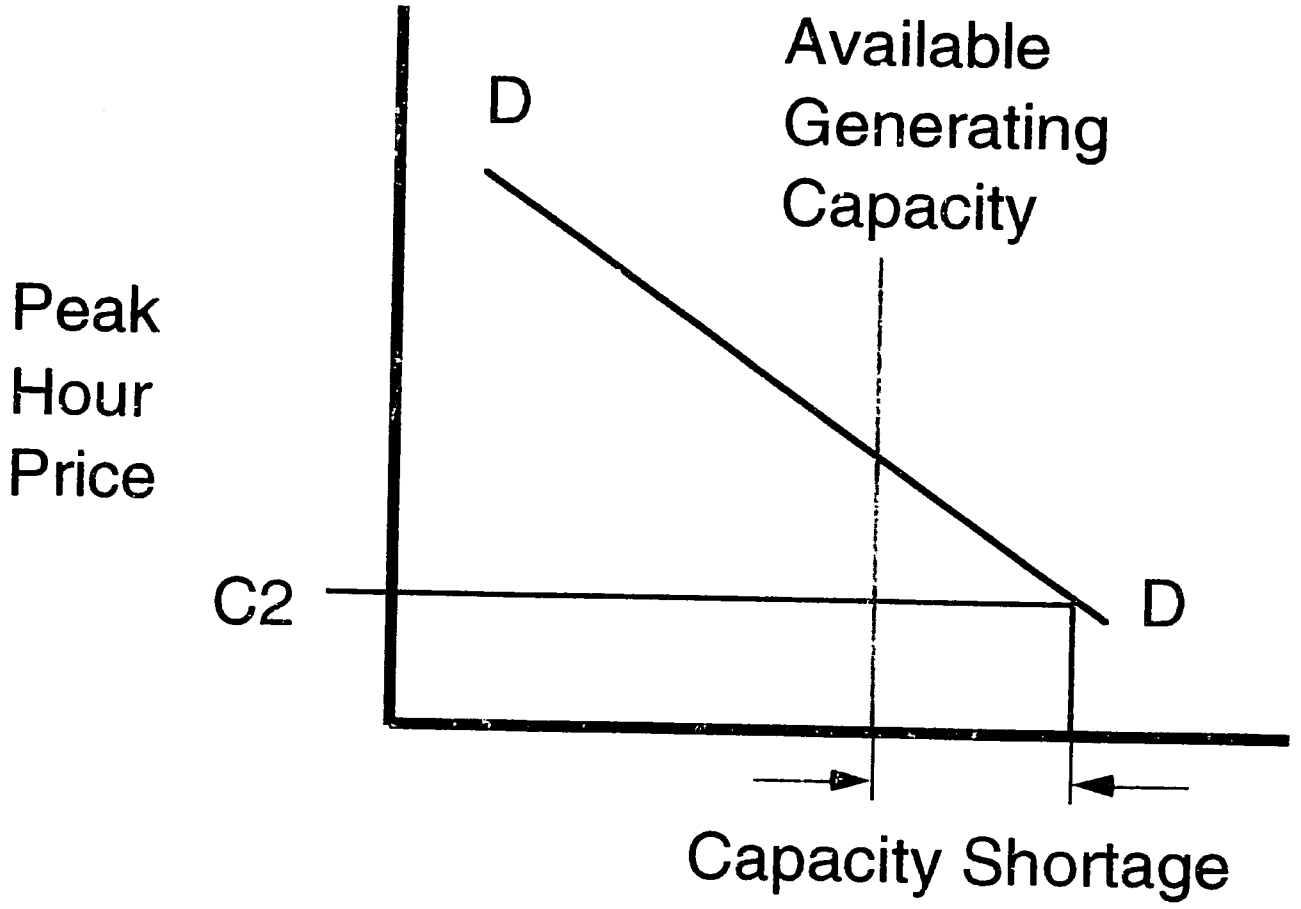
SYSTEM MARGINAL COST

- The system's hourly marginal cost of generation equals:

  - the marginal cost of the highest cost generating unit producing electricity if system is not capacity constrained.

  - the marginal cost of that unit plus an "outage cost" if demand is close to available capacity in that hour.

MARGINAL COST OF OUTAGE



LOST OPPORTUNITY IS MARGINAL COST

- When demand exceeds available generating capacity someone must be denied service.
- The marginal cost of the outage is equal to the unserved KWh that would have been put to the highest value.
- The highest value use is equal to the highest price that the customer would willingly pay for that KWh.

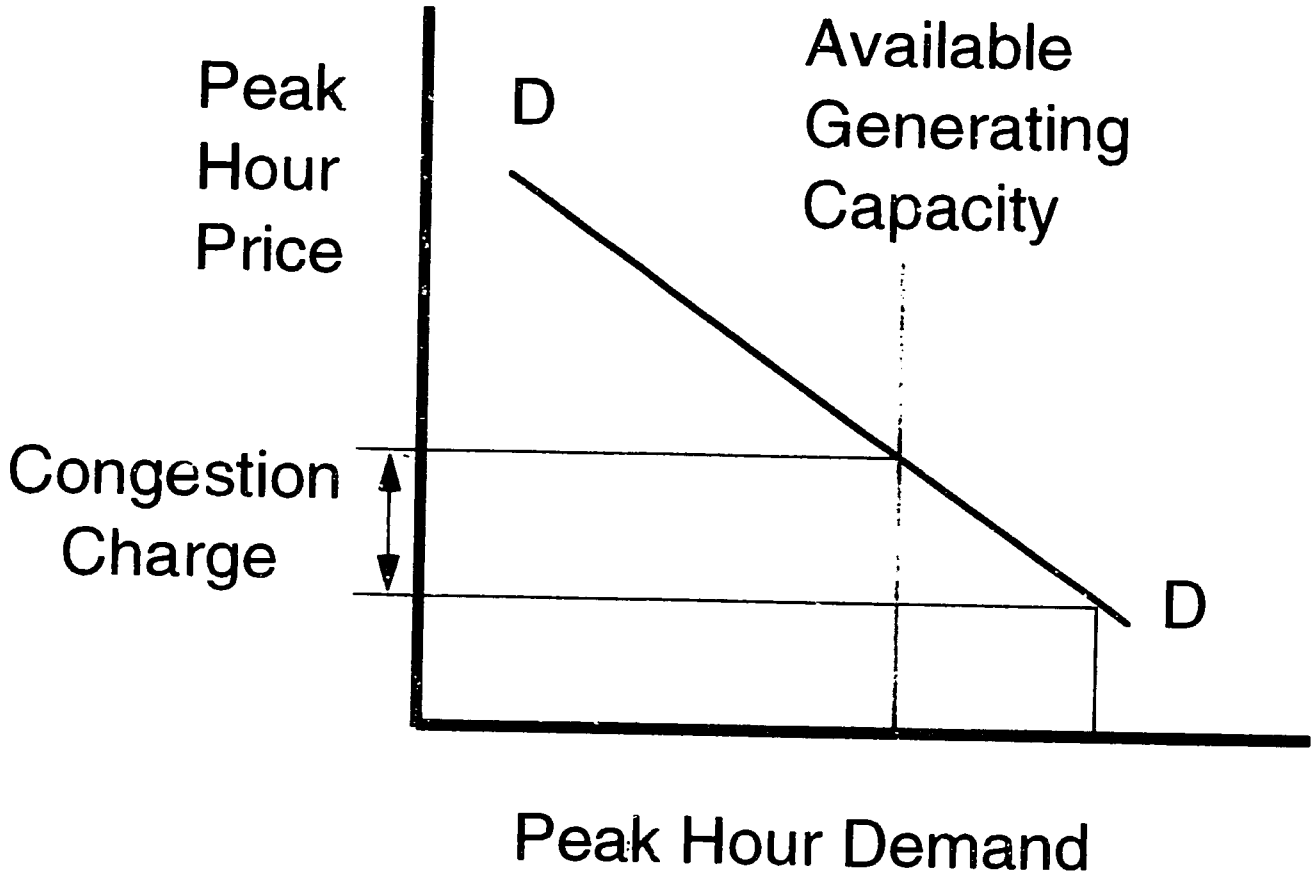
PEAK LOAD CONGESTION PRICING

- For each KWh delivered, each operating generator will receive the highest price bid for that hour.

- In addition, each generator will receive a congestion charge for each KWh delivered during *peak* hours.

- The purpose of the congestion charge is to ensure that electricity demand seldom exceeds available generating capacity.

CONGESTION CHARGE NEEDED



UNCERTAINTY PERVADES THE REAL WORLD

- Demand is uncertain, being determined by random events such as weather.

