UPGRADING SUGAR FACTORY OPERATIONS FOR IMPROVED ENERGY UTILIZATION

Presented To The Symposium

FUELS AND FEEDSTOCKS FROM TROPICAL BIOMASS

Caribe Hilton Hotel, San Juan, Puerto Rico
November 24 and 25, 1980

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH
UNIVERSITY OF PUERTO RICO — U.S. DEPARTMENT OF ENERGY

CEER - B-106

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Until very recently sugar mill operators thought of bagasse as a necessary evil. It had to be used as inefficiently as possible so that no money need be spent in getting rid of any excess over and above boiler firing capacity. Small quantities were stored for use during mill shut-downs but otherwise any excess was hauled away to be incinerated in some open space outside the factory grounds. As the price of energy has escalated in the wake of OPEC oil price rises, mill operators have become aware of the need of upgrading operations so that any excess energy over that required for sugar processing is not wasted. Changes in field operations have forced some sugar factories to supplement bagasse with expensive fuel oil in order to generate the power and steam required for milling cane and processing the juice into sugar and molasses. It is no longer possible to operate inefficiently and some sugar producing regions have taken steps to maximize energy efficiency and conservation in their sugar cane industry practices.

In Puerto Rico most sugar mill boilers are operated at very low pressures, ranging from 125 to 175 psig. In so doing, the ability to transform the heat values in bagasse into usable power is severely curtailed. While it is not possible to attain utility boiler pressures with such a low grade fuel as bagasse, bagasse boilers elsewhere are operated at much higher pressure without using any auxiliary fuels. This has been made possible by the use of bagasse dryers using waste heat from plant boilers. In so doing they have made possible higher furnace temperatures, less excess air requirements, higher boiler efficiency and lower particulate emissions.

In order to illustrate how the thermal balance of a sugar mill is affected by these factors, we have looked at a sugar mill processing 7,500 tons of cane per 24 hours under conditions more or less typical of Puerto Rico. We have calculated how much surplus electrical energy could be generated under optimum present operating conditions and also with the addition of a bagasse dryer and a high pressure boiler. The dryer would reduce moisture content of bagasse to 40% and the boiler would be operated at 640 psig and 640°F.T.T. A steam turbo-generator would utilize the excess steam under various schemes. The following options have been considered:

1. Operate under present conditions, with and without a bagasse dryer. Steam not needed for operations to be utilized by a neighboring industrial operation or expanded to 4" Hg. Abs. by use of suitable condensing equipment (Tables 1A and 1B; Figs. 1A and 1B).
2. Addition of a high pressure boiler and using all bagasse produced as fuel. Again excess low pressure steam to be provided to another industrial operation or expanded to 4"

Hg. Abs. under appropriate conditions (Table IIA and Fig.IIA).

3. Same as 2 above but burning only the quantity of bagasse required for generating 300,000 lbs per hour steam needed for sugar operations; the rest to be stored for off season operation or sold to others for fuel and/or fiber use (Table IIB and Fig. IIB).

Table III shows that electric power generation is not significantly increased by drying the bagasse to 40% moisture content if it is used to produce steam at the low pressures now prevailing in the sugar industry in Puerto Rico. Thus the available power increases only by 18% under optimum conditions. However, if a relatively high pressure boiler is fired with this 40% wet bagasse, it is possible to increase electrical power generation up to 128% over the former case.

In Case IIB less than half of all the raw bagasse produced by the sugar mill is needed to generate all the steam required for factory operations. This steam is capable of generating about 8500 KWe of which 2500 are consumed in house, the balance of 6000 KW are available for sale. The excess bagasse may be stored and used to run the steam and power system during the off-season, producing at least 16,000 KW for sale if enough generating and condensing capacity is made available.

