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SUGAR INDUSTRY OF PAKISTAN: POTENTIAL FOR GRID POWER SUPPLY

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TABLE OF ACRONYMS

A.I.D.	(U.S.) Agency for International Development
BST	Bioenergy Systems and Technology program (of USAID)
CWP	Control Work Plan
GOP	Government of Pakistan
IRG	International Resources Group, Ltd.
PPC	Private Power Cell
USAID	United States Agency for International Development
USDOE	United States Department of Energy
WAPDA	Water and Power Development Authority (of the Government of Pakistan)

TABLE OF CONTENTS

INTRODUCTION 1

BACKGROUND 2

SECTION I
SUGAR INDUSTRY TECHNICAL OPTIONS PRIMER FOR PRIVATE POWER 4

A. SUGAR MANUFACTURING AND EXISTING COGENERATION SYSTEMS 5

B. REQUIREMENTS FOR EXCESS POWER GENERATION 8

C. GENERAL APPROACH 11

D. FUEL CONSIDERATIONS 14

E. FIRM CAPACITY PROJECT BOUNDARIES 16

F. SITE SPECIFIC EVALUATION CRITERIA 17

G. STATUS OF THE SUGAR INDUSTRY 19

H. SUGAR INDUSTRY POWER POTENTIAL 23

I. SUGAR INDUSTRY PROJECT CATEGORIES 25

SECTION II
IMPLEMENTATION OF PRIVATE POWER PROJECTS IN THE SUGAR INDUSTRY IN PAKISTAN

A. BACKGROUND 27

B. TARIFF DETERMINATIONS AND CONTRACTS 28

C. BACKGROUND INFORMATION FOR TARIFF DETERMINATION 32

D. OTHER POLICY ISSUES 38

E. TYPICAL DESIGN OF A POWER PURCHASE TARIFF 39

1. Economic Efficiency 39
2. Marginal vs. Average Cost Pricing 39

F. MISCELLANEOUS TOPICS -- SUGARY INDUSTRY 41

G. RECOMMENDATION FOR INDUSTRY RESPONSE 43

SECTION III
CONTRACT MODEL FOR WAPDA POWER PURCHASE FROM PAKISTAN SUGAR INDUSTRY

A. BACKGROUND 46

B. OUTLINE OF BAGASSE COGENERATION CONTRACT STANDARD OFFER: AS-DELIVERED ENERGY (AND CAPACITY) 47

C. WAPDA STANDARD OFFER POWER PURCHASE AGREEMENT FOR AS-DELIVERED CAPACITY (AND ENERGY) 51

D. TYPICAL PROJECT STRUCTURE 56

SECTION IV
APPRAISAL REPORT ON PARACHA SUGAR MILL AND POWER HOUSE LTD PROPOSAL TO THE PRIVATE POWER CELL DATED MARCH 31, 1990

A. GENERAL COMMENTS 59

B. SPECIFIC COMMENTS 61

C. CONCLUSIONS 64

D. RECOMMENDED ACTION 65

ANNEX 1
WAPDA LOAD CURVES

ANNEX 2
LIST OF REFERENCES

ANNEX 3
LIST OF KEY PEOPLE MET

INTRODUCTION

As per the Control Work Plan prepared to both evaluate the potential for the private power project proposal of Mr. Saifullah Paracha, and to determine the potential aggregate private power input of the sugar industry of Pakistan, Mr. Robert Chronowski of IRG Washington carried out the Scope of Work under the CWP and prepared this series of briefs after a two week in-country mission.

The overall potential input of the sugar industry of Pakistan to the grid is on the order of 200 MW of 20-35 projects of 4 MW to 12 MW in size. Sufficient studies have been done on the sugar industry by many organizations, including USAID, such that the technical viability should not be an issue. To realize the potential, if this is desirable to WAPDA and beneficial to the country, it is a matter of setting the kWh price schedule and terms of contract that would encourage a sugar industry response.

The recommended approach is to estimate WAPDA's dry season peak time of day thermal price of production as a bench mark, and then average it with various hydro/thermal mix scenarios. This would then be used to determine an equitable target price for sugar mill derived power. If the pricing appears to produce mutual benefits, then WAPDA and the sugar industry (through the mill owners association) would be brought together using a seminar format. At that time, the technical, financial, and legal/contractual issues facing both WAPDA and the sugar industry would be thoroughly defined. WAPDA has asked that a standardized Power Purchase Agreement and Contract be prepared to deal specifically with the sugar industry. With power pricing and contractual information, a mill owner could easily make a determination as to whether or not to consider a private power project. WAPDA has requested that Robert Grimshaw prepare a CWP for a seminar for bringing WAPDA and the sugar industry together based on the above discussion points.

The consultant made it very clear to all concerned that a specific private power program with the sugar industry will only be carried forward if it can produce significant financial and economic benefits and meet all of the criteria as specified by the Private Power Cell and the USAID support program. The increased potential for profit to the sugar company will provide an incentive, but will not constitute the primary reason for the program.

There is interest both in the sugar industry and in WAPDA to proceed cautiously. The 200 MW potential would appear to have excellent value, especially during the winter (dry season) peak hours. The consensus of opinion was that the Private Power Support Project team continue in its definitional activities, until a solid value can be assigned to the program implementation, and a go/no go decision can be rationally made. Finally, bagasse combustion projects can be viewed as neutral projects with regard to the global CO_2 situation because the bagasse fuel source which releases CO_2 during combustion is balanced by a new sugar cane crop that absorbs CO_2. This should be a plus for implementation support.

BACKGROUND

What constitutes a viable sugar industry private power project is always a site-specific definition. One can, however, combine some generic boundaries with some very specific requirements to frame what could be termed as a viable project description. It is the intent of this report to provide guidelines that can apply to both existing plants, and plans for new facilities.

At the initial investigative level, neither the profitability for the sugar production, whether for domestic or export sales, nor sugar production efficiency is an issue. The base case is simply to look at whether or not adding a privately-financed cogeneration facility for sale of surplus electricity to the grid is a viable standalone option under certain financing and power purchase agreement assumptions. Once these boundaries are established, the specific sugar factory profitability, and the sugar production efficiency, hence bagasse availability, can be included in the sensitivity analysis to refine the projects to be implemented.

Normally, for a stand-alone sugar industry private power project to be successful, its size must be large enough, such that the entity purchasing the power will be willing to include some capacity replacement credit on top of energy savings in its power purchase pricing determinations. A normal assumption is that somewhere between 5 MW and 10 MW dedicated, year round or seasonally, to the grid can satisfy the criteria for capacity replacement credit, especially in an aggregated project program. The minimum size acceptable to WAPDA will define the design starting point at any site, if an additional facilities project is selected to be pursued by a sugar company. Most well-operated mills, during the grinding season, can supply the grid with some surplus kWh produced by their existing generators. The supply of surplus kWh from existing equipment on a time of day basis will be treated as a separate case. In this report clear preference will be given to larger firm capacity projects which will require new facilities, but supply substantially more capacity.

For sugar factories, the characteristics of existing or planned generation capacity, the amount of cane that is and can be grown, harvested and delivered to plant, and the efficiency of sugar production (tons of steam and kWh of electricity per tonne of cane processed) are the analytical starting points which define how much electricity can be generated as surplus with no capital investment. The next step is the consideration of adding topping cycle back-pressure turbine-generator(s) to enhance the amount of electricity produced. This requires a capital investment for used or new high-pressure/temperature steam boiler(s) and back-pressure turbine generators to allow the topping cycle to be employed. The investment however, will be less than what would be needed for a condensing cycle installation which will provide maximum kWh production potential and maximum flexibility of operations. If full year surplus power sales are being considered, the impact of adding condensing capability and extraction/condensing turbine generators is worth evaluating. Satisfactory

operation of the higher pressure/temperature steam cycles can normally be considered these days, as long as the proper training programs take place, and regular preventative maintenance is practiced faithfully. Generally, comparable equipment has been operated successfully in power company power stations, refineries, and in some newer industrial plants, such that precedents do exist, and qualified manpower can be found for operations and maintenance.

Before proceeding any further, it is necessary to back up and describe the normal sugar mill operations, and how cogeneration always fits into the operations. The private power approach will simply be to optimize on the cogeneration potential that is already there.

The balance of this report consists of four major standalone sections as per the request of the Private Power Cell:

(1) a Primer on the technical options for private power production in the sugar industry;

(2) a Policy Paper to guide private power development in the sugar industry of Pakistan;

(3) a Model Power Purchase Agreement for specific use with sugar mills in Pakistan; and

(4) an Appraisal Report of the Paracha Sugar Mills and Power House Ltd. proposal of March 31, 1990.

SECTION I

SUGAR INDUSTRY TECHNICAL OPTIONS PRIMER FOR PRIVATE POWER

A. SUGAR MANUFACTURING AND EXISTING COGENERATION SYSTEMS

Figure I-1 and the text that follows is taken from Enercon Report 89-144 and shows the sugar manufacturing process used in a majority of the sugar mills in Pakistan. It can be divided into three stages:

- Juice extraction
- Boiling
- Refining

The juice extraction stage consists of cane shredding and several stages of crushing under heavy rollers mechanically driven by mill steam turbines. The turbines are usually single-stage back-pressure type, typically utilizing steam at 300 psig and 580° F to provide the motive power required to drive the rollers.

The fibrous residue left after cane juice extraction is known as bagasse. Bagasse is a combination of fiber and moisture in almost equal proportions, and is used as the primary fuel in boilers to generate steam. The steam is almost always used for both process heat and electricity generation. Under ideal conditions, enough bagasse is produced to meet all boiler fuel requirements. In cases where it is not so, furnace oil, firewood or other fuels are used as supplemental fuels.

The boiling stage of the process is essentially an evaporation process. The juice is cleared of impurities. This step is known as clarification. This is followed by concentration of juice by preheating and evaporation. After evaporation, the juice turns into thick black syrup. The syrup is crystallized in vacuum pans and converted into raw sugar. In the refining stage, the raw sugar crystals are melted, treated with sulphur dioxide, SO2 (sulphitation), and crystallized in centrifuges which leave molasses as a by-product, yielding refined sugar.

The sugar processing equipment is designed to optimize the balance between the quantity of steam required in the process and the amount of bagasse produced to meet the plant energy requirements. No special consideration in normally given to producing extra bagasse for off-season use.

Figure I-2 shows a typical cogeneration system for a Pakistani sugar mill. Pressure and temperature ranges for primary steam are between 270-360 psig and 500-700° F. Typical utility boiler pressure and temperature ranges are between 1200 and 2400 psig (2400 psig is most common) and 950-1050° F. The low pressure and temperature ranges for the existing mills were designed to suit the steam requirements of the sugar manufacturing process which were not initially intended to produce excess power for sale using high-pressure steam.

Figure I-1: The Clarification Remelt Sulphitation (CRS) Process for Sugar Manufacturing

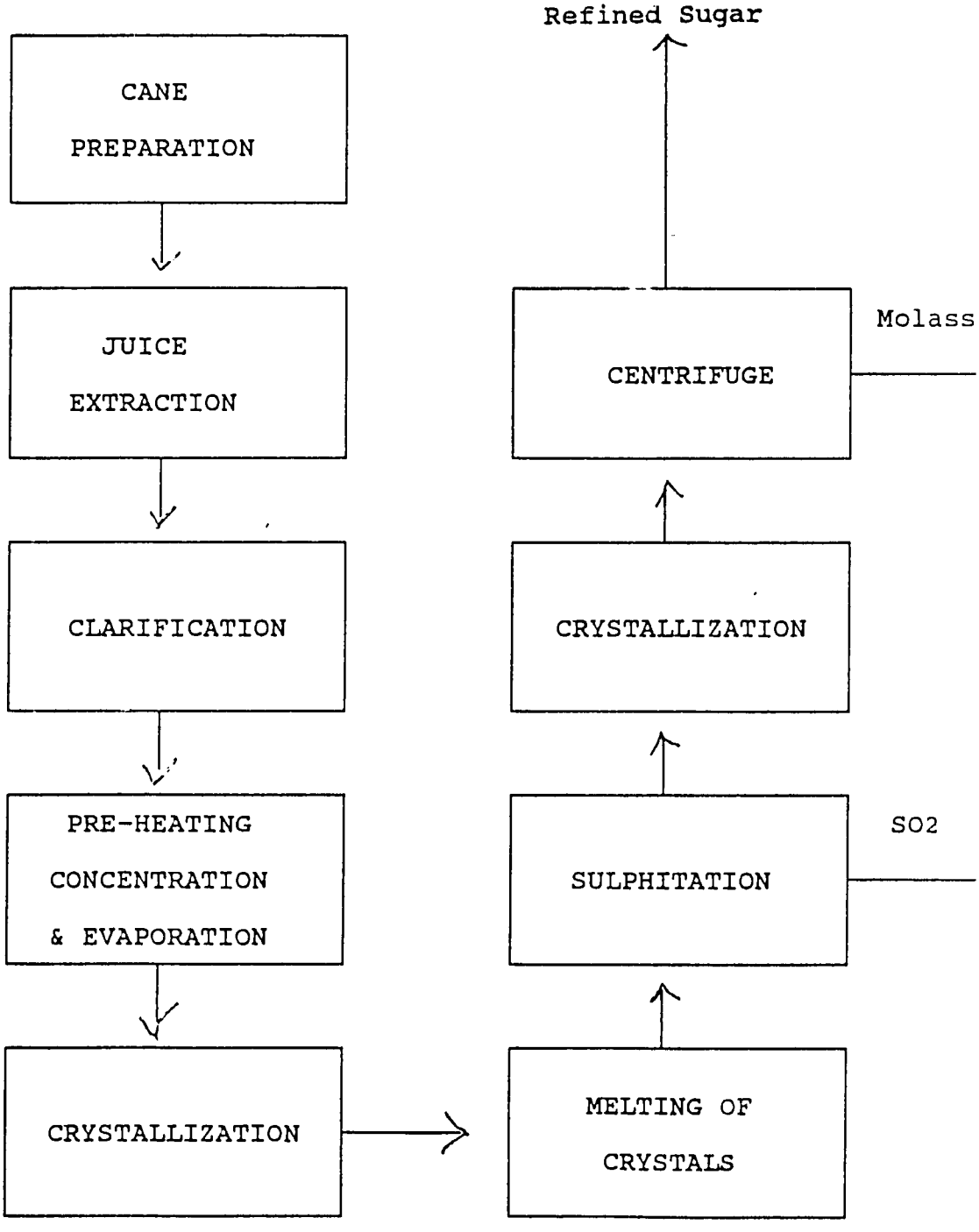

Figure I-2: Cogeneration System for a Typical Pakistani Sugar Mill

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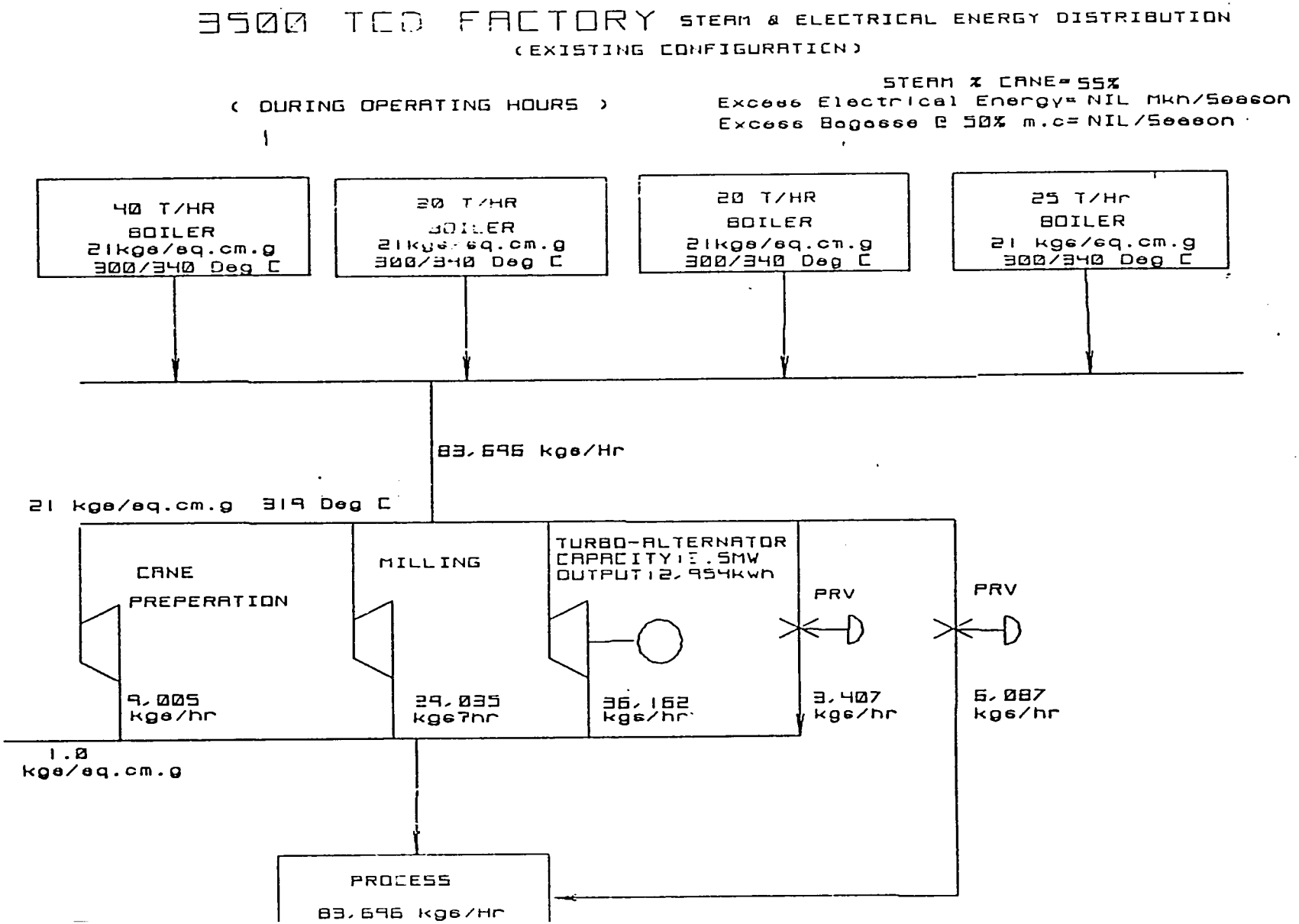

B. REQUIREMENTS FOR EXCESS POWER GENERATION

Commercial power generation at the sugar mills requires the implementation of one or more of the following measures:

- Install high-pressure boilers
- Install additional back-pressure turbine generators
- Replace back-pressure turbines with extraction-condensing turbines
- Produce surplus bagasse using bagasse dryers
- Decrease process heat requirements through efficiency gains
- Improve bagasse heat value and handling by drying, baling and/or pelletizing

As a first step, the existing low pressure boilers need to be replaced with boilers having a pressure range of at least 600 psig. Existing mills use steam at 270-360 psig which is not within the economic range for commercial power generation. Steam from high-pressure boilers, when passed through an extraction-condensing turbine, can provide extra mechanical energy to generate power at higher levels.

Higher pressure and temperature ratings, though desirable, increases costs significantly. At 600 psig and less, carbon steel piping is acceptable in a steam distribution system. Above 600 psig more expensive alloy piping is required. Also, the higher the pressure the higher the boiler feedwater treatment costs. At pressures greater than 600 psig, feedwater must be demineralized while at lower pressure, less costly water softening is acceptable.

Steam at above 600 psig can provide sufficient efficiency gains to generate commercially viable electric power at sugar mills. This pressure represents the threshold at which electric power generation begins to make commercial sense without converting the sugar mill into a full-scale utility power plant.

