# PRIVATE-SECTOR POWER GENERATION IN PAKISTAN:

# POTENTIAL, IMPEDIMENTS, AND POLICY ISSUES

FINAL REPORT
HBC Reference No. 86-179

PREPARED FOR:

U.S. Agency for International Development

Bureau for Science and Technology
Office of Energy
and
Bureau for Asia and Near East
Office of Technical Resources

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June 1986

CONTENTS


| | TITLE | PAGE |
|---|---|---|
| LIST OF EXHIBITS | | |
| EXECUTIVE SUMMARY | | i |
| INTRODUCTION | | 1 |
| CHAPTER 1 | POTENTIAL FOR PRIVATE-SECTOR POWER GENERATION | 1.1 |
| | INTRODUCTION | 1.1 |
| | CURRENT NON-UTILITY POWER GENERATION OPTIONS | 1.1 |
| | EXISTING ON-SITE POWER GENERATION | 1.2 |
| | EXISTING OFF-SITE POWER GENERATION | 1.4 |
| | POTENTIAL FOR ADDITIONAL ON-SITE COGENERATION | 1.5 |
| | POTENTIAL FOR ADDITIONAL ON-SITE POWER-ONLY PRODUCTION | 1.8 |
| | POTENTIAL FOR OFF-SITE POWER PRODUCTION | 1.8 |
| | Oil-Fired Systems | 1.9 |
| | Non-Pipeline Gas-Fired Systems | 1.10 |
| | Small-Scale Coal-fired Systems | 1.12 |




v

CONTENTS


| | TITLE | PAGE |
|---|---|---|
| | Small-Scale Hydro Power | 1.13 |
| | Renewable Power Systems | 1.16 |
| | TOTAL POTENTIAL FOR PRIVATE-SECTOR POWER GENERATION | 1.19 |
| CHAPTER 2 | IMPEDIMENTS TO PRIVATE-SECTOR PARTICIPATION | 2.1 |
| | THE INSTITUTIONAL FRAMEWORK | 2.1 |
| | CURRENT POLICY ISSUES | 2.4 |
| | UTILITY VIEWS | 2.7 |
| | PRIVATE-SECTOR VIEWS | 2.10 |
| | IMPLICATIONS | 2.15 |
| CHAPTER 3 | POSSIBLE APPROACHES TO DEFINING ELECTRICITY PURCHASE PRICE | 3.1 |
| | U.S. PUBLIC UTILITY REGULATORY POLICY ACT | 3.1 |
| | Key Provisions | 3.1 |
| | Eligibility Criteria | 3.2 |
| | Implementation Process | 3.2 |
| | AVOIDED COSTS | 3.4 |
| | METHODS FOR CALCULATING AVOIDED COSTS | 3.5 |
| | The Peaker or Short-Run Approach | 3.5 |




3

CONTENTS


| | TITLE | PAGE |
|---|---|---|
| | The Proxy Unit Approach | 3.6 |
| | The Long-Run Differential Revenue Requirements Approach | 3.7 |
| | APPLICABILITY TO PAKISTAN | 3.7 |
| | ILLUSTRATION OF AVOIDED COSTS CALCULATIONS FOR PAKISTAN | 3.8 |
| CHAPTER 4 | CONCLUSIONS AND RECOMMENDATIONS | 4.1 |
| | CONCLUSIONS | 4.1 |
| | RECOMMENDATIONS | 4.4 |
| GLOSSARY | | |
| APPENDIX A | PRIVATE-SECTOR POWER GENERATION POLICY DOCUMENT | |
| APPENDIX B | SCOPE OF WORK | |
| APPENDIX C | THE HUB CHOWKI PROJECT | |
| APPENDIX D | PARTIAL LIST OF NON-UTILITY POWER GENERATION UNITS | |
| APPENDIX E | SUMMARY OF COGENERATION MODEL | |
| APPENDIX F | FINANCIAL POTENTIAL FOR ON-SITE NON-COGENERATION SYSTEMS | |
| APPENDIX G | MAPS OF PAKISTAN | |
| APPENDIX H | DORMANT GAS FIELDS | |
| APPENDIX I | LIST OF CONTACTS | |
| SELECTED BIBLIOGRAPHY | | |

## EXHIBITS


| | |
|---|---|
| Exhibit 1.1 | Energy Input-Output Comparison between Conventional and Cogeneration Systems |
| Exhibit 1.2 | Characterization of Potential Industrial Cogeneration Candidates |
| Exhibit 1.3 | Summary of Technical Potential for Additional Industrial Cogeneration by 1995 |
| Exhibit 1.4 | Distribution of Industrial Process Heat Consumption by Ownership and Utility Service Territory |
| Exhibit 1.5 | Distribution of Technical Potential for Industrial Cogeneration by Utility Service Territory and Ownership of Host Site |
| Exhibit 1.6 | Basic Cogeneration Economics: Illustrative Cases for New Investment Decisions |
| Exhibit 1.7 | Cost of Power for Medium-Speed Diesel Power System |
| Exhibit 1.8 | Technical Power Generation Potential at the Dormant Gas Fields |
| Exhibit 1.9 | Cost of Power Estimates - Gas Turbines |
| Exhibit 1.10 | Technical Power Generation Potential from Coal |
| Exhibit 1.11 | Power Cost Estimates - Small Coal-Fired Power Plants |
| Exhibit 1.12 | Power Cost Estimates - Small-Scale Hydro |
| Exhibit 1.13 | Estimate of Yield of Crop Residues in Pakistan |
| Exhibit 1.14 | Power Cost Estimates - Biomass-Fired Power System |
| Exhibit 1.15 | Cost of Electricity from Private-Sector Power Generation Options |
| Exhibit 1.16 | Capital Investment Requirements |
| Exhibit 1.17 | Private-Sector Power Generation - Preliminary Estimate of Financial Potential and Possible Development |
| Exhibit 2.1 | Comparison of WAPDA and KESC Tariffs |

## EXHIBITS


| | |
|---|---|
| Exhibit 3.1 | Estimates of Avoided Energy Costs, for Selected WAPDA Thermal Plants |
| Exhibit 3.2 | Summary of Capital Costs and Capacity Credit for Alternative Thermal Power Additions |

## BACKGROUND

Pakistan's economic and social development is currently constrained by an electric power deficit of 1,500 MW, or about 38 percent of the national firm capacity. This deficit is expected to grow to 3,000 MW by the end of the Seventh Five-Year Plan (1993) if drastic measures are not taken. As a result, the Government of Pakistan (GOP) has placed high priority on programs aimed at reducing demand and increasing generation capacity.

On the demand management side, the GOP has implemented, with international lending institution assistance, a broad program of loss reduction, conservation, and load management.

With respect to generation, the country's two utilities -- the Water and Power Development Authority (WAPDA) and the Karachi Electric Supply Corporation (KESC) -- expect to install a total of 500 MW of new generation capacity each year until 1990, which is the maximum they are likely to achieve given current financial and institutional constraints. However, the 5-year investment program of WAPDA, which controls about 80 percent of current power generation and distribution in Pakistan, may be cut because of local currency shortages. If this reduction occurs, WAPDA may not be able to install more than 1,200-1,500 MW of new capacity before 1990, which would have the effect of increasing the generation deficit from its current level of 1,500 MW to more than 2,000 MW.

Even if the demand reduction and generation facility improvement and construction programs are successful, a substantial power deficit during several months of each year is expected for the foreseeable future unless additional generation capacity is brought on line.

The GOP is fully committed to closing the power generation gap, but its financial resources are limited. As a short-term solution to the power deficit, the GOP has authorized importation of small diesel generators. In the long run, however, the use of these generators will represent a suboptimal option which will increase Pakistan's dependence on imported oil. In addition, the GOP seeks to encourage private-sector investment in large-scale power generation -- a cornerstone of the Sixth Five-Year Plan -- and has developed a policy to this end. The policy, approved in August 1985, defines the conditions under which electricity from private power plants will be purchased by WAPDA and KESC (see Appendix A).

Although the GOP's policy does not explicitly address small-scale power generation by the private sector, such an option represents a viable means of reducing the power generation gap. In addition, it is a logical component of the GOP's policy. Small-scale power generation -- defined in this report as 30 MW or less -- uses a broad range of technologies and indigenous energy

resources that are not usually considered by electric utilities. These technologies include, among others, industrial cogen-eration (the simultaneous generation of electricity and useful thermal energy by the same system), small hydroelectric systems, and generators using agroindustry waste fuels, domestic coal, and natural gas..

## PURPOSE OF STUDY

The purpose of this study was to assess the potential for cogeneration and other small power production facilities in Pakistan, analyze the impediments to development of such power options, and recommend the first steps required to design and implement a program to exploit the potential. The study was carried out by a team of consultants from Hagler, Bailly & Company and Arthur D. Little during a 3-week visit to Pakistan, October 12-31, 1985. The team's scope of work is included in Appendix B.

Prior to the team's arrival in Pakistan, USAID and the Ministry of Water and Power requested that the original scope of the study be expanded to include the potential for private-sector investment in larger capacity power generation facilities. The Ministry sought an evaluation of the Hub Chowki 120-MW thermal power plant that KESC planned to build near Karachi and for which it has received two proposals, one from the private sector. A brief assessment of the Hub Chowki project is included in Appendix C. The project, together with other large-scale, private-sector generation options, will be covered in more detail in a separate report.

## STUDY FINDINGS

On the basis of its analyses, the study team reached the following major conclusions:

- private-sector small-scale power generation could play a major role in reducing current and projected shortfalls in electric generating capacity. Of the estimated maximum potential of 2,500 MW, some 1,500 MW could be installed before 1995, cutting the power generation deficit by two-thirds.

- The private sector in Pakistan has shown serious interest in investing in power generation and has the financial resources to do so. However, the private sector is concerned about the price that WAPDA and KESC are willing to pay for privately generated electricity. For their part, WAPDA and KESC have concerns about the private sector's ability to generate electricity.

- The GOP does not have sufficient institutional capability to implement its policy on power purchases from private power plants. The U.S. experience with PURPA (Public Utility Regulatory Policies Act), however, provides a strong base for developing this capability.

In the following sections, the study findings are discussed in more detail.

## Small-scale Power Generation Potential

The potential for small-scale power generation in Pakistan over the next 10 years is 2,500 MW. This generation potential is distributed as follows:

| | |
|---|---|
| Industrial Cogeneration | |
| Retrofit of existing facilities | 550 MW |
| New facilities | 640 MW |
| Off-Site Generation | |
| Gas-fired | 625 MW |
| Hydro-based | 550 MW |
| Coal-fired | 35 MW |
| Other sources | 100 MW |
| Total | 2,500 MW |

Of this potential, approximately 650 MW could be installed by 1990 and 1,540 MW could be in place by 1995.

The industrial cogeneration potential is 550 MW in existing facilities and 640 MW in facilities that could come on line by 1995. Cogeneration systems that use natural gas as their fuel will be the lowest cost approach for generating power, primarily because only one-third of the fuel cost is attributed to power generation, with the remainder attributed to process heat needs. Cogeneration systems in new industrial facilities not only provide power for industrial growth, but generate surplus electricity for other power users. The electricity from gas-fired cogeneration systems is estimated to cost 40-70 Ps./kWh (2.5¢-4.4¢/kWh).

The potential from gas-fired turbines is estimated at 625 MW, with the electricity from such systems costing about 60 Ps./kWh (3.8¢/kWh). This estimate assumes that the gas used will be low-Btu gas from dormant (low quality, non-pipeline) gas fields and associated gas from oil fields.

The potential generating capacity of small-scale hydro plants is estimated at 550 MW, with electricity costing about 60 Ps./kWh (3.8¢/kWh). Policies that would give the private sector access to the barrages (small irrigation dams) would enhance the prospects of this option.

The generation potential of small-scale coal-fired systems is estimated at 35 MW, given the current low coal production level and the need to site such systems where there is a concentration of coal to keep transportation costs low. The electricity generated by such systems will cost between 100 Ps. (6.3¢/kWh) and 150 Ps./kWh (9.4¢/kWh), making coal-fired systems the most expensive of the options considered.

In addition to the domestic energy sources cited above, only bagasse and cotton waste are likely to make a substantial contribution to small-scale power generation.

Imported oil could add several hundred megawatts to the total potential, although it would be expensive in terms of foreign exchange. Oil-fired generation systems using efficient diesel engines can range in capacity from five to several hundred megawatts. Private installation and operation of such systems would provide much-needed operating capacity quickly (in two years), producing power that could be sold profitably at rates near the utilities' own cost of thermal power generation. The electricity cost of a diesel unit using heavy fuel oil, ranges from for example, 75 Ps./kWh (4.7¢/kWh) to 120 Ps./kWh (7.5¢/kWh). This near-term option for addressing capacity shortfalls has reasonable economics and falls within the GOP's policy guidelines, but its success depends on the government's willingness to purchase power at 85-100 Ps./kWh (5.3-6.3¢/kWh). At present, the average sale price of power to industry ranges from 74 Ps./kWh (4.5¢/kWh) to 80 Ps./kWh (5.0 ¢/kWh).

Achieving the full 2,500 MW potential of small-scale rivate-sector power generation in Pakistan by 1995 will require a total capital investment of $2.9-3.9 billion, depending on the size and type of facilities installed. Of that investment, approximately 46 percent will be in domestic currency, and 54 percent in foreign currency.

In addition, achieving this potential would require the removal of several barriers including subsidized energy prices, lack of information about technologies and opportunities, and institutional constraints. The findings of this study indicate, however, that these barriers can be overcome.

## Private-Sector Capabilities and Concerns

The private sector in Pakistan is financially capable of developing the country's small-power potential as long as sufficient economic incentives are provided. The private sector has already demonstrated its ability to work

with foreign interests and obtain favorable financing for similar projects using such mechanisms as vendor credits. Furthermore, the private sector is already active in power generation. It is in the process of installing an additional 50-100 MW of on-site power, including some cogeneration units, which will bring the total private industrial generation capacity to roughly 550 MW. Of this capacity, 200-300 MW is likely to be operational almost year-round, with the remainder operating on a seasonal basis, e.g., in the sugar industry.

The private sector is also interested in the development of large-scale power for sale to the utilities. At least five proposals totaling 250 MW have been identified and reviewed by the study team. These 250 MW cover a wide range of technologies and fuels, including oil, gas, coal, and hydro. The proposed Hub Chowki project, for example, would produce 120 MW of power using diesel engines.

The private sector believes, however, that a large private power generation industry would be a dramatic departure from historical Pakistani and international practice. It thus seeks a demonstration of the GOP's commitment to such an industry. In addition, private-sector parties are concerned about the price at which WAPDA and KESC would purchase their electricity. There is currently a sizable difference between the utility estimate of what it would cost to produce power from a given plant and the private-sector estimate. The private sector would also like to have the option of selling power to more than one customer, e.g., WAPDA. It would like to "wheel" the power to consumers not served by the utility and in return pay WAPDA or KESC for such services. This arrangement, however, would enable utilities to earn income from their transmission and distribution network without any extra investment.

## Utility Concerns

WAPDA and KESC have concerns of their own. First, based on their experience, they do not think that the private sector has the technical ability to operate and manage power units of any size. In addition, they think that the need for large profits will push private power prices too high to be acceptable. Finally, WAPDA and KESC are worried that if industrial customers substantially increase on-site power generation, they will lose their most valuable customers, suffering greater financial problems as a result. In reality, however, the equivalent amount of power can easily be sold by the utilities to other industrial customers awaiting connection to the grid.

## Government of Pakistan Policies and Perceptions

In late 1985, the GOP initiated a policy on private-sector participation in power generation, designed to stimulate the development of large scale coal- or oil-fired power generation plants. This policy stipulated that:

- The Ministry of Water and Power specify projects for private-power generation as well as entertain power supply proposals from the private sector.

- The Ministry of Water and Power calculate the power purchase price paid by the utility to the private firm, based on what power production would cost if the utility had made the investment.

- A suitable return on equity be allowed, and that the purchase price and quantity be guaranteed for sale of private power to the grid, but that a fixed return not be guaranteed.

This policy is one of the first of its kind to be formulated in a developing country. To a certain extent it incorporates the spirit of the U.S. PURPA legislation, which has been successful in encouraging U.S. independent power producers to generate power for sale to the electric utility grid. The purchase price provisions of the GOP policy are close to the marginal cost of generation for public utilities and, if properly interpreted, could lead to prices that would be attractive to private investors. The policy thus provides a strong basis for early action in promoting private-sector participation in power generation. In addition, it provides a foundation for the inclusion of small-scale power generation options and other energy sources, such as a hydro, in the country's power supply base.

## RECOMMENDATIONS

To promote the use of cogeneration and other small-scale power options by the private sector in Pakistan, the study team recommends that the following actions be carried out:

1. The GOP should formulate policies to encourage private-sector small-scale power generation and should develop a capability to effectively implement and expand the existing private-power generation policy.

To achieve these goals, the GOP should initiate a program to:

(a) Develop methodologies for establishing the price of electricity purchased from private producers, taking into consideration such issues as:

- seasonal variations in the value of power to utilities and, particularly, the high value of power delivered during load shedding months,

- costs of providing service to remote areas -- such as Quetta and Gilgit -- and associated premiums that might be considered for power generated in these regions,

- special incentives for early entry of the private sector into power generation.

(b) Develop bid packages for early projects that provide sufficient financial, legal, and technical information to result in viable proposals.

(c) Define a process by which proposals are solicited, submitted, and evaluated.

2. The GOP should assess the potential of the dormant gas fields and recently discovered associated gas.

3. The GOP should expand the private-sector energy generation initiative by making available selected small hydro sites, barrages, dormant gas fields, and the associated gas available to the private sector for power generation. The existing hydro sites associated with irrigation or water supply facilities, in particular, could provide great opportunities for using water flows and heads created in existing non-power projects. The GOP should also provide incentives to the private sector for near-term development of these resources.

4. The GOP should undertake electric tariff studies that could lead to further rationalization of rate structures, thus improving utilities' financial status and providing a more suitable pricing environment for the private-sector power initiative in the long term.

5. The Ministry of Planning and Development should immediately initiate a program to familiarize both utility and industry decision-makers with cogeneration and independent power production options.

6. Because cogeneration is the most efficient use of natural gas, the GOP should permit the use of this fuel in cogeneration applications at those facilities meeting specific electrical and thermal efficiency requirements. Such use should be codified in a policy.

7. To promote cogeneration, the GOP should develop an information and incentives program giving preferential access to fuels and spare parts.

8. The U.S. private sector has special capabilities in almost all aspects of cogeneration and independent power generation technologies. The U.S. Agency for International Development (USAID) should develop programs that facilitate cooperative arrangements between U.S. and Pakistani firms in the design, equipment manufacture, project construction, and operation power systems. Such programs could include tours by U.S. company representatives in Pakistan (and vice versa), support for prefeasibility studies, and equipment financing via such mechanisms as the Energy Commodities Equipment Project.

9. The GOP should encourage private-sector parties to enter third-party arrangements to provide heat and power to government-owned industries with good cogeneration potential.

10. The GOP should arrange for detailed studies to assess the potential of biomass resources with more precision. Cotton waste and bagasse appear to represent substantial potential for power generation and should be specially evaluated. In the case of bagasse, the study should focus on (1) the potential for incremental power at existing sugar mills through energy efficiency and management improvements, and (2) the use of the mills' power systems during off-season.

11. As a first step, USAID should help the GOP in preparing detailed proposals for implementing all the above recommendations, including drafting detailed terms of reference for consultants, together with associated time frames and funding requirements.

For the last 10 years, the economy of Pakistan has grown at an average rate of about 6 percent per year. This growth has been particularly robust in the manufacturing sector (7.7 percent average annual rate) and in the public sector, which includes the electricity and gas subsectors (9.2 percent). This growth has been fueled by large increases in power generation, distribution, and consumption. National electric generation capacity, for example, has grown from 2,200 MW in 1975 to 5,500 MW today, an average rate of close to 10 percent per year.

The growth in electricity consumption has been both intensive and extensive. The intensive growth stems from an increase in the number of customers in already electrified areas and from higher consumption by existing customers. For example, recent growth in urban domestic consumption has averaged 21 percent per year. And in the last 10 years alone, 2.7 million new customers have been added in already electrified areas, approximately 77 percent of whom are in urban areas. The extensive growth has come from the extension of service to new areas. For example, over the last 24 years some 17,500 villages have been electrified.

However, the increase in the quantity of electricity consumed and the increasing number of customers served, together with the spatial spread of the customers to which electricity is delivered, have led to problems. There has been a deterioration in the quality of electric service, measured both in frequency and duration of outages and in voltage instability. Load shedding has become a necessity, often for periods of hours, and the situation is expected to continue.

The provision of electricity to a growing number of people reflects recent political objectives of the GOP. These objectives are explicitly embodied in the general targets of the Sixth Five-Year Plan and in decisions on relative power infrastructure budgets and pricing decisions. The emphasis on growth has led not only to outages and voltage instability, but to distribution expansion budgets that are larger in relation to generation or rehabilitation budgets than those in other developing countries. Moreover, most small urban and rural customers do not pay the economic cost of the power or energy that they consume. As a result, the utilities must pay for the shortfall, using funds that would otherwise be available for needed system improvements and expansion.

In the most recent estimate, the electric power capacity deficit was put at about 1,500 MW or approximately 38 percent of peak demand, and is expected to be more than 3,000 MW, or almost 40 percent of peak demand, by 1993.

Even if WAPDA and KESC succeed in installing 500 MW of capacity every year for the foreseeable future, as they intend, a deficit of 1,000-1,500 MW will remain. This deficit will exist even if the aggressive generation, distribution, and load management programs currently undertaken are successful.[1] Thus, the only way of reducing this power capacity shortfall lies with the private sector, both local and foreign.

## RATIONALE FOR PRIVATE-SECTOR INVOLVEMENT

The private sector can play an important role in reducing the electric power capacity deficit in Pakistan, for several reasons.

First, it is directly affected by the power shortage situation. In many countries, production losses owing to lack of power are estimated to be one order of magnitude higher than the actual cost of power; Pakistan is no exception.

Second, the private sector has the ability to enter the power generation field because it can attract technical and managerial resources and mobilize financial resources.

Third, the private sector is interested in entering the power generation field, as reflected in specific proposals to generate power for sale to utilities.

Fourth, timing is critical, and the private sector can install large quantities of power generation[1] faster than WAPDA and KESC, because it is less subject to bureaucratic constraints, and it can mobilize capital faster.

## CURRENT PRIVATE- AND PUBLIC-SECTOR ACTIVITIES

A number of private industries, in order to protect themselves from load-shedding and to meet new power requirements that cannot be provided by the grid, have been importing and installing on-site small-scale diesel generators. While these generators may be the only short-term solution for individual companies, they are much less efficient than cogeneration systems. In addition, the use of small diesel units will increase the country's volume of oil imports and will contribute to a more inefficient national power system over the long term.

Several private parties have submitted proposals to the Ministry of Water and Power. The proposals range from simple letters to detailed feasibility

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[1] USAID is currently assisting the GOP in these areas through a number of programs whose total funding is U.S. $400 million.

studies of projects between 25 and 500 MW using oil, coal, gas and hydro and are intended solely for producing electricity to be sold to WAPDA or KESC.

The GOP has responded to this private-sector interest by preparing a policy document intended to be used as a guide by utilities in purchasing bulk power from independent producers. The most important part of the document is the section dealing with the mechanism to be used to determine the purchase price of bulk power. According to the draft document, "...the Ministry of Water and Power will calculate the bulk purchase price of electricity for a power station, at a specific location, on the basis of the cost of production if the investment were to be made by WAPDA or KESC." The document also contains provisions that allow the private investor to make a fair return on equity and presents desired operational arrangements (see Appendix A).

Pakistan is in the forefront of developing countries in establishing a policy to encourage private-sector participation in power generation. This policy can easily embrace small- and medium-sized power generation facilities, including cogeneration units and renewable resources such as hydro, biomass, wind, and solar.

Of particular interest to Pakistan is the case of the United States, which enacted the Public Utility Regulatory Policies Act of 1978 (PURPA) to promote the development of cogeneration and small power production. PURPA mandates U.S. electric utilities to purchase power from cogenerators and small power producers that use energy sources other than oil and gas at the utilities "avoided cost," independent of the cogenerator's or small power producer's cost. The avoided cost, intended to be a reflection of the true value of the power to the utility, is established on the basis of utility marginal costs.

## BACKGROUND OF ANALYSIS

The AID Bureau for Asia and Near East (ANE) has initiated country-specific examinations of the potential for, and impediments to, private-sector power generation. This activity is part of a broader AID effort to promote the privatization of energy systems in Asia and is supported by the Bureau of Science and Technology, Office of Energy. The ANE initiative coincides with the initiative taken by the Government of Pakistan to formulate a policy facilitating private-sector participation in power generation. The analysis was carried out in Pakistan by a team of senior consultants of Hagler, Bailly & Company and Arthur D. Little, October 12-31, 1985. The scope of work for this study is presented in Appendix B.

## STUDY OBJECTIVES

The study team had several objectives:

(1) Preliminary identification of the technical and economic potential for private-sector cogeneration and small-scale power production, with emphasis on renewable and indigenous energy resources (particularly coal and gas)

(2) Identification of the policy, regulatory, institutional, and other impediments to private-sector power generation through cogeneration or renew- able/indigenous resources for sale to the grid

(3) Development of recommendations and an action plan for addressing the impediments to private-sector small-scale power generation.

This study focuses on power systems with individual capacities of 30 MW or less. However, such systems might be combined over time to result in significantly higher capacities.

## STUDY APPROACH

To realize its objectives, the study team collected data in Pakistan through a review of the literature and interviews with key representatives of the private and public sector, donor organizations, and USAID.

Just before the team's arrival, the Government of Pakistan and USAID requested that the scope of the study be expanded to include private potential for investment in larger capacity power generation facilities, with emphasis on a 120-MW thermal power plant at Hub Chowki near Karachi. It was subsequently agreed that the study would focus on small-scale generation systems, with a brief assessment of the Hub Chowki project (See Appendix C). The project, as well as other large-scale private-sector power generation facilities, will be covered in more detail in a separate report to be published at a later date.

## REPORT ORGANIZATION

The report on the study consists of four chapters:

In Chapter 1, an initial estimate of the private-sector power generation potential is developed.

In Chapter 2, the institutional framework and impediments to developing this potential are described.

In Chapter 3, alternative methodologies for establishing the price of electricity purchased from the private sector in Pakistan are described.

Finally, in Chapter 4 the study conclusions and recommendations are presented.

A glossary precedes the appendices and bibliography follows them. Appendices A through I provide additional information to support the main text of the report.



19

# CHAPTER 1: POTENTIAL FOR PRIVATE SECTOR POWER GENERATION



## INTRODUCTION

In this chapter, the potential for small-scale power generation in Pakistan outside the traditional structure of electric utilities is evaluated. The existing non-utility generation activities in the country are reviewed, the available power generation options are identified, and the potential generation capacity of each option is estimated.

The systems considered in this chapter cover a broad range of technologies and resources, most of them technically and economically available for development. The systems fall into two categories: "on-site" and "off-site". On-site systems are located at industrial plants to generate power for internal use and, if there is any excess, for sale to the grid. Off-site systems are installed for the sole purpose of power generation and the sale of the electricity to the grid or other customers.

Although the private sector has long been involved in on-site power generation, it has little experience with off-site generation. Off-site systems (e.g., gas-fired generators, hydro) are not necessarily technically sophisticated, but their use depends directly on the government's policy on national energy resources such as dormant gas fields, coal, and hydro. Off-site systems also include technologies that have limited potential at present, but may become significant in the future (e.g., photovoltaics).