CALCULATIONS

General Information:

Capacity - 7,500 tons cane/24 hrs
Fiber - 18% cane

Raw Bagasse Analysis		
	Fiber	42%
	Brix	5%
	Ash	1%
	Moisture	52%

Total Fiber = 7,500 x 0.18		1,350 tons/day
" Brix		161 "/day
" Ash		32 "
Total Dry Weight		1,543 tons/day
Total Raw Bagasse		3,214.6 tons/day
Flow Per Hour (Raw)		133.9 tons
Flow Per Hour (40% wet)		107.2 tons
H H V 40% bagasse	=	4,947 BTU/lb
HHV 52% bagasse	=	3,958 " "
OA Boiler Efficiency (40%)	=	68%
OA Boiler Efficiency (52%)	=	62%
Steam Rate 625 psig to 140psig	=	34.95 lbs/KWe
Steam Rate 140 psig to 15 psig	=	37.15 lbs/KWe
Steam Rate 140 psig to 4" Hg abs	=	19. 84 lbs/KWe

Case 1- OPTIMUM CAPACITY WITH LOW PRESSURE BOILERS

1a - Weight Raw (52%) bagasse	- 133,9 tons/hr
Total heat in bagasse	- 1,060 x 10^6 BTW/hr
Total heat to steam	- 657 x 10^6 BTW/hr
Steam flow	- 651 M lbs/hr
Steam for process	- 300 M lbs/lb
Balance for power	- 351 M lbs/lb
Surplus power to 15 psig	- 9448 KWe
" " to 4" Hg abs	-17,692 KWe

1b - Using bagasse dryer

Weight 40% W bagasse	= 107.2 tons/hr
Total heat in bagasse	= 1,060 x 10^6 BTU/hr
Total heat to steam	= 721 x 10^6 BTU/hr
Steam flow	= 714 M lbs/hr
Steam for process	= 300 M lbs/hr
Balance for power	= 414 M lbs /hr
Surplus power to 15 psig	= 11,144 KWe
" " to 4" Hg abs	= 20,867 KWe