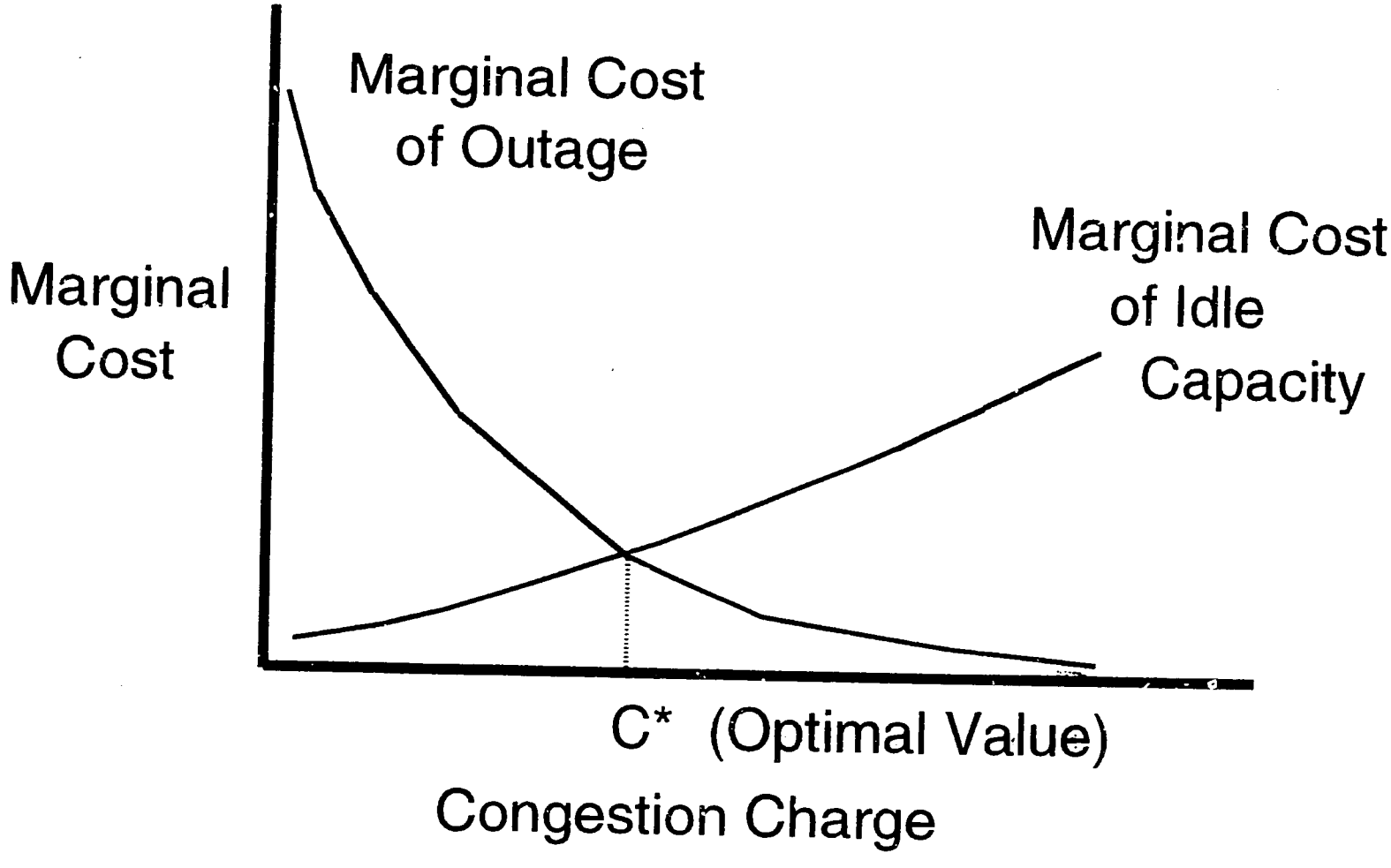
- Available generating capacity is even more uncertain because generating units break down.

- Thus, only the likelihood of an outage can be known in advance.

MUST BALANCE TWO COSTS

- Congestion charges cannot eliminate outages; they can only reduce the severity and frequency of occurrence.
- High congestion charges reduce outages but deny customers service when capacity is available.
- Low congestion charges make service available to more customers but allow more outages.

OPTIMAL CONGESTION CHARGE



WHEN TO ADD CAPACITY

- As electricity demand grows over time, the congestion charge will increase if capacity is not added.

- At some point the benefits from adding capacity exceed the cost of doing so.

- The congestion charge indicates when it is economic to add capacity.

CONGESTION PRICING APPLIED

- Although correct in theory, congestion pricing is difficult to apply because the costs imposed by outages are hard to quantify.

- The US and the UK apply congestion charges it in very different ways.

GENERATION PLANNING

- Traditionally, generation additions have been centrally planned.
  - The US uses regional committees representing the utilities
  - In the UK the Central Electricity Generating Board (CEGB) did it.
- The UK now relies on spot electricity prices to provide market incentives for adding generating capacity.

IS CENTRAL PLANNING BEST?

- The central planning approach has ensured high reliability in both countries.
  - But in both countries substantial excess capacity was built in the 1980s.
  - Most of the cost of that capacity was borne by the customers.

IS THE MARKET APPROACH BEST?

- The market-based approach places all of the risks and rewards on the Gencos.
  - But that may not ensure adequacy of supply.
  - Also, severe swings in electricity prices may result.

NEED FOR COMPATIBLE STRUCTURE

- Ultimately, the success of any pricing scheme depends on adopting a compatible industry structure.
- Specific provisions must be made for:
  - ensuring competition in generation
  - price regulating the transmission and distribution natural monopolies
  - coordinating generation operations
  - coordinating generation planning (?).

PRICING OF TRANSMISSION

- The marginal costs of transmission services is extremely complex.
- Optimal spot pricing theory offers a way to price transmission services but has only been solved for simple systems.
- Generally, transmission costs are treated as being fixed.
- The exception is transmission losses which are marginal costs.

CONVENTIONAL PRICING

- The conventional approach is to treat all transmission costs as fixed in the short run, thus are not marginal.

- However, transmission losses are variable, and do contribute to marginal costs.

CONVENTIONAL PRICING (CONTINUED)

- An energy (per KWh) surcharge is designed to:
  - cover power losses,
  - recover operating costs
  - recover the sunk capital costs
  - provide funds for future expansion.
- Similar to a "long-run" marginal cost approach.

CONVENTIONAL PRICING (CONTINUED)

- Transmission surcharges may be applied as:
  - single, system-wide "postage stamp" rates, or
  - area-specific rates.

- Load flow studies revealing transmission bottlenecks and losses can provide a basis for area-specific pricing.

CONVENTIONAL PRICING (CONTINUED)

- Conventional Approach is crude and basically wrong.

- But it is easy to apply.

- Fortunately, for most power systems generation costs are much greater than transmission (or distribution) costs.

PRICE REGULATION MAY BE NEEDED

- A transmission system is a natural monopoly; it has no competition.
- Price regulation may be required to preclude Transco (PSENN) from exploiting its monopoly power.
- This is true even if Transco (PSENN) is government-owned.
  - pricing guidelines can prevent selective taxation of consumers.

DISTRIBUTION MARGINAL COSTS

- As with Transmission, the marginal costs of distribution systems are complex.
  - But loop flow is less of a problem.
  - Line losses are more important
  - And many costs are traceable to specific customer classes.

COSTS BY VOLTAGE LEVEL

- Distribution costs vary by voltage level:
  - Higher losses occur at the lower voltages provided to small customers.
  - Also more investment is required per KWh delivered.

WHAT COSTS ARE MARGINAL?

- Distribution losses are variable, thus contribute to marginal costs.
- Much distribution investment is for equipment required to provide access.
  - These costs are fixed and do contribute to marginal costs.
- Some "Upstream" distribution costs are marginal but difficult to quantify.

DESIGNING RETAIL PRICES

- Retail tariffs are designed to recover all costs of serving the customer:
  - generation costs
  - transmission costs
  - distribution costs
  - supply costs.
- These costs include both marginal costs and fixed costs.

DESIGNING RETAIL PRICES (CONTINUED)

- Ideally, fixed costs are recovered through monthly or quarterly standing charges.
- Marginal costs are recovered through prices applied to customer's maximum KW demand and KWh usage.
- To the extent practical, prices should vary with time of use.

TIME-OF-USE METERING IS DESIRED

- To vary prices by time of day, metering of hourly usage is required.
  - Should be done for large commercial and industrial customers.
  - Usually not cost-effective for residential and other small customers.

- But prices for small customers should be varied by season of the year.