## CURRENT NON-UTILITY POWER GENERATION OPTIONS

The private sector can become an important power producer in Pakistan by pursuing three options:

### Option 1: On-site Cogeneration.

Under this option, companies could install cogeneration systems. Cogeneration is the simultaneous production of electricity and useful thermal energy (usually in the form of hot liquids or gases). The fundamental difference between a conventional energy system and a cogeneration system is that a conventional system produces either electricity of thermal energy, whereas a cogeneration system produces both. Traditionally, in most market sectors thermal energy is produced through the operation of equipment such as boilers and furnaces, and electricity is purchased from a utility. By recapturing and using some of

the thermal energy that is normally discharged from a thermal system, a cogeneration system can reduce fuel requirements substantially. For example, generating 30 units of electricity and 40 units of heat in a conventional energy system requires 150 units of fuel input (see Exhibit 1.1). Producing the same amount and mix of energy in a cogeneration system, however, requires only 100 units of fuel input. Furthermore, cogeneration systems located in industrial sites also improve power supply reliability and help to remedy the impact of power shortages.

**Option 2:** On-site Power-only Systems.

Under this option, private companies would use non-cogeneration (power only) systems to generate their electricity needs. This option is being actively pursued in Pakistan as a growing number of industrial plants purchase diesel generators to cope with load shedding. These systems, however, generally have low efficiencies, and will increase the country's reliance on imported oil. This option provides only a suboptimal short-term solution to the industry's power shortages, and is thus not evaluated in this report.

**Option 3:** Off-site Systems.

Under this option, private companies would use power-only systems to generate electricity for sale to the grid or other customers. Examples of such systems include gas turbines using low quality natural gas, coal-fired units, and small hydroelectric plants.

## EXISTING ON-SITE POWER GENERATION

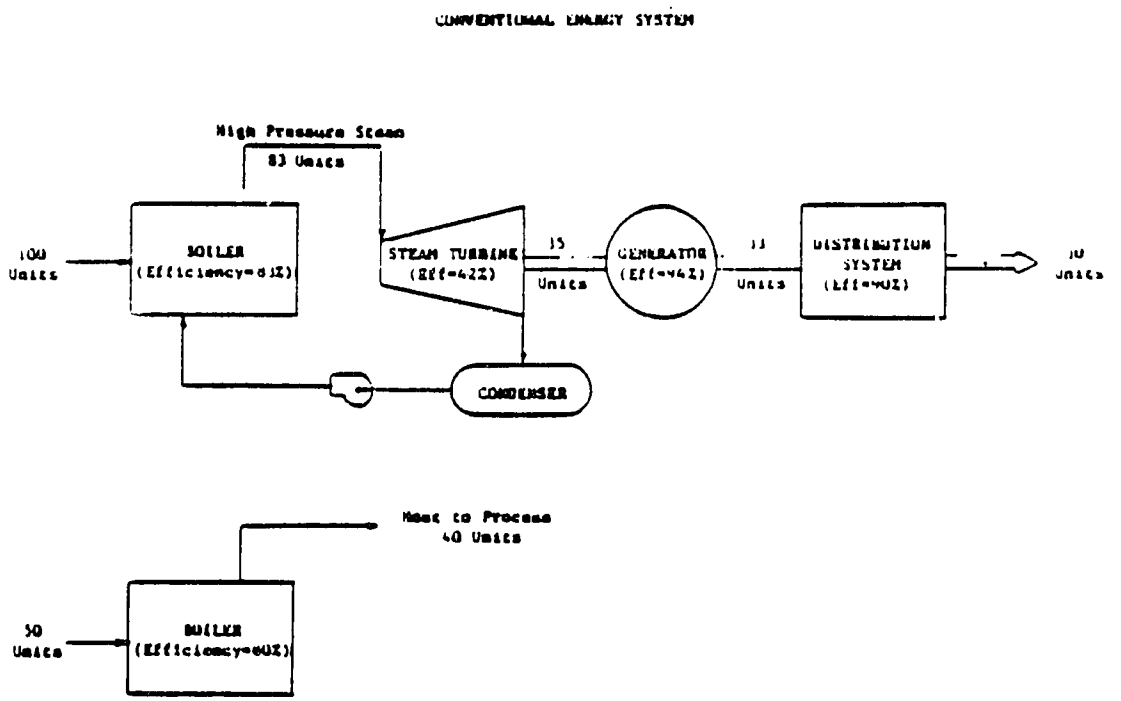
Based on surveys conducted by the Ministry of Water and Power and the study team's research, the total installed capacity not owned by WAPDA and KESC was an estimated 480 MW. In mid-1985, much of it consisted of cogeneration systems. Of the 480 MW, 450 MW were distributed as follows:

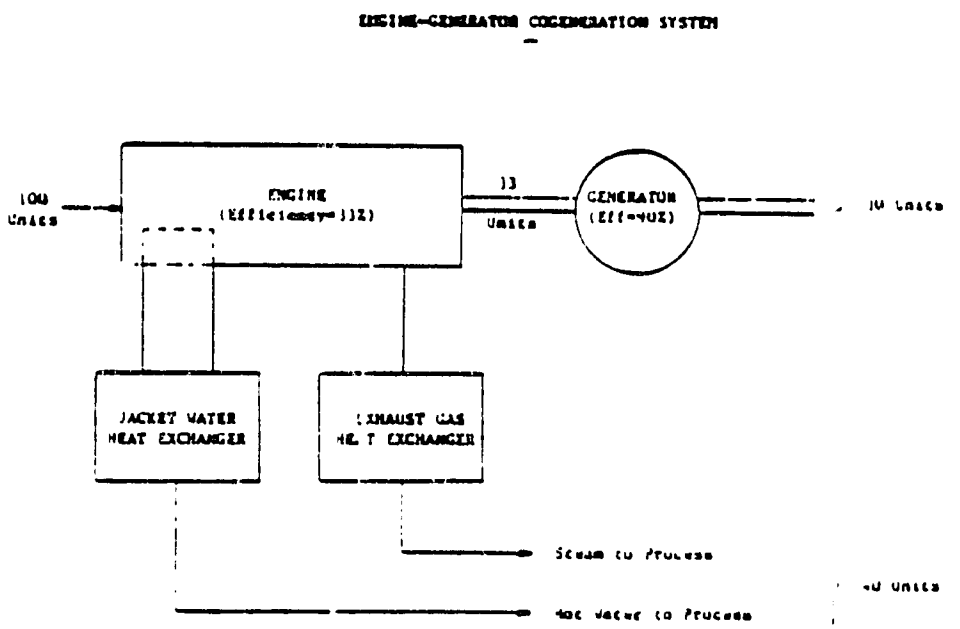
- 165 MW at PASMIC (steel mill)
- 180 MW in the sugar industry
- 75 MW in the chemicals and fertilizer industry
- 30 MW in the ordnance factories

Most of the balance was in the textile (15-20 MW), cement (8 MW), and other industries such as petroleum refining, glass, tobacco, plastics, electric products, gas compression (Sui gas), and paper. A partial list of generating units is presented in Appendix D. The average capacity utilization factor for these 480 MW is not known, but is likely to be less than 40 percent on average, for three reasons: (1) the sugar industry is

EXHIBIT 1.1

Energy Input and Output Comparison
Between Conventional and Cogeneration Systems




Source: Adopted from Orlando (1984)

seasonal, (2) only two of the three 55 MW turbines at the Pakistan Steel Mills operate at one time, and (3) the rates from WAPDA are lower than on-site production costs during the wet season. Consequently, total annual electricity production from the 480 MW of installed capacity is estimated at about 1,700 GWh, or 8 percent of total generation by KESC and WAPDA in 1985.

According to interviews conducted in the Karachi and Lahore areas with representatives of the Chambers of Commerce and with customs officials in Karachi, many companies are responding to power shortages and chronic load shedding by importing power generation units, mainly diesel generators. Typically, units under 1 MW are high-speed diesels that run on diesel oil (at about Rs. 3,220 ($201.2)/tonne), while units above 1 MW are medium-speed diesels that run on furnace oil (at about Rs. 1,720 ($107.5)/tonne or roughly half the price of diesel oil). Medium-speed units cost about $300-$400/kW FOB, compared with $150-$200/kW for high-speed units.

In addition to the 480 MW already installed, several larger capacity projects are planned, as the following examples illustrate:

- Pakland Cement in Karachi plans to install two 6-MW medium-speed diesel generators at its cement plant.
- Port Qasim Authority has ordered two 4-MW medium-speed diesel generators.
- Al Qawi Steel, near Karachi, is considering investing in two 20-MW steam turbine units.
- National Refinery in Karachi plans to install two 10-MW steam turbines by early 1987.
- Heavy found and forge, Faxila, plans to install a 15-MW cogeneration unit (two steam turbines of 7.5 MW each)

By and large, 100-150 MW of additional on-site power is expected to be added within the next 18 months, bringing the total non-WAPDA, non-KESC installed capacity close to 600 MW, or 10 percent of WAPDA and KESC capacity.[1] Only a negligible fraction of this 600 MW will be available for

[1] 4,370 MW for WAPDA and 1,105 MW for KESC, for a total of 5,475 MW as of October 1985. By the end of 1986, total capacity is expected to reach 6,000 MW.

sale to the grid.[2] However, about 40 percent will be used continuously (not just as back-up during load shedding) to meet on-site industry needs.

## EXISTING OFF-SITE POWER GENERATION

No one in Pakistan is currently engaged in off-site or independent power production for the sole purpose of selling electricity to utilities. However, the private sector has recently prepared a number of proposals for various ministries, including the Ministry of Water and Power. None of these proposals -- which vary from simple letters to comprehensive feasibility studies -- has yet received a response from the GOP, WAPDA, or KESC, because until recently there was no adequate policy framework in which to entertain such proposals. But the draft policy document prepared by the Ministry of Water and Power (see Appendix A) and accepted by the Committee on Private Sector Power Generation will constitute an official reference for evaluating such proposals. Examples of private-sector proposals include:

- The Hub Chowki power station project, consisting of 120 MW of diesel generation of electricity for sale to KESC. A prefeasibility study has been prepared by Pakland Cement Ltd., a private Pakistani company headquartered in Karachi (see Appendix C for data on the project).
- A 200-MW power station using diesel generation. A letter proposal has been prepared by Rupali Polyester Ltd., a fast-growing private enterprise headquartered in Lahore.
- A 70-MW power station based on a gas-fired combined cycle. This project is proposed by DARZAWA Power Limited for installation in Baluchistan.
- A 25-MW coal-fired power plant. This project is proposed by Habibullah Mines in Quetta.
- A 15-MW small hydro plant. This project is under study by Elektra Power Corporation (USA).

[2] PASMIC, for example, has a "buy and sell" agreement with KESC. It will sell all excess, or about 80 MW, from the raw steel mill to KESC and purchase about the same quantity from KESC for the rolling mill.

## POTENTIAL FOR ADDITIONAL ON-SITE COGENERATION

In this section, the estimated potential for additional cogeneration, primarily in the industrial sector is presented. The study team first estimated the technical potential. The technical potential is defined as the amount of generation capacity that can be given the current and expected state of the technology and the availability of natural resources. For cogeneration systems, this is defined as the maximum electric capacity that could be installed to meet either full thermal load or full electric load in existing and future individual plants. Next, the team subjected the technical potential to an economic analysis to determine the economic potential. The economic potential is that portion of the technical potential that can be developed with resulting electricity costs lower than the production cost of electric utilities. To determine the economic potential this analysis uses only the true economic costs and benefits and factors out the "transfer payments" such as taxes and duties that do not represent actual costs but rather shifts of resources from one sector to another.

Finally, in recognition of the fact that investment decisions are made by private investors using financial data and market conditions, the team developed an estimate of the financial potential. The financial analysis looks at the project from the viewpoint of the investor. It determines the actual cash flow using market values for capital costs, labor, and materials. It incorporates taxes, duties, profits, and other transfer payments explicitly, and determines the actual returns to the investor.

Since this study concentrates on the role of the private sector in power generation the emphasis of the analysis will be on determining the financial potential.

### Technical Potential

The technical potential for industrial cogeneration is based on those plants with sufficient process thermal loads to use systems that produce low- to medium-temperature process heat in addition to generating electricity. Such plants would include those using a significant amount of low pressure steam (exceeding 8 million Btu/hr at 200 psig) for process heat applications on an essentially continuous basis, i.e., exceeding 20 billion Btu/year or operating more than 2,500 hours annually.

Based on international experience, primarily in the United States, the team estimated the fraction of total fuel use for industrial processes that is suitable for cogeneration in each of 13 industry groups. The team then multiplied these fractions by the total fuel input to each industry group to estimate total thermal energy available for cogeneration. In addition, the team determined those features of plant operation that would define the technical characteristics of cogeneration systems in terms of industry

steam and electricity requirements, i.e., load factor and electric to thermal demand ratios (see Exhibit 1.2).

For the purpose of this study, the team assumed that cogeneration systems would be in electric load-following mode[3] -- that they would be installed to satisfy all the electricity demand of the industrial plant. This assumption was used because it represents a mid-case between a thermal load following mode and an electric output maximization (diesel) mode.

On the basis of its analysis, the team estimates that almost 1,850 MW of cogeneration systems could technically be installed in existing and new Pakistani industries by 1995, 590 MW in existing plants and 1,260 MW in new plants (see Exhibit 1.3). Food, fertilizer, and textile plants account for over 50 percent of the total potential, with fertilizer plants representing the largest potential. Although there is a large amount of steam (thermal energy) available for cogeneration in the sugar industry, the potential for additional cogeneration in existing plants is nil because they are already cogenerating (See Exhibit 1.3).

The team also broke down the technical potential by utility service area and plant ownership, based on a rough estimate of the distribution of process heat consumption (see Exhibit 1.4). It found that the cogeneration potential in the WAPDA service territory is more than twice as large as that in the KESC service area, and more importantly, that 65 percent of the potential is at privately owned sites (see Exhibit 1.5).

## Financial Potential

The financial potential of cogenerated power is defined here as an estimate of the amount that could be produced at a cost lower than or equal to the utility marginal cost (about Ps. 100/kWh or 6.3¢/kWh).[4] The economics of cogeneration are based on differential computations between (1) a base case, where steam, for example, is produced by a low-pressure boiler and electricity is purchased from the grid at utility retail rates and (2) a cogeneration case, where the system burns oil or gas to produce the same quantity and quality of steam as in the base case and simultaneously the same amount of electricity as that purchased from the utility under the base case.

[3] There is also a thermal load following mode where the cogeneration system matches the thermal load of the plant.

[4] In theory, the shadow price of electricity should have been used but it was not possible in the context of this limited effort to conduct such a complex analysis (impact of load shedding). The assumptions used here, however, are on the conservative side.

EXHIBIT 1.2

Characterization of Potential Industrial Cogeneration Candidates

| Industry | Percent of Fuel Use Suitable for Cogeneration | Annual Process Energy Use Suitable for Cogeneration (billion Bty/yr)* | Average Process Energy Load Factor (%)* | Average Electric to Process Steam Load Ratio (Btu/Btu)*** |
|---|---|---|---|---|
| Iron & Steel | 20 | 2,500 | 65 | 0.75 |
| Foundries | 10 | 15 | 60 | 1.00 |
| Cement | 10 | 175 | 50 | 3.00 |
| Glass ceramics | 10 | 105 | 55 | 3.00 |
| Refinery, petrochemicals | 100 | 6,950 | 90 | 0.25 |
| Organic chemicals | 50 | 1,375 | 70 | 0.25 |
| Inorganic chemicals | 50 | 7,320 | 70 | 0.25 |
| Fertilizers, pesticides | 100 | 12,825 | 50 | 0.25 |
| Textiles | 70 | 7,675 | 80 | 0.25 |
| Pulp & paper | 60 | 3,090 | 65 | 0.25 |
| Sugar refining | 100 | 50,310 | 35 | 0.05 |
| Leather & footwear | 10 | 40 | 50 | 0.25 |
| Food, beverages & tobacco | 60 | 2,235 | 60 | 0.25 |

* Total 1984 fuel consumption x fraction suitable for cogeneration.

** Actual energy used/maximum energy demand during those months when plants operate under normal conditions.

*** Electricity accounted for at 3,413 Btu/kWh.

Source: Hagler, Bailly & Company; based on data available from ENERPLAN/ENERCON and industry interviews

Exhibit 1.3

Summary of Technical Potential for Additional Industrial Cogeneration by 1995 (MW)

| INDUSTRY | EXISTING FACILITIES | NEW FACILITIES[1/] |
|---|---|---|
| Iron & Steet | 43 | 72 |
| Foundries | 1 | 1 |
| Cement | 11 | 0 |
| Brick | 0 | 0 |
| Glass, Ceramics | 7 | 1 |
| Refining, petro-chemicals | 42 | 208 |
| Organic chemicals | 12 | 31 |
| Inorganic chemicals | 80 | 217 |
| Fertilizers, pesticides | 173 | 332 |
| Textiles | 80 | 172 |
| Pulp & paper | 40 | 61 |
| Sugar refining | 0 | 61 |
| Metal products | 0 | 62 |
| Equipment & machinery | 0 | 0 |
| Leather & footwear | 0 | |
| Food, beverage & tobacco | 100 | 42 |
| Miscellaneous | 0 | 0 |
| Total (rounded) | 590 | 1,260 |

1/ Using average growth rates from ENERCON, Volume 2.

Source: Hagler, Bailly & Company

Exhibit 1.4

Distribution of Industrial Process Heat Consumption
By Ownership and Utility Service Territory

| INDUSTRY | NATIONALLY OWNED | | | PRIVATELY OWNED | | | TOTAL |
|---|---|---|---|---|---|---|---|
| | KESC | WAPDA | SUBTOTAL | KESC | WAPDA | SUBTOTAL | |
| Iron & Steel | 55 | 5 | 60 | 15 | 25 | 40 | 100 |
| Foundries | 20 | 20 | 40 | 30 | 30 | 60 | 100 |
| Cement | 10 | 70 | 80 | 20 | 0 | 20 | 100 |
| Brick | 0 | 0 | 0 | 0 | 100 | 100 | 100 |
| Glass ceramics | 0 | 0 | 0 | 40 | 60 | 100 | 100 |
| Refinery, petrochemicals | 40 | 0 | 40 | 30 | 30 | 60 | 100 |
| Organic chemicals | 25 | 25 | 50 | 25 | 25 | 50 | 100 |
| Inorganic chemicals | 20 | 30 | 50 | 25 | 25 | 50 | 100 |
| Fertilizers, pesticides | 0 | 60 | 60 | 0 | 40 | 40 | 100 |
| Textiles | 0 | 5 | 5 | 35 | 60 | 95 | 100 |
| Pulp & paper | 0 | 0 | 0 | 0 | 100 | 100 | 100 |
| Sugar refining | 0 | 10 | 10 | 0 | 90 | 90 | 100 |
| Metal products | 25 | 25 | 50 | 25 | 25 | 50 | 100 |
| Equipment & machinery | 25 | 25 | 50 | 20 | 30 | 50 | 100 |
| Leather & footwear | 25 | 25 | 50 | 25 | 25 | 50 | 100 |
| Food, beverages & tobacco | 0 | 0 | 0 | 50 | 50 | 100 | 100 |
| Miscellaneous | 25 | 25 | 50 | 25 | 25 | 50 | 100 |

SOURCE: Hagler, Bailly & Company; based on data collected on-site, and USAID reports.

Exhibit 1.5

Distribution of Technical Potential for Industrial Cogeneration by Utility Service Territory and Ownership of Host Site* (MW)

| SERVICE TERRITORY | FEASIBLE COGENERATION CAPACITY | |
|---|---|---|
| WAPDA | 407 | (69%) |
| KESC | 183 | (31%) |
| **TOTAL** | **590** | **(100%)** |
| HOST SITE OWNERSHIP | | |
| PUBLIC | 207 | (35%) |
| PRIVATE | 382 | (65%) |
| **TOTAL** | **590** | **(100%)** |

*For existing facilities only.

Source: Hagler, Bailly & Company

Typical steam loads in Pakistan vary between 10,000 lb/hour and 200,000 lb/hour. A representative size for a preliminary estimate of cogeneration economics can be taken as 50,000 lb/hour (roughly 20 tonnes/hour). For this size, the main technology options are:

1) Oil- and gas-fired high pressure (HP) boilers with straight back pressure (with/without extraction) steam turbines

2) Gas-fired combustion turbines with waste heat recovery boiler (WHRB)

3) Diesel engines running on furnace oil with WHRB.

At current capital costs, fuel efficiencies, and prices, all cogeneration options envisioned here provide lower total annual costs than corresponding non-cogeneration options. For example, in the case of the typical plant (50,000 lb of steam/hour and 10 GWh/year of electricity), a cogenerating gas boiler system will have a total annual cost of Rs. 20.2 million ($1.26 million), compared with Rs. 23.8 million ($1.49 million)for the corresponding non-cogeneration option (see Exhibit 1.6).

At current capital costs, fuel efficiencies, and prices, cogenerated electricity can be produced at Ps. 40-70/kWh (2.5¢-4.4¢/kWh), depending on the technology/fuel combination. In comparison, the WAPDA average retail rate is Ps. 80/kWh (5¢/kWh), and the KESC rate is Ps. 100/kWh (6.3¢/kWh).

The team assumed that if natural gas is an acceptable fuel for cogeneration, most systems matching steam loads greater than 20,000 lb/hr should be worth consideration, provided they operate on at least two shifts. The preliminary results suggest that cogeneration systems based on diesel engines using furnace oil will be only marginally attractive. If large gas engines can be used, the economics of such systems are likely to be more favorable.

The team developed detailed estimates of the cogeneration market using a proprietary model developed by Hagler, Bailly & Company. This model provides dynamic estimates of the cogeneration market over the next 10 years. By using the steam loads in the industries and their growth over time, the model determines the market for existing facilities (retrofit and replacement markets) as well as new facilities (new market). The differences between the various technologies are calculated through weighted coefficients derived from the life-cycle costs of the various alternatives competing in a given market.

EXHIBIT 1.6

Basic Cogeneration Economics: Illustrative Case for New (1985) Investment Decisions 1/

| | Base Case | | Cogeneration Options | |
|---|---|---|---|---|
| | Low Pressure Boiler | | High Pressure Boiler (elec/steam/steam turbine 0.135) | |
| | Oil | Gas | Oil | Gas |
| System Capital Cost (MRs) | 28.0 2/ | 25.6 2/ | 43.6 5/ | 39.9 5/ |
| Annual Capital Cost (MRs) | 5.6 | 5.1 | 8.7 | 7.4 |
| Annual O&M Cost (MRs) | 2.1 3/ | 1.9 3/ | 3.3 3/ | 2.8 |
| Annual Fuel Cost (MRs) 4/ | 12.6 | 8.8 | 14.4 5/ | 10.0 |
| Electric Capacity (MW) | 0.0 | 0.0 | 2.0 | 2.0 |
| Annual Elec. Gener. (GWh) | 0.0 | 0.0 | 10.0 | 10.0 |
| Annual cost of purchased electriciy (MRs) | 8.0 | 8.0(11) a/ | 0.0 | 0.0 |
| Sale of Excess Power (MRs) | 0.0 | 0.0 | 0.0 | 0.0 |
| Total Annual Cost (MRs) | 28.3 (31.3) | 23.8(26.8) a/ | 26.4 | 20.2 |
| Pay Back (years) b/ | n/a (n/a) | n/a (n/a)8(3) a/ | 3(1) a/ | 0.44 |
| Levelized elec. Cost c/ (Rs./kWh) | - - | - - | 0.61 | |

1/ All cases based on a given steam load = 50,000 lb/hr; 5,000 hours of operation/year; capital recovery factor = 0.2: load following mode for cogeneration units. Electricity requirements = 10 GWh/year.
2/ Based on U.S. $35/lb of steam/hour for oil and U.S. $32/lb of steam hour for natural gas.
3/ Based on 7.5% of capital costs.
4/ Based on 80% efficiency on oil, 78% on natural gas, Rs.1,720/toe for furnace oil; Rs.1,200/toe for natural gas.
5/ 30% surcost on LP boiler plus $225/kW for back pressure turbine.
6/ 4% of capital cost.
a/ First number in WAPDA area, second number in KESC area. N/A = Non applicable; MRs = million Rps; WHRB = Waste H
b/ Computed as = (cogeneration system capital cost - base case capital cost)/base case total annual cost - cogeneration total annual cost.
c/ Total annual cost (cogeneration - total annual cost expected purchased electricity generation.

NOTE: Capital and O&M cost are taken as market values because there is no duty on power systems and the foreign exchange content is comparable among various systems.

Source: Hagler, Bailly & Company.

The result generated by the model are as follows[5]:

(Units-MW)

| | National Market | New Facilities | Existing Facilities |
|---|---|---|---|
| Up to 1990: | 550 | 207 | 343 |
| 1991 - 1995 | 641 | 558 | 83 |
| Total (rounded) | 1,190 | 765 | 425 |

Detailed results and model assumptions are explained in Appendix E.

## POTENTIAL FOR ADDITIONAL ON-SITE POWER-ONLY PRODUCTION

The potential for additional on-site power-only (non-cogeneration) facilities was estimated for the existing industrial base by assuming that all industrial sites that were not candidates for cogeneration could feasibly install on-site power-only systems (i.e., diesel engines and gas turbines) to meet on-site electricity requirements. The estimated financial potential is 340 MW (see Appendix F for details of the analysis). Although this capacity would help individual facilities meet their electricity needs and reduce shutdowns caused by load-shedding, the installation of such capacity would not be desirable from the national perspective, since these units have lower efficiencies compared to utility plants and will increase the country's dependence on imported oil.

## POTENTIAL FOR OFF-SITE POWER PRODUCTION

The private sector has already indicated its interest in investing in dedicated power units and selling the output to the utility grid. The power generating options being considered include:

- Oil-fired system
- Non-pipeline gas-fired systems
- Small-scale coal-fired systems

[5] The major hypothesis and more detailed results are given in Appendix E.

- Small-scale hydropower
- Renewable (solar, wind, biomass) power systems

The initial cost and economics of these power options vary widely, which influences their potential for implementation by the private sector.

In the following sections, the potential power generation capacity from each of these options is estimated, taking into account resource availability, technology status, and economics. Some resource-specific considerations affecting the potential estimate are also discussed.

In this analysis the emphasis will be on determining the generation capacity that is attractive to the private sector, i.e., the financial potential.

## Oil-Fired Systems

There are several technical options for using petroleum products to generate power, including gas turbines, high-speed diesel engines, medium- and low-speed diesel engines, and steam turbine systems. Gas turbines and high-speed diesels usually have to use distillate fuels, which are expensive. Medium- and low-speed diesels can use furnace oil, which is currently about half the price of diesel oil. The private sector in Pakistan has already installed over 50 MW of diesel generation capacity in industry and has indicated an interest in installing dedicated 100-MW to 200-MW power plants to generate electricity for sale to the national grid. The advantages of medium-speed diesels include:

- Modularity, which allows capacity to be installed in increments as low as 1 MW and as high as 20 MW
- High thermal efficiency (over 40 percent), leading to low fuel consumption
- Short lead time, allowing construction in as little as 1-2 years.

The cost of electricity generated by a diesel power system is shown in Exhibit 1.7, assuming two prices of fuel oil -- Rs. 1,720/tonne ($108/tonne), which corresponds to the purchase price by KESC, and Rs. 2,288/tonne ($143/tonne), which corresponds to the current imported fuel oil price. The cost of electricity is about 88 Ps./kWh (5.5¢/kWh) for the lower cost fuel and 104 Ps./kWh (6.5¢/kWh) for the higher priced fuel. This range is in line with recent proposals from the private sector -- the Hub Chowki project, for example.