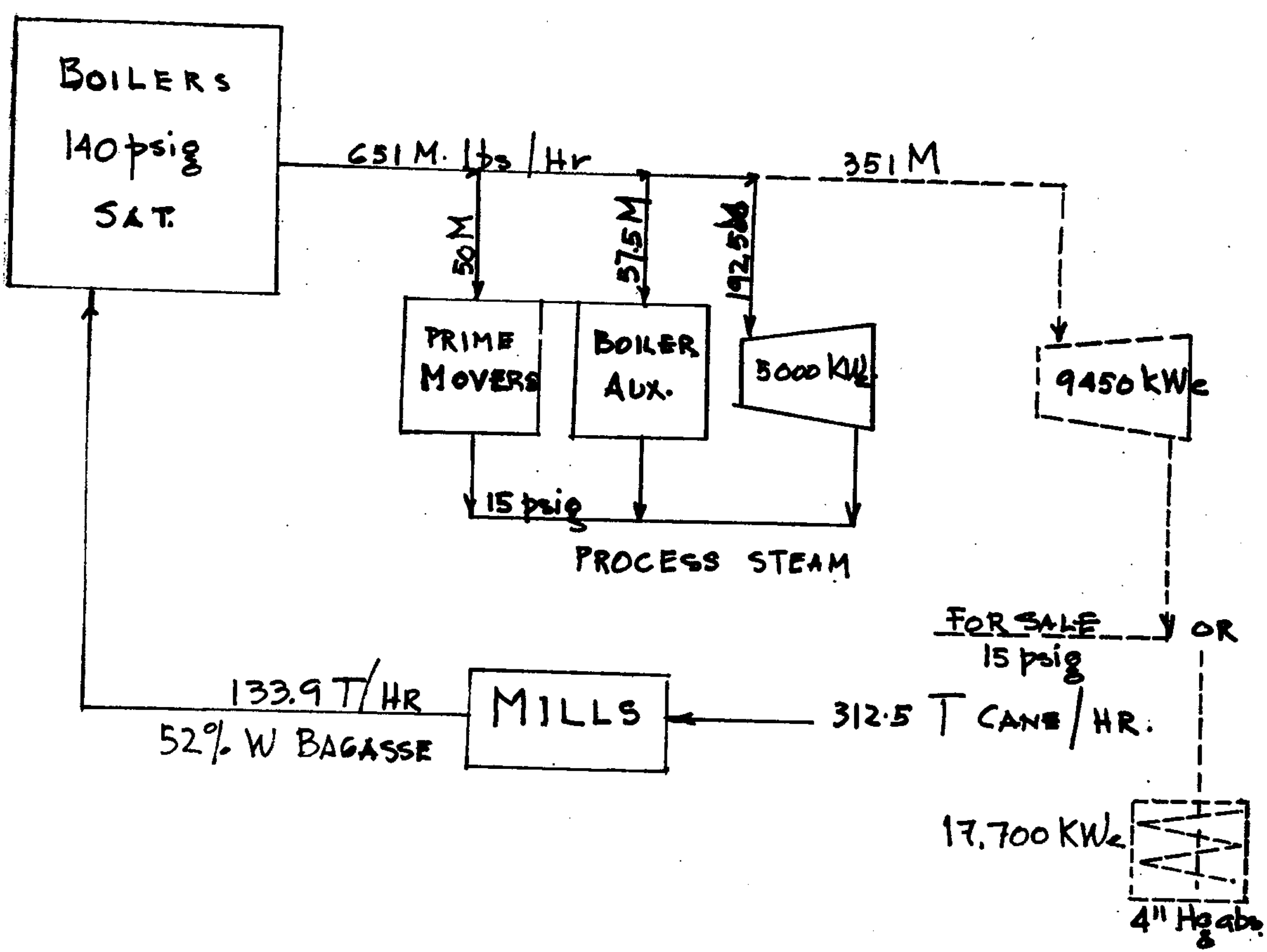
Case IIA - HIGH PRESSURE BOILER

Weight 40% W bagasse	=	107.2 Tons /hr
Heat in bagasse	=	1,060 x 10^6 BTU/hr
Heat to steam	=	721 x 10^6 BTU/hr
Steam flow	=	603.8 M lbs/hr
Surplus Power to 140 psig	=	17,276 KWe
-A Surplus power to 15 psig	=	8,178 KWe
-B Surplus power to 4" Hg. abs	=	15,313 KWe