Consistent with high-pressure boilers, an essential requirement is to replace the existing back-pressure turbines with extraction-condensing steam turbines. Most mills use back-pressure steam turbines designed to exhaust steam at temperatures and pressures suitable for process use and provide electric power barely sufficient to meet factory requirements. These turbines are not efficient from the commercial power generation viewpoint. Extraction/condensing steam turbines that are designed for steam extraction between inlet and outlet pressures, besides providing steam, will generate electric power more efficiently at a higher capacity, and will provide more process flexibility.

Reduction in process heat requirements through efficiency gains will lead to savings in bagasse. The surplus or extra bagasse saved can be used for power generation, which in turn will improve the overall power production costs by displacing supplementary fuel use.

Major users of the process steam are evaporators and juice heaters. Steam consumption in these can be improved by:

- installing pre-evaporators; and
- using vapor-bleeding techniques.

Process steam from the mill turbines at 10-15 psig is used to heat the juice to boiling point. Evaporation is carried out in stages of evaporators, and a final concentration of the syrup is formed in vacuum pans. Since boiling is an intermittent process, the corresponding steam demand fluctuates, requiring a correct matching of exhaust with the heating load. In a properly designed mill the exhaust steam, when not synchronized with the heating demand, would be used to generate power in an extraction-condensing turbine instead of being wasted to the atmosphere. Installation of a pre-evaporator prior to the triple- or quadruple-effect evaporator, with the juice heater and vacuum pans using the exhaust steam of the mill can result in a significant steam economy. The use of vapor from first and second evaporators (vapor bleeding) instead of exhaust steam, to heat the juice can also save considerable amounts of steam. Steam savings of up to 180-200 lbs/tonne of cane crushed can be attained by using pre-evaporators and vapor bleeding techniques.

In general, process steam use in sugar mills ranges from 380 to 636 kg per tonne of cane crushed. In Pakistan, 650 to 680 kg are required per tonne of cane crushed. With sound steam economy using pre-evaporators and vapor bleeding this can be reduced to 580 kgs. For a 4000 tpd mill this would save 128 tonnes of bagasse per day.

All energy saving measures at a sugar mill, including use of efficient boiler and turbine-generator systems, pre-evaporators, and vapor bleeding, will lead to savings in bagasse. The higher the bagasse savings, the lesser the use of supplementary fuel. Among all of these measures, the use of bagasse dryers results in direct savings in fuel costs. Bagasse as burned currently has a moisture content of about 50 percent with a typical heat value of 1850 kcal/kg. If the moisture content is reduced to 40 percent, then its heat value increases to 2525 kcal/kg, resulting in considerable savings in fuel costs.

Bagasse dryers use the heat in flue gases from the boiler to reduce the moisture content of bagasse. Combustion of dried bagasse as boiler fuel improves efficiency and results in reduced use of bagasse. Dryer bagasse gives higher flame temperatures which lower the volume of flue gases and results in reduced amounts of vapor and lower velocity. The lower velocity and volume will normally result in a drop in superheat temperature. On the other hand, over-drying of bagasse can lead to slag formation in the boiler due to the silicon content of bagasse. Also, excessive cooling of flue gases can lead to vapor condensation, resulting in corrosion in the dryers, cyclones and ducting.

As can be seen from the above discussion, design, installation, and operation of bagasse dryers requires balancing of several conflicting parameters and is a complex process. Bagasse drying techniques can save up to 12.7 percent bagasse, however, and are worthy of investigation.

Heat value of bagasse can be improved by using bagasse dryers. Handling and storage of bagasse for off-season use can be improved by baling or pelletization. This consideration only comes into play if off-season operations are to be considered.

C. GENERAL APPROACH

In order to set-up a viable privately-financed power project in line with the preceding discussion and to take it a step further, two basic guidelines must be adhered to; (1) The boiler(s) and turbine-generator(s) must be operated at as high a capacity factor as possible, and at as high a steam temperature and pressure as possible to operate at a high efficiency, and on the peak efficiency part of the efficiency vs. load curves. Generally, the boiler and turbine operations are most efficient in the 70 to 90% of capacity range; and (2) the plant must operate as close to full time as possible, as it is necessary to minimize the capital cost recovery component contribution to the price per kWh produced. With sugar factory season limitations for non-grinding season operations this will normally require use of a supplementary fuel. Supplementary fuel options for the non-grinding season can include residual fuel oil, wood chips and sawdust, rice hulls, rice straw and possibly other agriculture residues including the cane tops or trash, if the collection and delivery system can be commercialized at the right price. USAID, for example, has funded R&D programs to define the cost and to determine the viability of collecting and transporting cane trash to specific sugar factories in Jamaica, the Philippines, and Thailand. When a supplementary fuel is used that must be purchased, the amount purchased raises the average fuel cost component of each kWh produced; hence, the use of high value fuel must be minimized, and bagasse use maximized. As the supply of such fuels as agricultural residues, wood chips, and sawdust may be limited, the immediate fuel alternatives normally are cane trash or residual oil. The cane trash could provide a significant contribution, but probably not immediately, as it requires a substantial increase in the equipment infrastructure necessary for harvesting and transport. While the residual oil is immediately available, it normally involves additional petroleum or product imports and can have both financial and economic repercussions.

For illustrative purposes, referring to Figure I-3, it can be assumed that the high-pressure topping or extraction turbine-generator, and part of the normally found back-pressure turbine-generators could be operated regularly, with other back-pressure turbine-generators used for sugar production back-up. The output of the topping unit, or the bulk of an extraction unit output, could be dedicated to the grid supply. A generation capacity at any given time of 15 MW is assumed for these illustrative purposes, with 4.5 MW being used by the mill itself. A 180-day grinding season is assumed along with a 155-day non-grinding season, with a 30-day maintenance and overhaul period constituting a typical year. If the turbine generators are operated at an 85% capacity factor, based on 24 hr/day operation, the generation potential would be:

15000 kW x .85 x 24 x 335 = 102.51 million kWh/year
(out of a potential of 120.60 million kWh per year)

For 180 days: 15000 KW x .85 x 24 x 180 = 55.08 million kWh per grinding season.

Figure I-3: Topping Cycle Cogeneration Configuration Using Extraction/Condensing Steam Turbine

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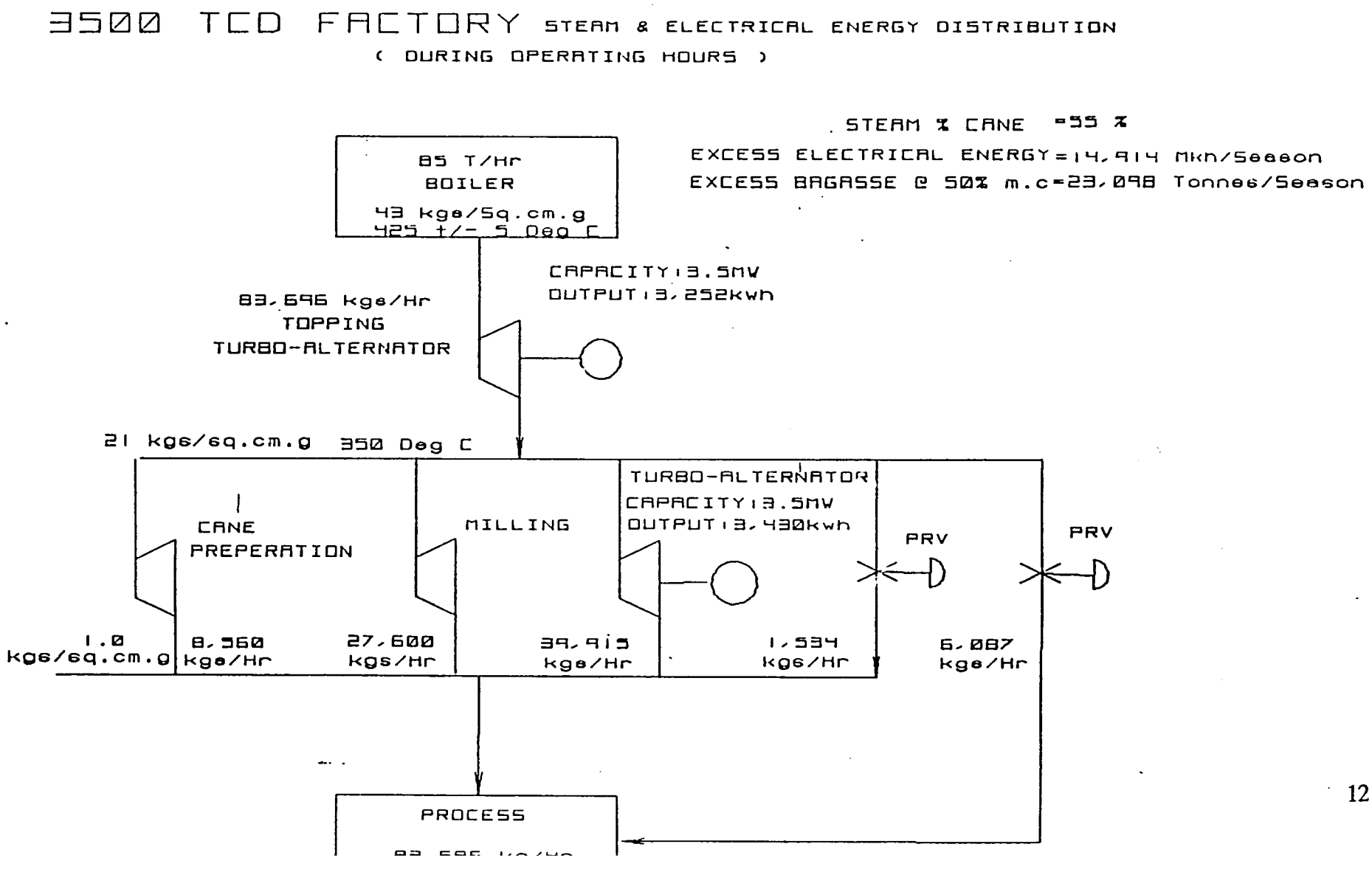

In this illustrative case for the grinding season of 180 days, the amount of kWh available for sale to the grid would essentially be 10,000 kw x .85 x 24 x 180 = 36.72 million kWh. During the non-grinding season (155 days) depending on the condensing capacity installed, we can assume a minimum of 10,000 x .95 x 24 x 155 = 35.34 million kWh to be available for sale to the grid for an annual potential of 72.06 million kWh, or a capacity factor of 82.26% for the 10,000 KW devoted to grid supply, or 55% on the full 15,000 kw capacity.

For any other size system, one can ratio the kWh produced, but only if the fuel supply is available on firm basis for a larger desired output. It is quite obvious that higher capital cost, higher interest rate, a shorter capital recovery time, and a lower capacity factor will all increase the cost of production component for each kWh produced, hence these are all target areas for optimization activities.

So as to not be overly simplistic, the sugar factory heat balance during the grinding season will actually dictate the amount of kWh to be sold to the grid, and its heat balance will vary according to the amount of cane available for processing and the fiber content at any given time. We also must account for the power generation facility's own energy demand which can require up to 6 or 8% of the rated capacity. The assumption here is that these are covered, and we are working with net outputs for the illustrative purposes.

During the non-grinding season, either full or partial condensing capacity (whichever was designed into the plants) will be used to allow independent operation of the power facility with the supplementary fuel supply. In some cases, evaporators and vacuum pans can be utilized as heat sinks to augment the condenser capability, or full condensing capability is installed, such that the non-grinding season kWh can approach the full-rated output of the installed capacity.

D. FUEL CONSIDERATIONS

At essentially full load, for illustrative purposes, a topping cycle (back-pressure turbines only) using two turbines in series operating with 600 psi 640°F inlet steam and exhausting at 15 psi needs 27.53 lb steam per kWh. Therefore, to produce 15000 kWh would require 412,950 lb. per hour of steam.[1] This translates to about 454.25 million Btu/hr fuel input corrected to about 698.85 million Btu/hr at 65% boiler efficiency, or 534.41 million Btu/hr at 85% boiler efficiency (residual oil case). For bagasse-fired boilers operating at 600 psig and 640°F, it is expected that 2.5 tons of steam will be produced by a ton of bagasse so that 82.6 tons of bagasse will be needed. At 24 hours per day operation for a 180-day grinding season,

82.6 x 24 x 180 = 356,832 tons bagasse required per season

At 30% by weight bagasse content, 356,832 tons bagasse divided by .30 yields 1,189,440 tons of cane to be processed (30% by weight of cane, based on 15% fiber and 50% moisture content wet basis) to rely totally on bagasse for the grinding season to be able to produce 64.80 million kWh of electricity for use by the sugar factory, or for export to the grid. Tempered by an 85% capacity factor, 55.08 million kWh would be produced requiring essentially the processing of one million tons of cane. When viewed from this perspective, steam conditions must be pushed as high as possible to make every ton of cane processed yield the maximum kWh production. Power generation during the non-grinding system will likely be almost totally dependent on the supplementary fuels, if the sugar factory is operated in the mode typical of most of the world. The tradition of incinerating the bagasse as a troublesome waste still haunts the sugar industry, and theoretical availability rates for excess bagasse are rarely achieved.

At a fuel oil price close to US $17.00 per barrel, the fuel only cost for the non-grinding season operating in a condensing made would translate to about 3.70 cents U.S. per kWh produced, if only oil is burned at 25% fuel tank to bus bar efficiency. At $34.00 per barrel the fuel cost only rises to 7.40 cents U.S. per kWh produced. For back-pressure turbines this cost would likely increase significantly. It is obvious that for a privately-funded power project using only back-pressure turbines, the efficiency of electricity production will not be

[1] It is probable that steam conditions of at least 650 psi 750°F will be necessary to produce a high enough efficiency for a viable project, while temperatures up to 850°F can be considered in certain cases. The 650°F is normally thought of as a way of avoiding the use of very expensive superheater high temperature resistant alloys. It is likely that sensitivity analysis will be required to define the optimum steam temperature for these projects.

high enough to use an expensive secondary fuel for non-grinding season operation, and that condensing systems are mandatory for full year considerations.

An extraction/condensing turbine generator can provide electricity at over twice the efficiency of the typical back-pressure configuration, if sufficient steam is generated to satisfy both power and process needs. The condensers will also allow a steam balance to be closed during both the grinding and the non-grinding season at high boiler and turbine loads permitting optimum efficiency operations. Burning totally residual fuel oil in this case which results in a fuel only cost component of not less than 3.70 cents U.S. per kWh could still be considered during the non-grinding season because it is diluted by the grinding season bagasse produced power cost. The availability of more excess bagasse or wood chips/sawdust/rice hull and/or cane trash must be pursued as it has both financial and economic implications that can be used to determine overall project viability.

E. FIRM CAPACITY PROJECT BOUNDARIES

The project boundaries for a viable firm-capacity project assuming private financing can therefore be set as follows for a minimum 5 MW of electricity available for sale to the grid:

1. A high-pressure and temperature steam cycle must be employed, most likely with a condensing/extraction turbine.

2. For non-grinding season operations, the total amount of bagasse and/or supplementary waste fuel such as wood chips, cane trash, straw, etc. must be such that the average fuel cost component of the power production cost is minimized. A 5 MW project will be difficult to achieve if the annual cane processed by the factory is less than 400,000 tons.

3. The rate of return made by the sugar factory owners/private power investors on electricity should be treated as an incentive in terms of attracting the sugar industry to produce and sell electricity for profit, just as they historically have done for sugar.

4. Interest rates offered by specific country Export-Import Banks, some development banks and private power funds will have a direct input into the capital cost recovery component of the total cost per kWh produced.

5. The power purchase agreement should at least match investor loan terms in years, and should be responsive to the fact that these projects can be treated as firm capacity year round if desired, and if adequate supplementary fuel contracts are provided.

Any sugar factory with a history of insufficient access to cane, or one that has irrigation water limitations that inhibit optimum cane productivity, or even no access to substantial amounts of other low-cost waste fuels, would appear to be at best a marginal site at which to consider a private power project. There is, however, generally sufficient potential for feasibility evaluative procedures to be undertaken at most sugar factories, if they process 400,000 tons or more of cane in a season, and if petroleum based fuel use can be proven to be essential for adequate revenue generation to cover debt service on an otherwise attractive project.

F. SITE SPECIFIC EVALUATION CRITERIA

The above discussion was based on a generic, hence somewhat simplistic, approach. The truth is that there is much complexity which must be dealt with in any site specific evaluation. A successful project can, however, be structured at one or more sugar factories in most countries, if the power company has the mandate to promote a multiplicity of private power projects and can pay adequate rates.

To identify and define a site-specific project will require dealing thoroughly with the following issues:

1. Fuel resources availability and firm supply contracts;

2. Water availability for processing and irrigation;

3. Clear guidelines from the power company regarding pricing, interconnection, fault protection, length of agreement, etc;

4. Optimum project sizing;

5. Optimum fuel mix for project life;

6. Optimum finance packaging including supplier credits and/or other concessionary rates;

7. Optimum steam balance for both sugar and power production;

8. Potential for partnership arrangements including offshore participation, if needed; and

9. Steam sales to the sugar factory for meeting process needs, if third parties are to become interested.

For any sited project, accurate projections must be made of maximum annual cane production based on historical date. For any site, a decision must be made based on risk analysis, regarding how much the total project payback depends on the availability of either cane from private lands (vs. estate-controlled), and on the availability of waste fuels other than residual oil, i.e. wood waste or other residues from both estate and private sources. For private power in the sugar industry, there will most likely always be an evaluation of supplementary fuels to get the capacity/availability factor necessary to make a viable project.

The efficiency of producing sugar has been only lightly treated thus far in this brief look at sugar industry private power potential. The efficiency upgrade, other than in newly designed factories, will likely result from the realization of profits from initial electricity sales, even if from only seasonal surplus. Once tangible revenues are generated, factory owners will be more likely to consider further investments in generating capacity and efficiency upgrades that will yield more bagasse to produce more power, hence revenues. It is not likely that efficiency upgrade investments will be made simply to produce sugar more efficiently, as that is what history confirms. Given the proper motivation in terms of potential financial rewards from power sales, and real results in key sugar industry facilities, the industry can be expected to respond and provide a substantial input into the Power Sector, and to increase the efficiency of bagasse use as an indigenous national energy resource.

G. STATUS OF THE SUGAR INDUSTRY

The sugar industry in Pakistan evolved from a relatively small base at the time of partition to its present status of importance in the agribusiness and agriculture sectors. As a cash crop, by 1988 it was second only to cotton, and it trailed only textiles in order of importance in the processing sector. In 1987 there were 41 sugar mills in Pakistan with the total reaching 48 by 1990 and more are planned. The estimated production capacity of these 48 mills is currently over 1.8 million tonnes of sugar per year.

The sugar is produced predominantly from sugarcane. The acreage under cane was reported as 842,000 hectares in 1989-90. In 1987 it accounted for 3.9% of the total cropped area, and 10.5% of the total value added for all crops in Pakistan. It is also a large employer with the average mill employing 1200 people during the grinding season. In 1987, Punjab province accounted for over half of the total cane produced, although there has been a shift in production to the Sind in recent years. Sugarcane is produced by approximately 500,000 farmers, mostly small, as one crop of many others. Only in the Sind are there large commercial farms specializing in cane production. Pakistan is just out of the tropics zone and is reported to use a relatively short cane growing season of 8-12 months, and the cane production is heavily dependent on fertilization and irrigation. The crop has proven to be very sensitive to severe drought conditions.