TARIFF DESIGN IS AN ART

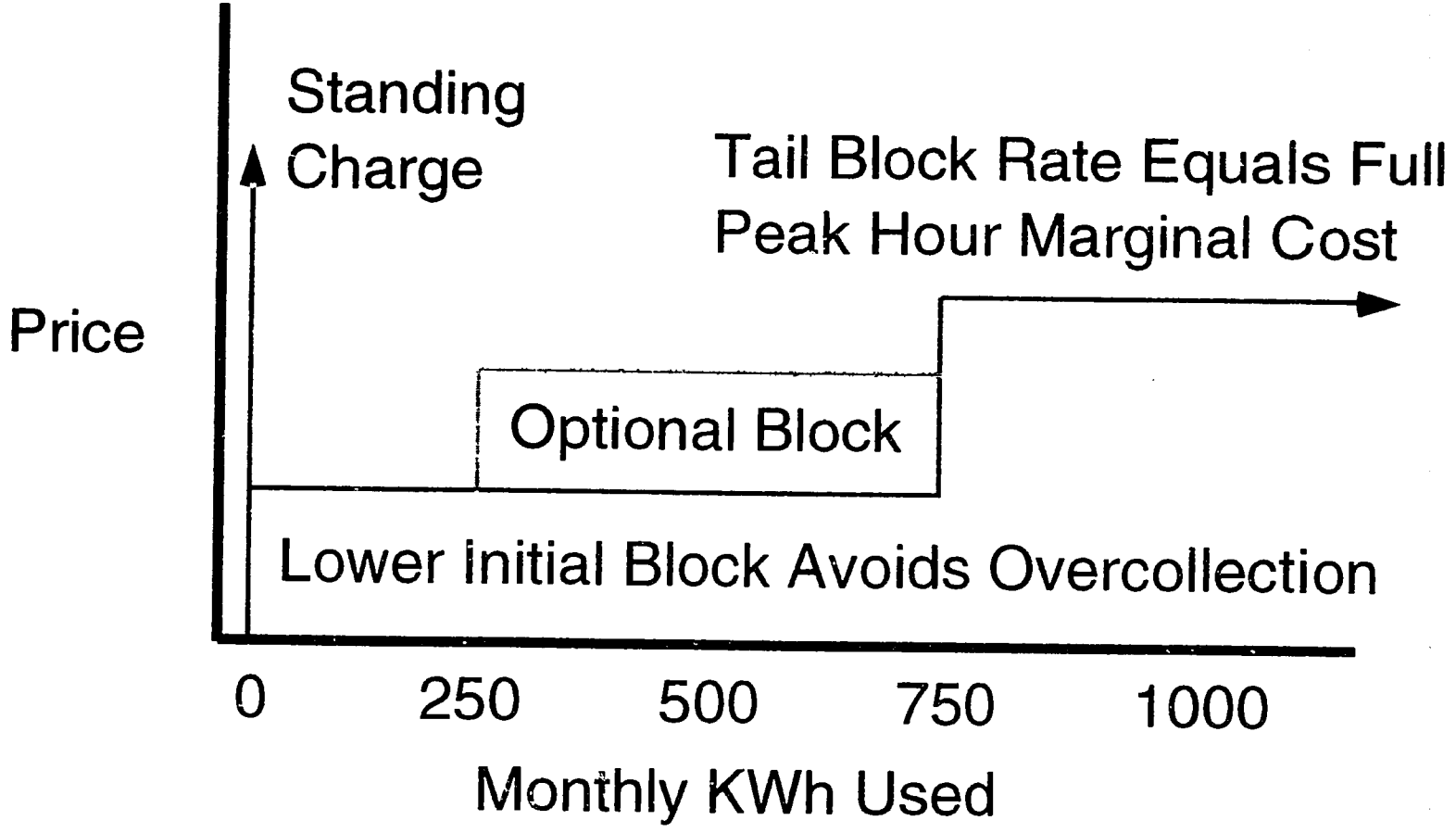
- Small customer tariffs usually involve compromises.
  - Typically some fixed costs may have to be recovered through energy prices.
  - Also, peak hour marginal costs may have to be recovered from non-peak usage.
- In such cases the "inverse elasticity" rule should be applied.

THE INVERSE ELASTICITY RULE

- The "Inverse elasticity" rule:
  - If some prices must deviate from marginal costs, those applied to the least elastic demands should deviate the most.

- Economic efficiency is only affected by pricing when the demand to which it is applied is elastic, i.e., where the customer has a choice

EXAMPLE OF A RESIDENTIAL TARIFF



NEED FOR PRICE REGULATION

- As with transmission, distribution systems are natural monopolies.
- They need to be price regulated to prevent exploitation of monopoly power.
- This is true even if a Distco is government-owned because electricity prices can be used to selectively tax consumers.

PRICING OBJECTIVES REVISITED - I

- Efficient use of electricity is encouraged if marginal generation costs are passed through Transco and the Distcos to retail customers.

- Retail customers should also be charged the marginal costs transmission and distribution costs they impose on the power system.

- To the extent possible, this means time-of-use pricing.

PRICING OBJECTIVES REVISITED - II

- Least-cost production results from paying Gencos prices equal to the system's marginal cost of generation because:
  - it makes efficient operation profitable for each Genco.
  - it makes least-cost construction of new capacity profitable.
  - it supports economic dispatch.

PRICING OBJECTIVES REVISITED - III

- Paying Gencos prices equal to the marginal cost of generation will ensure adequacy of supply.

- But only if congestion charges are set high enough to make investments in new capacity profitable.

PRICING OBJECTIVES REVISITED - IV

- Relying on pricing alone to ensure supply adequacy may promote price instability.

- This classic boom-bust cycle is apparent in other capital intensive market-driven industries.

- Some form of capacity planning coordination may be desirable.

PRICING OBJECTIVES REVISITED - V

- Paying Gencos prices equal to the marginal cost of generation will ensure their self-sufficiency.
  - Most will cover their operating costs, because marginal costs will generally exceed average costs.
  - Still, some inefficient, high cost Gencos may earn low returns on invested capital.

Power Industry Privatization Activities: How Others Do It

	United Kingdom (completed)	Thailand (in process)	Hungary (at planning stage)
Generation	Large generation companies (Gencos) plus some independent power producers (IPPs)	Existing generation to remain in hands of privatized state utility, EGAT. New generation to be undertaken by EGAT/IPP joint ventures	Existing power company to be split up & sold in pieces. All generation plants likely to be IPPs
Transmission	network remains a monopoly (regulated)	network remains a monopoly (unregulated)	network remains a monopoly

	United Kingdom	Thailand	Hungary
Distribution	Local monopolies with competition for large (high voltage) customers	Remains in hands of two monopolies (urban & rural), with competition for large industrial customers	Local distribution companies to be monopolies with competition for large customers
Price Setting	bidding system by 30 minute intervals	reguiated by government	bidding system
Outcomes			
Prices	Falling	Moderate	Likely to rise significantly
Efficiency	Improving	Reasonable (was not an issue in privatization)	Likely to improve signficantly

Petroleum Industry Privatization Activities: How Others Do It

	United States	Thailand	Indonesia
Price Setting	Set by supply/demand balance	Set with reference to ex-Singapore prices	Set rather arbitrarily, to subsidize users of middle distillates
Taxation	Low	High on gasoline, moderate on middle distillates, low on other fuels	high on gasoline and HFO, subsidies to middle distillates
Distribution	Free entry/exit	By refiners, importers, & retailers	State monopoly

	United States	Thailand	Indonesia
Retail	Free entry/exit	By approved firms	State monopoly
Outcomes			
Prices	Low	High, except for HFO	Low, with shortages of middle distillates
Efficiency	High	Reasonable	Low

ENERGY PRICING ANALYSIS FOR BULGARIA: METHODS AND MODELS

Donald I. Hertzmark
December, 1991

Introduction and Economic Background

A starting point from which to assess energy pricing options is to identify that set of energy prices which, from a purely economic point of view, results in patterns of energy production and use which yield the greatest net economic benefits to Bulgaria as a whole. Having first determined this set of energy prices, government analysts then can estimate the economic costs and supply-demand impacts of alternative pricing strategies. Such alternative pricing strategies will generally contain non-economic objectives along with the economic ones. The economic methodology is designed to assist the government analysts to determine the relative costs and merits of alternative pricing policies and divergences from market-determined pricing.

Energy prices should encourage patterns of production and use that will result in the energy production and use yielding the highest possible value to society. This objective can be translated into two general economic criteria:

1. Energy prices should cover the total costs of producing the energy resource, including the benefit to society of depleting the last unit of that energy;[1]
2. Energy prices should lead energy users both to choose the least-cost energy source for a given application and to use energy only as long as the value of the last unit of energy consumed equals or exceeds the cost to society of supplying that unit of energy.[2]

These principles of efficient energy pricing translate well into three of the specific requests which helped to frame the terms of reference for this technical assistance. These were:

1. The cost of producing resources; and
2. Determining the value to the country of different energy resources in various end uses; and
3. Economy-wide effects of energy pricing, including those on income, prices, and foreign trade.

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[1] This is the opportunity cost principle, perhaps the most fundamental concept of Microeconomics. The opportunity cost is defined as the value of the alternative actions foregone to make the present choice or to produce or purchase a good. This opportunity cost represents the values of alternative uses of the resources consumed to produce a given commodity. In the case of oil such resources might include drill ships, pipe, motors, drilling rigs, etc.

[2] The corollary of this is that a least cost supply should maximize the value of the resources to society. This is referred to technically as the duality or saddlepoint theorem.

Market Pricing Of Energy

As Bulgaria rebuilds its energy production and transformation industries and moves toward higher energy use per person, it is important that government decisionmakers use the best available information regarding costs, values, and comparisons among various options. To do this the project has proceeded from a firm base in economic theory with extensive instruction of the counterparts in the basics of that body of theory.

Market Clearing Prices

The first requirement of this component is a grounding in the analysis of supply and demand, It is one of the basic axioms of economics that the maximum value to society is achieved at a set of prices which results in Price = Long Run Marginal Cost (LRMC). The LRMC is defined as the cost of producing an additional unit of output when all factors of production -- labor, capital and physical resources -- may vary. For small additions of supply requiring little or no additional capital investment, the LRMC will be very low, reflecting primarily additional operating and maintenance costs. For much larger additions to supply (for example, a new coal mine and associated railroad), the LRMC will include the capital cost as well as operating and maintenance costs of both the production and transport of the incremental production.[3]

In a competitive market - where there are many buyers and sellers, none of which is dominant, and prices are free to vary - prices will tend toward and settle at an equilibrium point which balances supply and demand (Price P_o and Quantity Q_o in Figure 1). It also will be true that, as reflected in the supply and demand curves in Figure 2.1-1, (a) demand will decrease as prices increase (since for each increase in price there will be some consumers for whom the new price exceeds the perceived value of the good or service) and (b) over most of the range of production an increase in price will elicit additional supply (since some supply which previously was uneconomic will be profitable at the new higher price). When excess supply or excess demand is at a minimum, then economists say that the ruling prices have cleared the market.