Case IIB - 300,000 lbs/hr pressure boiler

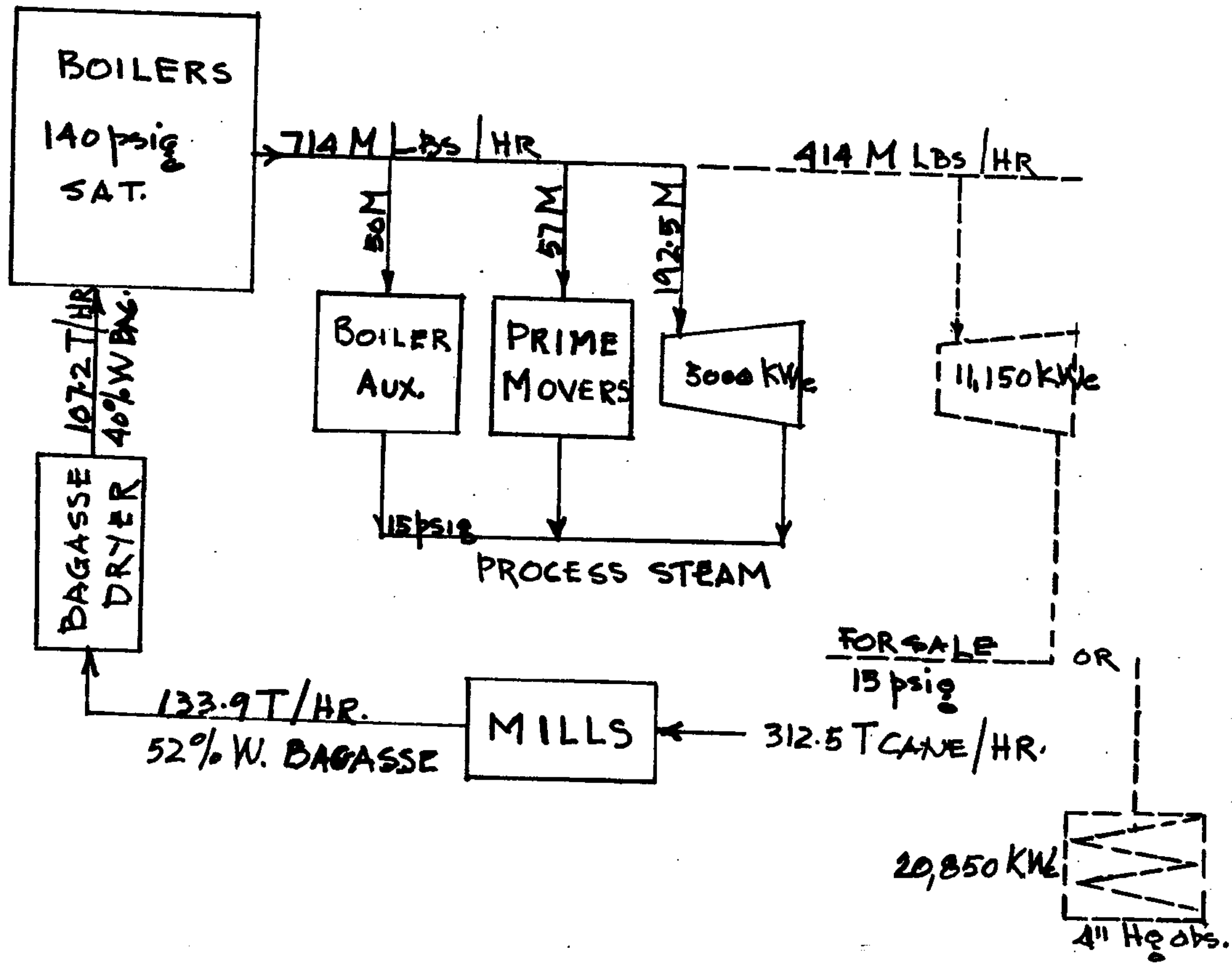
Steam flow	=	300,000 lbs/hr
Surplus power to 140 psig	=	8,584 KWe
Bagasse required	=	53.3 tons/hr
Surplus bagasse (40%w)	=	53.9 tons/hr
Equivalent raw (52%w) bagasse	=	67.4 tons/hr
To storage 67.4 x 24	=	1,617.6 tons/day