At the mills, the cane is sold on the basis of weight which is an unusual situation, although an experimental program is underway to tie the sales price to sugar content, hence sugar delivered to the mill. The sales by weight is an invitation to deliver a rather dirty cane supply, probably laced with significant cane trash and dirt. The sugar cane yield per hectare is reported to average between 38 and 40 tonnes (actually 42.98 reported for 1989-90), which is relatively low by international standards. Pakistan's neighbor India averages over 60 tonnes per hectare. There are many reasons for Pakistan's low average, but for the purposes of this report, it suffices to say that there is potential for increased productivity in the near future.

An important fact for consideration at this time is the age of the sugar mills which can be deduced from the following table:

Period	No. of Mills Established	Processing Capacity (tons per day cane)
before 1950	2	1800
1951-60	4	9450
1961-70	13	24400
1971-80	12	24000
1981-86	10	22000
1987-90	7	42600
Total	48	*124250

* Another source puts the installed capacity at 142,000 tonnes cane per day, and the above capacities are probably understated because of tax laws, except for the 1987-90 period.

Of the 41 mills installed prior to 1987, 9 are in the public sector, representing about 25% of the pre 1987 installed capacity. The relatively young age of the industry suggests that the factories should be relatively energy efficient, and if they are not, that efficiency improving actions should be effective.

The geographic distribution of the first 41 of the above mills is as follows:

	No. of Mills	Annual Sugar Capacity, tonnes	%
Punjab	20	522,240	45
Sind	16	455,040	39
NWFP	5	194,445	17
Total	41	1,171,725	100

It is likely that the distribution of all 48 mills has the Sind closing in on the Punjab, which is the largest producing area. The existing mills range in cane crushing capacity from 600 tonnes per day to well over 5000 tonnes per day, though the average size would be about 2000-2500 tonnes per day. More recently, there has been a trend towards the construction of larger mills, and the enlarging of existing mills, to improve efficiencies and lower unit production costs. The number of mills that crushed at least 400,000 tonnes of cane in the 1989-90 season were 28, according to the Technical Results of the 1989-90 season as published by the Pakistan Society of Sugar Technologists:

Sr. No	Name of Factory	Tonnes Cane Crushed
6	Shahtaj	452,906
12	Fauji S. Hill	643,399
13	Crescent	456,415
14	Husein	438,249
15	Pattoki	480,452
17	G. Samundri	465,104
18	Kamalia	543,807
19	Baba Farid	450,483
20	Ittefaq	745,335
21	Shakargang	708,632
25	United	431,360
26	Punjab	422,711
27	Brothers	424,266
30	Consolidated	451,244
31	Dadu	487,435
32	Alnoor	779,724
33	Habib	842,064
34	Mirpur Khas	582,187
35	Mehran	554,064
36	Fauji TM Khan	602,835
37	Bawani	552,696
38	Fauji Khoski	686,722
40	Shamurad	638,339
41	Faran	475,746
43	Sind Abadgars	510,787
44	Pangrio	458,952
45	Dewan	945,812
46	Sanghar	526,584

Note: There were 6 additional mills that crushed between 350,000 and 399,000 tonnes in 1989-90.

A potential complication for consideration of the sugar industry as a source of energy for grid electricity is the fact that until recently, bagasse was used as a feed stock for both paper and chipboard manufacture. While this might confirm that some of the sugar mills are relatively efficient, as they apparently generate their own power and steam from bagasse, yet still supply bagasse as a by-product, it also suggests that there is already a market value for bagasse which electricity production will have to compete with. In reality, the bagasse sold as a by-product might be a trade off where the revenues are used to buy furnace oil as an energy replacement.

The efficiency of the sugar mills is, however, questionable as the reported use of firewood and furnace oil (residual fuel oil) suggests. The usage rate varies from nil to a peak of 10 tonnes of firewood and 3887 liters of furnace oil per each 100 tonnes of cane processed. Only 5 mills out of 48 report no supplemental fuel use at all, while 10 report no use of firewood and 13 report no use of furnace oil. There would appear to be some very efficient mills, and some rather inefficient ones. The best candidates for grid electricity supply power projects are obviously the most efficient mills, while it is in the national interest to upgrade the wasteful performance of the inefficient mills. Each sugar mill proposing a private power project should have its historical performance scrutinized for the existing mills, and the design carefully reviewed for new mills.

Another interesting fact is that the sugar producers in Pakistan are profitable. Rates of return for the industry as a whole have been reported as follows by the Karachi Stock Exchange Reports for 1980-1986:

Year	Return on Investment %	Return on Equity %
1980	7.7	8.1
1981	19.5	32.2
1982	21.1	31.5
1983	15.5	22.8
1984	10.5	11.9
1985	13.4	21.2
1986	19.1	28.2

Profitable ventures are most willing to make further investments that will pay-back within reasonable periods, and that will increase profitability. While the mill owners tend to voice dissatisfaction with their profits, the fact remains that they are profitable. The private mills have been paying regular and excellent dividends to their investors, and are in good position to finance new projects.

H. SUGAR INDUSTRY POWER POTENTIAL

Pakistan has 28 mills that crushed 400,000 tonnes or more of cane in the 1989-90 season. Using a conservative factor that crushing 90,000 tonnes of cane will provide enough bagasse to produce 1 net mw of excess power per season (net here means that the sugar factory power needs have already been met), the cane crushed table presented in the last section can be expanded to show potential kW capacity available for sale to the grid. The assumption is made that new high temperature, high-pressure boilers and turbine generators will have to be procured to realize fully this potential. One potential advantage in Pakistan is that every piece of hardware excepting the steam turbines can be produced in-country, helping to stimulate the economy, while saving foreign exchange if the local boilermakers can increase the pressure and temperature ratings they can supply. This approach uses only commercially proven technology. Experimental systems such as proposed by Princeton University in the USA using bagasse gasifiers and steam injected gas turbines theoretically could extract 2 to 3 times the energy that conventional technology is capable of; however, the Princeton approach has never been used in a sugar factory anywhere. The expanded cane crushed table based on the use of conventional technology looks as follows, with the sugar factory needs already subtracted out:

Sr. No	Name of Factory	Tonnes Cane Crushed	Net MW Available
6	Shahtaj	452,906	5.03
12	Fauji S. Hill	643,399	7.15
13	Crescent	456,415	5.07
14	Husein	438,249	4.87
15	Pattoki	480,452	5.34
17	G. Samundri	465,104	5.17
18	Kamalia	543,837	6.04
19	Baba Farid	450,483	5.01
20	Ittefaq	745,335	8.28
21	Shakargang	708,632	7.87
25	United	431,360	4.79
26	Punjab	422,711	4.70
27	Brothers	424,266	4.71
30	Consolidated	451,244	5.01
31	Dadu	487,435	5.42
32	Alnoor	779,724	8.66
33	Habib	842,064	9.36

Sr. No	Name of Factory	Tonnes Cane Crushed	net MW Available
34	Mirpur Khas	582,187	6.47
35	Mehran	554,064	6.16
36	Fauji TM Khan	602,835	6.70
37	Bawani	552,696	6.14
38	Fauji Khoski	686,722	7.63
40	Shamurad	638,339	7.09
41	Faran	475,746	5.29
43	Sind Abadgars	510,787	5.68
44	Pangrio	458,952	5.10
45	Dewan	945,812	10.51
46	Sanghar	526,584	5.85
		Total MW Potential	175.10

Note: The 6 additional mills with cane crushing capacities between 350,000 tonne and 399,999 tonnes would add another 25 MW so that the estimated potential can be rounded off at 200 MW.

The total of 200 MW is significant, but the reader is cautioned that this is a theoretical potential, even if it is a conservative estimate. What it does show, however, is that the sugar industry, when treated as an indigenous energy resource and potential supplier, can make a significant contribution in the power sector, mainly in the more rural areas where the kWh and voltage control potential can have excellent value. Taken in another context, the 200 MW at a dry season capacity factor of .9 would produce 200,000 x .9 x 24 x 180 = 777.6 million kWh. If this displaces thermally generated kWh with an estimated fuel incremental cost of $0.04 per kWh, the dry season potential fuel savings to WAPDA would be $31,104,000. Taken on a full year basis, but using this power source only during peak hours of the wet season, the total annual fuel savings is significant, and could easily exceed $45 million per year. While these are estimates, that must be confirmed by detailed analysis of site specific projects, and by analysis of WAPDA's actual cost of production, they indicate the magnitude of the value of encouraging sugar industry to participate in private power development. As a point of reference, the proposal to the Private Power Cell by Mr. Saifullah A. Paracha would supply 9 MW of power to the grid during the crushing season and 11 MW during the off season from the crushing of 720,000 tonnes of cane. While this proposal appears to produce about 20% more power than the conservative factors utilized in this report will allow, it is possible to achieve such an output if the steam conditions are pushed hard enough. It is suggested, however, that the 84% boiler efficiency proposed by Mr. Paracha is optimistic, and his final engineering will lead him to revise his estimate of power output downward. The specific Paracha proposal will be discussed more fully later in this report.

I. SUGAR INDUSTRY PROJECT CATEGORIES

In terms of supplying power to the grid, individual sugar mills can take one of three approaches, or sequentially more than one, although the focus of this report thus far has been on only one approach. Basically, well run sugar mills can produce excess bagasse during the grinding season. All mills should have more turbine generator capacity installed than needed for processing, and by disrupting their steam balance somewhat, can combust this excess bagasse, and supply excess kWh to the grid during peak hours, or throughout the day if need be, if sufficient bagasse exists. While no individual mill could supply great amounts of power in this manner, the aggregate of multiple mills, especially if available during peak hours, could be considerable. This approach does not produce firm capacity that can be relied upon, but also does not require any major capital investment. A crude estimate would suggest that perhaps a maximum of 50 MW could be made available at the same time.

The second approach that mill owners can take is to make modest investments in most likely used equipment (turbine generators and perhaps boilers) that would allow the mill to produce more electricity from surplus bagasse during the grinding season only. This does have the intent of supplying power 24 hours per day, or at least most of the day during the season. This approach can produce firm capacity for the grinding season, although it may not in all cases. A crude estimate would suggest that perhaps 100 MW of firm capacity could be made available in this manner.

The third approach is a commercial business approach considering electricity a product that can be produced profitably year-round, if a supplementary fuel is available at the right price. In this case, a substantial investment is made in used, but preferably new, high-pressure-high temperature steam boilers and extraction/condensing turbine generators that allow the electricity production to be maximized. Some trade-off analysis will be needed to determine if importing steam boilers that have higher pressure/temperature capabilities than can be manufactured in Pakistan will produce sufficient benefits to justify the economic cost. The investment in this case is large enough that it will require adequate revenue generation year-round to cover debt service and to make an adequate return on investment. The sugar mill is investing in a firm capacity facility that the utility can rely on all year. In these cases, it is necessary that each sugar mill designing their own specific project be encouraged to search for supplementary fuels such as sawmill residues or other agricultural residues that could be utilized without difficulty in the bagasse boilers. Only after such a search is completed with negative results, should residual oil burning be accepted for supplementary off season purposes.

In conclusion, we can have 3 categories of sugar mill private power projects:

1. Year round firm capacity with crushing season bagasse burning and supplementary fuel for the off season;

2. Seasonal firm capacity, bagasse based; and

3. Seasonal time of day surplus power occasionally, bagasse based.

The value of each category to the power company purchasing the kWh and to the country itself will vary. As Pakistan has definite wet and dry seasons that correlate with winter and summer, and has a significant hydro component in its power plant inventory, dry season power, especially during the peak demand hours should have the highest value. Wet season, night time power should have the lowest value. Therefore it should be possible to structure a tariff schedule of the sugar industry that is both equitable to the sugar industry , and in-line with the time of day value of power to the power company.

SECTION II

IMPLEMENTATION OF PRIVATE POWER PROJECTS IN THE SUGAR INDUSTRY IN PAKISTAN

A. BACKGROUND

The Government of Pakistan has adopted a well publicized policy of encouraging private power development. With coordination from the World Bank, USAID, and other lending and donor agencies, a major private power program has been initiated. The GOP has established the internal mechanisms to evaluate and act on solicitations from private power developers. A high percentage of the private power proposals received involve international consortia which, while bringing non-traditional sources of finance to bear against Pakistan's growing shortage of power, will also transfer a portion of the resulting financial benefits offshore.

The sugar industry of Pakistan provides an opportunity to utilize an indigenous Pakistani industry waste product (bagasse) as a fuel resource.

As the potential power contribution from the sugar industry can vary from 50 MW to 200 MW+, depending on the GOP policy decision which itself will be a function of the price per kWh authorized, the GOP should seek to maximize the contribution as long as the authorized price is not out of line with other approved prices in the overall private power program.

As the 200 MW potential contribution is produced at its least cost when the sugar factory is operating because the bagasse fuel source is essentially free, grinding season power supply should be the focal point. The sugar milling season correlates well with the Pakistan winter (or dry period) such that the hydro capacity is inhibited and thermal asset use is maximized. WAPDA does utilize gas turbines for peaking and intermediate dispatch, such that there can be significant variations in WAPDA's own cost per kWh produced on a time of day basis. The most logical approach is to develop an estimated time of day cost of production profile and to average it out for winter day and night plus summer day and night. While a separate Control Work Plan will be required to do an accurate cost of production analysis, certain estimates can be made to bracket the value of a bagasse-produced kWh on a time of day basis.

B. TARIFF DETERMINATIONS AND CONTRACTS

In line with the three categories of projects the sugar companies could pursue, WAPDA could structure a standard agreement at three specific prices based on what implementation strategy is preferred. After meeting with WAPDA's Private Power Cell staff, the IRG WAPDA Advisor, and the WAPDA Member (Power), a basic strategy was decided upon. If the sugar companies can actually provide a reliable source of power, especially during the dry season at a reasonable delivered kWh price, it should be encouraged. The basic approach would be to set prices that are time of day averaged for both the dry and wet seasons whose value to WAPDA is in-line with its own cost of production during those specific time periods, i.e. dry season peak hours highest value; wet season night hours lowest value.

In order to set the price levels, WAPDA must know its own cost of production on both a peak/off-peak basis, and a seasonal basis. A CWP is under consideration which would bring in the appropriate short term expertise to formally develop this information. In the meanwhile, WAPDA has turned over certain kWh information vs. fuel consumption and cost data (both historical and projected) such that estimates with a comfortable degree of confidence can be made to support preliminary pricing decisions. To do this, WAPDA has agreed to turn over peak-day 24 hour demand curves for the 6 driest months and more cost details, if possible.

In theory, one price could be produced for the wet season power and one for dry season, both based on time of day averaging for WAPDA's production cost. Working with 4-12 mw blocks of capacity, it does not seem reasonable nor necessary to break the price down into capacity and energy increments, but to work with a time of day averaged number such that a capacity credit is averaged into the total cost. It is also not necessary to consider avoided cost calculations, even though the aggregate capacity for the sugar industry as a whole could help defer major new capacity decisions. The difficulty with only one unified price would be if WAPDA wished to <u>maximize</u> the capacity that the sugar industry make available. If it is to be maximized, a three-tiered, pricing scheme for both wet and dry season power could provide the proper incentive.

The following numbers are indicative only, and are preliminary. They are used here to demonstrate a concept, and <u>not</u> to propose firm prices. One should however, expect the final numbers to be relatively close to the ones here presented:

Price per kWh, rupees
Time of day average vs. value to WAPDA

Season	Surplus kWh No Investment	New Capacity Used Equipment	New Capacity New Equipment
Dry (6 months)	.65-.70	.85-.95	1.10-1.20
Wet (6 months)	.35-.40	.55-.60	.75-.80

This type of pricing should provide incentive for the sugar mills to invest in the new capacity.

One could simplify matters greatly by offering only one price such as 1.00 rupees per kWh dry season and .50 rupee per kWh wet season (or even prohibit wet season kWh depending on WAPDA internal reserve capability). This would not motivate the sugar industry to make the necessary investment to develop the maximum contribution of capacity, but would result in a lesser, but still significant sugar industry response.

The sugar industry will likely respond as the revenue generation potential is significant:

1 MW of capacity available for the dry season only would generate 1000 x 180 x 24 = 4.32 million kWh; if peak hours represent 6 hours per day, this still results in

$$\frac{4.32 \text{ million kWh}}{4} = 1.08 \text{ million kWh}$$

R O.70 x 4.32 million kWh = 3.024 million rupees
R O.70 x 1.08 million kWh = 756,000 rupees

At 1 rupee per kWh these would increase accordingly:
For a new 10 mw installation operating year round
R 1.20 x 10,000 kw x 180 x 24 + R .80 x 10,000 x 180 x 24 = 51,840,000 + 34,56,000 = 86,400,000 ru per year. If after O & M costs, debt services etc, the sugar mill makes only 10 % of this as true profit, that is still 8,640,000 rupees. Is this sufficient incentive?

While somewhat simplistic, this type of exercise can be used to gauge the response potential of the sugar industry. It is important to restate that the main goal here is not to make additional profits for the sugar industry; it is to provide sufficient incentive so that the sugar industry will supply kWh to WAPDA at a price that will save WAPDA money. In short, WAPDA must gain, but also be willing in a sense to share the gain with the sugar industry.

The form of the contracts and their terms should be as simple as possible. A GOP policy decision is needed with regard to supplementary fuel use during the wet season, in terms of whether or not to encourage furnace oil use. The reality is the average between the wet and dry season prices would provide either the necessary incentive or disincentive for

APPENDIX A

GENERAL TERMS AND CONDITIONS

A-1 DEFINITIONS

Whenever used in this Agreement, appendices and attachments hereto, the following terms shall have the following meanings:

Designated WAPDA switching center: That switching center or other WAPDA installation identified in Article 5.

Facility: That generation apparatus described in Article 2 and all associated equipment owned, maintained, and operated by Seller.

Interconnection facilities: All means required and apparatus installed to interconnect and deliver power from the Facility to the WAPDA system including, but not limited to, connection, transformation, switching, metering, communications, and safety equipment, such as equipment required to protect (1) the WAPDA system and its customers from faults occurring at the Facility, and (2) the Facility from faults occurring on the WAPDA system or on the systems of others to which the WAPDA system is directly or indirectly connected. Interconnection facilities also include any necessary additions and reinforcements by WAPDA to the WAPDA system required as a result of the interconnection of the Facility to the WAPDA system.

Net energy output: The Facility's gross output in kilowatt-hours less station use and transformation and transmission losses to the point of delivery. Where WAPDA agrees that it is impractical to connect the station use on the generator side of the power purchase meter, WAPDA may, at its option, apply a station load adjustment.

Prudent electricity practices: Those practices, methods, and equipment, as changed from time to time, that are commonly used in prudent electrical engineering and operations to design and operate electric equipment lawfully and with safety, dependability, efficiency and economy.

Special facilities: Those additions and reinforcements to the WAPDA system which are needed to accommodate the maximum delivery of energy and capacity from the Facility as provided in this Agreement and those parts of the interconnection facilities which are owned and maintained by WAPDA at Seller's request, including metering and data processing equipment. All

special facilities shall be owned, operated, and maintained pursuant to WAPDA's normal policy.

Station use: Energy used to operate the Facility's auxiliary equipment. The auxiliary equipment includes, but is not limited to, forced and induced draft fans, cooling towers, boiler feed pumps, lubricating oil systems, plant lighting, fuel handling systems, control systems, and sump pumps.

Surplus energy output: The Facility's gross output in kilowatt-hours, less station use, and any other use by the Seller, and transformation and transmission losses to the point of delivery into the WAPDA system.

Term of agreement: The period of time during which this Agreement will be in effect as provided in Article 7.

Voltage level: The voltage at which the Facility interconnects with the WAPDA system, measured at the point of delivery.