This does not mean that the economists' model of a freely competitive market is perfectly adaptable to Bulgaria. However, the idea is to start with the simplest analysis and gradually to complicate it with consideration of "real world" factors including government price controls, shortages, single buyers or sellers, environmental externalities and the like. Ultimately, the simple model can encompass a situation such as the one in the Polish electricity sector where demand consistently exceeds supply at ruling prices and costs.

The first step in the analysis stresses the state of prices and quantities of energy at an equilibrium point, that is, the price at which the quantities supplied and demanded are equal. Figure 1 shows such a point. At the equilibrium point:

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3 The variant of this concept that may prove the easiest to implement is the Average Incremental Cost (AIC) measure. Often the data necessary to calculate LRMC are unavailable. However, it is usually easier to obtain the information needed to estimate the AIC. As a result, AIC is commonly used in appraisals of investments as a proxy for the LRMC. In Theoretical terms this is not correct but it is useful as an approximation. The counterparts were given several computer models which will calculate AIC measures. These are discussed below.

- P = LRMC (See Figure 2) If the price P exceeds long-run marginal cost LRMC, at least one producer will profit from increasing its supply. If P is less than LRMC, at least one producer will have incurred a loss on its last unit sold and hence will cut back production until P, which represents the

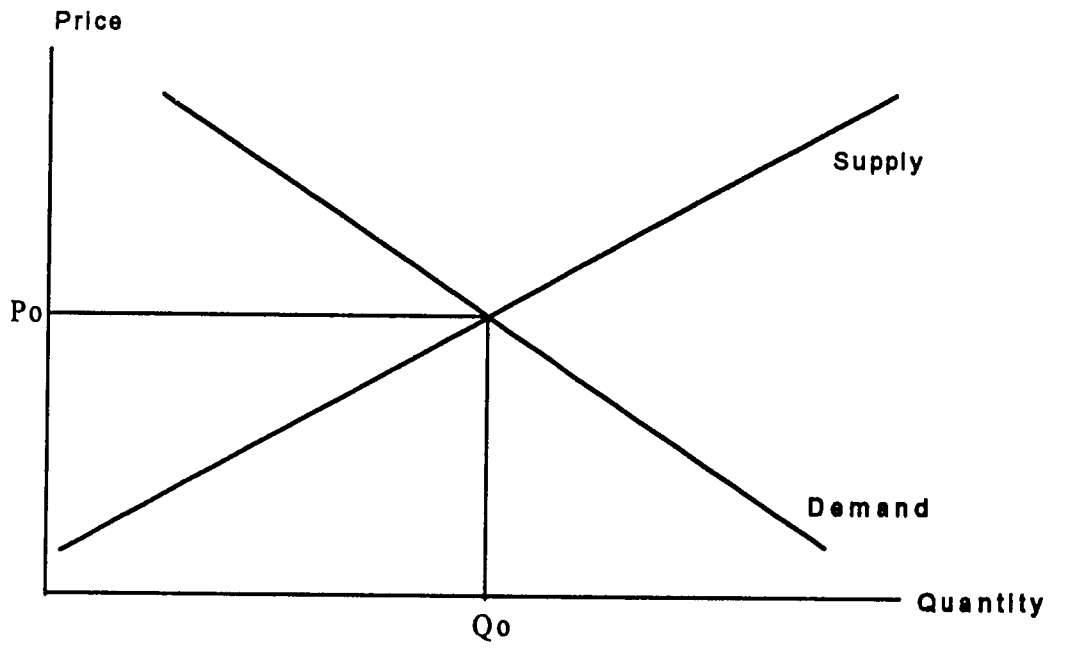

Figure 1: Supply and Demand Equilibrium

revenue derived from the last unit sold, is no less than LRMC, the incremental cost of producing that last unit. At equilibrium, LRMC = long run average cost (LRAC).

- The LRMC also equals some point on the short run marginal cost curve (SRMC, also shown in Figure 2). Since the SRMC is more simply and accurately measured than the LRMC, this equality has great significance for empirical work on supply cost estimation.

- P also equals the marginal benefit of the last unit sold, denoted here as MV. It generally is assumed that, for any consumer the MV of a given good declines as the volume consumed increases. For example, the marginal benefit (value) of the first bowl of rice to one who has none may be very high, the value the second bowl will be less, the third still less, and so forth. As long

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as for any consumer the marginal value, MV, of one more unit exceeds the price, P, of that unit, it will be worthwhile for the consumer to increase consumption by an additional unit. Where P is greater than MV, consumers will cut back their consumption until the price is no higher than the marginal value of the last unit consumed.)

Thus, in a reasonably free, competitive market, the price of a good or service will tend toward the point where price equals the long run marginal cost of production on the one hand and the marginal benefit to consumers on the other hand. In a given economy in which markets for all goods and services are competitive, where consumers are free to spend their resources to procure whatever set of goods and services yields them the greatest aggregate benefit and producers (at least in the long term) are free to use their resources to produce whatever set of goods and services they desire, all prices throughout the economy will tend toward the point where for each good and service P = LRMC = MV. That is, prices will equal the marginal cost of production and the marginal benefit to consumers.

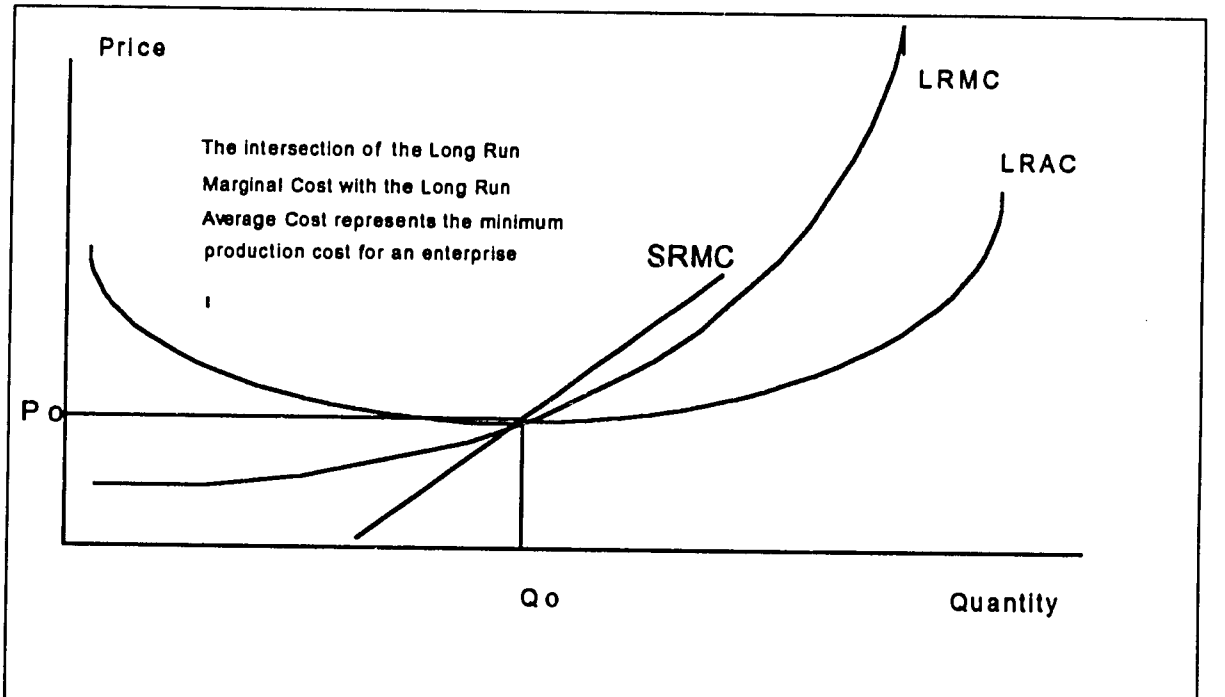

Figure 2: Relationship of Average and Marginal Costs

When energy price and/or quantity controls exist, as they have in Bulgaria, there are no statistically good measures of supply and demand in the conventional economic sense[4] Put simply, there is not enough marginal change in prices to provide the raw material for standard econometric studies.

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[4] Econometric models are used to measure the supply and demand responses to changes in prices. Normally such models assume competitive market behavior, a condition not always met in Bulgaria. As a result, econometric studies of official market transactions may be of less use than AIC and netback measures in Bulgaria.

For example when prices or quantities of a good are held below their market clearing levels, (that is the price where supply and demand are in balance) shortages will develop as demand rises unless government subsidizes the difference to encourage producers to manufacture quantities commensurate with demand or pay for rising imports through indirect subsidies.[5] Similarly, if prices or quantities of a good exceed market clearing levels, demand will fall or shift to some other comparable or replacement good which is lower in price. In Bulgaria,, the pricing of middle distillates is a good example of the first case. Continued subsidies by the government in the past led to ever rising demand, eventually outstripping the supply of such products at ruling prices.

This, in greatly abbreviated form, is the basic economic theory of pricing and resource allocation in purely competitive markets. In fact there are few purely competitive markets anywhere in the world and certainly no national economy where across all sectors all markets are competitive. The above theoretical basis therefore is useful in large measure as a benchmark against which to evaluate real-life market conditions and resource allocation. Resource allocation will result in maximum aggregate welfare to society where Price = LRMC = MV, because at such a price the marginal value to society of the last unit consumed will just equal the marginal cost of producing that last unit. Where prices diverge from this equality in either direction, there is additional cost for producers and higher prices for consumers. This results in a loss of aggregate benefits to society. Thus, in the context of energy prices society will benefit most where:

- Each energy price just covers the long run marginal costs of producing the last unit of that energy; and
- Each energy price just equals the marginal benefit to society of the last unit of that type of energy consumed.