The cost of oil-fired power is also highly competitive with the utilities' own marginal power costs. It should thus be consistent with rates

Exhibit 1.7

Cost of Power for Medium Speed Diesel Power System (1985)

| Fuel Cost | Large System Ps./kWh | (¢/kWh) | Small System Ps./kWh | (¢/kWh) |
|---|---|---|---|---|
| 1,720 Rs./tonne ($100/tonne) | 88 | (5.5) | 96 | (6.0) |
| 2,300 Rs./tonne ($143/tonne) | 104 | (6.5) | 112 | (7.0) |

Assumptions:

Large system (20 MW) Cost - $650/kW
Small system (4 MW) Cost - $800/kW

Capital recovery factor - 0.2
Capicity factor - 60%

Consumable Costs - 10% of fuel

Source: Arthur D. Little

offered by the utility to the private sector under the new policy, thereby ensuring interest by the private sector in oil-fired diesel power systems. There is no basic resource constraint on the potential for private sector power from this option, but other types of constraints exist, including:

- Government policies that limit the growth in fuel oil generating capacity to as low a level as possible, given the associated long-term (balance of payment) ramifications of relying too heavily on oil-based power generation
- Other options such as low-Btu gas fields and hydropower that produce lower cost power than oil-fired units
- Possible accelerated drilling programs by the government and private sector, which could result in large increases in natural gas reserves.

As a result of these constraints, the team assumed that oil-fired diesel power represents a short-term solution to capacity shortfall problems. The financial potential is not estimated because any large-scale plant would be cost competitive with the utilities.

## Non-pipeline Gas-Fired Systems

The GOP has drastically curtailed the use of pipeline natural gas for power generation. However, two sources of gas are not so restricted:

1) "Dormant gas fields." These eight gas fields (see map in Appendix G), identified over the last 30 years, contain low-quality gas that cannot be used in pipelines (see Appendix H).

2) The associated and non-associated gas recently identified at oil drilling concessions by Union-Texas, Occidental, and OGDC. This gas is often found in modest quantities, has a short life and is not near the pipeline, so its most effective use, in many cases, would be for power generation.

Both types of gas supply could in some cases be developed fairly rapidly and used for relatively low-cost power production. However, a number of basic policy issues -- private-sector participation in OGDC lease areas, gas pricing, and definitions of associated and non-associated gas -- must be resolved before this option can be exploited by the private sector.

## Technical Potential

Three gas fields are most likely to be developed by the private sector because of their size and availability. The power generation potential of these fields is shown in Exhibit 1.8.

If reserve estimates are verified by more detailed field appraisals, the technical potential for these three fields would be over 1,000 MW.

However, Uch, Zin, and Kairpur have not been appraised for over 25 years and all estimates of gas reserves must be treated cautiously. Needed drilling and seismic appraisal activity would take 12-36 months, and could result in changes, upward and downward, of field potential. Several industry observers believe that reserves at Uch, in particular, might be conservatively estimated.

No estimates have yet been made of gas reserves at the oil concessionary fields in Sind and the Potwas region. In Sind there are over 15 wells containing cap gas and associated gas, with associated gas at Karachi being flared. Industry experts are confident that additional gas will be found as more wells are drilled. Although much of this gas is pipeline quality, many of the wells might be more economically dedicated to power generation using skid-mounted turbines, given the high pipeline costs associated with connections into a multiplicity of modest-sized reserves.

## Economics

Non-pipeline gas is most likely to be converted to power using gas turbines. Preliminary cost of power estimates, assuming private-sector financing, are shown in Exhibit 1.9 for different gas prices. The gas price range reflects the uncertainty in government policies. A cost of Rs. 37.5 ($2.34)/mmBtu is consistent with two-thirds of imported fuel oil prices, while a gas price of Rs. 18.7 ($1.17)/mmBtu corresponds to the current market price.

The cost of power ranges between 48 Ps./kWh (3¢/kWh) and 97 Ps./kWh (6¢/kWh) within this gas cost range. This range is competitive with the cost of power generated by the utility.

## Financial Potential

Pakistan's non-pipeline natural gas resources have an estimated financial potential of 530-715 MW, half their technical potential.

However, a number of major institutional and policy issues could delay or even preclude the realization of this potential. These issues are discussed in more detail in the following chapter.

Exhibit 1.8

Technical Power Generation Potential at the Dormant Gas Fields

| Field | Reserves (TCF) | Energy (Btu/cu.Ft) | Power Potential (MW) |
|---|---|---|---|
| Zin | 0.1 | 460 | 60 - 80 |
| UCH | 2.5 | 270 | 850 - 1,150 |
| Kairpur | 1.0 | 120 | 150 - 200 |
| | | **TOTAL** | 1,060 - 1,430 |

Assumptions:

- Plant life = 15 years
- Capacity factor = 0.6
- Power cycle efficiency range from 30% (simple cycle turbine) to 40% (combined cycle)

Source: Arthur D. Little

EXHIBIT 1.9

Cost of Power Estimates - Gas Turbines

SYSTEM TYPE: SIMPLE CYCLE GAS TURBINES

| | GAS PRICE | | | | | |
|---|---|---|---|---|---|---|
| | Current Market Price Rs. 18.7 ($1.17)/mmBtu | | Two-thirds of imported Fuel Oil Price Rs. 37.5($2.34)/mmBtu | | Equal to Imported Fuel Oil Price Rs. 56.0($3.51)/mmBtu | |
| 50 MW | 37 | (2.3) | 72 | (4.3) | 94 | (5.9) |
| 20 MW | 64 | (4) | 85 | (5.3) | 107 | (6.7) |
| 5 MW | 85 | (5.3) | 105 | (6.6) | 128 | (8) |

Ps./kWh, Numbers in parenthesis are in cents/kWh

Assumptions:

a. System Type: Simple Cycle Gas Turbines

b. Efficiency: 30%

c. Capital Costs:

50 MW: $350/kW
20 MW: $500/kW
5 MW: $800/kW

d. Capital Recovery Factor = 0.2

e. Capacity Factor = 0.6

Source: Arthur D. Little

However, a number of major institutional and policy issues could delay or even preclude the realization of this potential. These issues are discussed in more detail in the following chapter.

## Small-scale Coal-Fired Systems

There are over 2,000 coal mines in Pakistan, with centers of production located in the Quetta area of Baluchistan, the Lakhra area of Sind, and in various locations in Punjab. Current production is about 2.5 million tonnes. Within this highly fragmented industry, there are roughly 20 mining groups that account for a major portion of production.

Several of the larger firms have assessed the prospects for installing small (10-50 MW) coal-fired power plants using coal from their own mines, possibly supplemented by coal from nearby smaller mining operations. This approach has the advantage of reducing (or eliminating) transportation costs.

Possibly the largest single barrier to a large near-term contribution from small-scale coal-fired generation is the fragmented nature of current coal production. With production scattered among many smaller mines, it is difficult to assemble sufficient coal in one area to fire coal plants of economical size. For example, a 25-MW power plant would use between 120,000 and 250,000 of coal per year, depending on coal quality and power plant efficiency.

The technical power production potential of coal, assuming the use of 10 percent, 25 percent and 50 percent of current nationwide production, is shown in Exhibit 1.10. The potential is likely to be in the lower end of this range, given the need for significant volumes of coal in a rather limited area to control transportation costs and the need for relative stability in current coal markets. Over the long term, mine modernization could result in increase in production levels and a resulting higher power production potential.

### Economics

Recent designs for small wood- and lignite-fired units, together with engineering studies in support of private-sector mine operators in Pakistan, indicate that the capital cost of small coal-fired power plants would range between $1,200 and $1,800/kW, on an installed basis (turnkey).

Equipment represents about 60 percent of these costs, because oversized stoker-boiler systems are needed to handle the relatively low-grade coal. Associated coal and ash handling equipment is also required. However, small units based on pre-engineered subsystems can probably be installed

Exhibit 1.10

Technical Power Generation Potential From Coal*

| % of Coal Produced | Tonnes/Yr | Power Potential (MW) |
|---|---|---|
| 10 | 250,000 | 40-60 |
| 25 | 625,000 | 110-140 |
| 50 | 1,250,000 | 200-300 |

*Based on current production levels estimated at about 2.5 million tonnes.

Source: Arthur D. Little

in 2-3 years, which would greatly reduce finance charges and control the escalation of costs during construction compared with large central plants.

The economics of coal-fired power generation depend on local coal costs. Power costs as a function of delivered coal prices ranging from Rs. 320 ($20)/tonne to Rs. 640 ($40)/tonne are shown in Exhibit 1.11. The lower figure corresponds to a mine-mouth operation with minimal coal transportation or handling charges, and the higher figure corresponds to a plant with substantial delivery charges.

On the basis of these coal costs the cost of power ranges from about 131 Ps./kWh (8.2¢/kWh) to 155 Ps./kWh (9.7¢/kWh). Over 50 percent of the power cost is associated with finance and capital charges in these power units, which makes the analyses sensitive to financial assumptions. As a result, favorable financial terms will affect these options more than those with lower cost equipment.

### Financial Potential

The power costs are significantly higher than current utility marginal costs and those of other options that might be available to the private sector. Consequently, both resource limitations and unattractive economics will tend to limit the potential of small-scale coal-fired power generation, at least in the near term. The financial potential of this option is estimated at only 25-50 MW.

## Small-Scale Hydro Power

The small-scale hydropower sites in Pakistan can be divided into four categories:

1) Barrages: the heads created by existing dams on the irrigation network are used to generate power in the 5 MW to 200 MW range

2) Canals: small dams are created on the irrigation canals for hydro power generation (50 kW to 5 MW)

3) Small rivers: dams are placed in smaller rivers of the North West Frontier Province (NWFP) and Punjab for hydropower generation of 100 kW to 100 MW

4) Mountain streams: specially designed turbines use the low flows and high heads in mountain streams for micro hydropower production (1 kW to 50 kW)



42

Exhibit 1.11

Power Cost Estimates - Small Coal-Fired Power Plants

| Coal Price Rs./tonne | ($/tonne) | Energy Cost Ps./kWh | (¢/kWh) |
|---|---|---|---|
| 320 | (20) | 131 | (8.2) |
| 480 | (30) | 144 | (9.0) |
| 640 | (40) | 155 | (9.7) |

Assumptions:

- Capital Cost = $1,500/kw fully installed
- O&M Cost = 16 Ps./kWh (1¢/kWh)
- Capacity Factor = 60%
- Capital Recovery Factor = 0.2
- Plant Efficiency = 25% (Overall)

Source: Arthur D. Little

The last category will occur primarily in remote northern areas that are usually isolated from the grid. The power so generated may be important on a local basis to satisfy important socioeconomic needs. The gross potential is, however, modest (2 MW) and is thus not considered further here.

Barrages. Studies undertaken jointly by WAPDA and GTZ contractors have identified a number of sites on barrages that have good potential for hydropower generation. The overall potential of these sites is in excess of 300 MW, with individual power units ranging from 5 MW to 200 MW. As the result of a recent study, four sites have been identified for development, probably by WAPDA itself:

| | | |
|---|---|---|
| Chasma | - | 200 MW |
| Jinnah | - | 120 MW |
| Jaunsa | - | 120 MW |
| Guddu | - | 50 MW |
| Total | | 490 MW |

WAPDA is currently undertaking a detailed feasibility study for Chasma and may issue tender documents for this project.

The barrage sites have the potential to attract private-sector development, but are considered to be strategic locations (referred to as "key points") and access to them is currently limited.

There is increasing interest in using small hydro sites for generation of power in both the autonomous and grid-connected modes. Examples of this interest include:

- A recent "agreement" between the Punjab Irrigation Department and a private party for the development of a 2.8 MW unit on link No. 2 of the DGK Canal. The Irrigation Department is also negotiating an agreement with a private party for a 3.8 MW site in upper Punjab.

- Proposals received by WAPDA from Electra Power Corporation (Palo Alto, CA) for development of small hydro sites. WAPDA provided Electra with two specific locations for detailed consideration:

  - a site in Gilgit with 4 MW of potential

  - two locations on the B.S. link in Punjab, one with 6 MW of potential and the other with 9 MW.

Canals. Pakistan has the largest irrigation canal network in the world. In Punjab alone there are about 23,000 miles of canals. Based on surveys undertaken by the Punjab Irrigation and Water Department over the past few years, there are about 230 sites that might be favorable for small-scale hydro power. Of these, 60 have the potential for more than 50 kW of output; together they have a potential of 92 MW.

Five of the more favorable sites have been selected for feasibility studies. They have a power potential of 1.5 MW to 5 MW, 5 ft. to 11 ft. heads, and flow rates of 4,000 cubic feet/sec to 11,000 cubic feet/sec.

If the projects are feasible, the government of Punjab plans to install and operate the facilities, which will not be connected to WAPDA and will serve only nearby tubewell pumps and villages. Nevertheless, their presence could reduce future power demands on WAPDA as the rural electrification program expands. Punjab Province probably has the bulk of small hydro sites on canals in Pakistan, both because of the very large canal infrastructure and the relatively hilly topography.

Small Rivers. The Ministry of Water and Power has identified numerous sites on about 12 of the smaller rivers flowing in the northern regions (Swat, Gilgit, Chitral) with good potential for small-scale hydro power generation. These sites have individual power potentials of 1 MW to 100 MW; many are reasonably close to the WAPDA distribution system and, if developed, would become grid-connected.

The potential for small-scale hydropower in Pakistan, based on information made available to the study team, is shown in the table below. The overall potential is estimated to be between 1,400 MW and 2,850 MW. Of this potential, however, about 300 MW-600 MW (21 percent) is on the barrages, where private parties may not be allowed to operate.

Technical Generation Potential From Small-Scale Hydropower (MW)

| | |
|---|---|
| Barrages & Link Canals | 300 - 600 |
| Canals | 100 - 150 |
| Small Rivers | 1,000 - 2,000 |
| **TOTAL** | 1,400 - 2,850 |

## Economics

The cost of implementing a small-scale hydro project depends on site conditions, location, system size, and heads. Pre-packaged small hydro turbine-generation-control units are becoming increasingly available as the result of worldwide interest in small-scale hydropower. The availability of such units will help reduce cost uncertainties and shorten implementation schedules. In making preliminary cost estimates, the study team divided the systems into two categories:

1. Barrages: The barrages themselves function as the dam, which significantly reduces civil works requirements.

2. Canals and rivers: These sites will require dam structures and other civil works, which increase costs.

For larger systems on the barrages, installation costs are estimated to be $600 to $1,200 per kW. The costs for smaller units on the canals and small rivers are estimated to be $1,000 to $2,000 per kW.

Operations and maintenance costs should be uniformly low, ranging from 6.4 Ps./KWh (0.4¢/kWh) to 9.6 Ps./KWh (0.6¢/kWh).

Preliminary estimates of power costs from small hydro sites are shown in Exhibit 1.12. The power costs of the barrage units would range from 38 Ps./kWh (2.4¢/kWh) to 69 Ps./kWh (4.3¢/kWh), depending on size and financing terms. The smaller canal and river systems would have significantly higher power costs ranging from 73 Ps./kWh (4.6 ¢/kWh) to 137 Ps./kWh (8.6¢/kWh), owing to higher capital costs and generally lower capacity factors.

## Financial Potential

Based on the information presented above, the team estimates the financial potential for small-scale hydro to be in the 400 MW-700 MW range.

## Renewable Power Systems

The renewable energy sources addressed are solar, wind, and small-scale biomass. In the United States and elsewhere there has been a great deal of activity in developing systems to use such renewable energy resources. As a result, these resources have been used in small remote applications as well as small utility (1-50 MW) applications.

Pakistan has been a leader in applying these technologies, as exemplified by the installation in the last few years of a large number of digester systems and solar village units based on photovoltaics. Moreover, several

Exhibit 1.12

Power Cost Estimates - Small Scale Hydro

a. Barrages:

| Capital Cost Rs./kW | ($/kW) | Energy Cost Ps./kWh | (¢/kWh) |
|---|---|---|---|
| 9,600 | (600) | 38 | (2.4) |
| 12,800 | (800) | 48 | (3.0) |
| 16,000 | (1000) | 59 | (3.7) |
| 19,200 | (1200) | 69 | (4.3) |

b. Rivers and Canals:

| Capital Cost Rs./kW | ($/kW) | Energy Cost Ps./kWh | (¢/kWh) |
|---|---|---|---|
| 16,000 | (1000) | 73 | (4.6) |
| 19,200 | (1200) | 86 | (5.4) |
| 24,000 | (1500) | 105 | (6.6) |
| 32,000 | (2000) | 137 | (8.6) |

Assumptions:

- Capital Recovery Factor = 0.2
- Capacity factor on barrages = 0.6
- Capacity factor on canals = 0.5

Source: Arthur D. Little

private-sector ventures for the production of photovoltaic and wind turbine systems are currently being formulated.

Private-sector prospects for manufacturing and installing power systems using renewable energy resources thus look promising in Pakistan. However, solar and wind systems will most likely be used initially to serve small loads in remote areas that cannot economically be served by conventional means (grid extensions, diesel generators).

The lack of biomass resources (e.g., bagasse, cotton stalks, rice hulls) in sufficient concentrations for use in power plants will probably limit their potential. The potential for power generation from each type of resource is presented below.

## Solar and Wind

Solar availability in most of Pakistan compares favorably with the very best regions of the United States. Wind resources, although poorly defined at this time, are probably marginally attractive in many coastal and mountain regions. Since the power generation potential from these sources is only limited by economics, the technical potential based on resource availability is not meaningful when discussing these energy sources.

## Biomass

Preliminary estimates of biomass availability in Pakistan are presented in Exhibit 1.13. Biomass resources are restricted to crop and animal wastes, since wood is already in short supply because it is used by rural populations for cooking. The crop wastes associated with sugar production are already heavily used for industry power and steam needs. The most underused crop waste is cotton stalks. The annual yield is about 3.6 million tonnes, which could produce up to 800 MW of power at a 60 percent capacity factor. The stalks could be converted to power using prepackaged boiler-steam turbine systems (1-50 MW) similar to those used to burn wood wastes in the United States and elsewhere.

Detailed field surveys of the distribution and current disposal of cotton stalks are not readily available. Even a modest availability of 10-20 percent of the total yield could produce 80 MW to 160 MW.

Bagasse is the largest source of biomass currently used in Pakistan and studies recently conducted by the GOP have concluded that up to 60 MW of additional power could be generated through more efficient use of the sugar mill power plants. Unfortunately most sugar mills are not connected to the grid and the use of bagasse would not be economically justified if it had to be transported over distances greater than 30 miles.

Exhibit 1.13

Estimate of Yield of Crop Residues in Pakistan 1978-1979

| Residue Origin | Thousands Tonnes |
|---|---|
| Wheat (straw) | 13,023 |
| Rice (straw) | 3,400 |
| Maize | 1,053 |
| Millet | 562 |
| Sorghum | 596 |
| Barley (straw) | 154 |
| Oats (straw) | 1,218 |
| Food grains subtotal: | 20,006 |
| Sugar Cane | 4,349 |
| Tops and Leaves | 4,349 |
| Bagasse | 2,810 |
| Molasses | 366 |
| Cotton | 3,586 |
| Other | 1,929 |
| Cash crops subtotals: | 13,040 |
| TOTAL CROP RESIDUES | 33,046 |

Source: Adapted from Muller (1980)

## Economics of Solar Power Generation

Solar power systems include major subsystems of photovoltaic (PV) arrays. Base prices for the PV panels alone currently range from $5,000 to $7,000 per kW in the United States. System costs, including controls, battery storage, and installation, are usually $15,000 to $25,000 per peak kW. However, total system costs, not including storage, have been as low as $10,000 per kW. Several of the PV systems that have been installed in Pakistan for village electrification have approached these lower cost figures.

Although much progress has been made in recent years to rapidly decrease PV costs, further cost reductions are expected to occur slowly. By the early 1990s, installed costs (including mounting, cells, protection equipment, wiring, and power conditioning) are expected to be about $5,000 per kW.

The capacity factor of PV systems, even in sunny regions, is only about 20-30 percent (without storage). With current system costs at about $12,000/kW, energy costs are over Rs. 9.6/kWh (60¢/kWh). Even with decreases in system costs to $5,000/kW, energy costs will generally be in excess of Rs. 4.8/kWh (30¢/kWh). Therefore, PV systems will continue to be used primarily for remote power markets where the costs of running distribution lines or operating small engine generators are prohibitively high.

## Economics of Wind Turbine Power Turbines

Altamount Pass in California is one of the largest U.S. windfarm developments. The installed wind turbine (WT) capacity in this 18-square-mile area is 360 MW, with 4,087 WTs installed as of January 1985. A typical WT rated at 100 kW would cost approximately $150,000 installed. Average power ratings range from 70 kW to 100 kW and cost between $90,000 and $150,000, for an average of about $1,500 per rated kW.

The available energy is proportional to the cube of the wind velocity. However, only a small fraction of the energy in the area swept by the blades of a WT is extracted as mechanical energy. A typical annual energy output for a 100 kW WT in California, in areas with wind regimes averaging greater than 14 mph, is approximately 210-240 kWh. The capacity factor for WTs on average is between 15 and 25 percent, owing to variations in wind velocities. With installed costs of WTs at approximately $1,500/kW, the cost of energy is around 192 Ps./kWh (12¢/kWh) in areas with favorable wind regimes.

Discussions with WT manufacturers and utility operators have indicated steadily increasing WT reliability and modest reduction in cost. By 1990, the cost of energy for WTs is expected to be reduced to 160-176 Ps./kWh (10-11¢/kWh). This cost approaches that of oil-fired units. However, achieving these relatively low power costs in Pakistan is contingent on identifying locations that have average annual wind speeds in excess of 12-14 mph. Such sites have not yet been identified and appraised in detail. Consequently, little if any impact is projected from private-sector development of wind farms over the near term.

### Economics of Biomass

The most straightforward approach to using biomass resources for power generation is to burn them in a boiler to drive small steam turbines. According to discussions with one manufacturer of prepackaged units, capital costs for installed capacities below 10 MW would be $1,400/kW-$2,000/kW.

The economic value of agricultural wastes is difficult to estimate. Where the power unit performs a much needed disposal function, the cost of the wastes may be zero (and a credit can even be obtained in some extreme cases). If additional collection and transportation of wastes are required to allow their use in a power system, the cost would reflect this effort.

Power cost estimates for a biomass-fired system are shown in Exhibit 1.14, assuming two cases: zero value of biomass, and a value of $25/tonne. Resultant power costs would range from 108.8 Ps./kWh (6.8¢/kWh) to 218 Ps./kWh (13.6¢/kWh), with the lower cost quite attractive. A survey is thus warranted to determine whether cotton stalk wastes or excess bagasse are available in sufficient concentrations to be used in small-power generating units.

### Financial Potential

Because of the lack of data on most resources, the financial potential is arbitrarily estimated at 50-100 MW, most of it from biomass (cotton wastes and bagasse).

## TOTAL POTENTIAL FOR PRIVATE-SECTOR POWER GENERATION

Cogeneration systems using natural gas or another fuel provide the lowest cost power, primarily because the power system is, in effect, charged only one-third the fuel cost, with the reminder being charged against process heating needs. The favorable economics of cogeneration systems extend to low (60 kW) power outputs, which means that even small

Exhibit 1.14

Power Cost Estimates - Biomass-Fired Power System
Unity Type: Prepackaged Steam Power System
Efficiency: 25%

| | Case A No Fuel Charge Ps./kWh | (¢/kWh) | Case B With Fuel Charge Ps./kWh | (¢/kWh) |
|---|---|---|---|---|
| 10 MW | 108.8 | (6.8) | 157 | (9.8) |
| 5 MW | 132.8 | (8.3) | 180 | (11.3) |
| 1 MW | 170.0 | (10.6) | 218 | (13.6) |

Assumption:

A. Costs

| | Installed Ps./kW | ($/kW) | O & M Ps./kWh | (¢/kWh) |
|---|---|---|---|---|
| 10 MW | 22,400 | (1,400) | 12.8 | (0.8) |
| 5 MW | 25,600 | (1,600) | 16.0 | (1.0) |
| 1 MW | 32,000 | (2,000) | 24.0 | (1.5) |

B. Capacity Factor = 0.5 to reflect seasonal variations in waste availability

C. Capital Recovery Factor = 0.2

D. Fuel Charge = Rs. 37/mmBtu ($2.30/mmBtu)

Source: Arthur D. Little

industries with a significant thermal load could consider the cogeneration option. Low-Btu gas-fired turbines, small-scale hydro, and biomass-fired power units also have power costs of under 60 Ps./kWh (3.8¢/KWh) in some cases (see Exhibit 1.15).

The cost of power from diesel power units using heavy oil ranges from 75 Ps./kWh (4.7 ¢/kWh) to about 120 Ps./kWh (7.5 ¢/kWh) in capacities over 5 MW. This range is consistent with what is probably the true marginal cost of thermal power from the utilities themselves. The coal-fired units produce the most costly power -- Ps. 100/kWh (6.3 ¢/kWh) to over Ps. 150/kWh (9.4 ¢/KWh)in lower capacities. This high cost of power is the result of relatively high capital and operating costs for small coal power units, even those without pollution control.

For comparison purposes, WAPDA's average sale price of power to industry ranges from 72 Ps./kWh (4.5¢/kWh) to 80 Ps./kWh (5.0¢/kWh), including fuel adjustments cost (FAC). Cogeneration, some hydro sites and gas turbines operating with low-cost gas could compete with the average range of electricity retail prices.

The marginal cost of power to WAPDA for oil-fired thermal power stations is 93 Ps./kWh (5.8¢/kWh) to over 112 Ps./kWh (7¢/kWh), depending on fuel oil price and capital cost assumptions. If price policies on purchases from the private sector are related to these marginal costs, all the power options except coal, wind, and solar become economically attractive.