A-2 CONSTRUCTION

A-2.1 Land Rights

Seller hereby grants to WAPDA all necessary rights of way and easements to install, operate, maintain, replace, and remove the special facilities, including adequate and continuing access rights on property of Seller. Seller agrees to execute such other grants, deeds, or documents as WAPDA may require to enable it to record such rights of way and easements. If any part of WAPDA's equipment is to be installed on property owned by other than Seller, Seller shall, at its own cost and expense, obtain from the owners thereof all necessary rights of way and easements, in a form satisfactory to WAPDA, for the construction, operation, maintenance, and replacement of WAPDA's equipment upon such property. If Seller is unable to obtain these rights of way and easements, Seller shall reimburse WAPDA for all costs incurred by WAPDA in obtaining them. WAPDA shall at all times have the right of ingress to and egress from the Facility at all reasonable hours for any purposes reasonably connected with this Agreement or the exercise of any and all rights secured to WAPDA by law or its tariff schedules.

A-2.2 Design, Construction, Ownership, and Maintenance

(a) Seller shall design, construct, install, own, operate, and maintain all interconnection facilities, except special facilities, to the point of interconnection with the WAPDA system as required for WAPDA to receive as-delivered capacity and energy from the Facility. The Facility and interconnection facilities shall meet all requirements of applicable codes and all standards of prudent electrical practices and shall be

maintained in a safe and prudent manner. A description of the interconnection facilities for which Seller is solely responsible is set forth in Appendix D or if the interconnection requirements have not yet been determined at the time of the execution of this agreement, the description of such facilities will be appended to this Agreement at the time such determination is made.

(b) Seller shall submit to WAPDA the design and all specifications for the interconnection facilities (except special facilities) for review and written acceptance prior to their release for construction purposes. WAPDA shall notify Seller in writing of the outcome of WAPDA's review of the design and specifications for Seller's interconnection facilities within 30 days of the receipt ot the design and all of the specifications for the interconnection facilities. Any flaws perceived by WAPDA in the design and specifications for the interconnection facilities will be described in WAPDA's written notification. WAPDA's review and acceptance of the design and specifications shall not be construed as confirming or endorsing the design and specifications or as warranting their safety, durability, or reliability. WAPDA shall not, by reason of such review or lack of review, be responsible for strength, details of design, adequacy, or capacity of equipment built pursuant to such design and specifications, nor shall WAPDA acceptance be deemed to be an endorsement of any such equipment. Seller shall change the interconnection facilities as may be reasonably required by WAPDA to meet changing requirements of the WAPDA system.

(c) In the event it is necessary for WAPDA to install interconnection facilities for the purposes of this Agreement, they shall be installed as special facilities.

(d) Upon the request of Seller, WAPDA shall provide a binding estimate for the installation of interconnection facilities by WAPDA.

A-2.3 Meter Installation

(a) WAPDA shall specify, provide, install, own, operate and maintain as special facilities all metering and data processing equipment for the registration and recording of energy and other related parameters which are required for the reporting of data to WAPDA and for computing the payment due Seller from WAPDA.

(b) Seller shall provide, construct, install, own, and maintain at Seller's expense all that is required to accommodate the metering and data processing equipment, such as, but not limited to, metal-clad switchgear, switchboards, cubicles, metering panels, enclosures, conduits, rack structures, and equipment mounting pads.

(c) WAPDA shall permit meters to be fixed on WAPDA's side of the transformer. If meters are placed on WAPDA's side of the transformer, service will be provided at

the available primary voltage and no transformer loss adjustment will be made. If Seller chooses to have meters placed on Seller's side of the transformer, an estimated transformer loss adjustment factor of 2 percent, unless the Parties agree otherwise, will be applied.

A-3 ENERGY SALE OPTIONS

A-3.1 General

Seller has two energy sale options, net energy output or surplus energy output. Seller has made its initial selection in Article 2(a).

A-3.2 Energy Sale Conversion

(a) Seller is entitled to convert from one option to the other 12 months after execution of this Agreement, and therefore at least 12 months after the effective date of the most recent conversion, subject to the following conditions:

(1) Seller shall provide WAPDA with a written request to convert its energy sale option.

(2) Seller shall comply with all applicable tariffs on file and contracts in effect between the Parties at the time of conversion covering the existing and proposed (i) facilities used to serve Seller's premises and (ii) interconnection facilities.

(3) Seller shall install and operate equipment required by WAPDA to prevent WAPDA from serving any part of Seller's load which is served by the Facility and not under contract for WAPDA standby service. At Seller's request, WAPDA shall provide this equipment as special facilities.

(b) If, as a result of an energy sales conversion, Seller no longer requires the use of interconnection facilities installed and/or operated and maintained by WAPDA as special facilities under a Special Facilities Agreement, Seller may reserve these facilities, for its future use, by continuing its performance under its Special Facilities Agreement. If Seller does not wish to reserve such facilities, it may terminate its Special Facilities Agreement.

If Seller's energy sale conversion results in its discontinuation of its use of WAPDA facilities not covered by Seller's Special Facilities Agreement, Seller cannot reserve those facilities for future use. Seller's future use of such facilities shall be contingent upon the availability of such facilities at the time Seller requests such use. If such facilities are not available, Seller shall bear the expense necessary to install, own, and

maintain the needed additional facilities in accordance with WAPDA's applicable tariff.

A-4 OPERATION

A-4.1 Inspection and Approval

Seller shall not operate the Facility in parallel with WAPDA's system until an authorized WAPDA representative has inspected the interconnection facilities and WAPDA has given written approval to begin parallel operation. Seller shall notify WAPDA of the Facility's start-up date at least 45 days prior to such date. WAPDA shall inspect the interconnection facilities within 30 days of the receipt of such notice. If parallel operation is not authorized by WAPDA, WAPDA shall notify Seller in writing within five days after inspection of the reason authorization for parallel operation was withheld.

A-4.2 Facility Operation and Maintenance

Seller shall operate and maintain its Facility according to prudent electrical practices, applicable laws, orders, rules, tariffs and shall provide such reactive power support as may be reasonably required by WAPDA to maintain system voltage level and power factor. Seller shall operate the Facility at the power factors or voltage levels prescribed by WAPDA's system dispatcher or designated representative. If Seller fails to provide reactive power support, WAPDA may do so at Seller's expense.

A-4.3 Point of Delivery

Seller shall deliver the energy at the point where Seller's electrical conductors (or those of Seller's agent) contact WAPDA's system as it shall exist whenever the deliveries are being made or at such other point or points as the Parties may agree in writing. The initial point of delivery of Seller's power to the WAPDA system is set forth in Appendix D.

A-4.4 Operating Communications

(a) Seller shall maintain operating communications with the designated WAPDA switching center. The operating communications shall include, but not be limited to, system paralleling or separation, scheduled and unscheduled shutdowns, equipment clearances, levels of operating voltage or power factors, and daily capacity and generation reports.

(b) Seller shall keep a daily operations log for each generating unit which shall include information on unit availability, maintenance outages, circuit breaker trip operations

requiring a manual reset, and any significant events related to the operation of the Facility.

(c) If Seller makes deliveries greater than one megawatt, Seller shall measure and register on a graphic recording device power in kW and voltage in kV at a location within the Facility agreed to by both Parties.

(d) If Seller makes deliveries greater than one and up to and including ten megawatts, Seller shall report to the designated WAPDA switching center, twice a day at agreed upon time for the current day's operation, the hourly readings in kW of capacity delivered and the energy in kWh delivered since the last report.

(3) If Seller makes deliveries of greater than ten megawatts, Seller shall telemeter the delivered capacity and energy information, including real power in kW, reactive power in kVAR, and energy in kWh to a switching center selected by WAPDA. WAPDA may also require Seller to telemeter transmission kW, kVAR, and kV data depending on the number of generators and transmission configuration. Seller shall provide and maintain the data circuits required for telemetering. When telemetering is inoperative, Seller shall report daily the capacity delivered each hour and the energy delivered each day to the designated WAPDA switching center.

A-4.5 Meter Testing and Inspection

(a) All meters used to provide data for the computation of the payments due Seller from WAPDA shall be sealed, and the seals shall be broken only by WAPDA when the meters are to be inspected, tested, or adjusted.

(b) WAPDA shall inspect and test all meters upon their installation and annually thereafter. At Seller's request and expense, WAPDA shall inspect or test a meter more frequently. WAPDA shall give reasonable notice to Seller of the time when any inspection or test shall take place, and Seller may have representatives present at the test or inspection. If a meter is found to be inaccurate or defective, WAPDA shall adjust, repair, or replace it at its expense in order to provide accurate metering.

A-5 PAYMENT

WAPDA shall mail to Seller not later than 30 days after the end of each monthly billing period (1) a statement showing the kilowatt-hours delivered to WAPDA during on-peak, partial-peak, and off-peak periods during the monthly billing period, (2) WAPDA's computation of the payment due Seller, and (3) WAPDA's check in payment of said amount. Except as provided in Section A-6, if within 30 days of receipt of the statement Seller does not make a report in writing to WAPDA of an error, seller shall be deemed to

have waived any error in WAPDA's statement, computation, and payment, and they shall be considered correct and complete.

A-6 ADJUSTMENTS OF PAYMENTS

(a) In the event adjustments to payments are required as a result of inaccurate meters, WAPDA shall use the corrected measurements described in Section A-4.6 to recompute the amount due from WAPDA to Seller for the as-delivered capacity and energy delivered under this Agreement during the period of inaccuracy.

(b) The additional payment to seller or refund to WAPDA shall be made within 30 days of notification of the owing Party of the amount due.

A-7 ACCESS TO RECORDS AND WAPDA DATA

Each Party, after reasonable written notice to the other Party, shall have the right of access to all metering and related records including the operations logs of the Facility.

A-8 CURTAILMENT OF DELIVERIES AND HYDRO SPILL CONDITIONS

(a) WAPDA shall not be obligated to accept or pay for and may require Seller to interrupt or reduce deliveries of as-delivered capacity and energy (1) when necessary in order to construct, install, maintain, repair, replace, remove, investigate, or inspect any of its equipment or any part of its system, or (2) if it determines that interruption or reduction is necessary because of emergencies, forced outages, force majeure, or compliance with prudent electrical practices.

(b) In anticipation of a period of hydro spill conditions, WAPDA may notify Seller that any purchases of energy from Seller during such period shall be at hydro savings prices quoted by WAPDA. If Seller delivers energy to WAPDA during any such period, Seller shall be paid hydro savings prices for those deliveries in lieu of prices which would otherwise be applicable. The hydro savings prices shall be calculated by WAPDA using the following formula:

$$\frac{\Delta QF - S}{\Delta QF} \times PP$$

where: ΔQF = Energy, in kWh, projected to be available during hydro spill conditions from all qualifying facilities under agreements containing hydro savings price provisions.

S = Potential energy, in Kwh, from WAPDA hydro facilities which will be spilled if all sugar industry thermal output is delivered to WAPDA.

PP = Prices published by WAPDA for purchases during other than hydro spill conditions.

(c) WAPDA shall not be obligated to accept or pay for and may require Seller with a Facility with a nameplate rating of one megawatt or greater to interrupt or reduce deliveries of as-delivered capacity and energy during periods when purchases under this Agreement would result in costs greater than those which WAPDA would incur if it did not make such purchases but instead generated an equivalent amount of energy itself.

(d) Whenever possible, WAPDA shall give Seller reasonable notice of the possibility that interruption or reduction of deliveries under subsections (a) or (c), above, may be required. WAPDA shall give Seller notice of general periods when hydro spill conditions are anticipated, and shall give Seller as much advance notice as practical of any specific hydro spill period and the hydro savings price which will be applicable during such period. Before interrupting or reducing deliveries under subsection (c), above, and before invoking hydro savings prices under subsection (b) above, WAPDA shall take reasonable steps to make economy sales of the surplus energy giving rise to the condition. If such economy sales are made, while the surplus energy condition exists Seller shall be paid at the economy sales price obtained by WAPDA in lieu of the otherwise applicable prices.

(e) If Seller is selling net energy output to WAPDA and simultaneously purchasing its electrical needs from WAPDA, energy curtailed pursuant to subsections (b) or (c) above shall not be used by Seller to meet its electrical needs. When Seller elects not to sell energy to WAPDA at the hydro savings price pursuant to subsection (b) or when WAPDA curtails deliveries of energy pursuant to subsection (c), Seller shall continue to purchase all its electrical needs from WAPDA. If Seller is selling surplus energy output to WAPDA, subsections (b) or (c) shall only apply to the surplus energy output being delivered to WAPDA, and Seller can continue to internally use that generation it has retained for its own use.

A-9 FORCE MAJEURE

(a) The term force majeure as used herein means unforeseeable causes beyond the reasonable control of and without the fault or negligence of the Party claiming force majeure including, but not limited to, acts of God, labor disputes, sudden actions of the elements, actions by federal, state and municipal agencies, and actions of legislative, judicial, or regulatory agencies which conflict with the terms of this Agreement.

(b) If either Party because of force majeure is rendered wholly or partly unable to perform its obligations under this Agreement, that Party shall be excused from whatever performance is affected by the force majeure to the extent so affected provided that:

(1) the non-performing Party, within two weeks after the occurrence of the force majeure, gives the other Party written notice describing the particulars of the occurrence,

(2) the suspension of performance is of no greater scope and of no longer duration than is required by the force majeure,

(3) the non-performing Party uses its best efforts to remedy its inability to perform (this subsection shall not require the settlement of any strike, walkout, lockout, or other labor dispute on terms which, in the sole judgement of the Party involved in the dispute, are contrary to its interest. It is understood and agreed that the settlement of strikes, walkouts, lockouts, or other labor disputes shall be at the sole discretion of the Party having the difficulty), and

(4) when the non-performing Party is able to resume performance of its obligations under this Agreement, that Party shall give other Party written notice to that effect.

(c) In the event a Party is unable to perform due to legislative, judicial, or regulatory agency action, this Agreement shall be renegotiated to comply with the legal change which caused the non-performance.

A-10 INDEMNITY

Each Party as indemnitor shall save harmless and indemnify the other Party and the directors, officers, and employees of such other Party against and from any and all loss and liability for injuries to persons including employees of either Party, and property damages, including property of either Party, resulting from or arising out of (a) the engineering, design, construction, maintenance, or operation of or (2) the making of replacements, additions, or betterments to, the indemnitor's facilities. This indemnity and save harmless provision shall apply notwithstanding the active or passive negligence of the indemnitee.

Neither Party shall be indemnified hereunder for liability or loss resulting from its sole negligence or willful misconduct. The indemnitor shall, on the other Party's request, defend any suit asserting a claim covered by this indemnity and shall pay all costs, including reasonable attorney fees, that may be incurred by the other Party in enforcing this indemnity.

A-11 LIABILITY; DEDICATION

(a) Nothing in this Agreement shall create any duty to, any standard of care with reference to, or any liability to any person not a Party to it. Neither Party shall be liable to the other Party for consequential damages.

(b) Each Party shall be responsible for protecting its facilities from possible damage by reason of electrical disturbances or faults caused by the operation, faulty operation, or nonoperation of the other Party's facilities, and such other Party shall not be liable for any such damages so caused.

(c) No undertaking by one Party to the other under any provision of this Agreement shall constitute the dedication of that Party's system or any portion thereof to the other Party or to the public nor affect the status of WAPDA as an independent public utility corporation or Seller as an independent individual or entity and not a public utility.

A-12 SEVERAL OBLIGATIONS

Except where specifically stated in this Agreement to be otherwise, the duties, obligations, and liabilities of the Parties are intended to be several and not joint or collective. Nothing contained in this Agreement shall ever be construed to create an association, trust, partnership, or joint venture or impose a trust or partnership duty, obligation, or liability on or with regard to either party. Each Party shall be liable individually and severally for its own obligations under this Agreement.

A-13 NON-WAIVER

Failure to enforce any right or obligation by either Party with respect to any matter arising in connection with this Agreement shall not constitute a waiver as to that matter or any other matter.

A-14 ASSIGNMENT

Neither Party shall voluntarily assign its rights nor delegate its duties under this Agreement, or any part of such rights or duties, without the written consent of the other Party, except in connection with the sale or merger of a substantial portion of its properties. Any such assignment or delegation made without such written consent shall be null and void. Consent of assignment will not be withheld unreasonably. Such assignment shall include, unless otherwise specified therein, all of Seller's rights to any refunds which might become due under this Agreement.

A-15 CAPTIONS

All indexes, titles, subject headings, section titles, and similar items are provided for the purpose of reference and convenience and are not intended to affect the meaning of the contents or scope of this Agreement.

A-16 CHOICE OF LAWS

This Agreement shall be interpreted in accordance with the laws of the Islamic Republic of Pakistan, excluding any choice of law rules which may direct the application of the laws of another jurisdiction.

A-17 GOVERNMENTAL JURISDICTION AND AUTHORIZATION

Seller shall obtain any governmental authorization and permits required for the construction and operation of the Facility. Seller shall reimburse WAPDA for any and all losses, damages, claims, penalties, or liability it incurs as a result of Seller's failure to obtain or maintain such authorizations and permits.

A-18 NOTICES

Any notice, demand, or request required or permitted to be given by either Party to the other, and any instrument required or permitted to be tendered or delivered by either Party to the other, shall be in writing and so given, tendered, or delivered, as the case may be, by depositing the same in any Pakistani Post Office with postage prepaid for transmission by certified mail, return receipt requested, addressed to the Party, or personally delivered to the Party, at the address in Article 4 of this Agreement. Changes to such designation may be made by notice similarly given.

A-19 INSURANCE

A-19.1 General Liability Coverage

(a) Seller shall maintain during the performance hereof, General Liability Insurance[3] of not less than $1,000,000.

(b) General Liability Insurance shall include coverage for Premises-Operations, Owners and Contractors Protective, Products/Completed Operations Hazard, Explosion, Collapse, Underground, Contractual Liability, and Broad Form Property Damage including Completed Operations.

(c) Such insurance, by endorsement to the policy(ies), shall include WAPDA as an additional insured if the Facility is over 100 kV insofar as work performed by Seller for WAPDA is concerned, shall contain a severability of interest clause, shall provide that WAPDA shall not by reason of its inclusion as an additional insured incur liability to the insurance carrier for payment of premium for such insurance, and shall provide for 30-days' written notice to WAPDA prior to cancellation, termination, alteration, or material change of such insurance.

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[3] Governmental agencies which have an established record of self-insurance may provide the required insurance through self-insurance.

A-19.2 Additional Insurance Provisions

(a) Evidence of coverage described above in Section A-19.1 shall state that coverage provided is primary and is not excess to or contributing with any insurance or self-insurance maintained by WAPDA.

(b) WAPDA shall have the right to inspect or obtain a copy of the original policy(ies) of insurance.

(c) Seller shall furnish the required certificates[4] and endorsements to WAPDA prior to commencing operation.

(d) All insurance certificates[4], endorsements, cancellations, terminations, alterations, and material changes of such insurance shall be issued and submitted to the following:

WAPDA/PPC
WAPDA House
Lahore, Pakistan

[4] A governmental agency qualifying to maintain self-insurance should provide a statement of self-insurance.

29m

APPENDIX B
ENERGY PRICES

(Example of one methodology if methodology must be given)

Energy Prices Effective January 1, 1991

The energy purchase price calculations which will apply to energy deliveries determined from meter readings taken from January 1, 1991 and onward are as follows:

Time Period	(a) Incremental Energy Rate[5]	(b) Cost of Energy[6]	(c) Revenue Requirement for Cash Working Capital[7]	(d) Energy Purchase Price[8] (d) = [(a)x(b)]+c
	(BTU/kWh)	($/$10^6$ BTU)	($/kWh)	($/kWh)
January 1 -				
Time of Delivery Basis On-Peak Partial-Peak Off-Peak				
Seasonal Average (Period B)				

[5] Incremental energy rates (BTU/kWh) are derived from WAPDA's marginal energy costs (which include variable operating and maintenance expense). They are based upon natural gas as the incremental fuel and weighted average hydroelectric power conditions.