Complicating The Theoretical Model

Applications of this theoretical benchmark to real-world markets, including energy markets in Bulgaria, are not always straightforward. For example:

- LRMC often is difficult to estimate since it involves imperfect information about not only present but future technology and costs -- including, in the case of fossil fuels, future costs of fields which have not yet even been explored. In the case of fossil fuels, LRMC must include costs of exploration as well as production (including costs of unsuccessful exploration). Hence, estimation of LRMC also requires estimation of, among other things, future exploration rates under various production sharing régimes and the finding rates resulting from such exploration effort. Given such measurement problems, economists have taken other approaches, including the use of SRMC as

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5 For example, controlled prices of refined products mightd normally make middle distillate sales uneconomic. However, if the government collects additional revenue on some refined products it may use the money to cross-subsidize the losers.

a proxy for LRMC. In addition, economists have developed surrogate measures, including Average Incremental Cost, to represent LRMC;

- Marginal benefit or marginal value to consumers is a concept which economists, despite many attempts, have not been able to translate into directly measurable terms. Thus, using the P = MV equality, marginal benefit usually is imputed from information on quantities purchased at various price levels -- i.e., the demand curve. Where prices are administered and only infrequently adjusted or where the prices of close substitutes are similarly controlled, as was the case for most forms of energy in Bulgaria, there may be too few data points to draw inferences about consumer preferences and perceived marginal value at various consumption levels. For economists, a useful surrogate for marginal value is the netback value. This concept is discussed below;

- Energy production often results in costs to society which are not included in LRMC calculations because they are not borne by the producer but which nevertheless are very real. In the energy sector, two such categories of cost are relevant.

  ✓ First, economists generally consider that, for any country which has a depletable resource such as oil, gas or coal, there is a cost to society of such depletion, in addition to the actual costs of physical extraction and processing. Oil, gas or coal in the ground are analogous not so much to a manufactured product as to the capital plant which produces that product. As capital equipment is used up and depreciated, so the country's fossil fuel capital should be similarly depreciated as it is used up. The typical form of such depreciation, the "depletion allowance", is discussed later.

  ✓ Second, energy extraction, processing, transport, or use may entail certain external costs or "externalities" borne by society at large rather than by the energy producers. Examples of externalities may include air and water pollution from mining or power production or loss of farm topsoil due to water runoff from uplands cleared for fuelwood.

The following subsections describe the surrogate estimating methods commonly used by energy economists. These measures attempt to recreate the supply and demand curves that might be measured were markets operating more freely and were information more readily available.

Cost of Supply

[*Note to the reader:* all mathematical notations and equations below may be ignored without loss of context.]

On the supply side, the key measures used in the analysis are the **short run marginal cost,** (SRMC) a computable proxy for marginal costs, **average incremental cost** (AIC) of production, a practical measure for approximating the long run marginal cost, and for non-renewable resources one adds the **depletion allowance** applicable to each resource. Together these constitute the economic cost of supplying the various non-renewable energy resources[6]

Short Run Marginal Cost

In general terms the short run marginal cost is the change in cost for a small change in output (normally set arbitrarily at one unit). Hence, strictly speaking, the SRMC includes only variable costs. Fixed costs are not a concern. This is certainly true if the market is close to balance with current prices and supplies. However, if supply is short, then additional supplies are worth more to the consumer than they cost the producer. In other words, the price of the good is too low.

In the case of electricity this means that under conditions of continual shortage, any increment to electricity supplies is worth not only the energy cost of the additional unit but also the value to consumers of reducing the volume of the shortage along with other costs imposed by supply insufficiencies. These costs include:

1. Decreases in the quality and/or reliability of service, possibly remedied by resort to backup generation;
2. Lack of adequate reserve margin; and
3. Value of unserved energy.

To calculate the true short run marginal cost, it is necessary to break the problem into two parts. The marginal energy cost is easily calculated and will not be dealt with here. The marginal capacity cost should be calculated as follows:

Calculate the change in reliability due to generating an additional unit with current equipment, accounting for unserved energy costs, and increased loss of load probability,

i.e.,

$$MCC = (OC\text{-}£) * (LOLP), \qquad (1)$$

Where:

- MCC is marginal capacity cost;

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6 Depletion of renewable resources is also possible. For a discussion, see Colin Clark, Mathematical Bioeconomics, (1976).

- OC is the cost of unserved energy;
- £ is the operating cost for the marginal capacity addition; and
- LOLP is the loss of load probability

If the MCC is greater than the right-hand-side of (1), then the system is under capacity and payment of a capacity credit is justified up to the value of that term. This method is easily operationalized in economic evaluation models based on commercial software.

Average Incremental Cost

Because the LRMC is difficult to measure precisely, some specialists use a slightly different economic concept, Average Incremental Cost. The AIC measures the additional investment and operating costs required to increase the output of an energy resource and to maintain it at a designated level of production for a designated period in time. In the electric power system, the AIC is the cost of the next unit in a utility's long range expansion plan. Specifically, the AIC is the discounted sum of additional investment and operating costs divided by the discounted volume of additional production. The AIC includes any production, transport, and if appropriate, distribution costs of the energy resource under analysis. It **does not include any past investments in capital, infrastructure, or development** but does include any new capital investments required to achieve the increment in production and to maintain existing output beyond its natural rate of decline.

i.e.,

$$AIC_0 = \frac{SUM^T_{j=1}\ [I_j + (R_j - R_o)]/(1+i)^j}{SUM^T_{j=1}\ [Q_j - Q_o]/(1+i)^j} \qquad (2)$$

where

I_j	=	capital cost in year j
R_j	=	operating and maintenance cost in year j
R_0	=	operating and maintenance costs in year 0
O_j	=	output of energy source in year j
O_0	=	output of energy source in year 0
i	=	discount rate
T	=	time horizon of the analysis. Year 0 is the initial point

(cf, Mashayekhi, 1983, pp. 8-9)

This measure of cost, like the LRMC, does not include taxes, royalties, externalities, market imperfections, and subsidies. Unlike LRMC, the AIC can be calculated from known (or knowable) data in a straightforward manner. Often, the AIC can be calculated from information that is available to the analyst from government and international sources. The only caveat is that the data must be corrected for the effects of domestic distortions and market imperfections.

It is possible to calculate the AIC using spreadsheet-based models on personal computers. Unlike the long run marginal cost calculations, no system-wide optimization or simulation is required. However, it is not clear that the AIC measure is superior theoretically to the SRMC measure, especially where demand consistently outstrips supply, as in Bulgaria. In particular, the AIC measure does not account for the value of marginal additions to generating capacity and is thus not useful for negotiating power purchase agreements from private generators. The AIC measure seems to be better suited to estimation of production costs for fuels than it is for the electric power sector.

To apply the AIC to fuels, account must be taken of the depletability of finite resources. To measure the value of such exhaustion, a depletion allowance (value), denoted as DV, is added to the AIC.

Depletion Allowance

The depletion allowance measures the additional costs of supplying exhaustible resources and reflects the fact that a unit of a resource used today will not be available at some time in the future and will have to be replaced by another resource which will normally be higher in cost.[7] The depletion allowance for a producer is not to be confused with a financial depletion allowance utilized for tax purposes.

The depletion allowance can be calculated only in relation to some assumed backstop fuel. It generally is defined as the difference between the present value of the backstop fuel price in the future year in which it is needed and the cost of the fuel under analysis. The analyst must know or assume the price of that backstop fuel at the time of exhaustion of the present fuel. The course of prices for the backstop fuel is known as the Economic Price Path (EPP). Such a path may be derived from simple escalation rates applied to current prices or it may result from sophisticated geological and engineering simulation. The EPP's used in this report usually come from the World Bank's "Fuel and Commodities Reports". Assuming that the backstop fuel price is well known, this depletion allowance value can be calculated. The usual formula for calculating the depletion (value) in any period along the economic price path is:

$$DV_n = \frac{\text{Economic Price of Backstop Fuel in year of economic depletion}}{(1+1)^{T-n}} \quad (3)$$

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7 The depletion allowance is sometimes referred to as the user cost (cf, Clark, op cit, page 103). In some formulations the depletion allowance has been included as a part of the economic rent. However, recent treatments have tended to separate the two into user cost/depletion allowance and pure economic rent. The depletion allowance is then included in the economic supply price along with AIC.

Where X is the backstop or alternative fuel and T is the year of economic depletion.

For example, oil or its equivalent at $45/bbl 25 years from today yields a DV_0 of $4.15/bbl using a 10% discount rate.

The depletion allowance in theory accrues to the owner of the resource. For Bulgaria this means the Government in virtually all cases. In practice, government resource owners generally allocate at least a portion of the depletion allowance to producers. If a producing company does not receive a sufficient return, including the depletion allowance, that firm will not invest to develop the supply of a given resource beyond the exhaustion of the current reserve. As a result, the distribution of the depletion allowance between producers and government critically affects future exploration, development, and production activities.[8]

It is important to note that the AIC of an energy resource is only *one* of the critical components determining the price of the resource. It is not a final consumer or producer price since those prices must also incorporate financial elements necessary to insure the long-term financial integrity of the project as well as to meet government revenue needs.