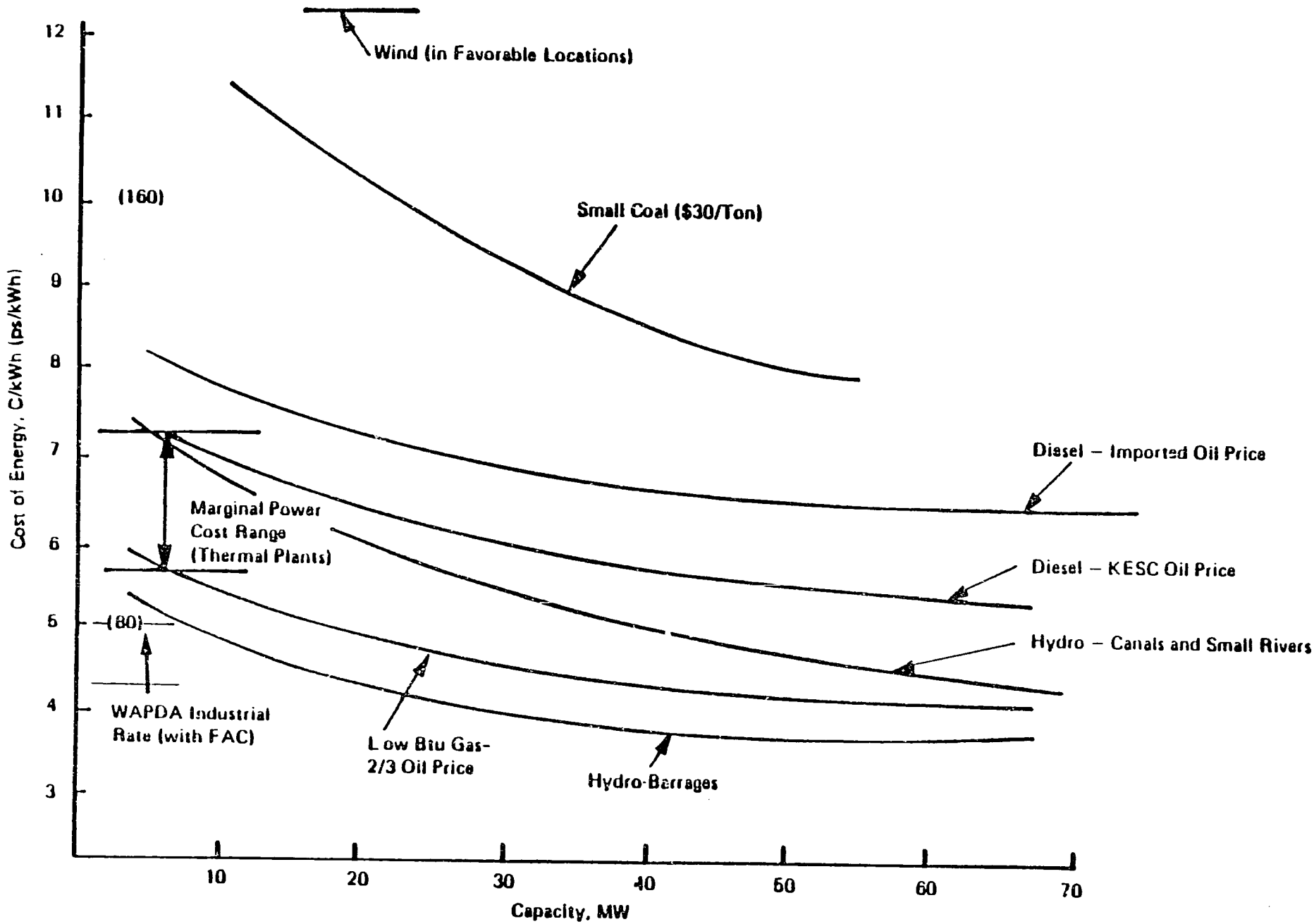
## Likely Market Penetration

Estimating the market impact of relatively unfamiliar technologies is always subject to a high level of uncertainty, even where market response data are well documented, as in the United States. Furthermore, the relationship between economics and market penetration depends on the market segment being considered.

For cogeneration applications in industry, the systems will usually require a payback period of less than 3 years to have a significant market penetration. This payback corresponds to a return on investment of over 35 percent. With highly favorable economics, the market penetration will usually range from 30 to 50 percent for new facilities and from 50 to 70 percent for existing facilities. The main constraints will be shortage of capital or more profitable uses of capital, expected modification in plant operations, and lack of operational capabilities for cogeneration equipment.

For larger independent power projects that have a financial structure similar to that of a utility, the economic criterion for significant levels of implementation will be closer to a 20-percent return on equity.

EXHIBIT 1.15 COST OF ELECTRICITY FROM PRIVATE SECTOR POWER GENERATION OPTIONS




Source: Arthur D. Little

Market Penetration in Pakistan is complicated by several factors:

- A lack of experience and information in industry on the application and economic potential of cogeneration technology
- Government policies on dormant gas and associated gas that inhibit (or prohibit) their use by the private sector
- Questions on the amount of capital that is realistically available for power projects, particularly if a 30-percent return on equity is required; total investment required to realize the economic potential is estimated to be $2.9-3.9 billion (see Exhibit 1.16), of which roughly 45 percent would be needed as equity from the private sector
- Continuing uncertainty in the private sector on the status of government policies
- The installation of power systems by industry to avoid disruptions caused by load shedding; the decision to install such a system is based on economic factors that are not directly related to utility tariffs or potential buyback provisions
- Limited access to barrages and canals

The study team estimates that 885 MW to 1,065 MW of private-sector power generation, using energy sources other than oil, could be developed by 1990 and could increase to 1,715 MW by 1995 (See Exhibit 1.17). This market development could cut the power deficit in half, with the remainder of the deficit to be eliminated by oil-fired power plants.

EXHIBIT 1.16

Capital Investment Requirement
(excluding oil-fired, off-site power plants)

| Technology | Additional Capacity (MW) | Range of Cost ($/kW) | Capital Requirements ($, million) Total | Domestic | Foreign |
|---|---|---|---|---|---|
| A. INDUSTRIAL COGENERATION | | | | | |
| Existing Facilities | 425 | 1,200-3,000 | 675* | 270 | 405 |
| New Facilities | 765 | 1,200-3,000 | 1,385 | 555 | 830 |
| B. OFF-SITE | | | | | |
| Non-pipeline gas/gas turbine | 625 | 350- 800 | 220- 500 | 100- 230 | 120- 270 |
| Small-scale hydro | 550 | 900-2,000 | 500-1,100 | 275- 605 | 225- 495 |
| Small-scale coal | 35 | 1,200-1,800 | 40- 60 | 20- 30 | 20- 30 |
| Biomass | 100 | 1,400-1,200 | 105- 150 | 55- 80 | 50- 70 |
| TOTAL | 2,500 | | 2,925-3,870 | 1,275-1,770 | 1,650-2,100 |

*The cogeneration capital requirements are a weighted average of the likely penetration rates for each cogeneration technology based on the model. The off-site capital estimates are based on more qualitative procedures.

Source: Hagler, Bailly & Company.

Exhibit 1.17

Private Sector Power Generation: Preliminary Estimate of Financial Potential and Possible Development, Excluding Oil-Based Systems (MW)

| A. INDUSTRIAL COGENERATION* | FINANCIAL POTENTIAL | POSSIBLE DEVELOPMENT | |
|---|---|---|---|
| | | by 1990 | 1991-1995 |
| - Existing Facilities | 425 | 345 (80%)** | 80 (20%) |
| - New Facilities | 765 | 210 (27%) | 555 (73%) |
| B. OFF-SITE | | | |
| - Gas | 530-715 | 185-250 (35%) | 370-500 (70%) |
| - Coal | 25-50 | 13-25 (50%) | 25-50 (100%) |
| - Hydro | 400-700 | 120-210 (30%) | 280-480 (60%) |
| - Other Renewable | 50-100 | 12-25 (25%) | 25-50 (50%) |
| TOTAL (rounded): | 2,195-2,755 | 885-1,065 | 1,335-1,715 |

*The cogeneration figures were generated from a market penetration model. The off-site estimates are based on more qualitative procedures.

**Estimated market penetration rate.

Source: Hagler, Bailly & Company

# CHAPTER 2: IMPEDIMENTS TO PRIVATE-SECTOR PARTICIPATION



The economic potential for private-sector power generation is unlikely to be fully realized in the near future because of a number of institutional barriers or impediments. In this chapter, the institutional framework, within which electricity generation, transmission, distribution, and transactions take place, is described. Then, the views of the public sector -- including WAPDA and KESC -- and the private sector on private power generation are presented, as expressed during the team's in-country visit. Finally, some observations are offered on the implications of these differing views for the likely development of private-sector power generation.

## THE INSTITUTIONAL FRAMEWORK

The electric power sector's institutional framework in Pakistan consists mainly of WAPDA, KESC, and the Ministries of Water and Power, Finance, and Planning.

The Water and Power Development Authority (WAPDA), which is headquartered in Lahore, is responsible for coordinating nationwide development of water and power resources. WAPDA carries out the design, construction, and operational activities of the federal and provincial governments. It receives funds from the following sources: federal and provincial government grants and loans, proceeds from bonds issued under GOP authority, loans obtained with special or general sanction of the government, grants and loans from foreign donors, and the sale of electricity.

WAPDA is organized in three "wings": the water wing, the finance wing, and the power wing. The power wing is Pakistan's major electric utility and is responsible for construction and operation of power generation, transmission, and distribution facilities, including rural electrification.

As of October 1985, the total generating capacity of WAPDA was 4,371 MW, of which 2,897 MW was hydroelectric and 1,474 MW was thermal. WAPDA operates three large hydro plants and a number of small ones. The thermal plants use primarily natural gas; high-speed diesel oil and fuel oil are used only marginally. WAPDA uses coal in only one of its thermal generation stations. The breakdown of capacity and electricity generation of the WAPDA system is shown below:

| | Capacity (MW) | Generation (MWh) |
|---|---|---|
| Hydroelectric | 2,897 | 12,245 |
| Thermal | 1,474 | 5,861 |
| Total | 4,371 | 18,106 |

In addition to its own generation, WAPDA also purchases electricity from KESC. During 1984 and 1985, for instance, WAPDA bought 674 MWh from KESC.

In recent years, however, the demand for electricity has grown much faster than WAPDA's supply expansion. As a result, load shedding, especially during the dry season, is practiced widely. In April 1985, for example, the supply shortage was as high as 1,400 MW, or over 30 percent of existing generation capacity.

WAPDA currently has an ambitious expansion program that includes the addition of over 2,600 MW of generation capacity by 1990. This capacity includes a number of thermal and hydroelectric projects in various stages of development.

The Karachi Electric Supply Corporation (KESC) is responsible for providing and maintaining adequate generation, transmission, and distribution facilities to meet the power requirements within its licensed service area. This area includes the district of Karachi, some part of the adjoining district of Tatta and a part of Lasbela district (Hub Chowki area) in the province of Baluchistan.

The total installed generating capacity of KESC's power system at the end of June 1984 is shown below.

| | Installed Capacity (MW) | Net Capacity (MW) |
|---|---|---|
| KESC's generating facilities | 1,138 | 1,035 |
| Karachi nuclear power plant | 137 | 42 |
| Pakistan steel mill | 165 | 30 |
| Total | 1,440 | 1,107 |

Except for the Karachi nuclear plant, all electricity in KESC's power system is generated by fossil power plants -- steam turbines, gas turbines, and diesel engines. The total energy supplied to the grid in 1983-1984 was 3,317 GWh.

KESC's power supply system is interconnected with WAPDA through a double circuit of 220 kV overhead transmission lines. Peak power supplied by KESC to WAPDA reached 215 MW in December 1984.

Since KESC has no hydroelectric plants, it has higher electricity tariffs than WAPDA. The tariff, as of June 1985, varied between 37 Ps.(2.3¢) per kWh for residential customers to over 110 Ps.(6.9¢) per kWh for commercial and industrial consumers.

KESC's generation capacity is expected to increase by 420 MW with the construction of the Pipri D-3 and D-4 steam plants, scheduled for completion in 1989.

KESC was originally a totally private company, but in 1951 the GOP purchased controlling shares of the company because KESC was unable to meet financial requirements for system expansion. Today only 6 percent of the stock is privately owned.

KESC's own program for investment in power generation is to end in 1990. By then, WAPDA is expected to be responsible for all power generation expansion projects nationwide.

KESC customers, especially in the industrial sector, pay much higher rates for electricity than WAPDA customers because of the high fuel cost to the utility system. The KESC fuel adjustment charge (FAC), which is computed as the average monthly charge per kWh produced during the 12 months preceding the 2 last months, was 63 Ps./kWh (3.9¢/kWh) in September 1985, compared with 15 Ps./kWh (0.9¢/kWh) in the WAPDA area (see Exhibit 2.1). Total electricity rates for industrial customers, which also include a fixed charge and an energy charge (before fuel cost), were about 110 Ps./kWh (6.9¢/kWh) in the KESC area, compared with 65-75 Ps./kWh (4.1-4.7¢/kWh) in the WAPDA area.

In spring 1985, the Karachi Chamber of Commerce protested vehemently to the GOP against this price difference, arguing that such high rates were discouraging industrial development in the Karachi area. The GOP subsequently decided to allow KESC to reduce the FAC by 23 Ps./kWh, which represented the contribution of the duty tax levied on oil. However, the GOP must now devise a new system to avoid the corresponding loss of revenues. It is currently working on a proposal to equalize the burden of this tax between WAPDA and KESC.

Ministries. The three GOP ministries most responsible for electric power matters are the Ministry of Water and Power, the Ministry of Planning, and the Ministry of Finance.

Exhibit 2.1

Comparison of WAPDA and KESC Tariffs*

| Category | WAPDA Energy Charge (Ps.*/kWh) | WAPDA Capacity Charge (Rs.**/kW/Month) | KESC Energy Charge (Ps./kWh) | KESC Capacity Charge (Rs./kW/Month) |
|---|---|---|---|---|
| I. General Supply | | | | |
| Tariff A-1 (Residential) | | | | |
| Up to 50 kWh | 37 | -- | 37 | -- |
| 51-250 kWh | 44 | -- | 44 | -- |
| 251-500 kWh | 55 | -- | 55 | -- |
| Above 500 kWh | 77 | -- | 77 | -- |
| Tariff A-2 (Commercial, Government) | | | | |
| Up to 100 kWh | 110 | -- | 106 | -- |
| Above 100 kWh | 122 | -- | 110 | -- |
| II. Industrial Supply | | | | |
| Tariff B-1 (Single Phase 230V, 3 Phase 400V) | | | | |
| Up to 20 kW | 69 | 24 | 50 | -- |
| 20 to 70 kW | 69 | 31 | 50 | -- |
| Tariff B-2 (3 Phase, 400V) | | | | |
| 70-500 kW | 40 | 88 | 29 | 88 |
| Tariff B-3 (11/33 kV) | | | | |
| 501 kw up | N.A. | N.A. | 27 | 85 |

*A fuel adjustment charge (FAC) is applied to all categories of customers except the customers falling within the purview of general supply Tariff A-1. This FAC is about Ps. 15 in WAPDA area and Ps. 40 in KESC area.

**$1 U.S. = 16 Rs. (1985), 1 Rs. = 100 Ps.

Exhibit 2.1 (continued)

| Category | WAPDA Energy Charge (Ps.*/kWh) | WAPDA Capacity Charge (Rs.**/kW/Month) | KESC Energy Charge (Ps./kWh) | KESC Capacity Charge (Rs./kW/Month) |
|---|---|---|---|---|
| Tariff B-4 (66/132 kV) 501 kW up | 35 | 83 | 23 | 83 |
| III. Bulk Supply | | | | |
| Tariff C-1 (400 V) | | | | |
| Licenses | 48 | -- | 39 | 64 |
| Other | 39 | 64 | 39 | 64 |
| Tariff C-2 (11/33 KV) | 37 | 62 | 37 | 62 |
| Tariff C-3 (66/132 KV) | 36 | 61 | 36 | 61 |
| IV. Tubewell Supply | | | | |
| Tariff D | | | | |
| Salinity Control and Reclamantion Project | 44 | -- | | |

**$1 U.S. = 16 Rs. (1985), 1 Rs. = 100 Ps.

The Ministry of Water and Power is responsible for developing and coordinating GOP policies on power generation, transmission and distribution. It currently has a very small staff and is headed by a Secretary for Power who has uniquely broad and deep experience with these matters. The ministry has been responsible for drafting and announcing a new policy for the purchase of bulk power from privately owned off-site power plants and could be responsible for the evaluation of proposals submitted by the private sector for power generation units.

The Ministry of Planning is involved in all stages of power development, as it is responsible for integrating the power sector into the national five-year plans. The Planning Commission within the ministry houses an energy unit that is more directly involved in day-to-day energy planning activities. ENERPLAN, the newly created energy planning unit, provides technical support to the ministry and is directly concerned with power-sector policy issues, including private-sector power generation.

Finally, the Ministry of Finance is responsible for final approval of all power-related investment programs and tariff changes.

## CURRENT POLICY ISSUES

Several policy issues are relevant to private-sector power generation:

- Power plant location, capacity, and price provisions
- Licensing
- Taxation of on-site power generation
- Fuel pricing
- Access to the grid for wheeling power
- Self-financing requirements.

Power plant locations, capacity, and price provisions: The recent policy document prepared by the specially appointed Committee on Private-Sector Power Generation for the Economic Coordination Committee provides a framework for the development of privately owned, utility-scale power plants designed to sell power to WAPDA or KESC. It applies only to plants using oil or coal. Although the policy does not explicitly refer to small-scale systems, many of the principles and guidelines could apply to such systems. The main elements of the policy are:

1. Location and Capacity

   (a) The Ministry of Water and Power will determine, in the context of agreed medium-and long-term plans, the location and capacities for thermal generation suitable to system conditions, and invite the private sector to install and operate them.

   (b) The Ministry of Water and Power may also entertain proposals made by private enterprises, on their own initiative, and consider them in the context of the agreed medium-and long-term plans.

2. Bulk Price

   (a) The Ministry of Water and Power will calculate the bulk purchase price of electricity for a power station, at a specified location, on the basis of the cost of production if the investment were made by WAPDA or KESC.

   (b) In determining the bulk price, a suitable return on equity will be taken into consideration. The rate of return on equity will be fixed in consultation with the Ministry of Finance.

   (c) Only the price and quantity of energy to be purchased, not a fixed return, will be guaranteed to the private entrepreneur.

   (d) If the station is located at a distance from the transmission system, a suitable discount for transmission costs may be provided.

   (e) The bulk tariff will be worked out on the basis of a 60-percent annual plant capacity factor. A purchase at this capacity factor would be guaranteed by WAPDA/KESC. A suitable penalty clause applicable to both the purchaser and the supplier of electricity will be incorporated in the contract to ensure that the purchases and sales do not fall below the minimum, except by mutual consent.

   (f) WAPDA/KESC would have the right to purchase power, over and above the 60 percent annual plant capacity factor, at the agreed price, and the private operator could not unreasonably withhold the supply.

   (g) The bulk purchase price may be in two parts:

      (i) The base price for energy

(ii) The cost of fuel

(h) A suitable escalation will be provided for the basic price of energy, taking into consideration key inputs only, e.g., labor. The fuel component will be directly linked to the cost of fuel, which will be the prevalent competitive market price. A formula for this linkage, assuming a certain plant efficiency, would be worked out.

The envisioned power purchase duration is 10 years.

This policy is to be extended later to fuels other than oil and domestic coal.

Licensing: A prospective self-generator must obtain a license to be allowed to generate its own power.

Taxation: The Ministry of Finance is exempting all electricity generating equipment from import duties. However, any quantity of electric power generated by the private sector is subject to a tax to be paid to provincial governments. This excise duty represents about 10 percent of the value of the electricity produced, at a retail price equivalent.[1]

Fuel pricing: Natural gas is still very cheap for all customers allowed to use it (about U.S. $1.20/mmBtu), but current policy is to increase its price to reach parity with fuel oil by 1993.

Furnace oil prices are low compared to international prices, -- Rs. 1,420/tonne or $88/tonne ($2.10/mmBtu) at the refinery gate. Delivered price to industry is Ps. 1,720/tonne, nationwide, or only $107/tonne. The difference of Ps. 300/tonne is the result of an import tax from which WAPDA and KESC are exempted. For comparison, the international border price is about $145/tonne. Diesel fuel, which is burned in very small units, is sold at Ps. 3,720/tonne, or roughly 85¢/gallon, which is close to international prices.

Access to the grid for wheeling power: Under current policies, no private party appears to be allowed to "hire" the utility transmission and distribution system for the purpose of shipping power from a private source to a private user.

Self-financing requirements for WAPDA: WAPDA is committed to self-finance its investment program at a 40 percent level. Current investments are around Rs. 10 billion ($630 million)/year.

[1] This must be checked further, as the team could not get a clear understanding of this provision.

### Non-pipeline Gas Issues

In addition to the general issues discussed above, there are several institutional and policy issues that apply specifically to non-pipeline gas.

Control of the dormant gas fields. The OGDC controls the dormant gas fields and has slowly developed several of them. It has been reluctant, however, to allow appraisal and development by the private sector and lacks the ability to quickly develop the fields with its own resources. Donor organizations have encouraged the OGDC to enter into joint ventures for the development of Uch and other gas fields. But little has happened to date.

The timely appraisal and development of Uch and other dormant fields will require a government commitment to open the fields to private concessions on commercially attractive terms.

Gas Pricing. The government has recently made progress in gas pricing policies and currently pays a price for non-associated gas at new fields that is related to international oil prices. This move has already raised the interest level of the private sector and has resulted in at least three proposals for additional exploration in Sind alone.

However, the price allowed for associated gas is still low (Ps. 4/mcf or 25¢ mcf) and uncertain. Most of the gas that could be quickly tapped is associated gas within the government's broad definition of that term. Any early initiative by the private sector will require improvements in associated gas pricing policies or a more narrow definition of the gas itself.

Gas Use Policy. The dormant gas fields contain gas that is not suitable for the pipeline and thus should not be subject to the government's restriction on the use of natural gas in power generation.

## UTILITY VIEWS

During the in-country visit, the team had numerous discussions with utility management at both WAPDA and KESC (as indicated in Appendix I). In the following sections the team presents the utilities' concerns and perceptions on private-sector participation in electricity generation, and then provides observations on these concerns.

### Concerns and Perceptions

Utility management has several concerns about any significant participation by the private-sector in power generation. Major initiatives on the private sector issue will have to constructively address these questions and concerns if full

cooperation from the utilities is to be forthcoming. Several of the issues most frequently raised are discussed briefly below:

- Lack of Capability: There is widespread concern that the private sector will be unable to reliably operate power systems of any significant size, and that allowing private operation of such systems could jeopardize overall system reliability. This perception was reinforced by references to the "poor performance" of small utilities operated by the private sector at Rawalpindi and Multan in the 1940s.

- Need for "Quick" Profit: As public-sector organizations, WAPDA and KESC are not required to make a profit. Utility management pointed out that its organizations operate for the national benefit, which allows the organizations to charge relatively low rates. In comparison, the private sector will only be interested in making a "quick profit," which will result in high selling prices and a lack of long-term commitment.

- Loss of Industrial Customers: The utilities are concerned about losing their best customers -- their industrial customers -- if on-site power generation, including cogeneration, is encouraged.

- Purchase Price: The utilities are concerned that they will be required to purchase power from private operators at costs well in excess of their average selling prices. As a result, they would have to raise tariffs, which would harm the general public and possibly compromise their financial performance, particularly if tariff increases are not allowed. For this reason, utility management is reluctant to buy from private-sector operators at rates significantly in excess of average tariffs.

The utilities did not express concern about the technical issues related to stability of voltage and frequency for interconnection with private-sector power producers, because they can specify in the contracts the technical conditions under which this power must be sold. These conditions may include precise requirements for installation of adequate breakers.

## Observations on Utility Perceptions

The interests of the utilities must be considered when formulating a program to allow private-sector power generation. The concerns raised by the utilities can probably be addressed by properly formulated policies. Observations on these concerns and measures to address them are presented below.

- Lack of Capability. The private sector is currently operating over 200 MW of generating capacity in Pakistan year around, including steam turbines, gas turbines, and diesel engines. By and large this capacity is operated efficiently, since industrial production is at stake.

  In addition, the availability of trained manpower is increasing as technicians return from the Middle East. Moreover, the recently announced government policy provides additional safeguards by requiring private operators to post bonds that will go into default if the power plant is not constructed and operated per agreements.

  The combination of favorable recent experience in power generation and overall financial self-interest should ensure adequate performance of private sector power generation facilities. In short, this concern on the part of the utilities is probably exaggerated.

- Need for "Quick" Profit. The private sector does require a good return on equity to be induced to invest in power generation projects. Discussions with interested parties indicate that needed rates of return are about 20 percent after tax. Assuming a 30-percent equity position, this return amounts to 15 Ps/kWh (about 1¢/kWh) of needed revenue on power sold, and should usually represent less than 15 percent of the cost of power.

  In addition, even though the utilities are not required to make a profit, they should be accumulating capital for future expansion at higher levels than is currently the case.

  The need for private investors to make a profit does not appear in itself to significantly increase the needed selling price over and above that which would have to be charged by the utility itself, particularly if the utility were operating in a financially sound manner.

- Loss of Industrial Customers. The issue of possible revenue losses to WAPDA and KESC if a significant amount of individual on-site power is produced by industry should not be overestimated, because there is much more potential for the utility to sell additional power, if available, than the likely on-site production potential from industry.[2]

[2] In the Karachi area, in particular, it is almost impossible for a new industrial customer to get a connection from KESC, according to the results of our interviews with industry.

- Purchase Price. It is true that private operators will often have to sell power at rates higher than current tariffs, particularly for systems operating on oil. However, the marginal generation cost of utility power plants is also considerably higher than their average costs. For a meaningful estimate of utility costs, these higher costs should be "rolled into" the overall rate structure of the utilities. The price that utilities should be prepared to pay for private-sector power should be related to their own marginal costs rather than to current average costs.

## PRIVATE-SECTOR VIEWS

The private sector in Pakistan is a dynamic and growing force. It is dominated by a number of families with assets in the range of U.S. $10-100 million. Well-informed Pakistani financial circles believe that these families are responsible for between 25 and 50 percent of all private investment. The balance is attributed to smaller investors. There is also a new class of investors -- overseas Pakistanis -- that has brought billions of U.S. dollars into Pakistan, especially in the last few years. Generally, private-sector entities or individuals seek business ventures that offer after-tax returns on equity of more than 20 percent. Illustrations of the private sector's willingness to invest in Pakistan include the recent development of a number of service industries, such as hotels, restaurants, and entertainment facilities, and manufacturing industries such as chemicals and pharmaceuticals, plastic products, synthetic fibers, processed food, electrical equipment and electronics, and construction materials.

There are no private domestic banks in Pakistan. The only private banks are foreign banks such as Chase Manhattan. Private capital must therefore be raised from Pakistani entities or individuals, or foreign commercial banks. In the Karachi area, in particular, it is almost impossible for a new industrial customer to get a connection from KESC, according to the results of our interviews with industry.

There are many instances where these various sources of private capital have come together to finance a large-scale industrial or commercial project. Two examples are the Pakland Cement Plant and the new Business and Trade Center currently under construction in Karachi.

In the area of electric power generation, private-sector involvement has been limited to the purchase of individual diesel generators (internal combustion engines with alternators sized from a few kilowatts to several megawatts).

Private capital has already been a major source of investment in the energy sector and is expected to continue during the current Sixth Plan. Based on the interviews conducted, private capital availability is not likely to be a

major constraint on the financing of several hundred megawatts of generating capacity.

## Concerns and Perceptions

Private-sector power generation investors can be divided into two groups: those investing in on-site power generation to supply their own needs and those investing in power plants with the purpose of selling all or part of the generated power to the grid. Both groups have a number of concerns in common, and each group has its specific concerns as well. Below, these generic and specific concerns are summarized as they were expressed to the study team during in-country interviews.

General Concerns. One concern is that the government's enthusiasm for private-sector participation will be short-lived, and is not shared by all government organizations. This perception is based on the fact that WAPDA and KESC have traditionally been reluctant to purchase power from independent producers and to allow industrial customers, which constitute their most valuable customers (as they pay higher rates on a regular basis), to produce their own power and thus deprive the utilities of their best source of revenue. Private-sector parties also indicated, however, that WAPDA and KESC now desperately need the assistance of the private sector because of the deteriorating power situation and political pressures.

The fear that government interest will wane is reinforced by the fact that very little private-sector participation was solicited in the drafting or review of the policy document on the purchase of bulk power by utilities. Private-sector representatives interpret this as a logical extension of the traditional "lack of dialogue" between the private and public sectors.

Nonetheless, as in any venture of this type, the key concern of the private sector lies in the economic benefit of entering the business. Private-sector parties feel that, despite the GOP's reassuring words, it will be difficult if not impossible to get a fair return on their invested capital for a sustained period of time. Because returns of 15 percent can currently be obtained just by lending money, with no tax paid, private-sector parties want to be convinced that they will get at least 20-percent, or better, a 25-percent, after-tax return on equity. They claim that they are currently getting such returns in their basic business lines and that opportunities other than power exist that can provide them with this level of return.

As a corollary of the previous concern, private-sector parties doubt the GOP is really willing to establish an attractive economic environment for both on-site power production and independent (off-site) power generation and implement liberal policies to promote that environment. They expressed concern about the likelihood of onerous regulations affecting their operations that would negate the expected benefits of their participation in this activity.