[6] Cost of natural gas.

[7] Revenue requirement for cash working capital.

[8] Energy Purchase Price = (Incremental Energy Rate X Cost of Energy) + revenue Requirement for Cash Working Capital. The energy purchase price excludes the applicable energy line loss adjustment factors. However, this figure is currently 1.0 for transmission and primary distribution loss adjustments and is equal to marginal cost line loss adjustment factors for the secondary distribution voltage level. These factors may be changed by WAPDA in the future. The currently applicable energy loss adjustment factors are shown in Table C.

TABLE B[9]

Time Periods

	Monday through Friday[10]	Saturdays[11]	Sundays and Holidays
Seasonal Period A (-)			
On-Peak			
Partial-Peak			
Off-Peak			
Seasonal Period B (-)			
On-Peak			
Partial-Peak			
Off-Peak			

[9] This table is subject to change to accord with the on-peak, partial-peak, and off-peak periods as defined in WAPDA's own rate schedules for the sale of electricity to its large industrial customers.

[10] Except the following holidays:

[11] The applicable energy loss adjustment factors may be revised.

TABLE C

Energy Loss Adjustment Factors[12]

	Transmission	Primary Distribution	Secondary Distribution
Seasonal Period A (-)			
On-Peak			
Partial-Peak			
Off-Peak			
Seasonal Period B (-)			
On-Peak			
Partial-Peak			
Off-Peak			

[12] The applicable energy loss adjustment factors may be revised.

D-3 INTERCONNECTION FACILITIES FOR WHICH SELLER IS RESPONSIBLE

SECTION IV

APPRAISAL REPORT ON PARACHA SUGAR MILL AND POWER HOUSE LTD PROPOSAL TO THE PRIVATE POWER CELL DATED MARCH 31, 1990

A. GENERAL COMMENTS

The proposal as put forth by Mr. Saifullah A. Paracha of Paracha sugar Mills Power House Ltd in his March 31, 1990 letter to Mr. G. M. Ilias has been evaluated for technical concept, financial and policy implications, and overall approach. The calculations used by Mr. Paracha to estimate his capacity of production correspond well enough with the very conservative estimating constants normally applied to such systems. The incentive approach would predict for the Paracha proposed plant an 8 MW net plant output to the grid, on average. While perhaps a bit optimistic in his calculations of a 9-11 MW output for grid supply, he is within the normal margins of reasonableness. Until detailed heat and material balances have been engineered and reviewed, it is reasonable to continue to accept the Paracha numbers, as he proceeds to develop his overall project plan.

There are some specific details of his calculations that warrant comment and these include his estimate of 1800 - 1850 kc/kg heat value of bagasse which by worldwide averages could be 10 - 15% too low. This would tend to make has estimates of power production and surplus bagasse availability too low. However, he uses a boiler efficiency of 84%, and when burning bagasse, even with air heaters and economizers, the boiler efficiency is unlikely to exceed 75 % vs. the 65 % or lower of normal bagasse fired boilers. This would tend to make Mr. Paracha's estimate of power production and surplus bagasse too high. If a fluegas bagasse dryer is employed as proposed by Paracha to reduce the bagasse moisture content, the efficiency of the boiler could approach but not likely reach 80%. Some caution is required because reducing the bagasse moisture content too low (below 35-40%) can cause excessive furnace temperatures within the boiler, and severe slagging can result, requiring a derating of the boiler to burn the dried bagasse. This will have to be carefully coordinated with the boiler manufacturer to avoid problems.

There is sufficient precedent that Paracha's basic technical conclusions of power output and surplus bagasse can actually be achieved, <u>if</u> sufficient cane is available to be milled, but more engineering will be required.

Mr. Paracha's cost build-up to define the necessary tariff uses a logical progression, but has some areas that must be investigated further. His overall cost estimate of 200,000,000 rupees is in the right range but could be somewhat on the low side, especially with a bagasse drying system included, when the costs of other similar projects elsewhere in the world are compared to it. Also, in his projections of operating costs, the costs of chemicals needed to operate the boiler and feed water system, spare parts, and necessary insurance coverage are not apparent. There is high probability that his cost estimate should be accurate at this stage within 25%, and possibly even 15%. For example, similar plants costed by the Canadians for Belize, the World Bank in India, A.I.D. for Jamaica and Costa Rica ranged from $700 per kw installed to $1400 per kw installed depending on the extent, complexity, and local component content of the project. While the roughly $1000 per kw allowed by Mr.

urnace oil use. For example, if the decision is to encourage furnace oil use, hence encourage wet season production, the wet season kWh price could be raised to .90 rupees rom .80 in the above table, bringing the full year average closer to 1.10 rupees per kWh. This should be high enough to make furnace oil burning in the sugar mills a net positive alue. On the other hand, if WAPDA simply wanted wet season stand-by capacity, they could pay only a small stand-by fee to the sugar mill that would guarantee start-up and generation of kWh at some specified capacity within a specified period of time throughout the wet season.

An appropriate price indexing scheme must be developed that is representative of WAPDA's changing costs of production such that annual price adjustments are made in the price to be paid to the private producer. Alternatively, WAPDA can use historical data and economic projections to set-up, for example, a 5 year price escalation schedule that is modified only if changes in certain indices exceed pre-defined limits.

The contract term should at least coincide with the loan payback period for any investments made for new capacity dedicated to the grid. It is suspected that 10 years would be a typical contract period, although for surplus capacity contracts here the sugar mill makes no investments, a 5 year contract would be adequate with renewal at WAPDA's pleasure.

As these contracts will be for small blocks of capacity (4 - 12 MW), the capacity should be actually dispatched as baseload at full capacity. There should be an incentive for exceeding the contract capacity factor terms, and a modest penalty for failing to meet the terms. For dry season operations a high capacity factor should be required (at least 80-85%), while if wet season operations are accepted, a 50 % capacity factor is likely to be sufficient.

Intertie requirements should be specified by WAPDA, and fault protection defined and mandated. Responsibility for transmission and connection to grid will probably revert to WAPDA, although this requires further thought so as to be truly equitable. Meters should be read monthly, and payments made by WAPDA to the power supplier in 30 days. The sugar industry representatives have questioned whether WAPDA will actually pay within a reasonable period of time for the power they take. If there are disagreements over bills, the process for resolution should be specified in the contract, and be automatically instituted for a timely resolution.

There is no need for all of the complex boiler plate normally present in private power operating and power purchase agreements, where firm capacity availability is critical to the power company. The contract, however, must be tight and cover certain contingencies. The form of the contract should be a WAPDA commitment to buy, and a sugar mill commitment to produce and sell so many kWh for a certain specified period of time at a certain price and at a certain capacity factor. If full agreement of the terms is exceeded for the full period, the power producer should get perhaps a 1.5 - 2 % bonus payment. If he fails to make the full agreed terms, he should be assessed perhaps a 5 % penalty.

As this is an internal Pakistani affair, normal Pakistani law would govern the agreement. If off-season power produced by a supplementary fuel is to be purchased, WAPDA should specify in the contract the minimum capacity factor it will commit to for the wet season, i.e. 40-50% etc, allowing WAPDA to purchase additional kWh at its convenience as necessary, and if available. For emphasis, the goal of such a contract is simplicity, such that both WAPDA and the sugar mills can have adequate assurance of performance, without complexity that is clearly not in-line with the relatively small size of the expected projects.

C. BACKGROUND INFORMATION FOR TARIFF DETERMINATION

The load (kW demand) curves (see Annex 1) received from WAPDA give a very graphic picture of the difference between winter and summer operations. The amount of water available dictates how much hydro can be dispatched, while the total load then dictates how much thermal capacity is dispatched. There are two distinct peak periods per day around 7:00 AM and 7:00 PM, each lasting several hours, with the PM peak being highest. The summer total demand is greater than the winter total demand, and the load is growing. The spread between thermal on-line above hydro on-line can be as much as 1300 mW at any given time during the winter.

The basic intent of the sugar industry private power program should be to reduce the spread between fossil thermal and hydro by reducing the kWh contribution of the least efficient/most costly thermal plants (probably older gas turbines).

The current unknown is the price at which natural gas is purchased. If one assumes parity with diesel (#2 distillate oil), which in July was selling for $0.826 per US gallon (4.80 rupees per liter) and now should have escalated at least 10% to $0.909 per US gallon, the fuel cost per kWh can be calculated as follows:

Gas turbine efficiency estimated at 28% (12,189.3 BTU/kWh)
Diesel fuel contains 140,000 BTU/US gallon

$$\frac{1{,}000{,}000 \text{ BTU}}{12{,}189.3 \text{ BTU/kWh}} = 82.039 \text{ kWh/million BTU}$$

$0.909/gal = $6.49/million BTU

$$\frac{\$6.49/\text{million BTU}}{82.039 \text{ kWh}} = \underline{\$0.0791} \text{ per kWh or } \underline{\text{Rupee } 1.74} \text{ per kWh}$$

To calculate the fuel cost increment for natural gas, one can now ratio with the diesel prices as follows, assuming the same efficiency of operation:

Assume gas priced at 40 cents US per therm, or $4.00 per million BTU, therefore

$$\frac{\$4.00}{\$6.49} = \frac{x}{.0791} \qquad x = \frac{4.00 \times .0791}{6.49}$$

x = $0.0488 per kWh or 1.07 Rupees

At $5.00 per million BTU:

$$\frac{\$5.00}{\$6.49} = \frac{x}{0.791} \qquad x = \frac{4.00 \times .0791}{6.49}$$

x = $0.0609 per kWh or 1.34 Rupees

Residual fuel oil (Bunker or #6 oil) was selling in July for 2294 rupees per tonne, therefore

Specific gravity = 0.98 and 2208 lbs/tonne

Efficiency of operation = 285

8.33 lb/gal X .98 = 8.1634 lb/gal

$$\frac{2294 \text{ Rupees}}{22 \text{ Rupees/dollar US}} = \$104.27 \text{ per tonne}$$

Assume minimum 25% escalation in price:

$104.27 X 1.25 = $130.34 per tonne current estimate

At 270.48 gallon/tonne and 148,000 BTU/gallon

$$\frac{\$130.34}{270.48} = \$0.482 \text{ per gallon and } \$3.26 \text{ per million BTU}$$

$$\frac{\$3.26}{\$6.49} = \frac{x}{.0791} \qquad x = \frac{.0791 \times 3.26}{6.49}$$

A coal case is also relevant and assuming the same efficiency of use:

$$\frac{\$45.00/\text{tonne}}{26.5 \text{ million BTU/tonne}} = \$1.70 \text{ per million BTU}$$

$$\frac{\$1.70}{\$6.49} = \frac{x}{.0791} \qquad x = \frac{0.791 \times 1.70}{6.49}$$

x = $0.0207 per kWh or <u>0.456</u> Rupees per kWh

At 270.48 gallons/tonne and 148,000 BTU/gallon

$$\frac{\$130.34}{270.48} = \$0.482 \text{ per gallon and } \$3.26 \text{ per million BTU}$$

$$\frac{\$3.26}{\$6.49} = \frac{x}{.0791} \qquad x = \frac{.0791 \times 3.26}{6.49}$$

x = $0.0397 per kWh or <u>0.874</u> rupees per kWh

A coal case is also relevant and assuming the same efficiency of use:

Assume $45.00 per tonne at 12,000 BTU/lb

$$\frac{\$45.00/\text{tonne}}{26.5 \text{ million BTU/tonne}} = \$1.70 \text{ per million BTU}$$

$$\frac{\$1.70}{\$6.49} = \frac{x}{.0791} \qquad x = \frac{.0791 \text{ X } 1.70}{6.49}$$

At $60.00 per tonne = $2.26 per million BTU

$$\frac{\$2.26}{\$6.49} = \frac{.0791 \text{ X } 2.26}{6.49}$$

x = $0.0275 per kWh or <u>0.606</u> Rupees per kWh

Hydro-produced power does not contain a fuel incremental cost, and is generally financed for long-term periods, i.e. 30 years, such that it will have the lowest total cost of production per kWh. For the sake of a comparison, a total cost of $0.0175 per kWh or 0.385 rupees per kWh will be used as the baseline above which all thermal plant production cost must be.

To the above thermal plant fuel cost component per kWh must be added the variable O&M costs that are tied directly to operations such as lube oil, chemicals, spare parts. The fixed operations and maintenance costs will not be considered. Again for the sake of simplicity, a flat rate of $0.005 per kWh (all rupees) will be added to all thermal production costs to provide the reference line for price determination.

A summary can now be made of the savings potential for backing out thermal-produced kWh with kWh purchased from the sugar industry.

Fuel Type	Estimated Fuel and O&M Cost per kWh (Rupees per kWh)
Diesel Oil (Combustion Turbine)	1.85
Natural Gas (Combustion Turbine)	1.18-1.45
Fuel Oil (Steam Turbine)	0.98
Coal (Steam Turbine)	0.57-0.72
Hydro -- Total Cost per kWh	0.385

Other alternatives such as diesel (piston) engines burning heavy fuel oil have not been calculated, but can be expected to be comparable to the costs experienced by the coal-fired steam plants.

The obvious policy conclusion is that the most expensive power comes from gas turbines regardless of fuel, and that is the power that the sugar factory produced power should displace, although the heavy oil-fired steam plants and diesel plants could also be considered as the value of saving the foreign exchange required to purchase petroleum fuels (or crude oil for local refining) has not yet been considered.

As fuel prices will vary with market conditions and other variables such as the current situation with Kuwait/Iraq demonstrates, low estimates based on steady prices and an overabundant supply of petroleum should not be used. Moderately escalated fuel priced such as used above will probably prove to be the long range trend and should be adopted for planning purposes.

While the above analysis is based only on estimates, the more detailed work to be completed by an already proposed CWP can be used to fine tune the numbers. While the exact magnitude of each cost component might vary, the relative order and gross magnitudes are expected to be relatively accurate. Thus, the sample sugar industry power purchase tariff presented earlier in this section can be used at this stage to get the program rolling, and as a baseline for follow-on work to optimize.

D. OTHER POLICY ISSUES

It is likely that some components for the sugar industry cogeneration systems such as the steam turbines and the high-pressure, high temperature steam boilers, might have to be imported until the Pakistani boiler manufacturing industry can gear up to handle the task. As the net effect of the sugar industry private power program would be to provide lower cost power and reduced recurring foreign exchange costs for fuel supply, it warrants consideration to exempt such imports of the necessary equipment from import duties until a cost competitive local supply can be provided. Import duties imposed on the equipment could provide the negative difference between an acceptable and unacceptable rate of return to the sugar mills under the tariff scenario envisioned.

The sugar industry as a whole cannot be expected to produce a spontaneous flood of project proposals. Encouragement and the proper incentives will be needed to initiate a widespread program as compared to a sporadic response. The basic policy to accomplish an optimized program should consist of the following elements:

1. Verify WAPDA cost of production with sufficient accuracy to establish pricing guidelines for sugar mill-generated surplus power.

2. Define policy with regard to use of supplementary fuels to permit non-grinding wet season (summer time) production of power at sugar mills.

3. Prepare standardized Power Purchase Agreement for sugar mill projects.

4. Prepare and distribute specific sugar industry promotional literature regarding private power program.

5. Prepare interconnection and fault protection requirements for sugar factory projects.

6. Bring sugar industry and WAPDA together in a seminar format to publicly introduce the program and all of its elements.

7. Evaluate and act on market lead proposals in such a manner that the approval process for such a project or projects is/are well down the road at the seminar time, and can serve as both a model and incentive for mobilizing the industry for the desired response.

E. TYPICAL DESIGN OF A POWER PURCHASE TARIFF

The setting of appropriate buy-back tariffs for non-utility produced power is a difficult exercise subject to compromises between conflicting objectives. Nevertheless, certain principles should guide the development of a rate schedule for bagasse cogenerated power:

- Economic efficiency as determined by the true resource costs of providing electricity supply.
- Financial requirements of both the cogenerator and the utility in order to provide incentives for implementation of economically attractive schemes.
- Equity considerations which influence how financial surpluses, if any, are appropriated.
- Ease of administration so as to not place an undue burden on utility billing and accounting units.

1. Economic Efficiency

The economic efficiency goal is promoted by designing a rate schedule which encourages the development of efficient cogeneration projects -- those which can supply power at a lower resource cost than the utility. Economic and legal interpretations of the efficiency criterion have consistently held that buy-back rates should be based on avoided cost principles, i.e., the cost which the utility would have incurred had it been required to generate the power through its own means.

2. Marginal vs. Average Cost Pricing

The avoided cost concept is the mirror image of marginal cost pricing, with the latter often appearing impractical to entities accustomed to costing and selling electricity on the basis of average fuel costs and historic (accounting) costs of capital plant. The accounting cost approach is concerned with the recovery of sunk costs, and implies that future economic resources will be as cheap or as expensive as in the past. There is ample evidence that the cost of fuel resources is becoming more expensive over time, so the utility's historic costs of generation might not be the best guide to future costs.

The marginal cost concept prices output on the cost of the "last" (costliest) unit produced. It is inherently a "forward looking" approach, consistent with least-cost generation expansion planning. The easiest way to grasp the importance of pricing at incremental as opposed to average cost is to imagine a downward-sloping demand curve for cogenerated power which

represents the utility's marginal costs. The more cogenerated power purchased, the lower the utility's costs. The more cogenerated power purchased, the lower the utility's marginal and avoided costs. Similarly, there is an upward-sloping aggregate supply curve of cogenerated power that would be forthcoming at various prices. The efficient amount of cogenerated power for a utility to purchase is indicated where the supply and demand curves intersect. If any more cogenerated power is purchased, resources are wasted because the utility could have supplied that power itself at a cost lower than the cogenerator's.

Parallel reasoning demonstrates why pricing cogenerated power at a utility's average cost of generation is similarly inefficient. Assuming that the utility's marginal costs exceed average costs, the result is that a less than optimal amount of cogenerated power will be purchased by the utility. Resources are wasted because the utility misses the opportunity to buy a block of power which could be supplied at a cost lower than the utility's.

Resource savings will be maximized only if the power is purchased from the cogenerators with the lowest costs, i.e., those making up the lower part of the cogenerated power supply curve. A price determined by the intersection of the supply and demand curves will ensure that only these low cost cogenerators sell power to the utility. Setting price equal to marginal (avoided) cost effectively excludes the higher cost cogenerators because they will not be wiling to sell at a price lower than their cost.

F. MISCELLANEOUS TOPICS -- SUGARY INDUSTRY

Besides meeting with Mr. Saifullah Paracha who proposes to build a new sugar mill in Punjab and incorporate a high pressure/high temperature steam cogeneration system, meetings were also held with representatives of the Mehran Group who operate 1 sugar mill, and the Crescent Group which operates 2 sugar mills. Bob Grimshaw was present at both meetings, and will keep in close contact with both of these sources to help develop an understanding of the industry view of private power.

While Mehran was more positive than Crescent, both were optimistic about the potential for private power from the sugar industry, and both suggested that the industry will respond to a WAPDA power purchase program that was straight forward and paid an equitable price. Both however, did stress that:

1. The sugar industry does not have a current good opinion of WAPDA;

2. The sugar industry now thinks sugar production first, and power sales as maybe worthwhile, but as a secondary priority;

3. The energy efficiency of the sugar industry is currently not good, and there is quite a lot of margin for improvement;

4. Profit margins gained by the sugar mill on sugar production, or electricity sales, should not be relevant to determining the price per kWh WAPDA will pay to the sugar mills; and

5. The sugar industry at-large should not be formally approached until the WAPDA sales price offer is firm, WAPDA has defined contractual terms, and WAPDA can send the industry definitive literature.

