SELF-GENERATING, LOAD DISPLACING SAWMILLS IN THE POST-BEEHIVE BURNER ERA IN BRITISH COLUMBIA

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An earlier version of this paper was presented to the
Second Biomass Conference of the Americas in Portland, OR in August 1995.

Abstract

The British Columbia Ministry of Environment, Lands & Parks has legislated that particulate emissions from about half the Province's 150 sawmill beehive burners (also known as tee-pee or wigwam burners) - the "Tier 1 burners" - must not exceed 120 mg/Nm^3 (milligrams per "normal" - i.e., standard - cubic metre, which is equivalent to about 0.052 grains per standard dry cubic foot). By the end of 1997 a number of Tier 1 burners will beginning shutting down. As of this writing it appears that all Tier 1's will be ordered shut down by the end of 1999. The "Tier 2" sawmill burners will have another several years before they too will have to meet the new standard.

The Heuristic **EnvirOcycler** can replace existing beehive burners. The **EnvirOcycler** is a stand-alone, two-stage, wet wood, combustor (updraft gasification followed by cyclonic combustion) which meets the new BC particulate limit and from which sensible heat can be recovered. Versions of this combustor have been in continuous service in the forest products industry for 16 years.

This paper describes two Self Generating, Load Displacing sawmill installations which feature an **EnvirOcycler** as part of an Energy Displacement Plant. An Energy Displacement Plant includes hot oil generators and recuperated gas turbine generator sets. The first installation is that of a 120 Mbf/y (Million boardfeet per year) sawmill (about 450,000 m^3 of logs) and features a 110 MBtu/h (Million Btu/h) **EnvirOcycler**, 48 MBtu/h of hot oil heat recovery for lumber drying/building heat and 3.3 MW of electric power produced by a recuperated, gas turbine driven, generator set. The second installation is for a 150 Million boardfeet per year sawmill (about 550,000 m^3 of logs). It features a 130 MBtu/h **EnvirOcycler**, 30 MBtu/h of dry kiln hot oil heat recovery (or 60 MBtu/h of hot water heat recovery) and 6.6 MW of recuperated gas turbine driven electrical power.

Other uses for this waste - Medium Density Fibreboard (MDF) and Sawdust Digestors (for pulp) - are examined. Finally, an analysis was conducted to determine what the *Equivalent Disposal Cost* of each ton of wet wood waste was, assuming revenue streams from the displacement of natural gas and electricity and from the sale of electricity during weekends and graveyard shifts. A 20% return on equity was stipulated. The analysis revealed that the Equivalent Disposal Cost - i.e., "the tipping fee" the sawmill would have to charge itself to realize a 20% return on its investment - is \$3.50/wet ton for the smaller sawmill and \$3.00/wet ton for the larger sawmill. By way of comparison, the Equivalent Disposal Cost for straight incineration without any heat recovery is \$6.75/ton. All costs are in Canadian dollars.

Introduction

By the end of 1997 British Columbia's forest products companies will be required to begin shutting down about half of their beehive burners (also known as tee-pee or wigwam burners) in order to comply with new BC Ministry of Environment, Lands and Parks (MoELP) beehive burner emission regulations. The new regulations abandon opacity readings and call instead for particulate emissions which are not to exceed 120 mg/Nm^3 (0.052 grains/sdcf). The remaining 75 or so burners have another several years before they too will have to shut down. This paper describes a beehive burner replacement incinerator which meets the new MoELP regulations, and from which useful energy can be recovered.

The replacement burner is the stand-alone, Heuristic **EnvirOcycler**. Versions of the **EnvirOcycler** have been in continuous service in the forest products industry since 1981. The **EnvirOcycler** employs a two-stage combustion process, It converts wood waste into a burnable "producer gas" in a large, first stage of gentle updraft gasification, which is then immediately burned in a second stage of vigorous cyclonic combustion. The second stage is placed directly above the first stage. First stage particulate carried up into the second stage is centrifugally thrown out to the second stage walls. This particulate then falls, under gravity, back down into the first stage. The **EnvirOcycler'**s first stage, built-in ash removal system removes the ash from the burner.