The significance of AIC and depletion value calculation is that in the absence of precise energy supply/demand data, the sum of AIC and depletion value measures the **economic** cost of supplying an energy resource such as gas or coal to end users.

Supply curves can be constructed from these data. This is done by calculating the economic supply costs associated with development of various volumes of a given fuel. The resulting mapping of quantities produced versus costs (price) represents a surrogate supply curve.

Netback Values

The AIC plus the depletion allowance provides a good approximation of the economic cost of supplying energy. On the demand side, the critical analytic measure is known as the **netback value**. This measure reflects the value of an energy resource to the purchaser or end user. That is, the netback value represents the highest price that a consumer is willing to pay for the fuel. Since it is assumed that a purchaser or end user wishes to buy a resource at the lowest cost possible, this allows the purchaser to evaluate the relative values of various fuels on a comparative basis. By varying the assumptions about costs for the processing, it is possible to derive a range of values for the prospective gas from new wells in Bulgaria.

Under a perfect market environment, a purchaser will demand a fuel only when the cost of the fuel is less than or equal to its value to the user, i.e., for some cost of resource X, (AIC_x + depletion $allowance_x$), the netback value, NB_x, must be such that:

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[8] A cost-plus rate of return price for domestic oil or gas in theory diminishes incentives for continued exploration and development by failing to remunerate producers for unsuccessful exploration and development efforts. Compensation for unsuccessful efforts is only accomplished in practice by permitting producers to capture some of the windfall from higher prices, i.e., by using a depletion allowance.

$$NB_x \geq AIC_x + DV_x, \text{ i.e., } NB_x \geq \text{economic supply cost}_x$$

If the netback value is calculated relative to the next best alternative fuel, then satisfaction of this condition assures that use of the resource, X, is economically feasible for a given end use. Conversely, if NB_x is less than AIC_x then the opportunity cost of the resources required to produce X is more than the value received by using X.

The netback value is calculated by taking into account the different capital equipment required to use different fuels and the different operating efficiencies that characterize each fuel as well as the economic supply cost of the next best alternative fuel. Because of the importance of locational factors, especially for gas and coal, netback values may vary significantly by location.

There are two ways of calculating netbacks. The first is the **opportunity cost** formulation. With this method, the proposed new fuel is compared against the next best alternative fuel. For Bulgaria, this formulation of the netback value is preferred in most domestic products, using domestic coal as the base case comparative fuel.

Consider a case in which we wish to know the value of oil as a replacement for coal in the power sector. This value can be defined as:

$$NB_{oil} = \frac{[I_{oil}/\text{unit} - I_{oil}/\text{unit} + F_{oil}/\text{unit}]}{Cons_{coal}/\text{unit}} \qquad (4)$$

where

I_{coal}	=	investment and operating costs required to use coal.
I_{oil}	=	investment and operating costs required to use oil.
F_{oil}	=	cost of fuel oil
$Cons_{oil}$	=	oil consumption per KWh in tonnes or 10^6 BTU

If the units are all kWh then the netback is the amount that a power plant can afford to pay for coal per 10^6 BTU or per tonne since the kWh drop out. A numerical example of this technique is given later in this section.[9]

An alternative formulation of the netback value of fuel oil starts from the price of the final product and nets out investment and operating costs.

i.e.,

$$NB_{coal} = \frac{P_e - I_{coal}/\text{unit}}{Cons_{coal}/\text{unit}} \qquad (5)$$

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9 Fuel netback values normally differ by the specific conditions governing their use. Consequently, netbacks for the same fuel, e.g., gas in base, shoulder, and peaking plants will vary.

where P_e = unit price of the product, e.g. a price for electricity for some class of users, usually bulk power sales.

This formulation is normally used when the energy is transformed into a standard internationally traded product - e.g., LNG, LPG, refined oil products. It is also used in the avoided cost formulation where P_e in equation (5) is replaced by the avoided cost .

Where markets are operating efficiently and few distortions exist, the two calculations should yield similar results. That is, in an efficient economy the price of a good should be close to its opportunity cost, i.e.

$$P_e/\text{unit} = [(I_{oil} + F_{oil}) / \text{units produced}]$$

The netback value shows the maximum a buyer is willing to pay for a fuel given either the sales price of the final product or the cost of the next best available fuel.

System Considerations in Power Plant Fuel Cost Analysis - Electric power transmission and distribution AIC's can vary substantially depending on the distance from the generation source to the point of use. For this reason, the netback value for fuel at a particular facility may differ from the system-wide netback value for that fuel. To avoid basing system-wide decisions on such single-valued calculations, and electric utilities, as well as natural gas distributors, generally prefer to plan on a system avoided cost basis. When a utility needs a new facility, it looks at the lowest cost to the system of providing additional capacity, not necessarily to the lowest cost of providing service by any single plant in the system. Such a planning scheme also permits the utility to address system wide loss of load probability (LOLP), impacts of alternative production/generation or transmission and distribution investments. System-wide avoided cost planning is used particularly when an integrated national electricity grid or gas pipeline network allows great flexibility in the movement of energy supplies. Many U.S. power utilities have refined the system avoided fuel cost concept to a system-wide fuel netback value calculation. The utility will then attempt to maximize this netback value. Such maximization is equivalent to minimizing all other costs and losses system-wide. For Bulgaria, netback analysis using a single plant or city gate provides a satisfactory approximation of average system avoided cost.

Leaving the discussion of systems issues and returning to the level of individual power station or fuel types, it is possible to obtain quite concrete results on netback values. Exhibit 1 shows how netback values for oil can be calculated in a system where oil provides the backstop fuel. The example used shows how coal quality and power plant efficiency and cost critically affect a fuel's value.

Economic Rent

As noted, the AIC plus the depletion allowance represents the lowest economic cost at which a producer can supply a resource without incurring an economic loss. In contrast, the netback value represents the highest value to the purchaser or consumer of the fuel delivered to a plant site or city gate. The difference between the economic supply cost and the netback value (the value of energy to the consumer) is the economic rent plus the consumer's surplus which can be distributed among producers, fuel purchasers, end users, and the

Government. Estimation and allocation of this range of value is an important aspect of an effective national energy pricing policy.

Economic rent is defined as a payment to any factor in excess of the amount required to obtain the services of that factor.[10] So defined, the economic rent is the area between the supply curve and the equilibrium market price. Any area above the equilibrium price but below the demand curve represents consumer's surplus.[11] Figure 3 illustrates the economic rent plus consumers' surplus available to energy producers and energy consumers. The area bounded by O, P_c, C, b reflects the area in which it is in the interests of both consumers and producers to negotiate a selling or purchase price. That is, between P_p and P_c can be found a price which pays for the fuel while at the same time meeting other social or financial objectives.

In general, point alpha in Figure 3 represents the economic optimum for all of the parties -- producers, consumers, and governments. Deviations from this point will increase the return for one or two of the parties by less than the loss of benefits incurred by the other(s).

Economic theory postulates that the selling price of a resource should be less than or equal to the netback value to the fuel purchaser. If the equilibrium selling price is greater than the netback value, the consumer will not buy. At the point of equilibrium and without distortions, taxes, and market imperfections, the netback values and the long run marginal cost should be equal. In reality institutional and other market barriers (e.g., non availability of alternative distribution systems) often make such equilibrium impossible. In such a situation, a producer may often try to capture additional economic rent or consumer's surplus. An

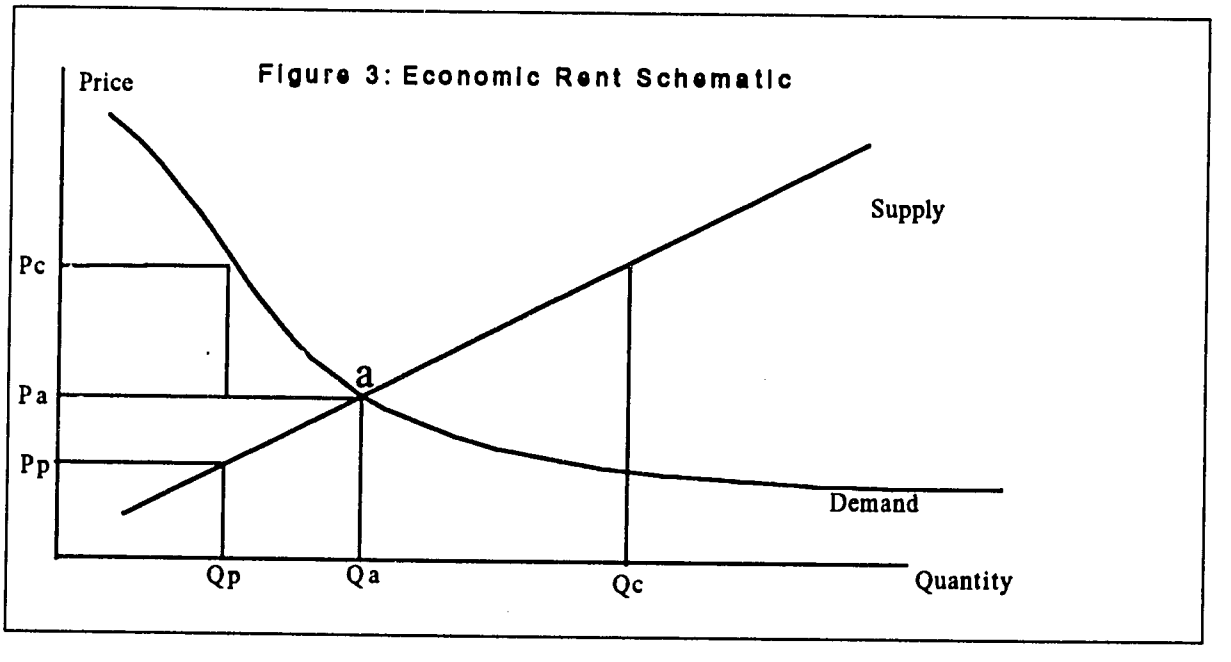

Figure 3: Economic Rent Schematic

10 MIT, Dictionary of Modern Economics, 1988, pp. 120-121.

11 If the price is set at any level other than market clearing, Po, then a portion of either the rent or the consumer's surplus will be reallocated. In figure 3 all prices < Po allocate some of the rent to consumers. Conversely for prices > Po, some of the consumer's surplus is allocated to the producers. Where taxes, royalties, and production sharing occur, then there will be some reallocation of both rent and consumer's surplus depending on the particular terms of the agreements and the taxes. On the subject of consumer's surplus, see Hal Varian, Microeconomic Analysis, Norton,