The contact thus far with the industry has been kept low key, and it does confirm that a meeting will be necessary between the industry and WAPDA to develop the proper mutual confidence level. Hence, the WAPDA/Sugar Association seminar approach would appear to have merit. Further, it would appear that a background document circulated to the industry prior to the seminar would likely be a deciding factor for high level (decision maker) attendance by the sugar industry.

Relevant to the progress to date, the sugar industry, while willing to have their mills visited at the time of the mission, suggested that mill visits after October and the start of the next crushing system, would be more appropriate.

Finally, no commitments were made by the consultants to anyone in the sugar industry, other than to give their potential power generation capability a fair hearing. It was clearly stated that the primary purpose of the private power program was to provide additional efficient and cost effective sources of generation to WAPDA for incorporation into their network of electricity generation sources.

G. RECOMMENDATION FOR INDUSTRY RESPONSE

The sugar industry in Pakistan has been studied extensively over the years for its ability to host cogeneration projects that would produce excess kwh for grid supply. On both the level of the individual mill, and the industry as a whole, the answer remains the same. A large number of mills are excellent sites for grid power supply projects, and the industry as a whole can make a significant contribution to the power sector. No more studies are needed! WAPDA should decide if the addition of 30-35, 4-12 MW projects to its grid in various rural areas is an attractive proposition. If so, the policy actions required are clear. It is the correct time to develop and implement a strategy to encourage the sugar industry market leaders to develop projects that will serve as models for the rest of the sugar industry and later encourage other relevant industries to follow. This should not be difficult as the technical viability of the projects can be assured if the hardware system is competently engineered. If the financial incentive to the sugar mills is sufficient (adequate rate for electricity sales and access to reasonable lines of credit), the industry is sure to respond. It should be recalled that sugar mills are already in the electricity supply business so that this is not a new design, procurement, or operations process for them. It is up to the Private Power Cell and WAPDA to develop the appropriate strategy and implementation policy, then make the encouraging moves to the sugary industry who have already approached WAPDA.

The industry is already talking about having matured as sugar producers, and needing to diversify as an industry. Here is their chance to start the diversification process. The government should also take advantage of the fact that the sugar industry is a Pakistani industry. Their participation in the Private Power Program would be a clear demonstration that the benefits of the Private Power Program do not necessarily have to accrue with foreigners, or groups with foreign interests. The public relations value of this could easily outweigh that of the actual kwh produced and supplied to WAPDA.

In terms of the plan of action for the sugar industry participation in private power, the following activities should be pursued on a priority basis:

1. WAPDA should determine and make public what tariff range will be appropriate for the various categories of potential sugar industry projects. It is likely that the tariffs will be time of day (or fossil fuel oriented) to encourage peak hour, and dry season availability.

2. Draft power purchase and operating agreements for cogeneration projects that are being developed for WAPDA should be adapted then adopted for specific use in sugar industry projects.

3. A letter of solicitation should be prepared inviting individual sugar mill owners to make expressions of interest in pursuing private power projects, if they in fact have an interest.

4. WAPDA with Private Power Cell assistance should conduct a 2.0-2.5 day seminar for the sugar industry (under the auspices of Pakistan Sugar Mill Owner's Association, and the Pakistan Society of Sugar Technologists) to clearly present what the technical, financial, and legal/contraction ramifications of such a program will be.

Representatives of both USAID's BST program and USDOE, both of which have been involved in transferring the private power successes of the Hawaiian sugar industry program, could be brought into the seminar. While A.I.D. and DOE might participate, it is essential that the seminar be a WAPDA-Sugar Industry meeting, and be under the direction of the Private Power Cell of the Ministry and WAPDA with A.I.D. and USDOE helping to bring credibility to the overall concept.

The technical sessions would provide details of how projects are specified, designed, and operated, with hardware considerations and operational interfaces between sugar processing, and power production fully explained. Slides and possibly videos from actual facilities would be used to make sure that everyone understands what must happen, and how to do it.

The financial session would really cover 2 things: the cost of and potential sources for finance for installing various types of cogeneration equipment in the sugar mills; and how certain electricity sales prices will allow a profit to be made by the sugar mills, if they make the needed investment to produce the power.

The legal/contractual session would clearly show the sugar industry the sequence of steps needed to develop a private power project, and walk them through a typical project cycle from project concept through the implementing of power purchase and operating agreements, including invoicing and any penalties or bonus that might apply. There should be no question after this session about what the responsibilities are for each of the participants in the project development process. Everyone should clearly understand the process and the boundaries.

The basis for the above recommendations is that both a national energy resource and an energy need exist, all within a thoroughly Pakistani infrastructure. The Private Power Cell and WAPDA need to act as the catalyst to start the process moving. Results can be expected relatively quickly, and the program has only positive economic, financial, and social potential. Once started, the process should have sufficient momentum, such that whatever the percentage of the sugar industry that will desire to participate will have the knowledge, basic resources, and proven path to follow. It is important that WAPDA interface directly with the sugar industry, as the sugar industry decision makers will pay more attention, than

if the contact were further removed. The Private Power Cell of the Ministry should encourage WAPDA to take the lead in this industry interface.

If the policy decision is made to encourage the maximum sugar industry response, a technical and financial analysis assistance mechanism can be set-up under WAPDA's Private Power Cell to help the industrial sugar companies evaluate their specific project potential, and in structuring their projects. This could be in the form of technical advice on how to decide on the size and type of equipment, and in the form of computerized financial analysis that would be useful in convincing both the mill owner and the finance sources of project viability.

SECTION III

CONTRACT MODEL FOR WAPDA POWER PURCHASE FROM PAKISTAN SUGAR INDUSTRY

A. BACKGROUND

A model for a special power purchase agreement designed specifically for the sugar industry must still contain all of the relevant items of more comprehensive agreements. In this case, we can outline the needs and then use a standard cogeneration agreement as an example. A first cut has been made in drawing up a model and both the outline and the first draft agreement follow. This should be viewed as the starting point and not the finished product.

B. OUTLINE OF BAGASSE COGENERATION CONTRACT STANDARD OFFER: AS-DELIVERED ENERGY (AND CAPACITY)

I. INTRODUCTION

- A. Purpose
- B. Scope
- C. Definition of Parties

II. LEGAL AUTHORITY

- A. Legislation
- B. Authority Vested in WAPDA
- C. Certification of Status of Licensee
- D. Authority Vested in Private Generator

III. DESCRIPTION OF PRIVATE GENERATOR'S PLANT

- A. Location
- B. Technology
- C. Sizing/Capacity Rating
- D. Fuel Supply
- E. Expected Operating Conditions

IV. PLANT CERTIFICATION

- A. Responsibilities Design/Construction
- B. Applicable Technical Standards
- C. Government Certification
- D. Proposer's Statement of Conformance
- E. WAPDA Rights of Inspection
- F. Approval and Commissioning

V. ENVIRONMENTAL AND SAFETY CERTIFICATION

- A. Applicable Environmental Standards
  - 1. Smoke
  - 2. Particulates
  - 3. Ash and Disposal
  - 4. Noise
- B. Environmental Certification
- C. Applicable Safety Standards
  - 1. Annual Boiler Inspection
  - 2. Operator's License
  - 3. Plant Safety Inspections
- D. Safety Certification

VI. OPERATION

- A. Responsibility for Daily Operation
  - 1. Identification of Plant Manager
  - 2. Reporting, Log Books
- B. Load Dispatch
  - 1. Dispatch Authority/Control
  - 2. Procedure/Communications
- C. Outages
  - 1. Scheduled Outages
    - a. Daily
    - b. Monthly
    - c. Yearly
  - 2. Forced and Partial Outages
    - a. Estimate of Frequency
  - 3. Notification
    - a. Party to be Notified
    - b. Communications
  - 4. WAPDA Right of Entry and Inspection

VII. GRID INTERFACE

A. Definition of Interfaces
   1. O/H Lines and Rating
   2. Transformers
   3. Switchgear
   4. Synchronization/Phasing
   5. Fault Detection/Load Trip-out
   6. Metering Equipment and Methods
   7. Technical Performance Standards
   8. Synchronization/Frequency Stability
   9. Voltage and Stability
   10. Power Factor
   11. Harmonics
   12. Isolation

B. Construction, Finance and Maintenance Responsibilities
   1. By WAPDA
   2. By Private Generator

VIII. POWER DELIVERIES

A. Scope of Deliveries
   1. Annual mWh
   2. Seasonal mWh
   3. Peak MW/MVA

B. Measurement
   1. Meter Reading
   2. Frequency
   3. Recording

C. Obligation to Purchase
   1. WAPDA Purchase Obligation
   2. Curtailment Due Hydro Spill Conditions

D. Provision of Back-up Power

IX. PRICING

A. Principles
   1. Avoided Cost Methodology
   2. Identification of Marginal Unit(s) in Service

B. Rate Schedule
   1. Off-Peak Energy
   2. On-Peak Energy
   3. As-Delivered Capacity
   4. Frequency of Revision

C. 1. Adjustments
2. Heat Rate Adjustment
3. Fuel Price Index
4. Power Factor/Line Loss Adjustment
5. Price Escalation Index

X. PAYMENTS

A. Calculation
1. Computational Formulas
B. Invoicing
1. Preparation
2. Frequency
C. Disbursement
1. Mode
2. Terms

XI. TERM OF AGREEMENT

A. Contract Duration
B. Unilateral Termination
C. Notices
D. Renegotiation
1. Mutual Agreement

XII. STANDARD TERMS AND CONDITIONS

A. Access to WAPDA Records and Data
B. Force Majeure
C. Indemnity
D. Liability
E. Several Obligations
F. Non-Waiver
G. Assignment
H. Insurance

C. WAPDA STANDARD OFFER POWER PURCHASE AGREEMENT FOR AS-DELIVERED CAPACITY (AND ENERGY)

ARTICLE NUMBER	ARTICLE TITLE	PAGE
1	Qualifying Status	52
2	Purchase of Power	52
3	Purchase Price	53
4	Notices	53
5	Designated Switching Center	54
6	Terms and Conditions	54
7	Term of Agreement	55

APPENDIX A: General Terms and Conditions

APPENDIX B: Energy Prices

APPENDIX C: As-Delivered Capacity Prices

APPENDIX D: Interconnection

AS-DELIVERED CAPACITY AND ENERGY POWER PURCHASE AGREEMENT BETWEEN

_____

AND

WAPDA

_____ ("Seller") and WAPDA referred to collectively as "parties" and individually as "Party", agree as follows:

ARTICLE 1: QUALIFYING STATUS

Seller warrants that, at the date of first power deliveries from Seller's Facility[1] and during the term of agreement, its Facility shall meet the appropriate qualifying facility requirements established as of the effective date of this Agreement.

ARTICLE 2: PURCHASE OF POWER

(a) Seller shall sell and deliver and WAPDA shall purchase and accept from the Facility having a nameplate rating of _____ kW located at _____ the as-delivered capacity and energy at the voltage level of _____ kV. Seller has chosen _____[2] as its energy sales option. Seller may convert its energy sale option as provided in Section A-3 of Appendix A.

(b) The scheduled operation date when Seller estimates first delivery of electric energy from the facility to WAPDA is _____ (date). At the end of each calendar quarter Seller shall give to WAPDA written notice of any change in the scheduled operation date.

(c) To avoid exceeding the physical limitations of the intermediate facilities, Seller shall limit the Facility's actual rate of delivery into the WAPDA system to _____ kW.

(d) The primary energy source for the Facility is Bagasse plus _____.

---

[1] Underlining identifies those terms which are defined in Section A-1 of Appendix A.

[2] Insert either "net energy output" or "surplus energy output" to show the energy sale option selected by Seller.

(e) If seller does not begin construction of its Facility by _____,
(date)
WAPDA may reallocate the existing capacity in WAPDA's transmission and/or distribution system which would have been used to accommodate Seller's power deliveries to other uses. In the event of such reallocation, Seller shall pay WAPDA for the cost of any upgrades or addition to WAPDA's system necessary to accommodate the output from the Facility. Such additional facilities shall be installed, owned, and maintained in accordance with the applicable WAPDA tariff.

(f) The transformer loss adjustment factor is _____%.

ARTICLE 3: PURCHASE PRICE

WAPDA shall pay Seller for as-delivered capacity at prices authorized by WAPDA and which are derived from WAPDA's calculated energy savings.

ARTICLE 4: NOTICES

All written notices shall be directed as follows:

to WAPDA: WAPDA
WAPDA House
Lahore
Attn: _____

to Seller: _____
_____
_____
_____
_____

ARTICLE 5: DESIGNATED SWITCHING CENTER

The designated WAPDA switching center shall be, unless changed by WAPDA:

_____
Name

_____
Location

_____
Phone Number

ARTICLE 6: TERMS AND CONDITIONS

This Agreement includes the following appendices which are attached and incorporated by reference:

APPENDIX A: General Terms and Conditions

APPENDIX B: Energy Prices

APPENDIX C: As-Delivered Capacity Prices

APPENDIX D: Interconnection

ARTICLE 7: TERM OF AGREEMENT

This Agreement shall become effective on the date of execution by the Parties and shall remain in effect until terminated by Seller.

IN WITNESS WHEREOF, the Parties hereto have caused this Agreement to be executed by their duly authorized representatives and effective as of the last date set forth below.

_____	WAPDA
Seller	
By: _____	By: _____
_____	_____
Type Name	Type Name
Title: _____	Title: _____
Date Signed:	Date Signed:
_____	_____

D. TYPICAL PROJECT STRUCTURE

The WAPDA/sugar industry program aims to significantly improve the efficiency of bagasse utilization in the main sugar mills in Pakistan, thereby improving overall energy efficiency in the mills and enabling the production of additional bagasse for use as fuel to cogenerate surplus electricity for export to the grid. The program would provide additional revenues to the sugar industry through electricity sales, while at the same time contributing to WAPDA's power supply and minimizing investment of public funds in new capacity.

The ideal project would involve an investment program to upgrade the sugar mills whereby each participating mill would be retrofitted to enable the production of electricity and bagasse substantially over and above internal mill requirements. The basic investment in each mill would typically involve the:

(a) addition of a high-pressure boiler;

(b) addition of a topping turbo alternator;

(c) installation of a bagasse drying system which uses waste heat from the boiler flue gases; and

(d) modification of the mill's electrical system to enable interconnection with the utility grid and dispatch of surplus power.

The exact retrofit equipment and investment costs would vary from mill to mill depending on the grinding capacity of the particular sugar mill, whether the retrofit investment would be undertaken in conjunction with capacity expansion. The export power from bagasse cogeneration would be seasonal but its availability during the grinding period (approximately November - April) coincides with WAPDA's months of high thermal demand due to minimum availability of hydropower.

E. OFF-SEASON FUEL ALTERNATIVES

Availability of an inexpensive off-season fuel might or might not improve the financial/economic return of bagasse cogeneration projects. This opportunity applies to the electricity maximizing investment configurations, which can operate in a condensing mode during the non-grinding season (about 155 days/year, allowing for maintenance) at reasonable fuel to electricity conversion efficiency. The idea is that year around sales of electricity serves to spread the investment capital over a large number of kilowatt-hours, reducing the unit cost of electricity production proportionately, if the season fuel is truly inexpensive.

Candidate off-season fuels in Pakistan include:

(a) Excess bagasse could be produced at neighboring mills. Because of spontaneous combustion risks, the excess bagasse has to be baled, pelletized or briquetted for storage. USAID is sponsoring on-going bagasse baling trials in Hawaii, Jamaica and Thailand. Pelletizing has been tried with discouraging results in Hawaii due to rapid die wear.

(b) Cane field trash recovery is practiced at the Romana mill in the Dominican Republic, and on an experimental basis at the Hacienda Luisita mill in the Philippines. The above mentioned USAID field trials aim at reducing collection and baiing costs through introduction of appropriate equipment.

(c) Other agricultural and forest industry residues, such as rice straw, sawdust, and offcuts may be available at unknown costs at certain Pakistani mills.

(d) Fuel oil is easily combusted in properly designed solid fuel boilers.

(e) Coal and/or peat are obvious off-season alternatives which, upon closer examination, present certain difficulties. First, Pakistani coal is of poor quality, making boiler flame stability problematic. Fluidized bed combustors can address this issue but do not have a commercially proven track record burning bagasse or coal/bagasse mixtures. Second, the supply of coal to relative small consumer is logistically difficult.

Fuel availability concerns aside, the key question becomes: How inexpensive must the supplementary fuel be? A sugar mill's willingness to pay for an off-season fuel will be based on two factors:

(a) The efficiency of the installed boiler and extraction-condensing turboalternator in converting the fuel into electricity for export sale; and

(b) The value of the additional electricity that can be produced during the off-season.

A quick calculation using economic prices can be made by utilizing the following assumption:

> The marginal cost of producing off-season electricity is the fuel cost. Operations and maintenance costs are ignored, causing a small distortion. Capital investment in the extraction-condensing turbine is considered a sunk cost for a mill choosing to invest in the maximum electricity alternative.

A 5-10 MW extraction-condensing turboalternator as used in the surplus electricity bagasse cogeneration cycle operates at a relatively low overall efficiency. Typically, the overall fuel to busbar efficiency is 17%. At this efficiency, the breakeven economic cost of energy at the turbine inlet can be calculated.

This calculated benchmark may be compared with the estimated economic costs of alternative fuels. The experience predicted conclusion is that none of the listed fuels will be sufficiently inexpensive to warrant use as an off-season fuel. The basic explanation is that the bagasse cogeneration investments depicted herein are economically attractive because the fuel is essentially "free," that is, a certain quantity of bagasse has to be combusted by the sugar mill for process steam requirements in any case. The savings from this free fuel when also used to produce electricity is sufficient to offset the capital cost of the necessary equipment. Excess bagasse available on site costs some handling charge delivered to the boiler, and therefore may be profitably burned for in-season additional electricity when no higher-value uses are available, i.e. paper, fiberboard, etc.

Once additional (off-season) fuel is sought, it ceases to be free. The sugar mill boiler/turbines are then competing against relatively efficient WAPDA equipment. To illustrate, a typical sugar mill installation might require about 1.25 kg of high ash coal to produce one kWh; a WAPDA power station probably needs only 0.79 kg to generate the same unit of electricity. The fuel cost disadvantage of the sugar mill can outweigh the economic gain from greater firmness in energy supply.

This is not to say that each project proposed should not evaluate its own unique situation. It only suggests that unless the supplementary fuel is available at a small nominal charge (perhaps transport plus small incentive payment), the cost of the off season kWh will be too high to be competitive at a time when WAPDA does not need the power. This must be addressed in the power purchase agreement.

APPENDIX A

GENERAL TERMS AND CONDITIONS

CONTENTS

SECTION	TITLE	PAGE
A-1	Definitions	1
A-2	Construction	2
A-3	Energy Sale Options	4
A-4	Operation	5
A-5	Payment	6
A-6	Adjustments of Payments	7
A-7	Access to Records and WAPDA Data	7
A-8	Curtailment of Deliveries and Hydro Spill Conditions	7
A-9	Force majeure	9
A-10	Indemnity	10
A-11	Liability; Dedication	10
A-12	Several Obligations	10
A-13	Non-Waiver	11
A-14	Assignment	11
A-15	Captions	11
A-16	Choice of Laws	11
A-17	Governmental Jurisdiction and Authorization	11
A-18	Notices	12
A-19	Insurance	12

Paracha is in the mid-range, it is possible that at this stage, a slightly higher cost should be estimated. It is better to be conservative now than to have to increase costs later, when it not only can be embarrassing, but can be a show stopper.