Finally, most parties indicated that the long-term risk of nationalization existed and that, based on the number of nationalizations that had occurred in the previous decade and the low compensation given to the stockholders, these risks should not be underestimated. Some dynamic investors, however, dismissed this argument, saying that any important economic activity in Pakistan, for example, fertilizers or cement, has always been and is likely to remain a potential target for nationalization. To them, this is "business as usual."

Concerns of those investing in systems to meet their own needs. In addition to the general concerns mentioned above, industry representatives interested in investing in a power system to meet all or part of their own electrical needs mentioned some specific concerns.

They are concerned that GOP policies discourage the use of natural gas for power generation, even though it accounted for 57 percent of all commercial fuels used in industry in 1984.[3] They fear that if they use gas in a cogeneration system (e.g., a high-pressure boiler with a straight back pressure turbine), as they are currently doing in a low-pressure boiler (and purchasing their electric power from the grid), they may be shut down. Because the price of natural gas to industry is about 50 percent that of oil, it would make no sense to cogenerate if natural gas could not be used.

Private-sector representatives also fear that if numerous on-site power generating systems using inexpensive furnace oil[4] and natural gas, where permissible, are installed, WAPDA and KESC will act to halt this trend before it damages utility revenues. Private-sector parties expect WAPDA and KESC to restrict the spread of private power generation by increasing their fixed charges so much that it becomes unattractive for private facilities to generate their own power.

Concerns of those investing in power plants dedicated to sale of bulk power to the grid. The concerns summarized below apply to those private parties that are interested in investing in dedicated power plants using oil, coal, gas, or hydro for the sale of bulk power to WAPDA and KESC.

Parties that wish to sell bulk power are not certain that the GOP is willing to establish realistic purchased power price provisions to make private-sector projects viable. Indeed, the policy document on bulk power purchases fixes the base for the transaction price as the production cost to WAPDA and KESC if the investment had been made by them. Private-sector

[3] Energy Yearbook, 1984 - Directorate General of Energy Resources - Ministry of Petroleum and Natural Resources, p.11.

[4] Furnace oil is currently available to industry at Rs. 1,720/tonne (U.S. $107) versus Rs. 3,220/tonne (U.S. $201) for diesel oil.

representatives declared that this formula has two major drawbacks. First, it will lead to unfair competition between the private-sector investor and the utilities, and second, it does not reflect the true value of the power to the utility. As a consequence, the private sector feels that this formula is biased in favor of WAPDA and KESC. The issue of unfair competition came from the perception of private-sector parties that there is no way they can prove on paper that they can produce power more cheaply than WAPDA or KESC because:

- They do not have access to low-cost capital as do WAPDA and KESC.
- They cannot easily prove that they will manage the plants more efficiently.

As a consequence, the spread between the price that the private sector feels it should receive for the sale of each kWh and the estimated production cost by WAPDA and KESC is great -- Ps. 90/kWh (5.6¢/kWh) versus Ps. 60/kWh (3.8¢/kWh) -- and complicates price negotiations.

The same policy document stipulates that no fixed return will be guaranteed and that the plant capacity factor will be 60 percent. Private-sector parties indicated that they would prefer to have the government establish a price for purchased power only (as is done in the United States under PURPA) and not get involved in details of private party financing (particularly rate of return). By taking this approach, the private entity has an incentive to operate efficiently and reduce costs because such savings will increase profit and return on investment.

On the issue of "fair price," the private sector argues that the numbers arrived at using the formula mentioned above are unlikely to reflect the true value of the power, because they fail to take into account:

- The fact that WAPDA and KESC have access to subsidized fuel prices.
- The fact that WAPDA and KESC do not include in their computations the indirect benefits that could result from the purchase of private power; namely, the possibility that they can better schedule maintenance and can operate their thermal units at lower capacity factors.

As a result, the private sector feels that the price likely to be arrived at by WAPDA and KESC will be no more than half of what it should be.

Finally, the private sector expressed concerns that the new policy provides for sale of power to WAPDA and KESC only. Private sector parties would

be very interested in selling the power they generate directly to other private parties, even if they need to use the WAPDA and KESC transmission and distribution system for wheeling this power.

## Observations on Private-sector Perceptions

There are a number of points that the GOP must clarify to make the proposed policy and its extension to small-scale power plants (including cogeneration) and the fuels other than oil and domestic coal attractive to the private sector.

The GOP has indicated that 20 percent would be acceptable as a reasonable rate-of-return requirement, so this should not be a point of major disagreement.

The Ministry of Planning and the Ministry of Finance are seriously committed to encouraging the private sector in power generation. Therefore, the risk of onerous regulations or nationalization should not be overestimated.

Access to natural gas for cogeneration is needed to justify cogeneration investment decisions.

With respect to the issue of possible "unfair competition," the facts do not fully support private-sector complaints, as supplier credit may be available at rates Lower (e.g., 9-10 percent annually) than the rates WAPDA or KESC must pay (11-14 percent annually). Indeed, even if the GOP gets loans at very low interest rates from international donors, WAPDA is still charged 11 percent annually.

The private-sector comments on guaranteed return on investment and maximum guaranteed capacity factor in the policy document deal with real issues. The GOP could concentrate its efforts on establishing the transaction price alone, without considering the rate of return to the investor.

The private-sector investor should have an incentive to improve power plant efficiency over time, therefore increasing return on investment. If such a possibility does not exist, there will be little incentive for the plant owners to improve management and operation. Similarly, the owner-operator should not only be allowed but encouraged to operate the plant beyond the 60-percent utilization rate mentioned in the policy document. For example, 60 percent of the maximum annual plant output could be sold to WAPDA or KESC and an additional 10-20 percent could be used on-site for industrial activities, provided this additional power does not transit through the utility system (which is not permitted under existing regulations).

## IMPLICATIONS

Given the difference of views between the private sector and public sector, the potential for private power generation is unlikely to be fully realized in the near term, especially in cogeneration and gas- and oil-fired power production. Because time is critical, however, it is important to ensure some success in the early stages of private-sector participation by removing some of the main hurdles.

Access to associated gas, coal, and gas from dormant fields, is a problem, but the central issue is still the price that the utilities are willing to pay for purchased bulk power. The formula proposed by the Ministry of Water and Power for determining the price based on the production cost of a similar power plant to be built by WAPDA or KESC is a major improvement over the previous practice of purchasing at the average retail rate. Methodologies to calculate the bulk purchase price for various categories of private-sector power generation are discussed in the next chapter to provide a basis for expanding the GOP's policy beyond imported oil and domestic coal-based systems.



74

# CHAPTER 3: POSSIBLE APPROACHES TO DEFINING ELECTRICITY PURCHASE PRICE



The electricity purchase price constitutes the main obstacle to extensive private-sector participation in power generation. It is uncertain what price WAPDA and KESC would be willing to pay for the excess power generated by industrial cogenerators and other on-site power systems and for the bulk power generated at dedicated off-site power plants.

In addressing this issue, it is useful to review other countries' experience. In particular, the case of the United States -- which enacted the Public Utility Regulatory Policies Act (PURPA) in 1978 -- is worth examining, because PURPA has facilitated the generation of more than 6,000 MW of private sector power over a period of 6 years, the most significant part of which is natural-gas-based cogen-eration.

In this chapter, the U.S. experience is reviewed, alternative methodologies for establishing the purchase price of electricity generated by the private sector are described, and the important factors in selecting a methodology appropriate for Pakistan are discussed.

## U.S. PUBLIC UTILITY REGULATORY POLICIES ACT

The Public Utility Regulatory Policies Act (PURPA) passed by the U.S. Congress in 1978 dramatically altered the legal standing of certain broad categories of private power production in the United States. Prior to 1978, U.S. electric utilities were under no obligation to interconnect with private power producers for the purpose of accepting power from them, nor were there clear guidelines on how rates for supplementary and backup power to such facilities should be developed.

Today, that is no longer true; U.S. electric utilities are obligated to purchase power from qualifying cogenerating and small power producing facilities at rates that reflect the value of the power to the utility, and they must provide supplementary, standby, and maintenance power to such facilities at reasonable rates.

### Key Provisions

PURPA contains several key provisions that significantly alter the legal standing of cogenerators and small power producers meeting certain size, fuel use, and efficiency criteria ("qualifying facilities" or "QFs"). First, it authorizes the Federal Energy Regulatory Commission (FERC) to order

electric utilities to interconnect with such qualifying facilities for the purpose of purchasing power from them and selling power to them.

Second, it requires that the rate for purchase of power from such facilities be based on the energy costs (i.e., fuel and operation and maintenance costs) and capacity costs that the electric utility avoids incurring as a consequence of the power provided by the qualifying facility.

Third, it requires electric utilities to sell power to the facilities for the following purposes: 1) to supplement a facility's own generation; 2) to serve as backup for use during forced outages at the facility; and 3) for use during periods of scheduled maintenance. Finally, it exempts most qualifying facilities from federal and state regulation as electric utilities.

## Eligibility Criteria

To be eligible for the benefits of PURPA, a facility must qualify as either a "small power producer" or a "cogenerator." A small power producing facility is defined as one using biomass, waste, a renewable resource, or any combination of these as its primary energy source. More than 50 percent of the total energy input must be from these sources, and the use of oil, natural gas, and coal must not, in the aggregate, exceed 25 percent of the total energy input. Furthermore, the total capacity of a small power production facility cannot exceed 80 MW.

Cogeneration facilities are defined as those using energy sequentially to generate both electricity and thermal energy that is usefully employed. Cogenerators must meet certain operating and efficiency standards: for topping cycle cogeneration systems, the usefully employed thermal energy must constitute at least 5 percent of the total energy output. For oil- or natural gas-burning cogeneration systems, the sum of the electrical output and one-half the total useful thermal output must be at least 42.5 percent of the total oil and gas input to the facility, or 45 percent if the useful thermal energy output is less than 15 percent of the total energy output of the facility. For bottoming cycle cogeneration facilities, the only requirement is that the useful power output be at least 45 percent of any oil or natural gas used for supplementary firing. There is no upper limit on the size of a qualifying cogeneration system.

## Implementation Process

PURPA established a two-step implementation procedure that involves both FERC and the state commissions. FERC's role was to establish broad rules defining the fuel use and efficiency criteria that must be met to qualify for the benefits of PURPA and to specify how rates for purchases and sales are to be determined. Based on these FERC rules, the state commissions were to establish detailed rules covering the determination of avoided costs and to be

responsible for the establishment of tariffs, rates, and interconnection equipment standards.

In 1980, FERC issued Order 69 implementing PURPA. This order contains several important interpretations of PURPA and the Federal Power Act:

1. A blanket obligation is imposed on all electric utilities to interconnect with all qualifying facilities. FERC's objective in instituting this blanket obligation was to relieve the facilities of the burden of an expensive and lengthy FERC application and hearing process.

2. The rate for purchase of power from qualifying facilities is equal to the full energy and capacity costs avoided by the utility in association with the power contributions of the qualifying facilities. In determining avoided capacity costs, future needs for capacity, not just present needs, are to be evaluated. Furthermore, in determining the effects of power produced by qualifying facilities on utility needs for capacity, the power output of the facilities is to be considered in the aggregate and not on a facility-by-facility basis. In concluding that full avoided costs (as distinguished from some fraction of avoided costs) are the appropriate basis for purchase rates, FERC reasoned that the purpose of PURPA was to provide the maximum encouragement to cogeneration and small power production consistent with keeping the remaining ratepayers whole; full avoided cost rates were considered to be the proper mechanism for accomplishing this objective. Ratepayers would benefit from the resource diversification and energy conservation of increased cogeneration and small power production, not from rate reductions.

3. The facility can sell power to the utility on an "as available" basis, in which case the rate for purchase is based on the utility's avoided costs as experienced. Alternatively, the facility can sell power "pursuant to a contract or legally enforceable obligation," in which case the avoided costs can, at the option of the facility, be based on an estimate of the avoided costs over the term of the contract, thus providing price security to the cogenerator or small power producer.

4. The facility can engage in arbitrage -- continuing to purchase its full power requirements from the utility and selling the entire output of the cogeneration or small power production system to the utility. The facility is thus allowed to receive payment for all of the power it generates at a rate equal to avoided costs, irrespective of the level of power consumption at the facility. In situations in

which the avoided costs are greater than the utility's rate for the sale of power, the qualifying facility is given the maximum incentive to generate, consistent with keeping the ratepayers whole.

5. Should the utility and the facility mutually agree, the utility can wheel the power produced by the facility to a second utility, which then incurs the purchase obligation. However, nothing in the PURPA statute nor in FERC's Order 69 requires utilities to wheel power for QFs.

## AVOIDED COSTS

The FERC Order required that rates for purchase be set equal to the electric utility's full avoided costs. Avoided costs were defined as those energy and capacity costs that the utility would avoid incurring as a consequence of the power provided by the qualifying facility, i.e., the utility's marginal savings. Avoided costs have little relation to the utility's normal rates for sales, which are based on the utility's average costs; avoided costs may be either higher or lower than rates for sales.

The energy component of avoided costs, consisting of fuel and O&M expenses, can be interpreted as the variable cost component of the utility's marginal savings. Since there will always be some variable cost savings when power is provided by a QF (except during rarelow load periods), there will always be some energy component to avoided costs.

The capacity component consists of those generation, transmission, and distribution capacity expenses that can be avoided because of the contributions of the QF. In determining the utility's ability to avoid capacity costs, it is necessary to consider future needs for capacity, not just immediate needs. In addition, the value of power from a group of QFs should be evaluated in aggregate (rather than considering the effect of each facility individually). Moreover, a utility's ability to avoid purchases from other utilities and to increase sales to other utilities should be accounted for.

The determination of when capacity costs are actually avoided and the magnitude of these costs is not a simple matter. For example, the mere fact that a utility will be purchasing new capacity, whether in the form of a unit it will own or in the form of firm purchase from other utilities, does not always imply that there are capacity costs that can be avoided. Consider, for example, a utility with excess capacity that has high operating costs because it is burning expensive oil at the margin. Assume also that this utility is experiencing slow growth in load. If there are new capacity options available to the utility that will provide power at a cost below the variable costs of oil, investment in new capacity may be justified, even though new capacity is not needed to maintain system reliability because of growing loads. The

justification is one of economic efficiency; the purchase of a new unit may result in lower costs to the ratepayers, even though it will add even more excess capacity. In many such cases, contributions from QFs are unlikely to alter the conclusion that new capacity is justified for economic reasons. Nonetheless, such new capacity investment should not be considered "avoidable" and would have no avoided generation capacity costs associated with it.

## METHODS FOR CALCULATING AVOIDED COSTS

Several methods of computing avoided costs have been developed for use in designing purchase rates. Avoided costs are, for all practical purposes, marginal costs, and these methods are essentially marginal cost computational procedures. The approaches differ not only in their computational details but also in their implicit conception of marginal cost. Among the major differences in the methods are the use of either short- or long-run costs as the basis for the analysis and the treatment of capacity costs.

The three most frequently used approaches to computing avoided costs are 1) the peaker approach, in which both marginal energy and marginal capacity costs are computed in the short run, 2) the proxy unit approach, and 3) the long-run differential revenue requirements approach (LRDRR), in which both marginal energy and marginal capacity costs are computed in the long run.

### The Peaker or Short-run Approach

One of the more common methods for separately calculating marginal energy and capacity costs involves using the so-called peaker approach. In this approach, short-run production costs are combined with short-run capacity costs. This approach has the virtue of simplicity; short-run production costs can be obtained from a utility system simulation model or from recent data on actual utility operations, yielding the short-run production costs with a minimum of effort. The marginal capacity cost is estimated as the cost of a small peaking unit.[1]

[1] The main justification for using the cost of the small peaking unit as a surrogate for capacity costs is that a utility could, at least theoretically, purchase such a unit on short notice if load growth warranted doing so. That is, if the utility actually purchases some other, more expensive, type of capacity, it will do so because the overall costs of operating the utility system will be lower as a result of the lower operating costs of the more capital-intensive plant. The more expensive unit is not being purchased solely to meet the utility's capacity needs, but is serving also to lower energy costs; marginal capacity costs are then properly measured by the cheapest type of capacity that can be purchased to fulfill capacity requirements.



19

The peaker approach will yield acceptable marginal cost results if a utility's generating mix is already optimal. Even in a non-optimal utility, such an approach may yield reasonable estimates of the short-run marginal costs of energy and capacity if oil-fired peaking units are used during peak loading periods. As long as oil is the marginal fuel during most hours of the year, the peaker approach will yield approximately correct marginal costs. The peaker approach is especially suitable for determining short-run avoided costs for use in tariffs for the purchase of energy provided on an "as-available" basis; i.e., with no firm commitment by the facility owner.

However, this approach is generally inappropriate for estimating long-run marginal costs if 1) oil is not the marginal fuel most of the time, and 2) the utility is also investing in new capital-intensive baseload facilities. Only if the "energy" component is redefined to include that portion of a capital-intensive plant that is properly associated with the plant's fuel displacement function will the peaker approach yield an acceptable result. Such a broad interpretation of "energy" costs is rarely seen in practice. Hence, the sum of the components of the marginal costs, computed using the peaker approach as it is usually applied, is not necessarily representative of actual present or future marginal costs.

## The Proxy Unit Approach

An approach that is used in several states in the United States for long-run rates in long-term contacts is the "surrogate" or "proxy" plant approach. In essence, this is a long-run marginal costing procedure. In this approach, the cost of a generic generating facility or a generating facility actually being planned by the utility is selected as a measure of the value of power to the utility, and hence as an appropriate measure of marginal costs. Marginal energy and marginal generation capacity costs are calculated jointly.

There are various ways of implementing this approach. One possibility is provided as an illustration: if a utility coal plant is selected as the basis for the rates, the energy costs associated with that facility, namely its fuel and O&M costs, are paid to the QF on a kWh basis, based on the costs for the fuel and estimated O&M costs in each year.

The total estimated installed cost of the utility plant is deflated to the year in which the QF begins providing power and is converted into a levelized annual payment. This annual payment can be paid on a peak kW basis, provided the QF meets certain reliability and supply characteristics criteria, or on a kWh basis where the kWh rate is determined using the estimated annual capacity factor for the utility plant.

## The Long-Run Differential Revenue Requirements Approach

In this approach, avoided costs are based on long-run marginal costs. The utility's future revenue requirements (total annual costs) are estimated both with and without the contribution of the QFs for a 15 to 25-year period into the future. The utility's capacity plan is separately optimized for the two cases; the present value of utility operating and capacity expenditures over some defined period (usually about 20 years) is minimized for utility loads that in the first case ignore the QFs and in the second include their contributions. The difference in future revenue requirements between the two cases is directly attributable to the assumed contributions from the QFs and, hence, is the estimated total avoided cost.

With the LRDRR approach, the avoided costs are computed in a single, integrated analytical procedure, eliminating the need for separate avoided energy cost and avoided capacity cost computations. This integrated computation ensures that energy and capacity components of the resulting total avoided cost are consistent.

The LRDRR approach permits the avoided costs of the small power producing and cogenerating facility to be tailored to the particular supply characteristics of the generating facility. In calculating the utility's revenue requirements with the facility present, the net loads to be met by the utility are reduced in a manner consistent with the supply characteristics of the qualifying facility. Furthermore, by breaking up the utility's future capacity options into small increments, and by treating the contributions from the facility as part of an aggregated group of similar facilities, a realistic assessment of the capacity value of the facility to the utility is obtained.

## APPLICABILITY TO PAKISTAN

Fundamentally, there are no differences between the definition of "avoided cost" for a utility in the United States and one in Pakistan. The selection of a methodology for calculating the avoided costs, however, depends on each utility's generation mix, load shape, future expansion plans, and technical and personnel capabilities in using a certain methodology. There are a number of specific guidelines that may prove to be helpful in Pakistan:

1. Since utilities in Pakistan have large capacity deficits, independent generation units should be given both capacity and energy credit.

2. The level of sophistication of the purchase price structure should not differ much from the utilities' rate structure. For example, utilities in Pakistan do not have time-of-day charges (no peak, off-peak pricing) at present. Therefore, the purchase price should follow the same structure. Otherwise, the utilities may need too

many personnel to administer such rates. This does not mean, however, that the utilities should underestimate the value of independent power. If there is an understanding that electricity will be sold to the grid during peak hours, when the most expensive generation units are in operation, the credit for such supply should include the high variable generation costs.

3. Since KESC and WAPDA have different rates, they should also have different purchase prices. KESC relies on thermal units for all of its supply, but WAPDA has a large hydro baseload capacity. Therefore, the avoided cost for KESC is higher than for WAPDA and should be reflected in their respective purchase prices.

4. Both utilities in Pakistan have extremely high transmission and distribution losses in their system (over 25 percent). As a result, when the power supplied to the grid by a qualifying facility can be used locally, extra credit should be allowed for the purchased power.

5. In the United States, PURPA allows utilities to negotiate the purchase price with a qualifying facility within the indicated general guidelines and provisions. Although this arrangement provides enough flexibility to ensure an effective rate for each facility, it may create difficulties in Pakistan, putting too great a strain on the utility's limited manpower. Therefore, each utility may have to use one fixed rate -- or a limited number of fixed rates -- across the board (within its region).

6. The establishment of purchase prices requires detailed analysis of KESC and WAPDA operation schedules, fuel and O&M costs, mix of generation units, and system losses both at present and during the term of an announced purchase price. Furthermore, the establishment of these prices should consider the role of the utilities in Pakistan. Utilities are agencies of the government and follow its overall national policies with regard to the need for power and its importance to the country. Therefore, the purchase price should take into consideration the attributes of non-utility power generation that are not easily quantifiable, such as improved national power system reliability and resiliency and increased industrial productivity. Consideration of these attributes would require a separate detailed analysis, however.

## ILLUSTRATION OF AVOIDED COST CALCULATIONS FOR PAKISTAN

This section contains sample avoided energy and capacity costs based on the available data on fuel and O&M costs of WAPDA plants and the capital cost

of WAPDA's alternative power plant additions. Since KESC and WAPDA have large capacity deficits, their purchase price should include capacity credit (for facilities that offer firm capacity).

Data on fuel type, fuel efficiency, fuel cost, and other O&M costs for a number of WAPDA plants are shown in Exhibit 3.1. The avoided energy cost is the sum of fuel cost and variable O&M costs. The fuel cost estimates are based on each plant's fuel efficiency (measured in Kcal input to kWh output) and the fuel prices available to WAPDA. The avoided energy costs for these plants vary between 30 Ps./kWh (1.9¢/kWh) to 177 Ps./kWh (11.1¢/kWh). The gas turbines at Faisalabad and Shadhra, running on expensive high-speed diesel oil and relatively low efficiency, have the highest fuel costs, and thus the highest avoided energy costs.

The avoided capacity charge should be based on the capital cost of WAPDA's future plants. Capital cost figures for a number of alternative thermal power plants currently considered by WAPDA are shown in Exhibit 3.2. The combustion turbines, using very expensive fuel, have the lowest capital cost (Rs. 101/kW per month). While steam plants have high capital costs (over Rs. 380/KW per month).

Avoided energy and capacity costs for a number of WAPDA plants are shown in Exhibits 3.1 and 3.2. However, the avoided cost to WAPDA depends on which plant or fuel is being used on the margin. To determine the utility's marginal electricity cost, detailed simulation models covering the short term, for energy cost, and the long, term for capacity cost, are need. In addition, an accurate marginal cost should take into account the transmission and distribution losses in the system. Such an exercise is beyond the limited scope of this study.

Exhibit 3.1

Estimates of Avoided Energy Costs, for Selected WAPDA Thermal Plants

| Plant Name | Fuel Type | Heat Rates Kcal/kWh | Fuel Cost Ps./kWh | O&M Cost Ps./kWh | Avoided Energy Cost Ps./kWh |
|---|---|---|---|---|---|
| Multan | Furnace oil | 3000 | 46 | 3 | 49 |
| Faisalabad ST | Furnace oil | 2900 | 44 | 3 | 47 |
| Faisalabad GT | High speed diesel | 4000 | 152 | 5 | 157 |
| Shadhra GT1 | High speed diesel | 4200 | 169 | 8 | 177 |
| Guddu 2 | GAS | 2600 | 27 | 3 | 30 |
| Hyderabad | Furnace oil | 5000 | 83 | 6 | 89 |

Source: Hagler, Bailly & Company; based on data from WAPDA.

EXHIBIT 3.2

Summary of Capital Costs ($/kW) and Capacity Credit ($/kW/Yr) for Alternative Thermal Power Plant Additions

| Plant Name | Capital Cost ($/kW) | Construction Time (Yrs) | Plant Life (Yrs) | Levelized Capital Cost ($/kW per Month) |
|---|---|---|---|---|
| Pipri (210 MW) | 916.4 | 3.5 | 30 | 11.3 (178)* |
| Jamshoro #1 (300 MW) | 1,522.4 | 5.0 | 30 | 23.93 (383) |
| Duki (100 MW) | 1,230.0 | 5.0 | 30 | 19.33 (309) |
| Imported Coal (600 MW) | 1,287.4 | 5.0 | 30 | 20.24 (324) |
| Imported Coal FGD (600 MW) | 1,544.8 | 5.0 | 30 | 24.28 (388) |
| Combustion Turbine (100 MW) | 571.1 | 2.0 | 25 | 6.34 (101) |

*Numbers in parentheses are in Rs./kW per month.

Source: Hagler, Bailly & Company; based on data from Lakhra Power Feasibility Report, USAID, August 1985.

In this chapter, the major findings of the study are summarized as conclusions and recommendations for accelerating private sector power generation in Pakistan are presented.

## CONCLUSIONS

The conclusions are organized in three categories: general; those related to on-site power; and those related to off-site power.

### General

1. Private-sector power generation could play a major role in reducing current and projected gaps in electric generating capacity. Up to 1,500 MW could be installed before 1995, cutting the power generation deficit in half.

2. The private sector in Pakistan has shown a serious interest in investing in power generation, including participating in joint ventures with foreign -- especially U.S. -- companies.

3. The private sector has the financial resources to make significant investments in power generation, both via individuals and, more generally, public limited companies.

4. The government's policy document on bulk power purchase is a constructive initial framework for accelerating private-sector interest in power generation. It recognizes the importance of marginal power costs when setting purchase rates from private producers. If properly implemented, this policy will provide a good basis for early development of private-sector power generation.

5. However, the policy only deals with oil- and coal-fired facilities. Expansion of the policy to include cogeneration, dormant gas, and renewable resources is necessary to induce widespread private-sector participation and to focus on the use of indigeneous energy resources.

6. The GOP currently does not have sufficient institutional capability to implement and expand the policy and deal at the working level with the complex electricity pricing, technical interface, and contractual issues associated with purchasing power from private

generators. The U.S. experience with PURPA provides a strong base for developing this capability.

7. The philosophy of PURPA, which applies to U.S. cogeneration and small power production based on energy resources other than oil and gas, can usefully be considered when extending the new policy to cogeneration and renewable-based power generation in Pakistan. However, more simplicity will be required for its successful implementation, because neither WAPDA nor KESC currently operates a sufficiently sophisticated planning system to allow detailed evaluation of avoided costs.

8. Further progress in rationalizing tariff levels and structures, including demand charges and seasonal variations in pricing, will help accelerate private-sector power investments by providing a more favorable overall pricing environment for electricity sales to utilities and additional incentives for industrial on-site power generation.

9. Tariff rationalization will benefit the utility by encouraging independent power producers to generate preferentially during load shedding periods, thereby directly addressing utility problems.

## On-Site Power

1. There is already a substantial on-site generating capacity in Pakistan, estimated at 480 MW as of mid-1985. Total installed capacity by the end of 1986 is projected at around 600 MW, with cogeneration accounting for about 350 MW. Increasing disruptions owing to load shedding and the recent elimination of import duties on small generating units have resulted in a rapid increase in industrial on-site power generation.