example illustrates these issues. Suppose a government acts as both a monopolist, the only seller of fuel to final consumer, and a monopsonist, the only buyer from producers. Suppose further that the government has decided to ration this fuel, i.e., $Q_p < Q_c$ as in Figure 3. If the government tries to sell the fuel for $P_a < P_c$ the consumers will get an additional portion of the consumer's surplus. However, such a price will lead to excess demand, at Q'. Therefore, the government is likely to choose to tax the fuel to ensure that excess demand does not arise. At any price to producers above P_p, there will be greater supply than the government wishes. Therefore, the government would choose to keep prices for suppliers at or near P_p.[12]

Such a system can work indefinitely but carries definite costs. Consumers pay more than would be the case in a less restricted market. At the same time, they consume less than is socially desirable. On the supply side prices are lower and quantity supplied less than is socially desirable. The above example has direct relevance to many energy pricing issues including gas pricing to the power company. In the next phase of the project, the team will relate these concepts of rent, netback value, consumer's surplus, and AIC to of pricing policy options available to the Government.

New York, 1978, pp. 207-211.

12 This is obviously a stylized model. No government has perfect monopoly or monopsony power. However, it does illustrate the basic issues in the allocation of rent and consumer's surplus.

Exhibit 1

Calculating Netback Values:

A Numerical Example Using Coal and Oil-fired Power Plants

Let the hypothetical parameters for coal and oil power plants be as shown. These values will be taken at their base case default levels - e.g., those costs and efficiencies which correspond to standard international costs and practices. For this case the data is:

- Investment & O&M costs for oil = $0.01763/kWh
- Investment & O&M costs for coal = $0.02127/kWh
- Heating value of coal = 20,700,000 BTU/t (Silesian coal, for example)
- Heating value of fuel oil = 6,500,000 BTU/bbl
- Fuel cost for oil = $0.01776/kWh, for crude oil at $15/bbl,
  and = $0.0296/kWh, for crude oil at $25/bbl, where fuel cost/kWh = {(heat rate/kWh)/ heating value of oil in BTU/bbl} x price of fuel oil
- Coal consumption/kWh = 0.473 kg for 20,700,000 BTU/t coal
  = (9800 BTU/kWh) /20,700,000 BTU

Using the formula defined above for Netback Value and substituting the above values into the equation we get

$$\text{NB coal} = \underline{(0.0176 - .0.2127 + (0.01776 \text{ or } 0.0296))} \qquad (1)$$

$$= 0.000473$$

$$= \$29.79/\text{t if crude oil} = \$15/\text{bbl, and}$$

$$= \$54.82/\text{t if crude oil} = \$25/\text{bbl}$$

The netback value can be recalculated for higher quality coal. For example, if the heating value of the coal were 24 MMBTU/t, then the denominator of the NB equation would change to 0.000408. This would bring the results to $34.53/t and $63.55/t for crude oil at $15 and $25/bbl, respectively.

These values show what the operator of a coal-fired power station of the characteristics given in the assumptions could pay for coal under varying circumstances of coal quality and crude oil prices. **These values do not indicate what the plant should pay. Rather, they indicate the upper bounds of the economically feasible prices for coal.** Note that the calculated netback value is sensitive to all of the parameters that make up the capital and fuel charges for the oil-fired facility. In particular, plant factors and heat rates can change the calculated netbacks dramatically.

The other type of netback, the one that uses the final product price, can also be used with the data given above. Suppose, for example, that the power company were to announce that they would purchase baseload power from all interested parties at their average avoided cost (economic) of $0.043/kWh. Now suppose that there are two power plants

proposed, one oil-fired and the other coal-fired. What the operators of these proposed plants can pay for their fuels will be:

$$NB_{oil} = \frac{(0.043 - 0.01763)}{0.00148} \quad (2)$$

= \$17.14/bbl of fuel oil

(~\$20/bbl of crude oil)

$$NB_{coal} = \frac{(0.043 - .02127)}{0.000473 \text{ or } 0.000408} \quad (3)$$

= \$45.94 for 20.7 MMBTU/t coal or \$53.26 for 24 MMBTU/t coal

Again, the value of the permissible maximum price is affected by heat rates, capital costs, plant factors, among other things. For example, a heat rate of 10,600 BTU/kWh in the coal plant would lower the netback values for coal by raising the denominator of eq (3), above. In this instance the coal netbacks would fall to \$42.44 and \$48.72, respectively, for the low and high BTU coals.

Optimization Models

An alternative approach to AIC and netback calculation is the use of an optimization model to show what the price of a fuel ought to be if the energy sector is running efficiently. This approach is used in the oil industry on oil refining issues.

As noted previously, in an environment in which price or quantity controls have often played an important role, as is the case in Bulgaria, prices and costs may diverge from their true economic values, i.e., those which accurately reflect the relative value to the economy of utilizing scarce resources. Taxes and subsidies also cause a divergence of actual prices from their economic values. In some cases, these prices will be higher and in some cases lower depending on government policy.

It is, therefore, necessary to construct surrogate measures of what these values would be in a more competitive market in order to eliminate or reduce the distortions introduced by fiscal and regulatory systems. The values that emerge from these adjustments constitute what are commonly called the **shadow prices** of the variables in which the analysis is focused.[13]

For example, in the refining sector all final products (e.g., gasoline, #2 oil, etc.) are produced jointly. Therefore, the value of a one barrel reduction in demand for gasoline is not necessarily measured accurately by the current price of the product at the border. Rather, it is the cost to the entire production system in terms of other products jointly produced (gasoil, kero-jet, fuel oil), refining capacity saved, and changes in transportation costs. In a well functioning open refining system, the balance of these forces should be about the same in the home market (Bulgaria) as in the international market (Rotterdam).

This concept of the shadow price is equivalent to the shadow price concept pioneered by Dorfman, Samuelson, and Solow.[14] That is, the removal of market distortions, imperfections, taxes, subsidies, and rents yields the full economic cost in foregone alternative uses of the resources. A refining sector model running on non- distorted prices, costs, and technical coefficients should calculate a shadow price for, say gasoline, that is identical to the shadow price obtained by removing distortions from measured market prices or their proxies.[15] Thus, the optimization shadow prices derived from an optimization model are analytically equivalent to the shadow prices resulting from a methodical removal of market distortions and imperfections, i.e., the World Bank's shadow pricing approach.[16]

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13 Shadow prices are nothing but the opportunity costs of resources of products. That is, they measure what resources must be used up to produce a particular product or supply a particular resource. Shadow prices use economic measures of cost exclusively. All inefficiencies and distortions are, in principle, removed from the measured shadow price.

Such shadow prices are, technically, the dual variables of an optimization model. In that sense, they give the change in the objective function, say minimizing the costs of oil refining, transporting, marketing, importing, and exporting oil products. In such a system, the shadow prices of any one product will indicate the change in total costs if consumption of that product is reduced by one unit (barrel).

14 See Dorfman, R., P.A. Samuelson, and R.M. Solow, Linear Programming and Economic Analysis, New York, McGraw-Hill, 1958. See especially Chapters 6 and 7.

15 Proxies for market prices may be used where markets do not exist for particular goods.

The shadow prices of an energy sector optimization model represent the economic value to Bulgaria of providing additional amounts of a fuel to either the domestic or international markets. In short, where prices and costs diverge from one another or where key energy facilities (refineries, power plants, gas pipelines) are not being utilized efficiently, an optimization model can show the net national costs incurred by inefficient operating procedures.

Shadow prices can also be used in the analysis of energy demand. The shadow price of LPG can be calculated using an optimization model to represent the minimum price that consumers should be willing to pay for LPG in two different cases, the first based on current uses, the other based on substitution for kerosine. The calculated shadow price of additional LPG demand, if less than the value of kerosine exports, indicates a potential economic gain to the country from such substitution. Conversely, the differences between the two LPG shadow prices also indicates the cost of present programs

.Similarly, natural gas can be allocated into the power sector to substitute for other fuels. The calculated shadow prices indicate the value to the country of natural gas in terms of, for example, fuel oil substitution. This approach takes into account all of the costs to the refining system of the resources required to obtain fuel oil for the electric power sector.