I-a.

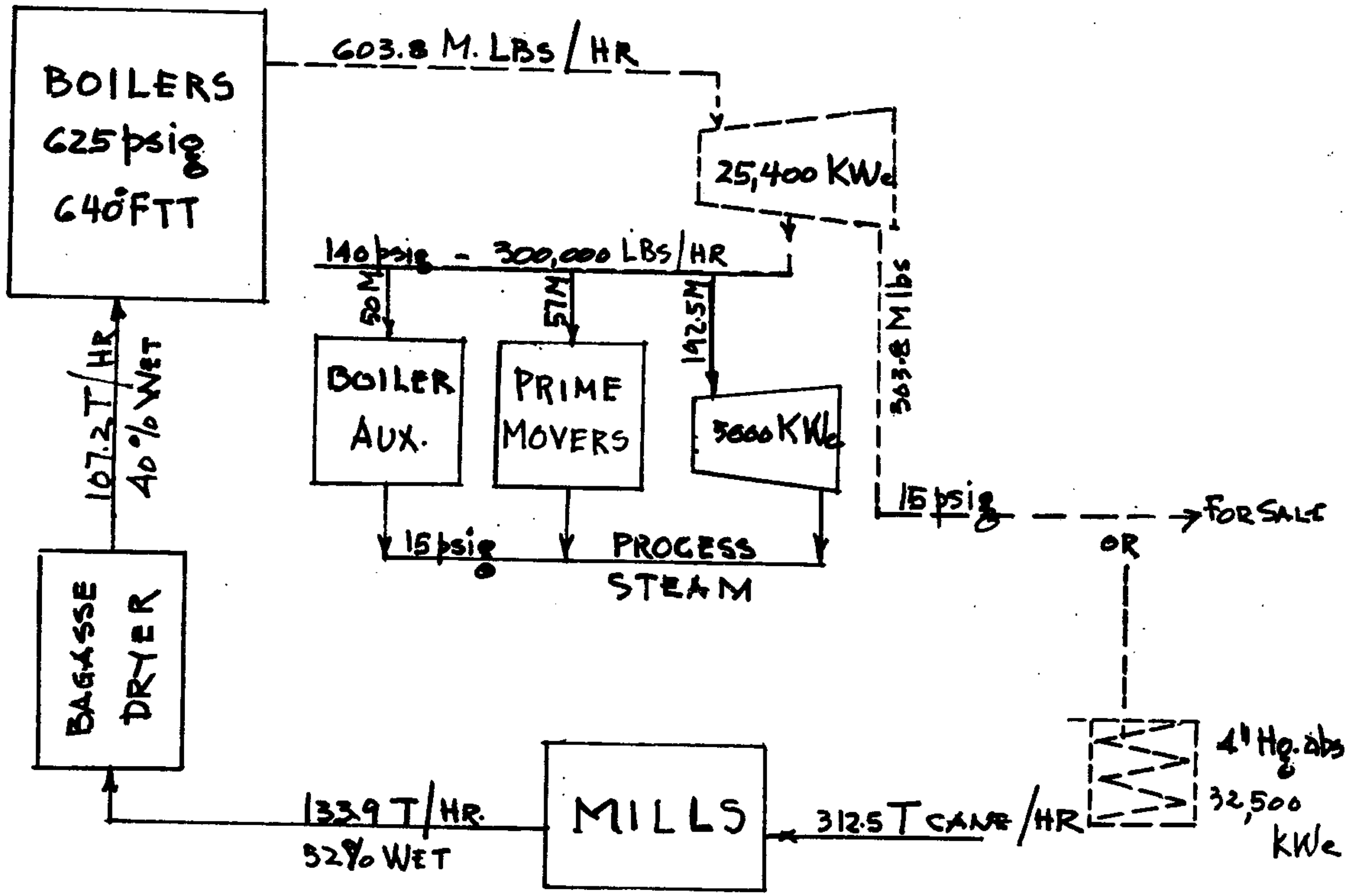


BOILERS
140 psig
SAT.
651 M. lbs/Hr
50 M
57.5 M
192.5 M
351 M
PRIME MOVERS
BOILER AUX.
5000 KWe
9450 kWe
15 psig
PROCESS STEAM
FOR SALE
15 psig
OR
17,700 KWe
4" Hg abs.
133.9 T/HR
52% W BAGASSE
MILLS
312.5 T CANE/HR.

I-b


BOILERS
140 psig
SAT.
714 M LBS/HR
414 M LBS/HR
80M
57M
192.5M
BOILER AUX.
PRIME MOVERS
3000 KWe
11,150 KWe
15 psig
PROCESS STEAM
FOR SALE
15 psig
OR
20,850 KWe
4" Hg abs.
1072 T/HR
40% W BAG.
BAGASSE DRYER
133.9 T/HR.
52% W. BAGASSE
MILLS
312.5 T CANE/HR.

II-a



BOILERS
625 psig
640°F TT
603.8 M. LBS/HR
25,400 KWe
140 psig - 300,000 LBS/HR
80M
57M
192.5M
BOILER AUX.
PRIME MOVERS
3000 KWe
363.8 M lbs
15 psig
15 psig
FOR SALE
OR
PROCESS STEAM
107.2 T/HR
40% WET
BAGASSE DRYER
133.9 T/HR.
52% WET
MILLS
312.5 T CANE/HR
4" Hg. abs
32,500 kWe