2. A growing fraction of on-site power generation systems will be operated year-round because the marginal cost of operation, that is, fuel plus other direct costs, is competitive with KESC and WAPDA retail rates for large-scale units operating on any fuel other than diesel (e.g., bagasse, coke oven and blast furnace gas, natural gas, furnace oils, hydro).

3. Many generating systems with capacities over 500 kW are purchased by private companies to provide power not only during load shedding but on a full-time basis because they cannot get connected to the grid, particularly in the Karachi area.

4. No private party is currently engaged in the sale of excess power from on-site generating units to WAPDA or KESC. Only PASMIC,

the government-owned steel mill near Karachi, is involved in a buy-and-sell arrangement.

5. The private sector has not sold power to the grid -- even though excess capacity is known to exist -- because there has been no clear policy, particularly with regard to price, for evaluating the financial transactions. The private sector tends to think that WAPDA or KESC would not pay more than its average production cost minus a discount, or only about 40-50 Ps./kWh (about U.S. 3¢).

6. Current GOP policy encourages the import of both cogeneration and non-cogeneration systems, exempting both from import duties.

7. Because non-cogeneration systems are easier and faster to install, simpler to operate and cheaper on a capital cost per kW basis, they are generally preferred by the private sector, although they may not be the least-cost option on a life-cycle basis. Other factors limiting the development of cogeneration units include the lack of information about and experience with these systems in most industrial companies.

8. About 300 MW of cogeneration and 350 MW of non-cogeneration could be economically installed in existing plants in Pakistan before 1990, but 35 percent of this potential lies in government-owned facilities. In view of the current public investment policy, which provides funding only for maintenance, such installation is doubtful.

9. Pakistan's national interest would be better served by providing adequate information and incentives to the private sector for development of cogeneration rather than power-only systems.

## Off-Site Power

1. Several options for off-site power production using indigenous energy resources could be economically attractive, especially those based on non-pipeline gas and small hydro power.

2. Non-pipeline gas alone could generate over 500 MW of power using relatively low-cost power sytems. However, several policy issues regarding the pricing of associated gas and private-sector participation in the development and use of the dormant gas fields require immediate attention if this option is to have a near-term impact.

3. Small-scale power based on coal has only a modest potential, given current production levels and the scattered distribution of

resources. In addition, the economics of small-scale coal-fired power systems are not as favorable as those of several alternative systems.

4. Oil-fired power systems installed with private capital should be viewed as a short-term expedient. The government should emphasize increased use of indigenous energy resources.

5. Solar power generation will be too costly in the near term to be used for grid-connected power generation. Such systems may, however, have special applications in remote regions as part of rural electric systems. Special provisions and incentives in the GOP's policy would be needed to encourage private-sector investments in this and other non-grid connected options.

6. Wind power could be a favorable field for private-sector investment if locations with sufficiently high wind speeds can be identified. To date, insufficient wind resource data are available to make judgments on this option.

## RECOMMENDATIONS

1. The GOP should formulate policies to encourage efficient private-sector power generation. It should also develop the capability to effectively implement and expand the current private-sector power generation policy. To achieve these goals, the GOP should initiate a program to:

   (a) Develop methodologies to calculate appropriate electricity purchase prices from private producers, taking into consideration such issues as:

      (i) Seasonal variations in the value of power to the utilities and, particularly, the high value of power delivered during the load shedding months

      (ii) Costs of providing service to remote areas -- such as Quetta and Gilgit -- and associated premiums that might be considered for power generated in these regions

      (iii) Special incentives for early entry of the private sector into power generation to accelerate the process.

(b) Develop bid packages for early projects that provide sufficient financial, legal, and technical information to result in viable proposals.

(c) Define a process by which proposals are solicited, submitted, and evaluated.

2. The GOP should assess the potential of the dormant gas fields and recently discovered associated gas.

3. The GOP should expand the private-sector energy generation initiative by making available selected small hydro sites, barrages, dormant gas fields, and the associated gas available to the private sector for power generation. The existing hydro sites associated with irrigation or water supply facilities, in particular, could provide great opportunities for using water flows and heads created in existing non-power projects. The GOP should also provide incentives to the private sector for near-term development of these resources.

4. The GOP should undertake electric tariff studies that could lead to further rationalization of rate structures, thus improving utilities' financial status and providing a more suitable pricing environment for private-sector power initiatives in the long term.

5. The Ministry of Planning should immediately initiate a program to familiarize both utility and industry decision-makers with cogeneration and independent power production options. This program should consist of seminars, short courses in-country, and tours of facilities both in Pakistan and the United States, as well as the publication of brochures.

6. Because cogeneration is the most efficient use of natural gas, the GOP should permit the use of this fuel in cogeneration applications at those facilities meeting specific electrical and thermal efficiency requirements. The GOP should develop the details of such a policy and its application to specific technologies.

7. To promote cogeneration, the GOP should develop an information and incentives program, consisting of preferential access to fuels and spare parts. For example, the duty tax on furnace oil, which applies to industry in general, could be reduced for cogeneration systems.

8. The U.S. private sector has special capabilities in almost all aspects of cogeneration and independent power generation technologies. USAID should develop programs that facilitate

cooperative arrangements between U.S. and Pakistani firms in the design, equipment manufacture, project construction, and operation of power systems. Such programs could include tours by U.S. company representatives in Pakistan (and vice versa), support for prefeasibility studies, and equipment financing via such mechanisms as the Energy Commodities Equipment Project.

9. The GOP should encourage private-sector parties to enter third-party arrangements to provide heat and power to government-owned industries with good cogeneration potential.

10. The GOP should arrange for detailed studies to assess the potential of biomass resources with more precision. Cotton waste and bagasse appear to represent substantial potential for power generation and should be specially evaluated. In the case of bagasse, the study should focus on (1) the potential for incremental increases in power from existing sugar mills through energy efficiency and management improvements, and (2) the use of the mills' power systems during the off-season.

11. As a first step, USAID should help the GOP in preparing detailed proposals for implementing all the above recommendations, including drafting detailed terms of reference for consultants, together with associated time frames and funding requirements.

**Associated gas** Natural gas from gas fields associated with oil fields.

**Avoided costs** The decremental cost for an electric utility to generate or purchase electricity that is avoided through purchase of power from a cogeneration facility.

**Back-up power** Electric energy or capacity supplied by an electric utility to replace energy ordinarily generated by a facility's own generation equipment during an unscheduled outage at the facility.

**Barrages** Small dams used generally for irrigation purposes.

**Base load** The minimum continuous load on a power system over a given period of time.

**Biomass** Any organic material not derived from fossil fuels.

**Bottoming-cycle cogeneration facility** A cogeneration facility in which the energy input to the system is first applied to a useful thermal energy process, and then the reject heat emerging from the process is used for power production.

**Bulk power** Medium or high voltage power sold in large quantities.

**Capacity** The load for which a generator, turbine, transformer, transmission circuit, apparatus, station, or system is rated. Capacity is also used synonymously with capability.

**Capacity costs** Costs associated with capital investments in electricity production and delivery.

**Capacity factor** The ratio of the average load on a generating resource to its capacity rating during a specified period of time, expressed as a percentage.

**Captive power** The power produced by generation units at industrial plants primarily for on-site use.

**Cogeneration** The sequential production of electricity and useful thermal energy from the same fuel source.

**Cogeneration facility** Equipment used to produce electric energy and forms of useful thermal energy (such as heat or steam).

**Combined cycle** The use of waste heat from a gas turbine topping cycle for the generation of electricity in a steam turbine generator system.

**Dormant gas** Natural gas from gas fields discovered in the 1950s and 1960s but not developed yet, generally because of the lower quality of the gas, the size of the field or the distance from the gas pipeline system.

**Dual-fuel capacity** Thermal systems capable of using two different types of fuel for combustion.

**Electric load following operation** The operation mode of a cogeneration system that is sized to meet exactly the process electric load requirements.

**Energy costs** Costs associated with fuel use in electricity production.

**FERC** The U.S. Federal Energy Regulatory Commission.

**Firm capacity** Capacity available at all times except for forced outages and scheduled maintenance.

**Furnace oil** A heavier and cheaper refined petroleum product used commonly in Pakistan.

**GOP** Government of Pakistan.

**Heat rate** A measure of generating station thermal efficiency generally expressed in Btu per net kilowatthour. The average heat rate is computed by dividing the total Btu content of the fuel burned by the resulting net kilowatthours generated. The marginal heat rate is calculated as the additional (saved) Btus needed to produce (or not produce) the next kilowatthour.

**Hydel** Hydroelectric power.

**Interconnection** The physical system of electrical transmission between a qualifying facility and a utility.

**Interconnection costs** Reasonable costs of connection, switching, metering, transmission, distribution, safety provisions, and administration incurred by the electric utility directly related to the installation and maintenance of the physical facilities necessary to permit interconnection with a qualifying facility that are in excess of the costs the electric utility would have incurred if it had not engaged in interconnection operations. Interconnection costs are not included in the calculation of avoided costs.

**KESC** The Karachi Electric Supply Corporation Ltd.

**Kilowatt (kW)** An electrical unit of power equal to 1,000 watts.

**Kilowatthour (kWh)** A basic unit of electric energy equal to the use of 1 kilowatt for a period of 1 hour.

**Levelization** A financial arrangement whereby payments are constant over a specified period and are based on forcasted values and the value of money over time.

**Line losses** Losses in electricity that occur during transmission and distribution.

**Load** The amount of electric power delivered to a given point on a system, or the total amount of demand on the system.

**Load shedding** Scheduled and unscheduled but deliberate disconnecting of load from the grid by a utility because of supply shortage.

**Load factor** The ratio of average load to peak load during a specified period of time, expressed as a percentage.

**Marginal cost** The change in total cost caused by a change in output. Marginal cost can also be understood as the additional cost to produce an additional unit of output, or the savings from producing one unit less of output (i.e., avoided cost).

**Natural gas** Unmixed natural gas or any mixture of natural gas and artificial gas.

**Nonfirm power** Electric power available as surplus only,

which is supplied by the power producer at the producer's option and can be interrupted by the power producer at will.

**Off-site power** Power generated from systems not associated with existing industrial or commercial plants.

**OGDC** Oil and Gas Development Corporation.

**Oil** Crude oil, residual fuel oil, liquid natural gas, or any refined petroleum product.

**On-site power** Power generated from systems located at industrial or commercial plants for internal use with and without sale to utilities.

**Outage** Interruption of electricity supply by the utility or because of faults in the utility's system.

**Peak load** The maximum electric load consumed or produced in a stated period of time. It may also be characterized as the minimum instantaneous load within a designated interval of a stated period of time.

**Policy document** Document prepared by the Committee for Private Sector Induction in the Power Generations for the Economic Coordination Committee, Planning and Development Division, Ministry of Planning, Draft, August 22, 1985.

**Power-only system** Power system constructed for the sole purpose of electricity generation (no cogeneration of thermal energy).

**Purchase price** The price a utility will pay for electricity purchased from a qualifying facility.

**PURPA** The U.S. Public Utility Regulatory Policies Act of 1978.

**Qualifying facility (QF)** A cogeneration facility or a small power production facility that satisfies FERC regulations.

**Rate** Any price, rate charge, or classification made, demanded, observed, or received with respect to the sale or purchase of electrical energy or capacity, or any rule, regulation, or practice respecting any

such rate, charge, or clarification, and any contract pertaining to the sale or purchase of electrical energy or capacity.

**Renewable resources** Energy resources that are not depletable, such as hydro and solar.

**Reserve margins** Extra power generation capacity available to (1) meet anticipated demands for power or (2) serve load in the event of a loss of generation resulting from an unscheduled outage. The reserve margin is the ratio of excess capacity to anticipated peak load, expressed as a percentage.

**Simultaneous purchase and sale** A regulatory convention that allows a qualifying facility to simultaneously sell its own generated power to the utility while purchasing its requirements from the utility; an exchange of electrical flow does not necessarily occur.

**Small scale** Power generation facilities with a capacity under 50 MW.

**Spinning reserves** Reserves operated at less than the rated capacity to relieve imbalance on the system.

**Thermal load following operation** The operation mode of a cogeneration system that is sized to meet exactly the process thermal load requirements.

**Topping-cycle cogeneration facility** A cogeneration facility in which the energy input to the facility is first used to produce useful power output, and the reject heat from power production is then used to provide useful thermal energy.

**Total energy input** The total energy in all forms supplied by external sources other than supplementary firing.

**Total energy output of a topping-cycle cogeneration facility** The sum of the useful power output and useful thermal energy output.

**Useful power output of a cogeneration facility** The electrical or mechanical energy made available for use, exclusive of any such energy used in the power production process.

**WAPDA** Water and Power Development Authority.

**Waste** By-product materials other than biomass.

**Waste heat recovery boiler** A device to recover thermal energy from exhaust gases to produce steam.

**Wheeling** The use of transmission facilities of one utility system to transmit power to another utility system or between customer facilities within a single utility system or between utility systems.



97

**GOVERNMENT OF PAKISTAN**
**PLANNING AND DEVELOPMENT DIVISION**
**SUMMARY FOR ECONOMIC COORDINATION COMMITTEE**

Subject - Private Sector Induction in the Power Generation

1. On a Summary submitted by the Ministry of Water and Power, the ECC decided to constitute a Committee to resolve the basic issues involved in the induction of private sector in power generation.

2. A meeting of Committee was held on 14th July, 1985 (list of participants attached).

3. Before setting out the recommendations of the Committee, it might be useful to consider the rationale of private sector participation in power generation.

Firstly, inadequate investment in power has been the principal reason for recent power shortages. As funds for public sector investment will continue to be less than the requirements in the forseeable future, it appears desirable to mobilize private resources for development of the power network.

Secondly, WAPDA is burden ed with manifold responsibilities and is examining ways of decentralization. Privately operated generation units will relieve WAPDA of some of its future day to day responsibilities.

Thirdly, power generation is a convenient point for inducting private participation. In the light of experience gained, the role of private enterprise in the development of the power system could be enlarged.

4. It was agreed to recommend the following procedure for induction of private enterprise in bulk power generation:

I. Location and Capacity

(a) The Ministry of Water and Power will determine, in the context of agreed medium and long-term plans, the location and capacities for thermal generation suitable to system conditions, and invite private sector to install and operate them.

(b) The Ministry of Water and Power may also entertain proposals made by private enterprise, on their own initiative, and consider them in the context of the agreed medium and long-term plans.

II. Bulk Price

(a) The Ministry of Water and Power will calculate the bulk purchase price of electricity for a Power Station, at a specified location, on the basis of the cost of production, if the investment were to be made by WAPDA or KESC.

(b) In determining the bulk price, a suitable return on equity will be taken into consideration. The rate of return on equity, would be fixed in consultation with Finance.

(c) No fixed return will be guaranteed to the private entrepreneur. The guarantee will be only for price and quantity of energy to be purchased.

(d) Where the station is located at a distance from the transmission system, a suitable discount for transmission costs may be provided.

(e) The bulk tariff will be worked out on the basis of 60 percent annual plant factor. A purchase at 60 percent annual plant factor would be guaranteed by WAPDA/KESC. Suitable

penalty clause applicable to both the purchaser as well as to the supplier of electricity will be incorporated in the contract to ensure that the purchases and sales do not fall below the minimum, except by mutual consent.

(f) WAPDA/KESC would have the right to purchase power, over and above the 60 percent annual plant factor, at the agreed price, and the private operator would not unreasonably withhold the supply.

(g) The bulk purchase price may be in two parts:

(i) The base price for energy.

(ii) The cost of fuel.

A suitable escalation will be provided for the basic price of energy, taking into consideration key inputs only e.g., labour. The fuel component will be directly linked with the cost of fuel which will be the prevalent competitive market price. A formula for this linkage, assuming certain plant efficiency, would be worked out.

III. Inviting of bids and acceptance of offers

(a) Private entrepreneurs will submit bids for the capacity and location, in term of bulk price of power desired by them. Where the bulk price offered by the entrepreneur is lower or equal to the price, computed in accordance with para (II) above, the Ministry of Water and Power may accept the offer. Where the price bid is higher than the bulk price computed under para (II) above, the Ministry of Water and Power may either reject the offer or seek sanction of ECC, giving reasons for accepting the higher price.

(b) Since timely installation and proper operation of the plant is of importance, a bank guarantee will be taken from the private entrepreneur to ensure recovery of penalty in case of default.

(c) The financial position, experience and other credentials of the applicant will be examined while considering his offer.

(d) Bids will be invited by WAPDA/KESC under the aegis of Ministry of Water and Power. The agreement with the private sector will be at two levels i.e., between WAPDA/KESC and private sector party and between GOP and private sector with GOP as underwriter.

IV. Tax and Fiscal Status:

(a) The power station would be treated, as an industrial establishment, for purposes of tax, and other fiscal regulations.

(b) Concessions available for large scale industry in specified areas will be available to the power plant as well, and will be reflected in the determination of the bulk rate.

(c) The entrepreneur may raise local and foreign finance in accordance with regulations applicable to industry, in general.

V. Labour Laws - The consensus was that the essential services Act may be made applicable to the labour working in the privately owned power house, since the same is applicable to the Government owned power house. The Ministry of Labour, however, was not in favour of this proposal and they advocated that the existing laws applicable

to industry should be applied to the privately operated power house as well.

VI. Fuels- Entrepreneurs should be restricted to two specified fuels, namely oil and indigenous coal. Other fuels may be added later. Bids can be invited for plants based on specific fuel/fuels (HSD, F.O., LDO or Coal) depending upon location and available time for construction. Infrastructure requirements for fuel transportation will be kept in view while evaluating bids.

VII. Inspection and Monitoring- In order to ensure that power plant is being properly maintained/renovated and proper standards are being observed, periodic inspection and monitoring be ensured in the contract.

5. The Summary has been prepared in consultation with Ministries of Finance, Water and Power, Petroleum and Natural Resources and Labour, Manpower and Overseas Pakistanis.

6. The proposals made in paragraph 4 are submitted for approval.

7. The submission of the Summary has been authorized by the Minister of Planning and Development.

V.A. JAFAREY,
Secretary General

Islamabad, the 22 August, 1985.

## LIST OF PARTICIPANTS

**Planning and Development Division**

1. Mr. V.A. Jafarey,
   Secretary General.

2. Dr. Ghulam Rasul,
   Joint Chief Economist.

3. Mr. Ashfaq Mahmood,
   Chief.

4. Mr. Ghulam Haider,
   Deputy Chief

**Ministry of Water and Power**

5. Mr. Muhammad Akram Khan,
   Additional Secretary (Power).

**Ministry of Petroleum and Natural Resources**

6. Mr. Ashiq Ali,
   Director General.

7. Mr. Muhammad Iqbal Qureshi,
   Director.

**Ministry of Labour, Manpower and Overseas Pakistanis**

8. Mr. S.S. Huda,
   Joint Secretary.

Enerplan Project

9. Mr. Sadaqat Hasan Mir,
   Managing Director.

10. Mr. M. Izharhul Haque,
    Deputy Managing Director.

Karachi Electric Supply Corporation

11. Mr. S.M. Arshad Bokhari,
    Managing Director.

12. Mr. S. Hashim Abbas,
    Project Engineer.

**STUDY OF IMPEDIMENTS TO PRIVATE SECTOR OFF-SYSTEM ELECTRICAL GENERATION IN PAKISTAN**

The study will examine the impediments to and potential for off-system private sector electrical generation. The team will visit with key power sector, private sector, and government policy officials to determine their views, collect and analyze existing data and information, and debrief the Mission on their preliminary findings and recommendations. A draft report will be prepared before departure and a final report will be prepared within 21 days after receipt of Mission and AID/W comments.

The study will not examine remote non-grid connected electrical generation issues or large scale (generally 50 MW or greater) private generation issues.

**Team Qualifications**

The team -- a team of two (an engineer and an energy specialist) should be in Pakistan on or about October 6-13 for up to 3 weeks. One member will prepare the final report after return.

The two will work with a third team member funded separately by AID who will have a separate scope of work that elaborates upon this scope. The third member's work will be incorporated into the draft and final reports.

The team should be senior level, at least one with U.S. PURPA experience (particularly with respect to industrial cogeneration issues and economics) and preferably have some Pakistan in-country experience.

**Study Objectives**

(1) Preliminary identification of the market and economic potential for cogeneration and private sector small power production from renewable and indigeneous resources (particularly coal and gas),

(2) Identification of the policy/regulatory/institutional and other impediments to off-system private

sector electrical generation from cogeneration or renewable/indigeneous resources for sale to the grid

(3) Development of recommendations and an action plan for addressing the impediments to off-system generation.

**Background**

1. Description of country energy situation: Describe briefly using existing data, the current country energy situation and the factors influencing the introduction of private sector off-system electrical generation. Such factors may be power sector constraints, e.g., capital availability, skilled manpower, inadequate generation capacity, system reliability. Other factors may be the size and type of industrial base and its capacity for cogeneration.

2. U.S. experience: Briefly describe the Public Utility Regulatory Policies Act (PURPA) and the U.S. experience in fostering private sector non-utility electrical generation.

**Current Off-System Generation**

Identify any current purchase arrangements between public utilities and non-utility generators of electricity. Identify any projects under discussion or in the planning stage. Determine the amount of and trend in private (captive) diesel or fuel oil based generation.

**Potential for Off-System Generation**

Estimate the potential for non-utility renewable or indigeneous energy based-generation and cogeneration and assess the character of the generation, i.e., intermittent, seasonal, daily peaks, etc.

Make preliminary estimates of industrial cogeneration potential. Use existing industrial data and growth projections and identify the market for cogeneration by industry type, size of current and projected electricity/steam demands, applicable cogeneration technologies and energy supply (coal, gas and/or oil). Develop prototypes of cogeneration systems relevant to the industrial market and indicate their financial viability; indicate the payment by the utility for surplus generation that would make the system financially attractive. Provide an estimate (range, if appropriate) of potential electrical

generation that could be available for sale to the grid and an estimate of the capital investment needed.

Identify other decentralized private sector generation options and based on existing information estimate the potential electricity that could be provided to the grid. Identify the energy resources, the energy conversion technology options and the institutional arrangements for generating the electricity. For example:

- bagasse or rice hulls, steam boilers and mill owners
- wind, wind conversion systems and private partnerships
- coal, steam boilers and coal mine owners.

For the major generation options, indicate the financial viability of the systems and the utility payment for the surplus generation that makes the system financially viable.

## Utility System Description

Briefly describe the WAPDA and KESC utility systems, ownership, fuel use, marginal cost of generation, load projections and system expansion projects, tariffs.

Determine the utilities' technical concerns about off-system generation such as system protection, metering, reliability, etc., and any related concerns about the purchase of off-system generation.

Identify the factors affecting the utility's marginal costs. Derive an estimated "avoided cost" and the price a utility might reasonably be expected to pay for intermittent power during peak and off-peak.

Discuss the basis for the calculation, whether fuel cost should be used in establishing the price to be paid by the utility for intermittent power or whether some capacity cost should also be included in the price.

## Power Sector Policies

Analyze the policy/legal/regulatory framework governing the power sector including:

Government policy on non-utility generation of electricity for sale to the grid

Legal and regulatory authority for generation of electricity, and

Rate setting mechanisms and source of authority.

## Impediments to Off-System Generation

Analyze the policy, legal, regulatory, institutional or other problems and impediments to off-system generation; determine the positions of key institutions, industries and individuals concerning the impediments to and potential for private sector off-system generation including but not limited to the utilities, government ministries, or commissions responsible for energy and utilities, key industrial and private sector entities, and policy- and law-makers.

## Costs and Benefits of Off-System Generation

Identify the costs and benefits of the indigeneous/renewable-based off-system electrical generation from the utility, user and national perspective.

## Recommendations

Provide policy/legal/regulatory and other recommendations that will foster introduction of private indigenous/renewable energy-based generation and cogeneration for sale to the grid; describe AID's options to foster such generation.

Prepare a draft report before departure from the country and provide 40 copies of the final report including a complete Executive Summary within 21 days of receipt of comments on the draft from USAID/Pakistan and AID/W/ANE/TR/EFE.

In early 1985 the Karachi Electric Service Company (KESC) received a proposal from the Pakland Cement Company for a 120 MW oil-fired diesel engine power plant to be located at Hub Chowki. At a meeting in October 1985, the Secretary of Water and Power requested that the USAID mission team focus attention on the Hub Chowki Project. This project is of high priority to GOP. The USAID mission team was requested to provide the following specific inputs:

- A draft announcement for the Hub Chowki project soliciting expressions of interest from foreign and local private-sector organizations.
- A review of the feasibility studies and opinions on how the purchased power rates should be determined.
- Guidance on the process (e.g., schedule, steps) to stimulate the development of Hub Chowki by the private sector.

**Pakland Cement Company's Proposal**

In early 1985 the Pakland Cement Company submitted a proposal to KESC to construct and operate a central station power plant at Hub Chowki. The 120-MW power plant would consist of six 20-MW medium-speed diesel engines using furnace oil as fuel. The proposed power plant would operate in a baseload configuration, providing all generated electric power to KESC at a price that would allow Pakland Cement Company to achieve an acceptable return on its equity. The expected startup date for the diesel engine power plant was estimated at less than 2 years from the time that successful negotiations had been completed with KESC. The scope and nature of the proposed project from Pakland Cement Company had been in part dictated by an equivalent project successfully operating in Sri Lanka. This proposed project would represent a major step in the company's strategy to diversify into the energy field, while providing benefits to Pakistan.