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[18] The MIT Dictionary of Modern Economics (op cit) defines shadow prices as ". . . The opportunity cost of producing or consuming a commodity . . . A set of shadow prices may be constructed reflecting the marginal costs of production or the marginal value of their use as inputs." Page 385.

Reforming Energy Prices: A Brief Guide

One of the key problems facing a country contemplating price reform is the seeming complexity of the task. In large measure price reform is complicated because of two main factors. These are:

1. High perceived political costs since there must be losers as well as winners; and
2. Additional complications for regulatory bodies not now required to examine and adjust prices periodically.[1]

The particular pattern of energy prices in Bulgaria has produced disparate impacts on different groups of the population. There have been winners and there have been losers from the price structures for energy that have been in effect over the past 40 years. The winners, those groups benefiting from the current pricing structure, include heavy industry, urban households, and urban commercial users (hotels & shops). On the other hand rural and agricultural groups, motorists, small manufacturers have been the losers in the current energy pricing scheme. Over time, pricing reform that is based on international pricing levels and structures will change some of the relative prices for energy

How Low Energy Prices Harm Their Intended Beneficiaries

It would seem paradoxical that low energy prices will hurt the interests of the poor. However, where prices are below the costs of production and where supply is rationed administratively *and* where demand cannot respond to changes in the relative prices and availabilities of various fuels, those groups that are not well represented in the allocation process will lose out.

Thus energy is certainly inexpensive for the rural dwellers. But if they have insufficient supplies and the wrong mix of products at that, then the low prices scarcely benefit them. Evidence from other countries has shown time and again that higher prices along with adequate and flexible supplies are generally preferred to low cost but insufficient supplies.

For example, low prices to the agricultural sector may result not only in reduced supplies to that sector and to the economy in general but may also retard the incentives for investment in better and more efficient machinery, safer pesticides, and more efficient processing. And, of course, agricultural output is exquisitely sensitive to timing. Typically, users are willing to pay a premium to obtain energy supplies at the right time, rather than watch a harvest go to waste.

[1] Note that this second factor disappears if the country decides to move to full market pricing.

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in the country. Some of these changes are predictable and result from the government's reforms which have already pegged wholesale petroleum product prices at world levels. They include:

- Rising coal prices for domestic users and rising costs of using coal as environmental standards are enforced;
- Increased prices for middle distillates, diesel, kerosine and jet fuel, as the excess demand occasioned by years of low prices necessitates higher investment in the refining of such products;
- Rising costs in the refining sector to meet international specifications for gasoline and diesel fuel;
- Demand (capacity) charges for large gas and electricity users; and
- Taxes on refined oil products to provide revenue for the government and also to provide funds for road repairs, airport construction, etc.

Principles of Energy Price Reform and Decontrol

Observing the several principles for pricing listed below can assist a country in reforming its energy pricing system. These principals follow straightforwardly from standard economic policy strictures. They are:

- Some way must be found to compensate the losers - generally the urban poor and heavy industry;
- The efficiency gains from better resource allocation must be identified, where possible, and some of those gains should be distributed to those bearing the costs of such reallocations;
- Reliance on international market prices is simpler than trying to invent complicated cost-plus formulae to price domestic energy resources;
- Pricing adjustments should be frequent and common, not requiring acts of Parliament or the cabinet;
- Quantities of energy demanded must be permitted to vary in response to changes in price;
- Supplies of energy should be linked explicitly with domestic energy prices - that is, energy producers should receive prices that are related and proportional to what consumers pay for that form of energy;[2] and
- All resources required to produce a final product need to be priced efficiently as well.

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[2] To take one of the most common examples, high gasoline prices in most countries have little or nothing to do with ex-refinery prices for gasoline. Hence, when there is a requirement to make massive new investments in gasoline supply to meet environmental restrictions on various components of that fuel, these investments will necessarily take away from other projects. The revenues from gasoline sales, *per se*, do not cover the costs of such investments. Hence the investments may not be made in a timely or appropriate manner.

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Efficient Regulation of Energy Prices: An Important Step Toward A Free Market

Few countries are willing to go the route of full deregulation of energy prices. In Bulgaria, the government has indicated that substantial energy assets, electric power, gas transmission and distribution, coal mining, and oil refining will remain in state hands for the time being. Hence the recommendations below will be aimed at making state-controlled or regulated prices more efficient. Ultimately, an efficient pricing system can assist the nation in making a transition to a largely deregulated energy market.

Steps to More Efficient Price Determination

1. Perhaps the first step is to determine the cost of supplying energy in raw or processed form. The results of such analysis will give policymakers a good idea about whether the sector is operating efficiently relative to world price and cost levels.
2. The second step is to establish a series of basis prices for key energy products. In the refined product sector this can be done be reference to the ex refinery prices of key product outputs at a major international terminal. The country can then decide what sort of differential it must add to account for local cost differences. For coal, the reference price can be the delivered price of coal at a recognized international terminal (e.g., ARA). Establishing baselines for natural gas is more difficult. However the price of natural gas in domestic markets is bounded from below by its value as LNG feed and from above by the values of competing petroleum fuels, #2 oil or #6 oil or LPG. In the electricity sector, the fuel price basis should be accommodated through a fuel-price adjustment clause.
3. The next step is to decide on the taxes and other levies that will be laid on energy prices. Constant taxes have the advantage of making government revenues predictable while *ad valorem* taxes will keep relative prices constant. Economists prefer *ad valorem* taxes since they distort relative prices the least. If the nation continues to import crude oil on a cash basis, some sort of import tariff will normally be added to the crude oil price. As with the excise levies, economists prefer a percentage tariff rather than a fixed levy. However, revenue considerations may call for a fixed amount of tax in order to maintain stability in government revenues.

Adjustment Intervals and the Mechanics of Changing Prices

Determining a baseline price level and a tax structure gets policymakers to an initial set of prices. The hard part is to determine the proper intervals for adjustment. If prices are not to be adjusted on a daily basis, the country will

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need some sort of *buffer fund* to accommodate day-to-day changes in energy prices.[3] This fund will cushion the short term fluctuations in world energy prices. The buffer fund will need to be paid for by a specific tax on energy products, usually a constant amount per unit sold.

To make a system like this sufficiently flexible and to make the size of the buffer fund as low as possible, adjustments should be carried out quarterly at the least but preferably weekly or monthly. Adjustment at this frequency is also useful from a political standpoint since it prevents the buildup of long term imbalances or pressures that make ultimate pricing reform so difficult.

The adjustment interval will need to be based in part on the volatility of the markets on which the country relies for its energy imports. For example, if Bulgaria purchases most of its oil on the Mediterranean spot market, then adjustments made only on a monthly basis could lead to a large buffer fund requirement. However, to the extent that the crude oil, gas, and coal comes from domestic producers or is purchased on long term contracts abroad, adjustments may be relatively less frequent.[4]

Finally, the system needs to be reviewed periodically to make sure that the bases and the adjustment intervals are still appropriate. For example, a shift to use of more natural gas or coal will make a pricing structure based largely on oil prices more difficult to administer.

Reforming price setting in this manner does not guarantee greater economic efficiency or higher national income. It is a first step in permitting energy users and producer to make the best uses of their energy and investment resources. However, pricing reform, even if brilliantly conceived, will not succeed if rigidities elsewhere in the economy prevent the necessary reallocations of investment and energy resources than must accompany effective price reform.

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[3] Private firms, of course, must use such buffer funds to cushion the enterprise from the daily fluctuations in costs and revenues. In the private sector, this is usually referred to as working capital. Even completely private energy companies do not have daily adjustment of prices at the consumer level. Rather, they will average the prices paid for inputs over a period of time, weight these costs against the market conditions and charge accordingly.

[4] This point does not include exchange rate risks which have the effect of increasing the potential volatility of energy import prices.

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Institutional Aspects of Energy Price Decontrol

There are several key institutional elements of administering an energy price reform program that are crucial to its success. These elements include the following:

- Minimal administrative and political steps in the adjustment process;
- Automatic or formula-based price changes for most products and most sectors;
- Regulatory institutions that are aimed only at representing the public interest vis-à-vis monopolies, not at regulating the energy sector as a whole; and
- Elimination of quantitative restrictions on the trade in energy and refined energy products.

In a country the size of Bulgaria, the institutional apparatus required for effective price regulation can be quite small. Until and unless independent power generators are allowed to sell electricity in the country's power grid, there will be no particular need for a regulatory agency with a brief in that area. However, once other entities are allowed to sell electric power, an independent regulatory body may need to be created.

In the petroleum and natural gas areas, there will need to be a unit with the responsibility of monitoring the movements of energy prices and also to administer the buffer fund. Once adjustment intervals are set up, the energy pricing unit will not need to intervene on any regular basis.

To accommodate the periodic imbalances that might arise, the energy pricing unit should be involved with the government's energy planning activities as well.[5] It is advisable to keep pricing and investment decisions tied to the same perceptions of reality in order to minimize the impacts of regulatory and pricing decisions on the investment by private firms and state enterprises.

Finally, there will be a need to look at new enforcement mechanisms, more appropriate to a liberalized market. In particular, better efforts are essential in the following areas: tax collection, contractual enforcement, and environmental protection assurance (e.g., fuel sampling, testing of vehicles and stationary pollution sources). Retail prices for refined oil products should remain outside the purview of the enforcement authorities. In electricity and gas, there will be scant need for enforcement at the present time.

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5 In fact, if the rules are devised properly, there should not be sufficient work in the price regulation area to keep more than 1-2 people occupied.

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