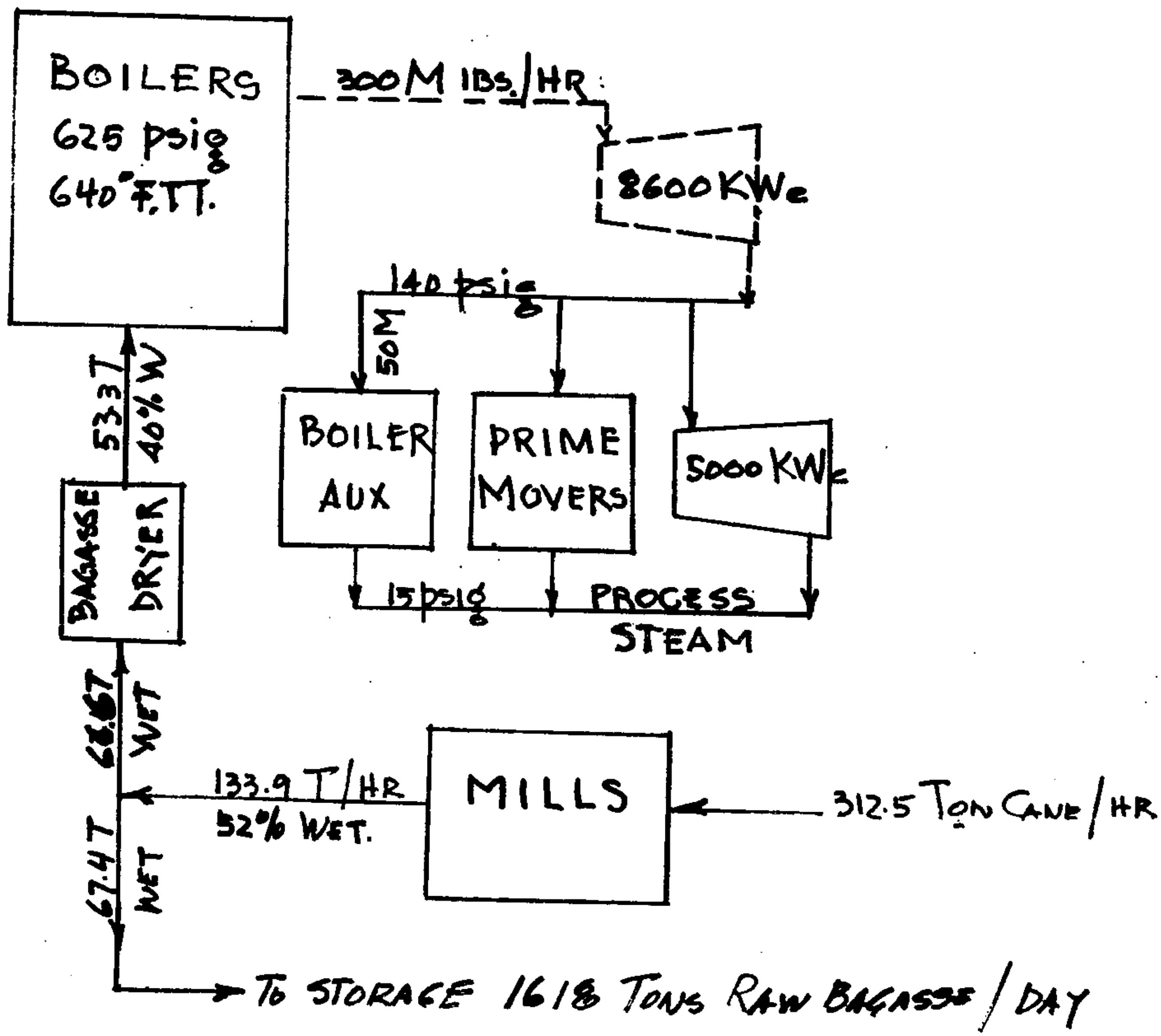

BOILERS
625 psig
640°F.T.T.
300M lbs./HR
8600 KWe
140 psig
50M
BOILER AUX
PRIME MOVERS
5000 KWe
15 psig
PROCESS STEAM
53.3T
40% W
BAGASSE DRYER
66.5T
WET
133.9 T/HR
52% WET.
MILLS
312.5 Ton Cane/HR
67.4T
WET
To STORAGE 1618 Tons Raw Bagasse/DAY

TABLE III - AVAILABLE POWER

	IA	IB	IB-IA	IIA	IIA-IB
Bagasse Moisture %	52	40	----	40	----
Steam Pressure Psig	140	140	----	640	----
Wt Steam Mlbs/hr	651	714	+ 63	304	- 110
To Process Mlbs/hr	300	300	----	300	----
To Power Mlbs/hr	351	414	+ 63	304	- 110
Power to 15 psig, KWe	9,448	11,144	+1696	25,454	+14,310
Power to 4"Hga, KWe	17,692	20,867	+3175	32,589	+11,722