A meeting was held in Karachi with Mr. Paracha and his engineer Mr. Nasim Aziz. Mr. Paracha had formerly applied for, and received, a permit to build a new sugar mill in the Sindh after having feasibility studies done in 1987 by Tate & Lyle, the English sugar industry consultants. The current potential for instability in the Sind led Mr. Paracha's Board of Directors to recommend abandoning the Sind project, and to evaluate a site in the Punjab. When feasibility was indicated for the new site in the Punjab, he made an application to build the sugar factory in Sargoda. The closest sugar factory is reported to be 50 km from his site, and his cane availability study is reported to indicate sufficient land and cane to support his project. Mr. Paracha has made local bank inquiries, and he reports that the only open area in his finance package depends on whether or not WAPDA will sign a power purchase agreement that will satisfy his bank.

An interesting thing about Mr. Paracha's approach is that he apparently recognizes that the most cost efficient way of integrating a private power plant into a sugar factory is during the initial plant design stage. He also treats the electricity as a product just like sugar. It is a straight forward business approach. However, as Paracha is new to the Pakistani sugar industry, his approach and opinion are not necessarily that of the sugar industry as a whole. He is as-yet precluded from joining the relevant sugar industry associations, and being accepted into the sugar community. Thus, the input of the industry insiders is still very much needed, and should be actively pursued.

The current plan for continuing the evaluation of the Paracha proposal would be for Bob Grimshaw to join Mr. Paracha in a tour of the proposed project area. As there is an adjacent rice industry to the proposed site, they will at that time estimate the potential for rice hull supply as a supplementary fuel. This is not to say that rice hull burning is being encouraged or recommended: the resource available will simply be estimated.

What can be concluded preliminarily now is that Mr. Paracha has put forth a proposal worth pursuing further. WAPDA and /or the Private Power Cell should now formally acknowledge Mr. Paracha's proposal, and at a minimum, extend an expression of serious interest.

A discussion was also held with Mr. Paracha concerning the use of new vs used equipment, plus the absence of the capability of the Pakistani boiler makers to supply steam boilers of over 25 bar pressure and 330° C temperature at this time. A sugar industry response to private power could provide sufficient stimulus for the Pakistani suppliers to develop the ability to build such technology in Pakistan. The steam conditions above 25 bar and 330° C will be are necessary to achieve the efficiencies required to produce enough surplus electricity to make a major private power thrust in the industry a worthwhile initiative.

B. SPECIFIC COMMENTS

To arrive at the specific comments, both the Paracha Letter Proposal and the Tate & Lyle study were reviewed. To establish a frame of reference, the Tate & Lyle study was done for a Sind project site, and considers coal as a supplementary fuel for both in-season and out-of-season operations. Mr. Paracha's Letter Proposal suggests the use of residual fuel oil. The Tate & Lyle report is based on a 4000 tonne per day cane crushing plant, while Mr. Paracha's letter suggests 4000 tpd as an example. Therefore, the following comments are offered:

1. Rather than giving an example of what might be done, a proposal for a private power contract should be specific, stating the actual intended size of the sugar mill and relating the surplus power generated to the actual or planned conditions. The Private Power Cell and WAPDA should not have to make inferences regarding the proposer's intent.

2. Some evidence of cane availability to support a 4000 tpd plant should be supplied with the proposal. Orally, Mr. Paracha stated that a cane availability study was made, and that satisfactory results were obtained.

3. Some evidence that land is available for the plant site should be provided in terms of an option to buy, a land lease, a deed, a Letter of Intent to sell, etc.

4. The application for permission to build the sugar mill in the Punjab should be included with the proposal to confirm that the proposer is serious about his intent to build a sugar factory, and has initiated all of the proper project development steps.

5. If financing has been approved for the sugar factory portion of the project, a letter of intent from the finance source or similar documentation should be provided with the proposal for the private power project.

6. The Tate & Lyle sugar production process scheme with its integration of a surplus electricity production cogeneration system, while meeting with normal standards of engineering practice does not entirely coincide with, or back up Mr. Paracha's specific proposal. This is an observation, not a criticism, as the Tate & Lyle study was not provided with the proposal and was volunteered by Mr. Paracha to demonstrate his sincerity.

7. Mr. Paracha's cost information and methodology of calculations are reasonable, however, they are not backed-up by vendor quotes in the documentation provided. This is not to suggest that they do not exist, simply to say that such information was not provided with the proposal.

The "concept" as proposed by Mr. Paracha is valid in terms of overall size and in its ability to produce a sufficient supply of kWh so as to be of value to WAPDA. There is need for the concept to be presented as a formal project development plan.

As a new sugar factory must be built before this particular cogeneration project can be implemented, there are policy implications that must be considered above and beyond just the Paracha proposal:

- A detailed implementation schedule should be prepared by Paracha so that WAPDA can evaluate both where and when the kW and kWh will be available at the fully rated capacity based on bagasse fuel; the timing may or may not be advantageous in the area where his plant will be built;

- Paracha cannot be considered as a true market leader as the market does not necessarily recognize him yet;

- While the sugar industry will become aware of Paracha's proposal, and it might help motivate additional action, this is not guaranteed; true market leaders (in the sense that their actions traditionally are watched by and followed by the bulk of their peers) must be identified and motivated to consider projects in existing mills that can happen more rapidly than can a project in an entirely new facility;

- To be fair to the Paracha proposal, it must be evaluated on its own merits, but in parallel with the above considerations and with the full understanding of the need for an overall industry response.

Mr. Paracha in his financial presentations should be advised to make sure that the costs of the cogeneration system be apportioned between the cogeneration of power for the factory itself (i.e. to factory investment column) and to the grid sales investment accounting column. This was not made clear in his letter proposal submission.

Paracha needs to refine his engineering concept to provide WAPDA with two options at this stage and some clarifications:

- A grinding season only case with no supplementary fuel considered;

- A full year case with as many supplementary fuel options provided as can be verified for the particular site;

- A fuel pile to busbar efficiency calculation including incremental efficiencies of major components, i.e. boiler and turbogenerator;

- A heat and material balance for each option of the cogeneration system proposed;
- A breakdown between foreign exchange costs and rupee costs, if imported components are needed.

C. CONCLUSIONS

The conclusions to be drawn at this stage are first and foremost that insufficient information was presented in a less than optimum format for a definitive decision to be made. On the other hand, the technical design direction and engineering approach are in line with what is happening elsewhere in the world in the most advanced sugar mill cogeneration projects. The business approach of treating electricity as another marketable commodity is also commendable.

The overall conclusion is that the Paracha letter proposal can be considered as a good starting point. It is now up to the Private Power Cell and WAPDA to respond in such a way as to encourage Mr. Paracha to submit the clarifications as needed, and a formal proposal with all of the definitive backup information included.

D. RECOMMENDED ACTION

At this time the Private Power Cell should send Mr. Paracha a confirmation letter concerning his proposal. The letter should contain the following points:

- An acknowledgement that WAPDA is definitely interested in industrial cogenerators as sources for private power projects; and

- An acknowledgement that his technical approach is good, but that he should submit more information in a formal proposal format as per the eleven points presented in IV-B.

In addition, if and when Paracha submits a formal proposal with all of the information required, a cost benefit analysis must be conducted to verify that he benefits are there to compensate for nay foreign exchange expenditures made.

ANNEX 1

WAPDA LOAD CURVES

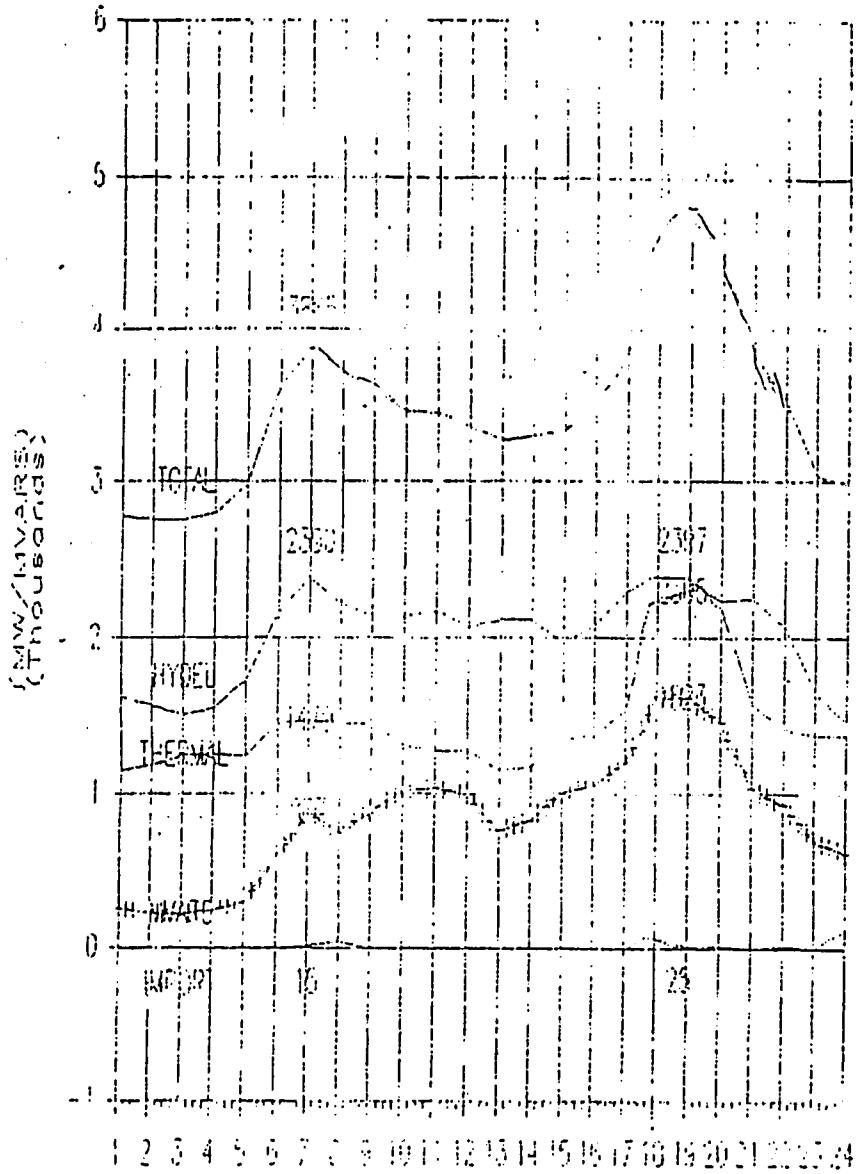
DAILY LOAD CURVE

LDC (WAPDA) 5-12-89

Fax no 755
6-12-89

(1)

4694



LF.Hy 34 1 Sys 1.76 + Tre.49.76/s1830 hrs

Load shedding by LDC due to less capability

From : 1127 Hrs
To : 1833 Hrs
Duration : 06 min.
Quantum 59 MW

Load shedding by CEB Quetta to avoid overloading of 132/33 KV Grid

i) 0730 ii) 1915 Hrs
i) 0120 ii) 2330 Hrs
i) 00-50 ii) 01-15
i) 14 MW ii) 17 MW

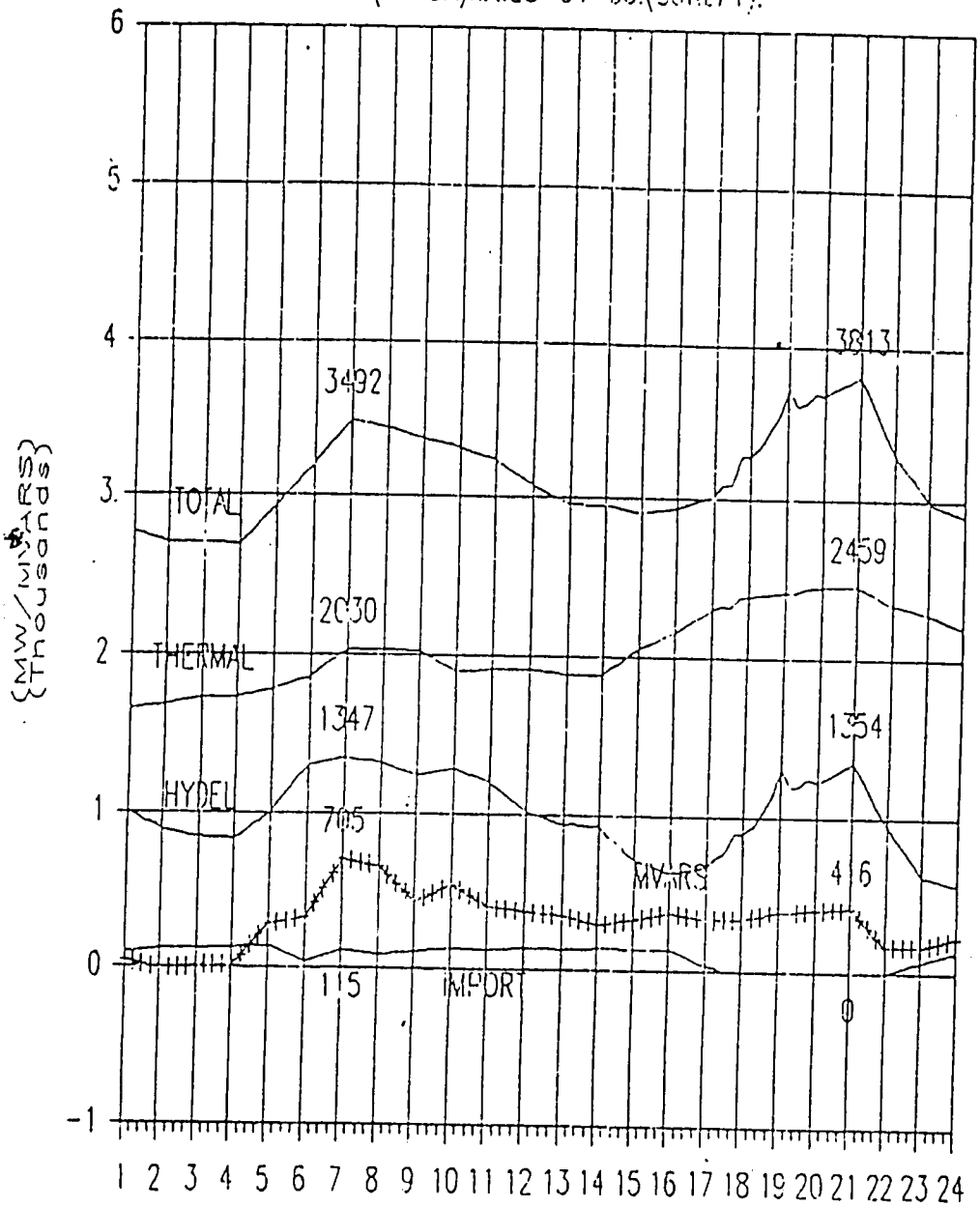
BEST AVAILABLE COPY

DAILY LOAD CURVE

F.N. 1209 / 23.1.90

②

L.D.C. (WAPDA).D(:28-01-90.(SUNDAY).



DPC Thursday 1/2/90 CE LDC Muhammad Ikram ul Haq

LF.Hy 75.5 Sys 81.87 + Fre:49.7 c/s2100HRS

LOAD SHEDDING BY REGIONS.

FROM (HRS)	TO (HRS)	DURATION (HRS)	QUANTUM (MW)
1730	2030	3	1300
2030	2230	2	1000
2230	0530	7	600
0530	1730	12	1000

1/2/90

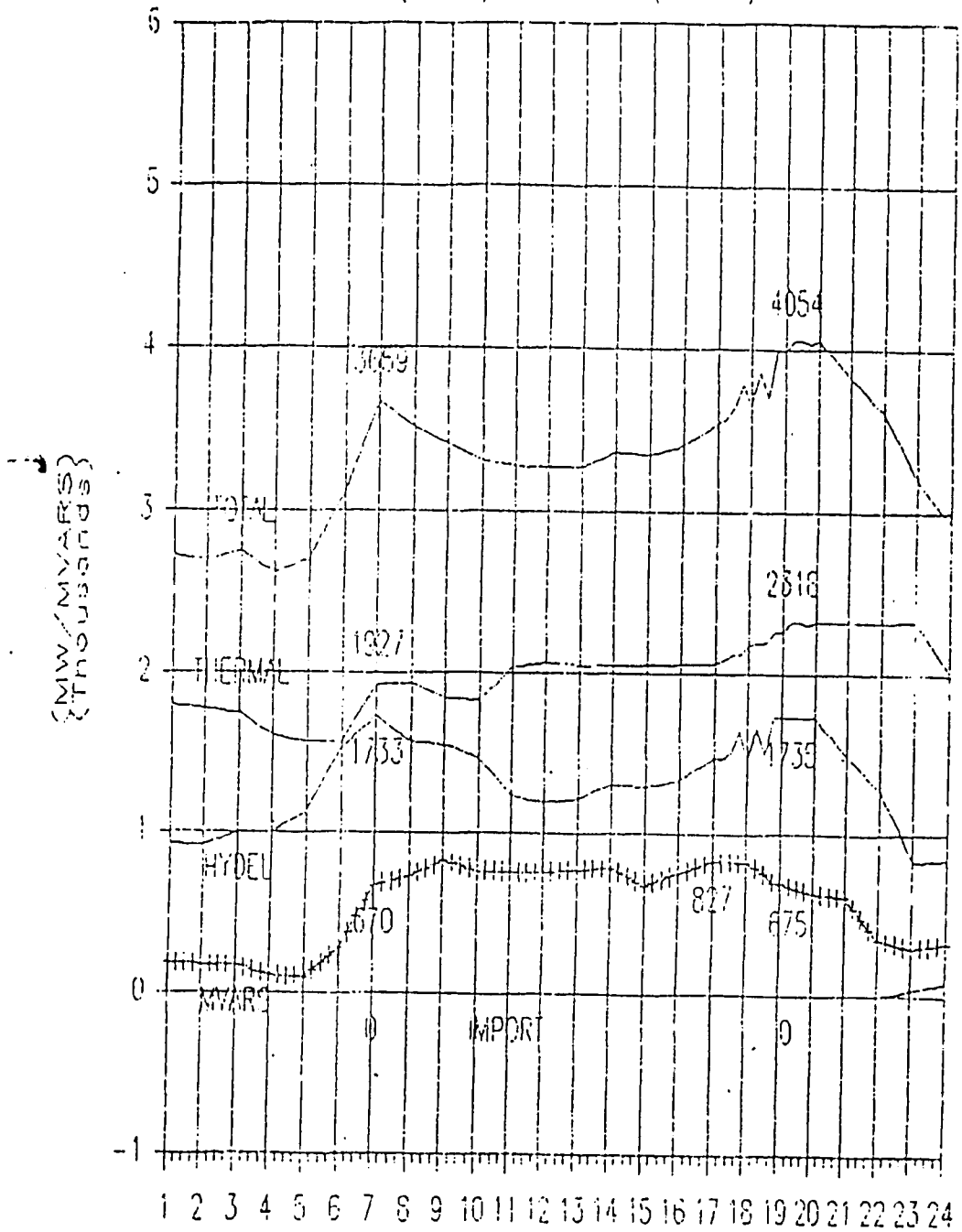
BEST AVAILABLE COPY

DAILY LOAD CURVE

Fuse Nr. 1796
dt; 26.2.90

(3)

L.D.C. (WAPDA).DA:25-02-90.(SUNDAY)



DPC 26.02.90. CE LDC Muhammad Ibro.