Exhibit C-1

## HUB CHOWKI

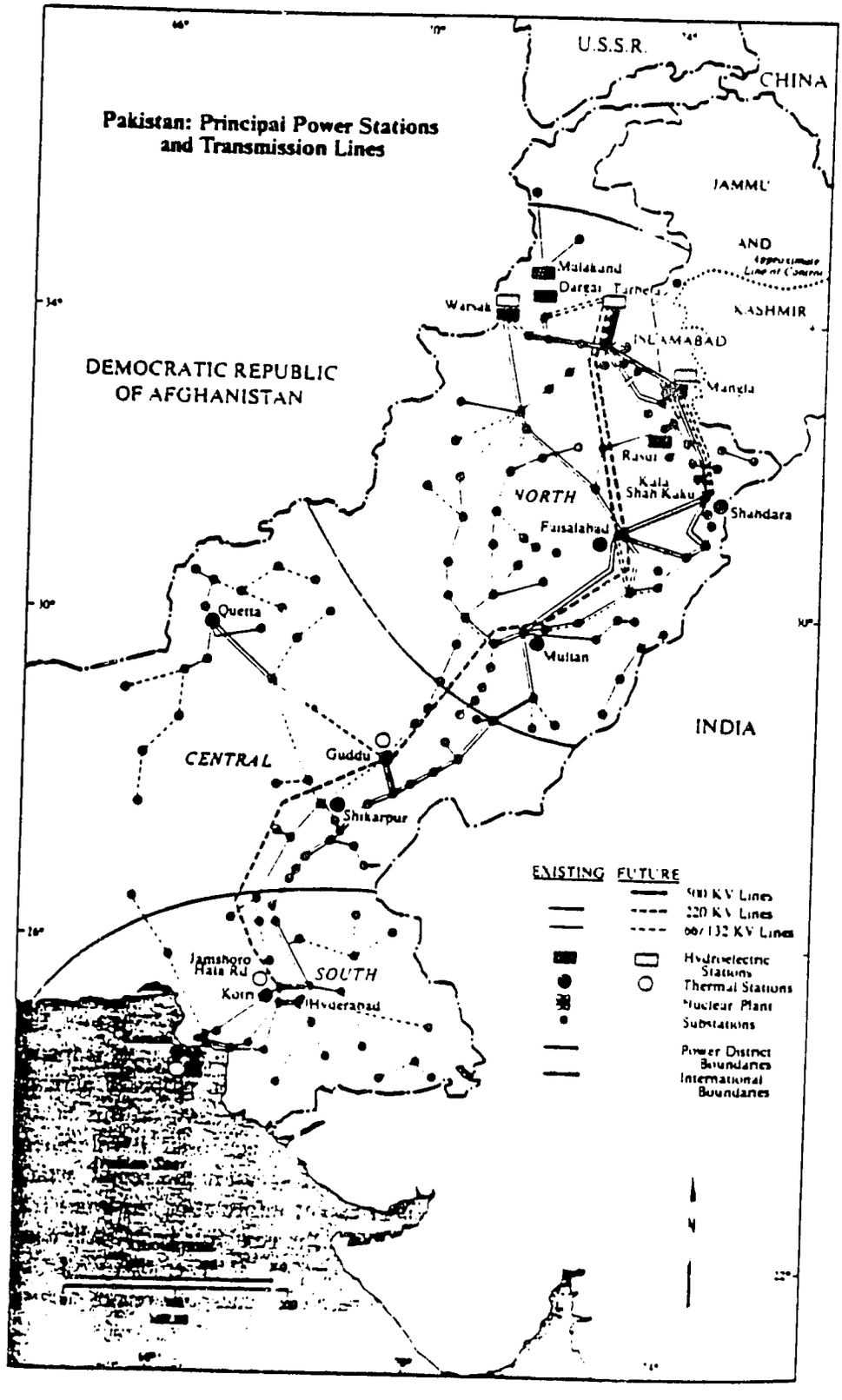
## BASIC ASSUMPTIONS

| | | |
|---|---|---|
| **A. Technical** | | |
| 1. | Plant gross output[1] (20 MW x 6) | 120 MW |
| 2. | Annual power generation[2], net | 630.72 GWh |
| 3. | Annual power generation[3], gross | 660.44 GWh |
| 4. | Specific fuel consumption, gross, furnance oil | 215 gr/kWh |
| 5. | Specific fuel consumption, diesel oil[4] | 185 gr/kWh |
| 6. | Specific lube oil consumption, gross | 2gr/kWh |
| **B. Economic** | | |
| 7. | Plant service life | 20 years |
| 8. | Capital costs, before duties [5] | Rs. 10,400/kW |
| 9. | Percent foreign exchange | 70 |
| 10. | Furnace oil Price | Rs. 1,415/Mtonne |
| 11. | Diesel oil price | Rs. 3,220/Mtonne |
| 12. | Lube oil price | Rs. 12,000/Mtonne |
| 13. | Consumption OEM[6] | Rs. 0.128/kWh |
| **C. Financial** | | |
| 14. | Depreciation | 20 years, S. Line |
| 15. | Interest on foreign debt | 11%, 20 years |
| 16. | Interest on local debt | 14%, 9 years |

Source: Pakland Cement

Notes:

1. i.e., before auxiliaries consumption
2. 120,000 X 8,700 X .6 (net capacity factor = 60%)
3. assuming 4.5% self consumption for auxiliaries
4. for start-up
5. construction period of 24 months, based on World Bank guidelines
6. includes G&A


Pakistan: Principal Power Stations and Transmission Lines
U.S.S.R.
CHINA
JAMMU
AND
KASHMIR
DEMOCRATIC REPUBLIC OF AFGHANISTAN
INDIA
NORTH
CENTRAL
SOUTH
Malakand
Dargai
Tarbela
Warsak
ISLAMABAD
Mangla
Rasul
Kala Shah Kaku
Shandara
Faisalabad
Quetta
Multan
Guddu
Shikarpur
Jamshoro Hala Rd
Kotri
Hyderabad
EXISTING
FUTURE
500 KV Lines
220 KV Lines
66/132 KV Lines
Hydroelectric Stations
Thermal Stations
Nuclear Plant
Substations
Power District Boundaries
International Boundaries
N

benefits of the proposed Hub Chowki project or any other well-conceived private-sector power generation project to KESC and its customers could be dramatic. However, several major issues need to be reconciled:

- The preferential access of KESC (and WAPDA) to concessionary financing, which results in low "calculated" power generation costs against which the private sector must compete.
- The tax status of profits to the private sector from central station power generation investments. The private sector in Pakistan typically requires a minimum of 20-percent return on equity after taxes.
- The procedures in calculating a price for purchased power that incorporates the scheduled additions of Bin Qasim Units 3 and 4 beginning in 1989, and the highly seasonal variation in WAPDA's needs for purchases of excess electric power from KESC.

However, all of these issues are secondary to the key issue of deciding if the 120-MW Hub Chowki project is the "best" solution to the short-term need of KESC for additional electric power.

Assuming such is the case, a recommended process for inviting and evaluating bids from the private sector for construction of the Hob Chowki power plant is presented in Exhibit C.3.

ii) UCH

The gas was discovered in Sui Main Limestone at a depth of 3,985 feet in an exploratory well drilled by PPL in 1954 on the basis of a geologic and seismic survey. The field is located in Nasirabad district, Kohlu Agency, Baluchistan. The gas contains 27 percent methane, 25 percent nitrogen, 46 percent carbon dioxide and traces of hydrogen sulfide gas. During testing, after acidization, the absolute open flow was about 140 mmcfd. The recoverable reserves estimated on the basis of a single well are 2.5 tcf with reservoir pressure of 2,016 psig.

iii) KOTHAR

This field is located in Dadu District, Sind. It is a surface anticline. An exploratory well was drilled by OGDC on the basis of geologic and seismic survey. The gas was discovered from Sandstone of Ranikot at a depth of 4,960 feet. On testing, the well showed an absolute open flow potential of 12 mmcfd. The estimated reserves are 0.025 tcf.

(iv) JANDRAN

This field is located in Kohlu Agency, Loralia District, Baluchistan. It is a surface anticline. An exploratory well was drilled by AMOCO on the basis of a geologic survey. The gas was discovered from Sandstone of Nispha formation of Cretaceous. The absolute open flow potential of four zones is about 14 mmcfd. The estimated recoverable reserves on a single well basis are 0.015 tcf. Jandran is located in a remote, sensitive area where security measures are not available; therefore, this field has remained unexplored.

v) LOTI

The Loti gasfield is located in Dera Gugti Agency, Baluchistan. The Loti structure is a large anticline spread over an area of 125 square kilometers. The structure was delineated after conducting an extensive geological and seismic survey. The well was drilled down to a depth of 2,252 meters. On production testing of the well, good quality gas in commerical quantity was encountered in Pab and Sui Limestone formations. The tests have established the well's producibility as 8-14 (mmcfd) with heating values ranging between 801 Btu/cf and 941 Btu/cf. On

# Appendix D PARTIAL LIST OF NON-UTILITY POWER GENERATION UNITS

Group 1: Dedicated
Two of the fields, Kothar and Loti, have already been or are in the process of being developed and the gas dedicated to the pipeline.

Group 2: Remote
Two of the fields, Zin and Jandran, are located in remote regions that would make their appraisal and development a lengthy and costly process. Appraisal alone could take 2-3 years. Also, the remoteness of the locations complicates connection of power units to the grid.

Group 3: Committed to WAPDA
Over the past year the OGDC drilled two additional wells at Punjpir and Nandpur. At both sites there is sufficient gas to support about 25 MW of generating capacity. It has been decided by the GOP that WAPDA will have access to this gas.

The Planning Commission has asked for additional appraisal work at both these fields consisting of additional wells and seismic surveys. The new wells could be completed within 18 months and readily converted into production wells.

Funds for materials required by these wells is included in the World Bank Energy Sector Loan (ESL), which provides $52 million for 14 wells.

Group 4: Other
Two of the fields, Uch and Khairpur, are currently sitting idle and there are no firm plans for their development by OGDC or anybody else, despite their proximity to Karachi. Appraisal of these fields would only take 12-18 months. However, OGDC has no resources at present to undertake the necessary well drilling and seismic work.

## C. POTENTIAL AT UCH/PRIVATE-SECTOR PROPOSALS

Of the so-called dormant gas fields, Uch probably has the greatest potential and has elicited some interest in development by the private sector. This interest resulted in a preliminary proposal in 1984 from a firm called Petrocon Ltd of Lahore prepared by Mr. A.V. Loan, Managing Director.

Consumer Owned Generation Units in Pakistan (with Capacity over 50 kW)

| Name of Site, Location | No. of Sets | Effective Generating Capacity (kW) |
|---|---|---|
| I. **Karachi** | | |
| Nagaria Textile Mill Ltd. Karachi | 3 | 3,000 |
| Paracha Textile Mill Ltd. Karachi | 2 | 600 |
| Well Come Pakistan Ltd. Karachi | 3 | 600* |
| Hoesht Pak. Sector 22 Karachi | 3 | 50 |
| Glaxo Laboratories Pakistan Karachi | 3 | 392 |
| Dawood Cotton Mills Ltd. Karachi | 6 | 2,600 |
| Arshi Cinema Karachi | 1 | 100 |
| Prince Glass Works Karachi | 2 | 300 |
| Pakistan Tobacco Company Karachi | 1 | 200 |
| Pakistan Gables Ltd. Karachi | 3 | 473 |
| Philips Electric Industries Karachi | 3 | 695 |
| Pakistan Steel Mills Co. Karachi | 2 | 110,000 |
| Sind Alkalis Ltd. Karachi | 1 | 3,000 |
| Arabian Sea Enterprises Karachi | 2 | 800 |
| Chloride Pakistan Ltd. Karachi | 1 | 95 |
| Brook Bond Pakistan Ltd. Karachi | 1 | 200 |
| Carnpak Ltd. Karachi | 2 | 260 |
| Metropolitan Steel Cor., Ltd. Karachi | 2 | 310 |
| National Refinery Ltd. Karachi | 2 | 225 |
| Pakistan Machining Tool Factory Ltd. Karachi | 1 | 250 |
| National Motors Ltd. Karachi | 4 | 750 |

*Estimate

| Name of Site, Location | No. of Sets | Effective Generating Capacity (kW) |
|---|---|---|
| II. **SIND (continued)** | | |
| Sandos (Pakistan) Ltd., Sind | 2 | 405 |
| Pakistan Fertilizer Ltd. Sind | 3 | 17,520 |
| Fauji Fertilizer Co. Ltd. Sind | 2 | 15,000 |
| ESSO Fertilizer Factory Sind | 2 | 19,000 |
| SUBTOTAL | | 72,403 kW |
| III. **PUNJAB** | | |
| NASHAT MILLS LTD. Faislabad | 1 | 150 |
| ICI (Pakistan) Manufactures Ltd. Jhelum | 3 | 2,000 |
| Pakistan Ordnance Factories Wah Cantt. | 2 | 10,000 |
| Cresent Boards Ltd. Faislabad | 2 | 5,700 |
| Cresent Sugar Mills & Distillery Ltd. Faisalabad | 3 | 2,000 |
| Lawrencepur Woollen and Textile Mills Ltd Attock | 2 | 400 |
| Cresent Jute Products Ltd. Faislabad | 1 | 71 |
| Rafhan Maiza Products Ltd. Faislabad | 1 | 350 |
| Sargodha Textile Mills Ltd. Sargodha | 2 | 70 |
| Abbasi Textile Mills Ltd. Rahim Yar Khan | 3 | 600 |
| FESTO Sugar Mills Ltd., Darya Bhakkar | 3 | 2,249 |
| Zeenat Textile Mills ltd. Faislabad | 5 | 536 |
| P.I.D.B. Kamaila Sugar Mills Ltd. Kamaila | 3 | 3,976 |
| Lever Brothers (Pakistan) Ltd. RaHIM YAR KHAN | 1 | 250 |
| Heavy Mechanical Complext Ltd. Texila | 1 | 35 |

116

| Name of Site, Location | No. of Sets | Effective Generating Capacity (kW) |
|---|---|---|
| IV. **BALUCHISTAN (continued)** | | |
| Quetta | | |
| Mir Dadir Bakhsh & Brothers Quetta | 2 | 400 |
| Pakistan Television Corp. Ltd. Quetta | 1 | 140 |
| Lasbela Textile Mills Ltd. Baluchistan | 6 | 5,030 |
| SUBTOTAL | | 9,765 kW |
| V. **N.W.F.P.** | | |
| Mustekam Cement Ltd. Abbatabad | 1 | 300 |
| Khyber Textile Mills Ltd. NWFP | 1 | 50 |
| Charsadda Sugar Mills Ltd. Charsada Distt. Peshawar. | 3 | 3,400 |
| Khazana Sugar Mills NWFP | 2 | 3,000 |
| FIDC Bannu Sugar Mills Bannu | 3 | 3,170 |
| Frontier Sugar Mills & Distillery Ltd. Takht Bhai | 2 | 2,500 |
| Premier Sugar Mills & Distillery Co., Ltd. Mardan | 4 | 3,400 |
| Adamjee Paper & Board Mills Ltd. Peshawar | 2 | 3,000 |
| SUBTOTAL | | 18,820 kW |
| **TOTAL** | | 433,684 KW |

## SUMMARY OF TEAM MEETINGS (CONTINUED)

| DATE | PERSON VISITED | RANK | ORGANIZATION |
|---|---|---|---|
| OCT.18 | DR. MASOOD AHMED | HEAD, ENERGY SYSTEMS DIVISION | ZELIN LTD, KARACHI |
| OCT.19 | MR. ARSHAD BOKHARI | MANAGING DIRECTOR | KESC, KARACHI |
| | MR. BASHIR A. CHOUDRY | CHIEF ENGINEER | KESC, KARACHI |
| | MR. HASHIM ABBASS | PROJECT ENGINEER | KESC, KARACHI |
| | MR. ASHRAF | CONTROLLER FINANCE | KESC, KARACHI |
| | MR. AKHTAR HUSSEIN | MANAGING DIRECTOR | PAKISTAN ENGINEERING SERVICES LTD, KARACHI |
| OCT.20 | MR. J.W.J. HARDY | VICE PRESIDENT | UNION TEXAS, KARACHI |
| | MR. KENNETH WHITE | V.P (COUNTRY MANAGER) | CHASE BANK, KARACHI |
| | MS. MARINA CUSHING | PROGRAM ASST. | USAID, KARACHI |
| | DR. SHAHID K. HAK | PROGRAM MANAGER | ENAR PETRO TECH |
| | MR. M SIDDIQI | MANAGING DIRECTOR | PAKLAND CEMENT LTD, KARACHI |
| | MR. MUKHTAR BAIG | GENERAL MANAGER | HABIBULLAH MINES LTD., ISLAMABAD |
| OCT.21 | MR. ABDUL KARIM | PRESIDENT | KARACHI CHAMBER OF COMMERCE & IND |
| | MR. UNVER ISA | PRESIDENT | DARWAZA POWER PLANT |
| | MR. J. ABBAS ZAIDI | SENIOR VICE PRESIDENT | NATIONAL DEVELOPMENT LEASING CORPORATION, KARACHI |
| OCT.22 | MR. RIAZ SAMEE | CHAIRMAN, POWER SECTOR | LAHORE CHAMBER OF COMMERCE & IND., LAHORE |
| | MR. STUHLMAN | CHIEF CONSULTANT MANAGEMENT | EBASCO/AEPES/ITECO, LAHORE |
| OCT.23 | MR. CHAUDRI QASIM | CHIEF EXECUTIVE | CHAUDRI CABLES LTM, ISLAMABAD |
| | MR. THOMAS BRADY | PRESIDENT MANAGER | OCCIDENTAL OF PAKISTAN, ISLAMABAD |
| OCT.24 | MR. AKRAM KHAN | SECRETARY, POWER | MINISTRY OF WATER AND POWER, ISLAMABAD |
| | MR. EUGENE STAPLES | DIRECTOR | USAID, ISLAMABAD |
| | MR. ASHFAQ MAHMOOD | HEAD, ENERGY | PLANNING DIVISION, ISLAMABAD |
| | MR. M.S. BUTT | ENGINEERING ADVISOR | MINISTRY OF WATER AND POWER, ISLAMABAD |
| | MR. SADAQAT HASAN MIR | MANAGING DIRECTOR | ENERPLAN, ISLAMABAD |
| | MR. M. IZHARHUL HAQUE | DEPUTY MANAGING DIRECTOR | ENERPLAN, ISLAMABAD |

The study team developed detailed estimates of the Pakistan cogeneration market using a dynamic model developed by Hagler, Bailly & Company. The model develops estimates of the cogeneration market over a 10-year period, using the steam demand in the various industries and their growth rate.

The four cogeneration technologies considered are:

1) oil-fired high pressure boiler with straight back pressure steam turbine.

2) gas-fired high pressure boiler with straight back pressure steam turbine.

3) gas-fired combustion turbine with waste heat recovery boiler.

4) oil-fired diesel engine with waste heat recovery boiler.

The model determines the market for existing facilities and for new facilities, as well as the allocations for each technology in each market. These allocations are calculated through weighing coefficients derived from the life cycle costs of the various alternatives competing in a given market.

The model works with regions (the regions need not to be geographic regions, e.g., two regions can be geographically identical but have different steam demands) Pakistan is broken down into four regions, as follows: first, the country is partitioned between KESC and WAPDA; then, these two regions are subdivided into public sector and private sector. The input data used in this model are summarized in Exhibit E.1.

The estimates for economic cogeneration potential have been developed under a set of conservative assumptions, the most important of which is a buyback rate for electricity equal to 70 percent of the retail rate of

Energy Year Book 1984, by Directorate General of Energy Resources, Ministry of Petroleum and Natural Resources.

Half-Yearly Accounts, by National Development Leasing Corporation Limited, June 1985.

Low Head Hydro Power at Barrages and Canal Falls Stage-1, Ranking Study Report by WAPDA, dated May 1984.

National Energy Conservation Program Vol. I, dated April 21, 1985.

National Energy Conservation Program, Vol. II: Supporting Data and Analysis, prepared for the Members of the Working Group on Energy Conservation, April 21, 1985.

Pakistan Biomass Energy Reconnaissance Report, by AID/Washington, D.C.

Power Supply Organization and Existing Power Facilities.

Power System Statistics, Ninth Issue (November 1984) by Planning Dept. Power Wing, WAPDA.

Private Sector Induction in the Power Generation, by GOP Planning and Development Division Summary for Economic Coordination Committee, dated August 22, 1985.

Schedule of Tarriffs, effective July 1985, by WAPDA.

Solicitation of Expressions of Interest and Qualifications Information to Participate in the Lakhra Coal Mine and Power Generation Project and to Sell Power to WAPDA, by USAID, dated May 13, 1985.

Special Tariff Issue, (New Electricity Tariff effective July 1, 1985) from a fortnightly bulletin "WAPDA News, July 1, 1985".

The Coal Industry in Pakistan: Requirements for Growth, by MMDS Mathtech Division and A.F. [illegible]rguson & Co. under USAID contract, February 4, 1985.

The West Pakistan WAPDA Act, 1958; West Pakistan Act XXXI of 1958, dated April 24, 1958.

Exhibit E.1

Input Data for Cogeneration Market Analysis Model

Regions

I. KESC Service Area, Publicly Owned Industry
II. KESC Service Area, Privately Owned Indusry
III. WAPDA Service Area, Publicly Owned Industry
IV. WAPDA Service Area Privately Owned Industry

Fuel Prices

| | Price (1985 ($/mmBtu) | Annual Esculation |
|---|---|---|
| Furnance Oil | 2.53 | 2% |
| Natural Gas | 1.10 | 13% for 8 yrs, 11% thereafter until it reaches furnace oil price |
| Electricity | 17.00 (WAPDA)<br>20.00 (KESC) | 4%<br>4% |

electricity in the WAPDA and KESC regions. The markets obtained are as follows:

| | National Market (MW) | New Facilities (MW) | Existing Facilities (MW) |
|---|---|---|---|
| Up to 1990: | 550 | 207 | 343 |
| 1991 - 1995: | 640 | 558 | 82 |
| | 1,190 | 765 | 425 |

More detailed results of the model are presented in Exhibits E.2 to E.9.

## Project Evaluation

In conducting its evaluation of the proposed project, the team met with senior managers from both KESC and Pakland Cement Company to review the technical features and expected economic performance of the diesel engine power plant. However, the primary source for the evaluation was the proposal submitted by Pakland and the subsequent assessment conducted by KESC.

The Pakland Cement Company estimated a selling price for electricity generated by its proposed 120-MW diesel engine central station power plant of 87 Ps./kWh (or U.S. 5.5¢/kWh). This price is based on an assumed "tax free" return on equity of 20 percent and a 70/30 debt-to-equity ratio. In addition, Pakland assumed debt financing of 14 percent, which is consistent with normal commercial financing rates available to the industrial sector in Pakistan. The capital costs, non-fuel operating and maintenance costs, and efficiencies assumed by Pakland Cement Company in preparing its proposal appear reasonable ,based on comparisons with recent World Bank studies and discussions with a U.S. firm installing diesel engine power plants in the United States.

The baseline assumptions used in the evaluation are displayed in Exhibit C.1. Using these assumptions, the team determined the unit cost of electricity production in the first year of operation. In addition, it estimated how this cost would change with changes in two key parameters affecting the overall financial performance of the proposed project: income tax rate and annual capacity factor. The current tax laws in Pakistan provide the same types of deductions for determining taxable income as currently allowed under U.S. federal tax codes, i.e., depreciation and debt interest expenses. As shown in Exhibit C.2, the unit cost of electricity production varies between Rs. 0.78/kWh and Rs. 0.90/kWh and is greater when income taxes are included than not, despite the large deductions resulting from depreciation and debt interest. In contrast, increasing the annual capacity factor of the power plant results in a significant reduction of the unit production cost of electricity.

## Conclusions and Recommendations

Given the estimated marginal cost of electricity generation currently incurred by KESC of about Rs. 2/kWh, the potential

Exhibit E-3

COGENERATION SYSTEM MARKET
SALES PROJECTIONS (MW - ELECTRIC)
INDUSTRY: ALL
REGION: ALL
MARKET APPLICATION: NEW
SIZE RANGE: ALL

| Technology | 86-87 | 88-89 | 90-91 | 92-93 | 94-95 | Total |
|---|---|---|---|---|---|---|
| FO Boiler/ST | 5 | 5 | 5 | 5 | 4 | 24 |
| NG Boiler/ST | 7 | 6 | 6 | 5 | 5 | 28 |
| GT/WHRB | 48 | 70 | 90 | 101 | 107 | 417 |
| Diesel/WHRB | 0 | 7 | 29 | 87 | 173 | 296 |
| TOTALS | 59 | 88 | 130 | 198 | 290 | 765 |

Source: Hagler, Bailly & Company

Exhibit C-2

HUB CHOWKI PROJECT
Cost of Production in First
Year of Operation (Rs. million)

| Item | CF=60 % TR=0 % | CF=60% TR=40 % | CF=75 % TR=0 % | CF=75 % TR=40 % |
|---|---|---|---|---|
| Operating Expenses | | | | |
| Fuel Costs | | | | |
| Furnance Oil | 194.9 | 194.9 | 243.6 | 243.6 |
| Diesel Oil | 11.8 | 11.8 | 14.7 | 14.7 |
| Lubrication Oil Costs | 15.8 | 15.8 | 19.8 | 19.8 |
| Other Operating & Maintenance Costs | 84.5 | 84.5 | 84.5 | 84.5 |
| Depreciation Expenses | 62.4 | 62.4 | 62.4 | 62.4 |
| Interest Expenses | | | | |
| Foreign Debt Interest | 37.8 | 37.8 | 37.8 | 37.8 |
| Local Debt Interest | 20.7 | 20.7 | 20.7 | 20.7 |
| Total Expenses | 427.9 | 427.9 | 483.5 | 483.5 |
| Net Equity Investment | 312.0 | 312.0 | 312.0 | 312.0 |
| Returns on Equity (20% after tax) | 62.4 | 62.4 | 62.4 | 62.4 |
| Revenue Requirement | 490.3 | 570.9 | 545.9 | 626.5 |
| Electricity Sold (GWH) | 630.7 | 630.7 | 788.4 | 788.4 |
| Unit Production Cost (Ps/kWh) | 77.7 | 90.5 | 69.2 | 79.5 |

CF = Capacity Factor
TR = Tax Rate

Source: Hagler, Bailly & Company

Exhibit E-5

COGENERATION SYSTEM MARKET
SALES PROJECTIONS (MW - ELECTRIC)
INDUSTRY: ALL
REGION: ALL
MARKET APPLICATION: RETROFIT
SIZE RANGE: ALL

| Technology | 86-87 | 88-89 | 90-91 | 92-93 | 94-95 | Total |
|---|---|---|---|---|---|---|
| FO Boiler/ST | 9 | 6 | 2 | 0 | 0 | 18 |
| NG Boiler/ST | 12 | 7 | 2 | 0 | 0 | 22 |
| GT/WHRB | 148 | 85 | 21 | 6 | 3 | 262 |
| Diesel/WHRB | 0 | 6 | 5 | 4 | 4 | 19 |
| TOTALS | 169 | 105 | 29 | 10 | 7 | 321 |

Source: Hagler, Bailly & Company

Exhibit C.3

## HUB COMBINED POWER PLANT PROJECT
## MAJOR MILESTONES

| LESTONE | DESCRIPTION | COMMENTS |
|---|---|---|
| SS ANNOUNCEMENT NISTRY) | THE MINISTRY OF POWER AND WATER WILL ISSUE A NOTICE TO INVITE EXPRESSIONS OF INTEREST FOR THE ENVISIONED PROJECT FROM PRIVATE PAKISTANI AND FOREIGN PARTIES | INTERESTED FIRMS WILL PREPARE PREQUALIFICATION INFORMATION TO DOCUMENT THE TECH. AND MANAGERIAL CAPABILITIES |
| MISSION OF QUALIFICATIONS IVATE FIRMS) | INTERESTED PARTIES WILL SEND WITHIN 45 DAYS A LETTER AND PREQUALIFICATION INFORMATION | |
| QUALIFICATION NISTRY) | THE MINISTRY OF POWER AND WATER (AND OTHER CONCERNED ORGANIZATIONS) WILL REVIEW THE PREQUALIFICATION DOCUMENTS TO SELECT A SHORT LIST OF PREQUALIFIED FIRMS WHICH WILL BE ALLOWED TO BID ON THE PROJECT | THE PREQUALIFICATION WILL ENTAIL FIRST ASSESSMENT OF THE TECH. ABILITY OF THE PARTIES AND ALSO OF THEIR FINANCIAL AND MANAGERIAL CAPABILITIES. |
| PARATION OF RFP NISTRY) | THE MINISTRY OF POWER AND WATER, IN CONSULTATION WITH OTHER CONCERNED GOVERNMENT ENTITIES WILL PREPARE A DETAILED TENDER DOCUMENT OR REQUEST FOR PROPOSALS TO BE USED FOR PREPARATION OF FEASIBILITY STUDIES. | THE RFP WILL BE SUFFICIENTLY DETAILED TO PROVIDE GUIDANCE TO PRIVATE PARTIES REGARDING THEIR ABILITY TO MEET REQUIREMENTS, INCLUDING BULK PURCHASE PRICE OF POWER AND OTHER CRITICAL PROVISIONS (E.G. ESCALATION) |
| PARATION OF POSALS VATE FIRMS) | PREQUALIFIED PARTIES (INCLUDING POSSIBLE JOINT VENTURES BETWEEN PAKISTANI AND FOREIGN FIRMS) WILL BE ALLOWED 90 DAYS FOR PREPARATION AND SUBMISSION OF PROPOSALS. | |
| UATION OF POSALS ISTRY) | AN EVALUATION COMMITTEE WILL BE SELECTED TO REVIEW THE PROPOSALS AND RANK THE OFFERS. | THE EVALUATION MAY CONSIDER ONLY THOSE PROPOSALS OFFERING A BULK PURCHASE PRICE BELOW OR EQUAL TO THAT PROVIDED IN THE RFP. EVALUATION WILL BE MADE ON TECHNICAL AND MANAGERIAL CAPABILITY FIRST, AND THEN ON PRICE. |
| . NEGOCIATION ISTRY AND ) | THE EVALUATION COMMITTEE WILL RECOMMEND THE PARTY BEST MEETING TECHNICAL, FINANCIAL, MANAGERIAL AND PRICE REQUIREMENTS | |