— LF.Hy 76.2 Sys 88.8 + Tre 50.0 c/s 1915PS

LOAD SHEDDING BY REGIONS

FROM (HRS)	TO (HRS)	DURATION (HRS)	QUANTUM (MW)
1500	2100	03-00	1000
2100	1200	21-00	NIL

BEST AVAILABLE COPY

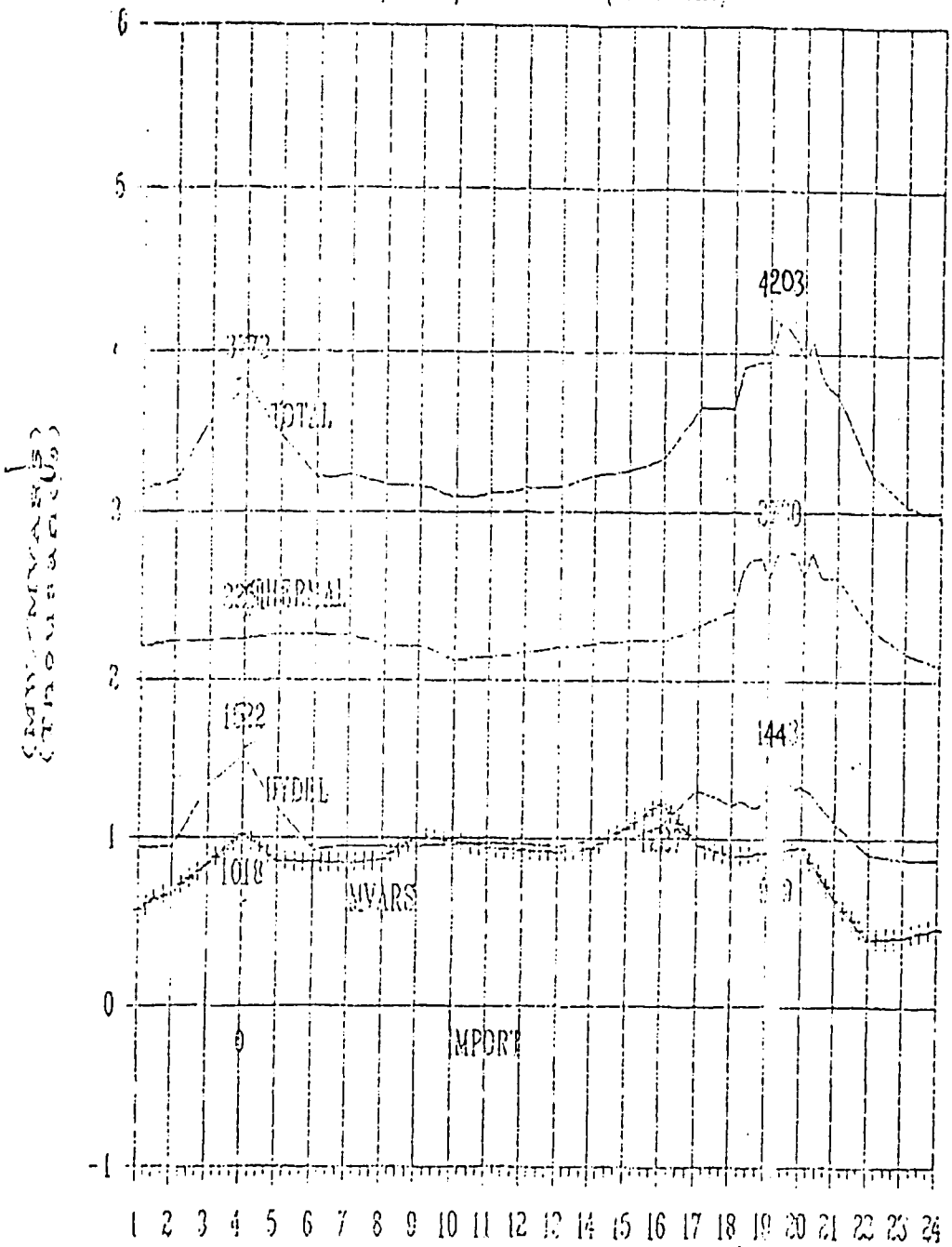
Chaudhri Bashir 26/2/90

26/2/90

DAILY LOAD CURVE

L.D.C. (WAPDA).DE:29-03-90.(THURSDAY)

(4)



DPC 31.3.90 CE LDC 31.3.90

– J.F.Hy 72.3 Sys 80.0 + Freq 50.0 c/o 1915HRS

LOAD SHEDDING BY REGIONS.

	FROM (HRS)	TO (HRS)			QUANTUM (MW)
1	1830	[illegible]	FURNACES & HEATING	100%	150
2	1830	[illegible]	TEXTILES	50%	[illegible]
3	1830	[illegible]	CEMENT	50%	50
4	1830	[illegible]	TUBEWELL,SCARP & PRIVATE	50%	[illegible]
	2030	[illegible]	at a time		
5	[illegible]	[illegible]	GENERAL		[illegible]
			TOTAL:-		[illegible]

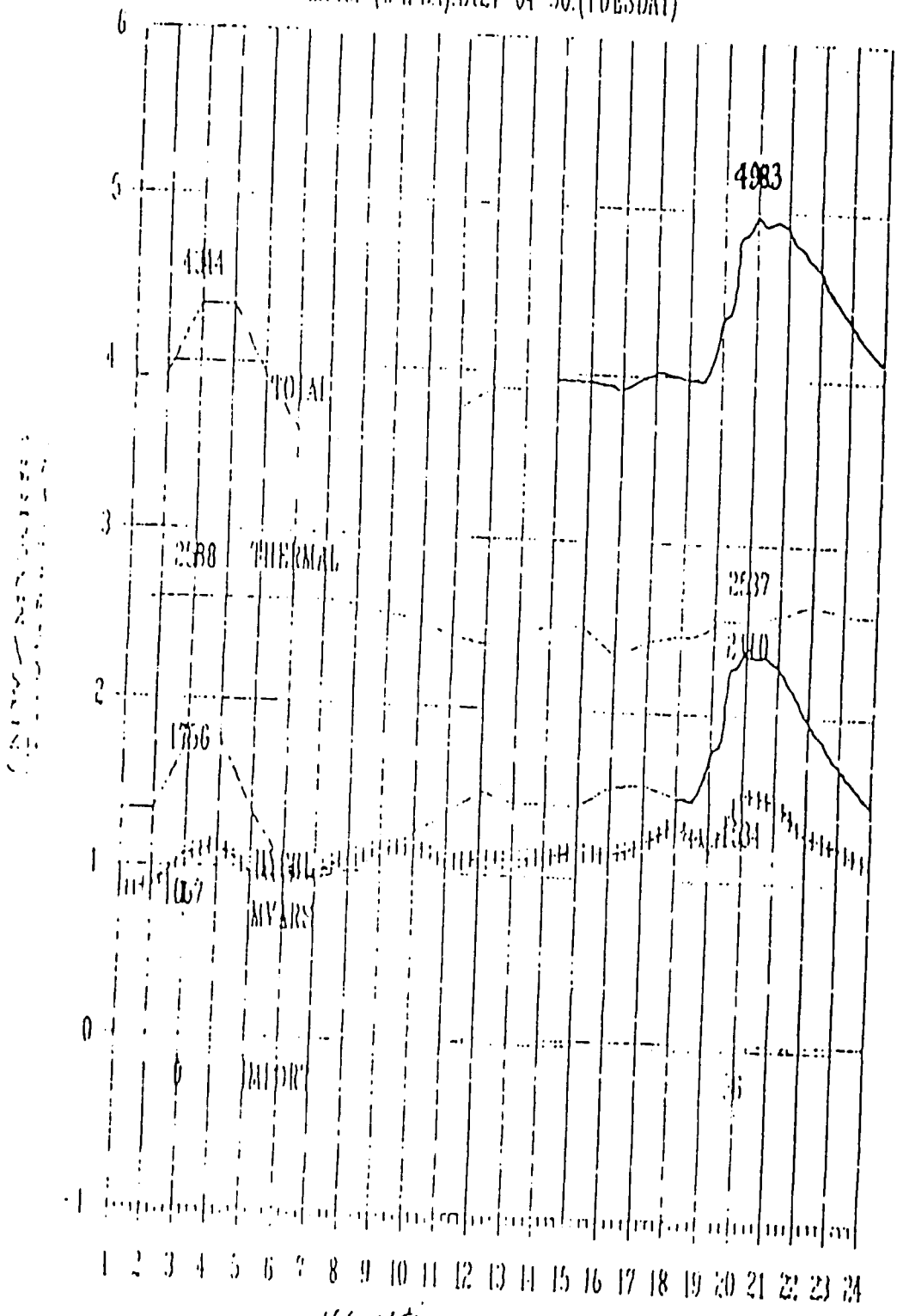
BEST AVAILABLE COPY

10

DAILY LOAD CURVE

L.D.C. (KAPDA).0124-04-90.(TUESDAY)

(5)



DIC

CE LDC

LP.H) 62.8 Sys 80.7

Freq:50.0 @ 20:00HRS

BEST AVAILABLE COPY

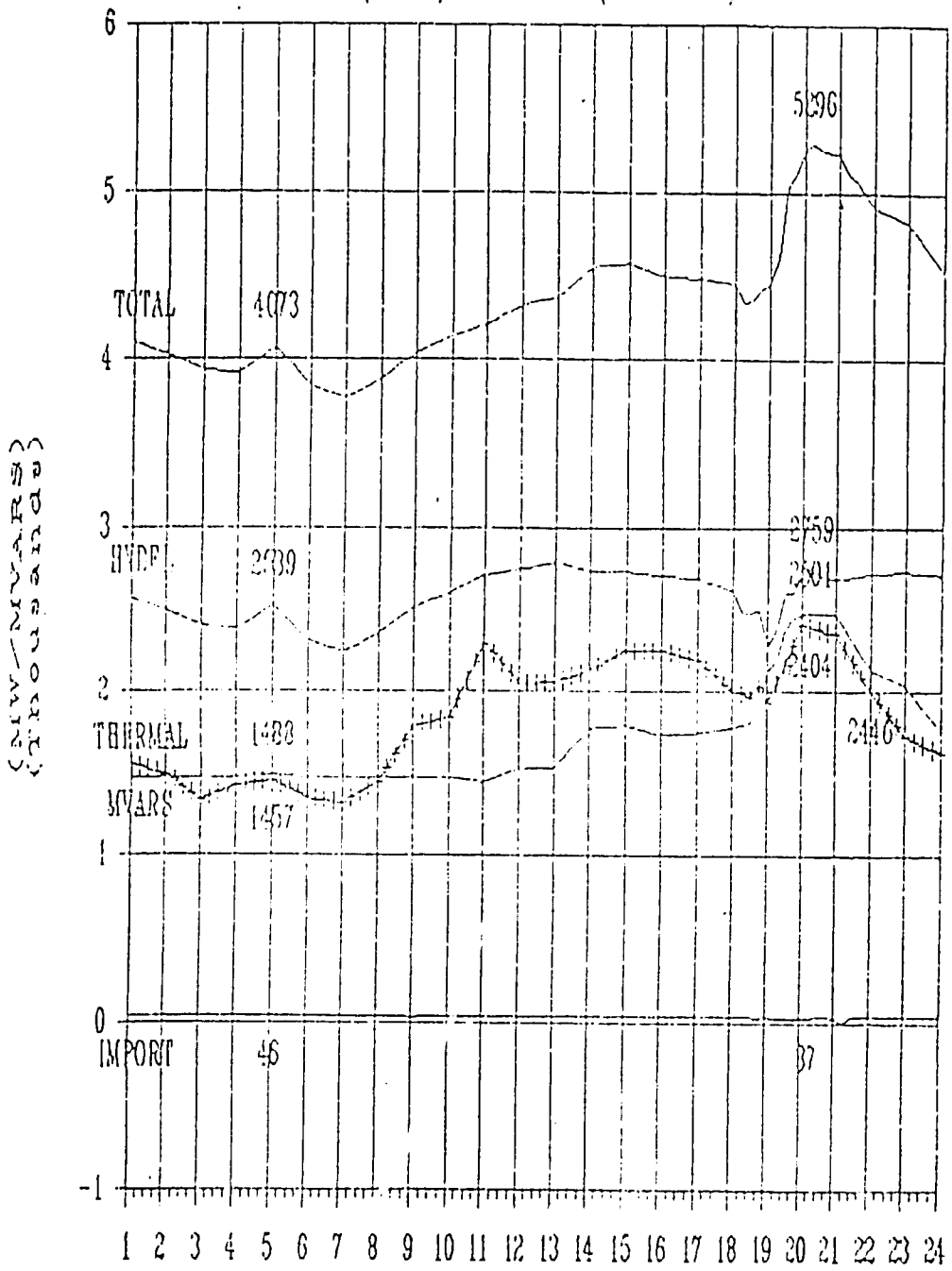
71

DAILY LOAD CURVE

Loc: 03-10 28-05-90

L.D.C. (WAPDA).DI 23-05-90.(WEDNESDAY)

(6)



DPC_____ LDC Muhammad Ghaznavi 24/5/90

— LP.Hy 929 Sys 81.9 + Freq:50 c/s 2015 HRS

· .TH 68.82

24/05/90

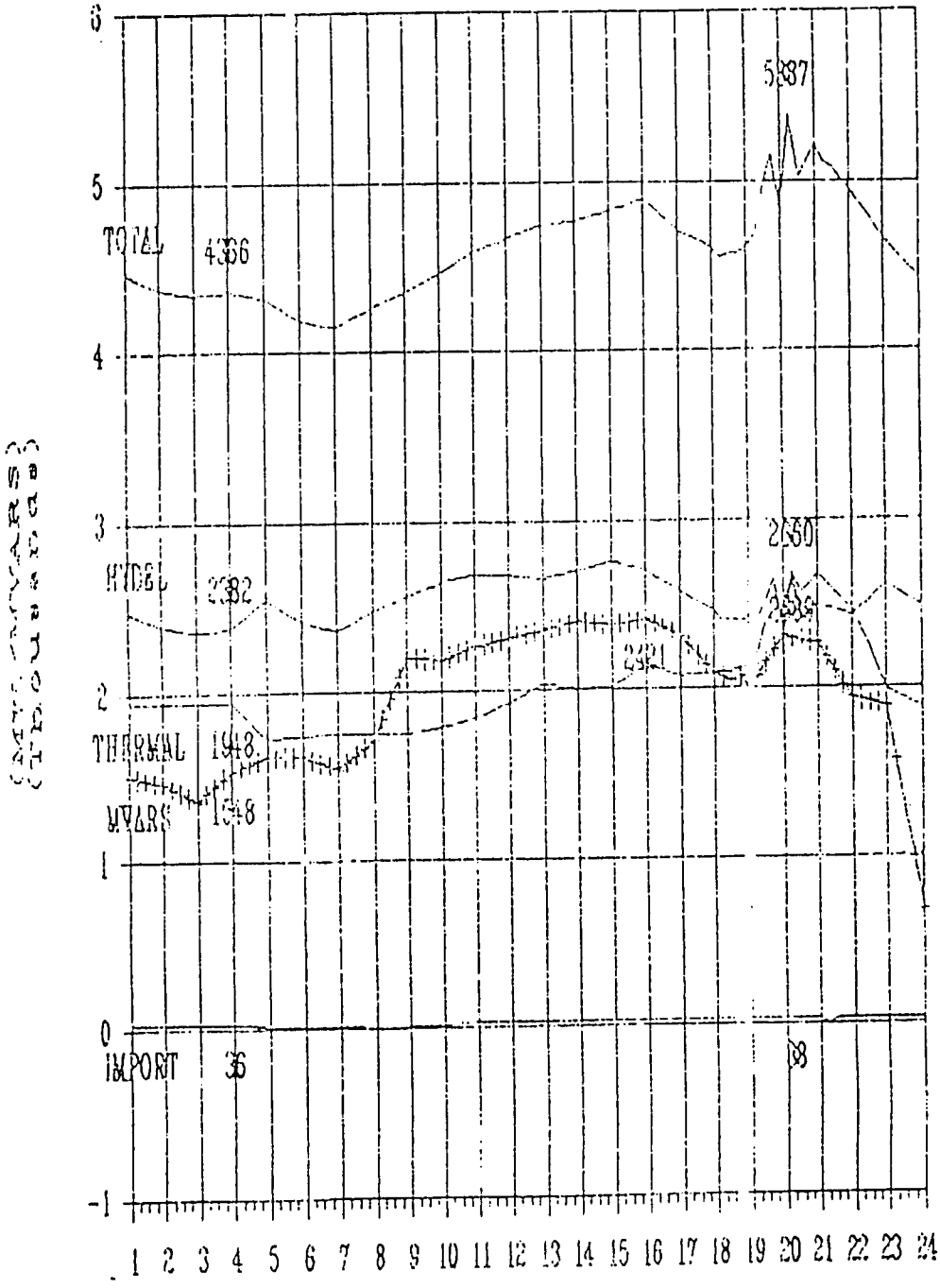
BEST AVAILABLE COPY

72

DAILY LOAD CURVE

(7)

L.D.C. (WAPDA).DT 21-06-90.(THURSDAY)



DPC_____ CE LDC_____

— LF.By 91.7 sys c/3 + Freq c/s 1015 HRS

BEST AVAILABLE COPY

73

ANNEX 2

LIST OF REFERENCES

BEST AVAILABLE COPY

LIST OF REFERENCES

1. Financial Synopsis of Technical Results 1989-90, Pakistan Society of Sugar Technologists.
2. S. Paracha's letter to Mr. G.M. Ilias dated March 31, 1990.
3. Guidelines for Cane Industry, World Bank, July 1982.
4. Speech by H.A. Naqui, President Pakistan Society of Sugar Technologists, July 21, 1990.
5. The Pakistan Sugar Industry: An Economic and Policy Analysis, AID/Government of Pakistan, October 1988.
6. Identifying the Basic Conditions for Economic Generation of Public Electricity from Surplus Bagasse, The World Bank, October 1983.
7. Speech by M. Akram, Chairman, Pakistan Sugar Mills Association, July 21, 1990.
8. Power for the Grid from Sugar Cane Residues, USAID, August 1989.
9. Mauritius: Bagasse Power Potential 1987-2000, World Bank, October 1987.
10. India: Maharastrtra Bagasse Energy Efficiency Project, The World Bank, March 1990.
11. Cane Availability Study, Paracha Sugar.
12. Technical Study for Cogeneration in Sugar Factory, Tate & Lyle for S. Paracha, September 1987.
13. Electric Power Generation at Sugar Mills in Pakistan, ENERCON-89-144, December 1989.
14. Belize Renewable Energy Study, Canadian International Power Services, Inc., July 1989.

ANNEX 3

LIST OF KEY PEOPLE MET

LIST OF PEOPLE MET IN PAKISTAN

Mian Shahid Ahmad, USAID, Islamabad
Ken Luisser, USAID, Islamabad
Jack Swift, USAID, Islamabad
Carl Duisberg, USAID, Islamabad
Doug Huber, USAID, Islamabad
Mohammad Ebrahim Hasham, Mehran Sugar Mills Ltd Islamabad/Karachi
Ghulam Murtaza Ilias, PPC/MWP, Islamabad
Shahid Hafeez Ahmad, PPC/MWP, Islamabad
Robert Grimshaw, Queltech(IRG), Lahore
Javid Akhtar, WAPDA Member (Power), Lahore
Faryad Hussain Malik, WAPDA/PPC, Lahore
Mohammad Arshard, WAPDA/PPC, Lahore
Saifullah A. Paracha, Paracha Sugar, Karachi
Nasim Aziz, Pakways, Karachi Engineering Company
Khalid Akbar, Crescent Group, Karachi
Jamil Ahmed Khan, Crescent Group, Karachi