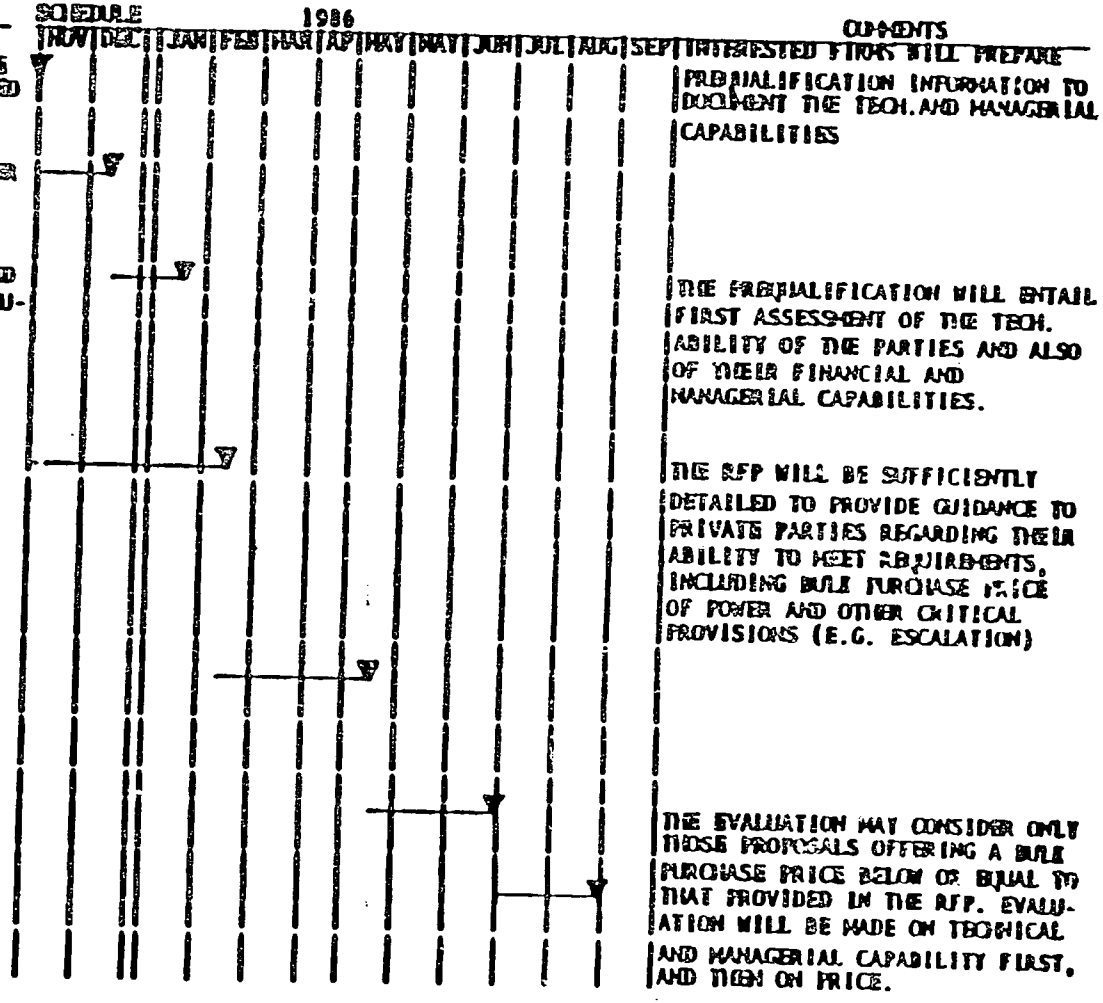


Exhibit E-7

COGENERATION SYSTEM MARKET
SALES PROJECTIONS (MW - ELECTRIC)
INDUSTRY: ALL
REGION: 2
MARKET APPLICATION: ALL
SIZE RANGE: ALL

| Technology | 86-87 | 88-89 | 90-91 | 92-93 | 94-95 | Total |
|---|---|---|---|---|---|---|
| FO Boiler/ST | 4 | 3 | 1 | 1 | 1 | 10 |
| NG Boiler/ST | 5 | 3 | 2 | 1 | 1 | 11 |
| GT/WHRB | 68 | 42 | 30 | 28 | 27 | 196 |
| Diesel/WHRB | 0 | 4 | 12 | 31 | 58 | 104 |
| TOTALS | 76 | 52 | 45 | 61 | 86 | 320 |

Source: Hagler, Bailly & Company

Exhibit E-9

COGENERATION SYSTEM MARKET
SALES PROJECTIONS (MW - ELECTRIC)
INDUSTRY: ALL
REGION: 4
MARKET APPLICATION: ALL
SIZE RANGE: ALL

| Technology | 86-87 | 88-89 | 90-91 | 92-93 | 94-95 | Total |
|---|---|---|---|---|---|---|
| FO Boiler/ST | 8 | 6 | 3 | 3 | 2 | 22 |
| NG Boiler/ST | 10 | 7 | 4 | 3 | 3 | 26 |
| GT/WHRB | 74 | 72 | 52 | 50 | 52 | 299 |
| Diesel/WHRB | 0 | 6 | 14 | 38 | 73 | 120 |
| TOTALS | 91 | 90 | 73 | 93 | 129 | 478 |

Source: Hagler, Bailly & Company

| Name of Site, Location | No. of Sets | Effective Generating Capacity (kW) |
|---|---|---|
| I. **Karachi (continued)** | | |
| Pakistan Refinery Ltd. Karachi | 1 | 600 |
| Park-Davis & Co., Ltd. Karachi | 1 | 70 |
| Sui Gas Transmission Company Ltd. Karachi | 35 | 3,070 |
| State Life Insurance Corp., Karachi | 3 | 400 |
| Habib Bank Ltd. Karachi | 1 | 250 |
| Jubilee Spinning & Weaving Mills Ltd. Karachi | 2 | 350 |
| Hussain Textile Mill Ltd. Karachi | 4 | 1,230 |
| Shalimar Silk Mills Ltd. Karachi | 1 | 75 |
| Karachi Port Trust Karachi | 2 | 1,600 |
| SUBTOTAL | | 135,245 kW |
| II. **SIND** | | |
| Pfizer-Laboratories Ltd. Karachi | 2 | 91 |
| Pakistan Services Ltd. Karachi | 1 | 90 |
| Bengal Fibre Industries Ltd. Karachi | 1 | 240 |
| National Bank of Pakistan Karachi | 1 | 150 |
| National Cement Industries Karachi | 3 | 4,450 |
| Wazir Ali Industry Hyderabad | 4 | 800 |
| Fauji Sugar Mills Sind | 3 | 4,495 |
| Fauji Sugar Mills Hyderabad | 5 | 3,862 |
| Mehran Sugar Mills Hyderabad | 2 | 3,150 |
| Mirpur Khas Sugar Mills Ltd. Mirpur Khas. | 4 | 3,150 |

# APPENDIX F: FINANCIAL POTENTIAL FOR ON-SITE NON-COGENERATION SYSTEM



The most likely on-site power-only system to be used in Pakistan is the medium-speed diesel engine (800 rpm), sized between 0.8 MW and 6 MW and using furnace oil. Levelized annual costs of power are about 94 Ps./kWh (5.9¢ kWh) (see Exhibit F.1). Therefore, such systems are not economically justified in the WAPDA area, unless cost of outage is also taken into consideration. Based on interviews conducted during this study, the team estimates that a substantial proportion of industries can cope with load shedding without incurring any significant loss. About 65 percent of the estimated generation potential in the WAPDA area (about 560 MW) consists of plants operating two shifts or less that can accommodate for load shedding and adjust their production planning accordingly. For the other 35 percent, mostly large industries operating three shifts and representing a potential of 200 MW, the installation of a generator is financially justified if load shedding exceeds 300 hours/year. For the last 2 years, load shedding has exceeded this level, and is expected to continue.

In the case of KESC service area, where the technical potential is estimated at 410 MW, the effects of load shedding have been less than in the WAPDA area, both are likely to increase in frequency at least until 1988, when a new power plant Bin Qasim #3, comes into operation. For this reason, many industrialists are currently importing generating sets. In addition, it may be cheaper for some large industries operating long hours to produce their own power (at about 90 Ps./kWh or 5.6¢/kWh) than to buy it from KESC. The financial potential is estimated at 140 MW, or 35 percent of the technical potential.

| Name of Site, Location | No. of Sets | Effective Generating Capacity (kW) |
|---|---|---|
| III. **PUNJAB (continued)** | | |
| Bahawalnagar Sugar Mills ltd. Bahawalnager | 3 | 4,006 |
| Khinoor Sugar Mills Ltd. Khushab | 4 | 3,200 |
| Pattaki Sugar Mills Ltd. Khushab | 4 | 4,964 |
| Pasurur Sugar Mill Ltd. Sialkot | 3 | 3,552 |
| PMDC Makerwal Collieredes Distt. Mainwali | 1 | 592 |
| The Thal Industries Corp. Ltd. Leiah Sugar Mill, Leiah | 3 | 3,250 |
| Dawood Hercules Chemical Ltd. Sheikhupura | 2 | 150,000 |
| The National Silk & Rayon Mills Ltd. Faislabad | 2 | 200 |
| Shakorjing Mills Tahatule Sing Raw Jhong | 2 | 2,000 |
| SUBTOTAL | | 200,151 kW |
| IV. **BALUCHISTAN** | | |
| National Mining Co. Quetta | 3 | 139 |
| Balan Mining Enterprises Khurdar | 2 | 400 |
| Bala Engineer Ltd. Basbella | 2 | 842 |
| Pakistan Oxygen Ltd. Baluchistan | 2 | 51 |
| Pakistan Broadcasting Corp. Quetta | 4 | 104 |
| M. Raza Khan & Co. Quetta | 2 | 155 |
| Bolan Textile Mills Balell Quetta | 6 | 1,250 |
| Pioner Cable Ltd. Lasbela Baluchistan | 1 | 230 |
| Mullick Wilayet Hussain & Sons Ltd. Quetta | 2 | 300 |
| Harnai Woollen Mills Ltd. Harani PIDC | 4 | 532 |
| Baluchistan Eng. Works Ltd. | 1 | 192* |

*Under construction

Exhibit F.1

## BASIC ECONOMICS OF ON-SITE POWER

Case Definition:

| | |
|---|---|
| o Load = | 4 MW |
| o Operations = | 5,000 hr/year |
| o Capital recovery factor = | 0.2 |
| o Furnace oil at = | Rs. 1,720/tonne ($107.50/tone) |

Costs

| | | |
|---|---|---|
| o Capital cost | : | Rs. 38.4 million |
| o Annual capital charge | : | Rs. 7.7 million |
| o Annual O&M costs (9% of capital cost) | : | Rs. 3.5 million |
| o Annual fuel cost (220 g/kWh) | : | Rs. 7.6 million |
| Total Annual Cost | : | Rs. 18.8 million |

| | | |
|---|---|---|
| Levelized annual cost of electricity | | 94 Ps./kWh (5.9¢/kWh) |
| Value of electricity: | WAPDA, retail | 88 Ps./kWh (5.0¢/kwh) |
| | KESC, retail | 118 Ps./kWh (6.9¢/kWh) |

Source: Hagler, Bailly & Comapny

# PAKISTAN INDIGENOUS ENERGY SOURCES

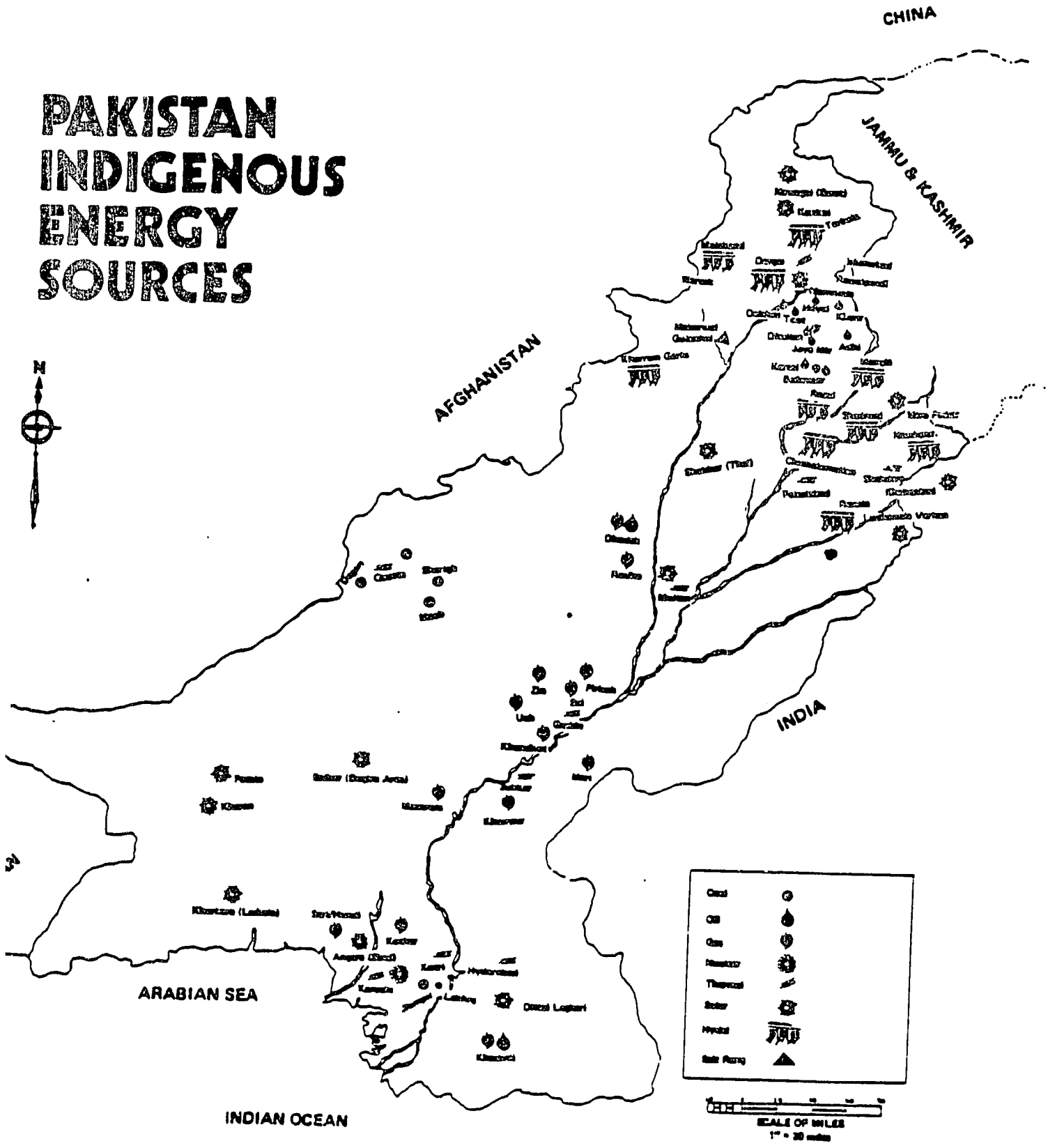


Exhibit E.1 (cont'd)

Industry

| No. | Name | Current Steam Demand ($10^{12}$ Btu) | Annual Growth Rate % | Captive Steam Fraction (%) |
|---|---|---|---|---|
| 1 | Iron, Steel | 2.500 | 6 | 0 |
| 2 | Foundries | 0.015 | 6 | 0 |
| 3 | Glass and Ceramics | 0.105 | 6 | 0 |
| 4 | Refinery | 6.950 | 8 | 0 |
| 5 | Org. Chem. | 1.375 | 7 | 0 |
| 6 | Inorg. Chem. | 7.320 | 7 | 0 |
| 7 | Fert., Pesticides | 12.825 | 6 | 0 |
| 8 | Textiles | 7.675 | 6 | 0 |
| 9 | Pulp & Paper | 3.090 | 6 | 0 |
| 10 | Sugar Refining | 50.310 | 5 | 50.31 |
| 11 | Food, Beverage & Tobacco | 2.235 | 6 | 0 |

Other

| | |
|---|---|
| Tax rate: | 40% |
| Depreciation: | linear, 10 years |
| discount Rate: | 15% |
| Capital Cost Escalation: | 1% per year |
| Buyback Rate: | 70% of retail price |

Source: Hagler, Bailly & Company

The GOP has drastically curtailed the use of pipeline natural gas for power generation. However, two sources of natural gas that do not fall under this policy include:

- "Dormant gas fields," that refer to eight gas fields identified over the last 30 years containing low-quality gas that cannot be used in pipelines.

- Both associated and non-associated gas recently identified at oil drilling concessions by Union-Texas, Occidental, and OGDC. These gas supplies are often found in modest quantities, have short lives and are not near the pipeline, so their most effective use would in many cases be for power generation.

## A. DORMANT GAS FIELDS DESCRIPTION

Eight gas fields in Pakistan are referred to as "dormant" since, until recently, nothing was done to develop them since their discovery in the 1950s and 1960s. These fields are currently held by the OGDC. Brief descriptions are presented below:

### i) ZIN

A small quantity of gas at low pressure was found in Sui Main Limestone at a depth of 2,973 feet in an exploratory well that was drilled by Pakistan Petroleum Limited (PPL) in 1953 on the basis of geologic survey. This field is located in Kohlu Agency, Baluchistan. It contains 46 percent methane, 8 percent Nitrogen, 45 percent carbon dioxide and traces of hydrogen sulfide gas. During testing the well gave an absolute open flow of 3 million cubic feet of gas per day (mmcfd) after acidization. The recoverable reserves reported by PPL on the basis of single well are 0.1 trillion cubic feet (tcf), with a reservoir pressure of 279 psig.

Exhibit E-2

## COGENERATION SYSTEM MARKET
## SALES PROJECTIONS (MW - ELECTRIC)
## NATIONAL TOTALS

| Technology | 86-87 | 88-89 | 90-91 | 92-93 | 94-95 | Total |
|---|---|---|---|---|---|---|
| FO Boiler/ST | 16 | 12 | 7 | 6 | 5 | 46 |
| NG Boiler/ST | 21 | 15 | 8 | 6 | 6 | 56 |
| GT/WHRB | 214 | 171 | 124 | 118 | 120 | 748 |
| Diesel/WHRB | 0 | 14 | 38 | 101 | 194 | 346 |
| TOTALS | 252 | 213 | 177 | 231 | 325 | 1197 |

Source: Hagler, Bailly & Company

completion of Phase I, the field will be capable of producing 30 mmcfd. The field is being appraised by OGDC.

vi) KHAIRPUR

The Khairpur gas field is located in Sind Province. The structure was established on the basis of a gravity and seismic survey. The gas is found in Sui Main Limestone at a depth of 2,020 feet with a reservoir pressure of 953 psig. The estimated recoverable reserves are 1.0 tcf. The gas contains 12 percent methane and 88 percent inert gases. Hydrocarbon Development Institute of Pakistan (HDIP) carried out a study of the Khairpur field through an RTM engineer, who has recommended that Khairpur gas may be used to generate electricity. The case is under submission to the Ministry of Water and Power for its consideration.

vii) PANJPIR

Panjpir gas field is located in Multan, Punjab Province. The structure measures about 20 square kilometers. Results of production testing carried out so far indicate that the discovery well can produce 14 mmcfd from three zones, and on completion of Phase I, the field will produce over 40 mmcfd.

viii) NANDPUR

This gas field is located in District Multan. The well was drilled to a depth of 2,100 meters. Upon testing of the well, gas in commercial quantity was found in Jurassic formation at interval 2,070-1,892 meters in the first zone, which produced gas at the rate of 10.00 mmcfd; the second and third zones in Cretaceous formation produced gas at the rate of 7.71 mmcfd and 8.3 mmcfd, respectively. Upon completion of the Nandpur Development project, production of 60 mmcfd with 40 percent combustible content is expected.

B. FIELD STATUS

Based on recent discussions (October 1985) with the OGDC, these fields can be divided into four categories:

Exhibit E-4

COGENERATION SYSTEM MARKET
SALES PROJECTIONS (MW - ELECTRIC)
INDUSTRY: ALL
REGION: ALL
MARKET APPLICATION: REPLACEMENT
SIZE RANGE: ALL

| Technology | 86-87 | 88-89 | 90-91 | 92-93 | 94-95 | Total |
|---|---|---|---|---|---|---|
| FO Boiler/ST | 2 | 1 | 1 | 1 | 0 | 6 |
| NG Boiler/ST | 3 | 2 | 1 | 1 | 1 | 7 |
| GT/WHRB | 19 | 16 | 13 | 11 | 10 | 68 |
| Diesel/WHRB | 0 | 1 | 4 | 10 | 17 | 32 |
| TOTALS | 23 | 20 | 18 | 22 | 28 | 111 |

Source: Hagler, Bailly & Company

This proposal, "Development of Uch Gas Field," describes the required field delineation and development work to deliver gas to a combined cycle power plant. It also includes above-ground gas treatment facilities for removing of some the carbon dioxide and hydrogen sulfide.

Main points raised in the proposal include:

- The gas reserve estimate of Uch, at 2.5 tcf, is probably conservative, possibly by a factor of 2.
- Using even very conservative estimates of gas reserves (2.5 tcf), the Uch field can support 300-700 MW of power generation over a period of 3 years.
- The estimated cost for the field development is about U.S. $126 million (in foreign currency) and Rs. 530 million (in local currency).
- The cost of gas over the first 10 years, when the loans are amortized, will be about Rs. 15.5 ($1.00) per mcf (roughly $2 per mmBtu based on the upgraded gas heat content).
- There is sufficient know-how, skilled labor, and capital in Pakistan to undertake the development work, particulary if it is done through joint ventures with foreign companies, several of which have shown an interest.

This proposal further reinforces the contention that a change in policies that would allow private-sector access to Uch is critical if private capital is to be used to significantly expand the country's power generating capacity.

Exhibit E-6

COGENERATION SYSTEM MARKET
SALES PROJECTIONS (MW - ELECTRIC)
INDUSTRY: ALL
REGION: 1
MARKET APPLICATION: ALL
SIZE RANGE: ALL

| Technology | 86-87 | 88-89 | 90-91 | 92-93 | 94-95 | Total |
|---|---|---|---|---|---|---|
| FO Boiler/ST | 2 | 2 | 1 | 1 | 1 | 5 |
| NG Boiler/ST | 3 | 2 | 1 | 1 | 1 | 7 |
| GT/WHRB | 43 | 30 | 22 | 21 | 22 | 139 |
| Diesel/WHRB | 0 | 2 | 6 | 18 | 34 | 61* |
| TOTALS | 48 | 36 | 31 | 41 | 57 | 212 |

Source: Hagler, Bailly & Company

# Appendix I LIST OF CONTACTS

Exhibit E-8

COGENERATION SYSTEM MARKET
SALES PROJECTIONS (MW - ELECTRIC)
INDUSTRY: ALL
REGION: 3
MARKET APPLICATION: ALL
SIZE RANGE: ALL

| Technology | 86-87 | 88-89 | 90-91 | 92-93 | 94-95 | Total |
|---|---|---|---|---|---|---|
| FO Boiler/ST | 3 | 2 | 1 | 1 | 1 | 9 |
| NG Boiler/ST | 4 | 3 | 2 | 1 | 1 | 12 |
| GT/WHRB | 29 | 28 | 19 | 19 | 20 | 115 |
| Diesel/WHRB | 0 | 2 | 6 | 15 | 29 | 52 |
| TOTALS | 36 | 35 | 28 | 36 | 52 | 188 |

Source: Hagler, Bailly & Company

## SUMMARY OF TEAM MEETINGS

| DATE | PERSON VISITED | RANK | ORGANIZATION |
|---|---|---|---|
| OCT.13 | MR. SADAQAT HASAN MIR | MANAGING DIRECTOR | ENERPLAN |
| | MR. M. IZHARUL HAQUE | DEPUTY DIRECTOR | |
| OCT.14 | MR. J.G. FOSTER | FIRST SECRETARY (DEV). ENERGY SECTOR | CANADIAN EMBASSY, ISLAMABAD |
| | & MR. JOHN M. MUNDY | FIRST SECRETARY (COMMERCIAL) | -DO- |
| | MR. CHARLES MOSELEY | | USAID/ISLAMABAD |
| | MR. JAMES BEVER | | USAID/ISLAMABAD |
| | MR. JOHN MORGAN | | USAID/ISLAMABAD |
| OCT.15 | MR. AKRAM KHAN | SECRETARY FOR POWER | MINISTRY OF WATER (POWER), ISLAMABAD |
| | MR. GAUHAR ALI | ENERGY PROJECTS ADVISOR | WORLD BANK/ISLAMABAD |
| | MR. M.S. BUTT | ENGINEERING ADVISOR (POWER) | OFFICE OF THE CHIEF ENG. ADVISOR, ISLAMABAD |
| | | | MINISTRY OF WATER (POWER), ISLAMABAD |
| | MR. WAJAM HAIDER | CHIEF, CORPORATE PLANNING | OGDC |
| | MR. MIRZA | SECRETARY | MINISTRY OF PRODUCTION, ISLAMABAD |
| | MR. ASHFAQ MAHMOOD | HEAD, ENERGY | PLANNING COMMISSION |
| | DR. S.H.R. ZAIDI | SENIOR TECHNICAL MANAGER | FAUJE FERTILIZER CO., RAWALPINDI |
| OCT.16 | KHAWAJA DAWOOD | GENERAL MANAGER (GENERATION) | WATER & POWER DEVELOPMENT AUTH, ISLAMABAD |
| | MR. M. ARSHAD | CHIEF ENGINEER (PLANNING) | (WAPDA) LAHORE |
| | MR. SHAKOUR AHMAD | CHIEF ENGINEER GENERATION (THERMAL) | -DO- |
| | MR. JEHANGIR | DIRECTOR, TARRIFS | -DO- |
| | MR. JAFFERY | CHIEF ENGINEER (HYDEL) | -DO- |
| | MR. M. AMANULLAH | GENERAL MANAGER | DAOOD - HERCULES, LAHORE |
| | MR. R. EINSTING | CONSERVATION SPECIALIST | EBASCO |
| OCT.17 | MR. RIAZ SAMEE | CHAIRMAN (POWER GROUP) | LAHORE CHAMBER OF COMMERCE & IND. |
| | MR. SHARIF | JOINT SECRETARY | -DO- |
| | MR. MIAN M. AKHTAR | SECRETARY IRRIGATION PUNJAB | GOVT. OF PUNJAB. DEPARTMENT OF |
| | | | IRRIGATION & POWER, LAHORE |
| | RAJA SAEED AKHTAR | GENERAL MANAGER DISTRIBUTION | WAPDA, LAHORE |
| | MR. ABDUL HAYEE | FINANCE MANAGER | RUPALI POLYESTER, LAHORE |
| | REPRESENTATIVES FROM | | ITTIHAD CHEMICAL INDUSTRY, LAHORE |
| | | | RAVI RAYON MILL, LAHORE |
| | MR. DON RUOTOLO | GENERAL MANAGER | EBASCS TEAM, LAHORE |
| | DR. Z. FIKRI | MANAGING DIRECTOR | FACE LTD, LAHORE |

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