Particulate levels in the **EnvirOcycler**'s 2,000^{o}F products of combustion conform to the MoELP requirements of 120 mg/Nm^3. In addition, vigorous two-stage combustion inherently results in low levels of nitrous/nitric oxide (NO_x) and carbon monoxide (CO).

Once a sawmill has installed an **EnvirOcycler**, and has shut down its beehive burner, it is then in compliance with the MoELP particulate regulations. The sawmill can then carry on as it did before or, if it chooses, it can recover energy from the sensible heat in the **EnvirOcycler**'s 2,000^{o}F products of combustion. The heat can be recovered in *stages* or all at once. The sawmill can, for example, elect to *first* recover heat for its dry kilns and its buildings and *later* recover additional heat for electrical power generation. In *displacing* its purchased gas and electricity the sawmill becomes a Self Generating, Load Displacing (SGLD) facility.

Energy Displacement Plant

The sawmill achieves SGLD status by means of, what is referred to herein as, an *Energy Displacement Plant* (EDP). An EDP comprises an **EnvirOcycler**, a combination of hot oil (or other thermal fluid) generators and one or more *recuperated* gas turbine (G-T) generator sets. A recuperated gas turbine is one in which the normal, fossil fuel fired, combustion chamber is replaced by a *recuperator*, i.e., by an external, high temperature, gas-to-air heat exchanger. The recuperator transfers heat from the **EnvirOcycler**'s 2,000^{o}F products of combustion to the G-T's compressor discharge air and, in so doing, heats this air up to the G-T's turbine inlet temperature.

A 63 MBtu/h **EnvirOcycler,** firing a nominal 40 MBtu/h recuperator of a 3.3 MW G-T generator set, is shown in Sketch 1. The sketch shows hot oil and hot water waste heat recovery along with a Temperature-Entropy (T - S) diagram of the open loop Rankine cycle.
The EDP's hot oil generator(s) provides hot oil for dry kiln and building heat, thereby displacing natural gas or propane. The EDP's recuperated G-T generator set(s) (readily available in the 3 to

5 MW range) displace most, if not all, of the electricity used by an average size BC Interior sawmill. Surplus electric power available during weekends and graveyard shifts can be sold to BC Hydro or to the PEO - the Power Exchange Organization - a collection of Western North American utilities, for added revenue.

Two such EDP's are discussed in this paper. The first EDP disposes of all the wood waste (bark, sawdust and shavings) generated by a typical 120 Mfb/y (Million boardfeet per year) BC Interior sawmill - approximately 100,000 wet tons per year at a wet basis moisture content of 46% - in a 110 MBtu/h **EnvirOcycler**. This EDP generates 3.3 MW of electric power and 48 MBtu/h of hot oil dry kiln/building heat. A Solar Centaur turbine generator, manufactured by Caterpillar's Solar Turbine Division in San Diego, CA, was selected. Figure 1 shows this EDP's Flow Diagram. The Centaur's turbine inlet temperature is 1,660^{o}F.

The second EDP disposes of all 125,000 wet tons of wood waste generated by a nominal 150 Mfb/y BC Interior sawmill in a 130 MBtu/h **EnvirOcycler**. This EDP generates 6.6 MW of electricity in two Solar Centaurs and 30 MBtu/h of hot oil heat. Figure 2 shows the Flow Diagram for this EDP with hot oil heat recovery.

However, if the sawmill restricts the maximum dry bulb temperatures in its dry kilns to the 175^{o}F to 185^{o}F range - the temperature range consistent with the production of top quality J Grade or Machine Stress Rated (MSR) lumber - then an additional 30 MBtu/h can be recovered by using 250^{o}F hot water as the heat recovery fluid rather than hot oil.

Sketch 1 shows why additional heat is recovered. The extra MBtu/h are available because the lower stack temperature leaving the hot water generator - 350^{o}F for hot water versus 600^{o}F for hot oil - leads to a larger delta T across the heat exchanger. The enthalpy difference of the air/**EnvirOcycler** products of combustion mixture across the hot water generator is 2.1 times larger than the same enthalpy difference across the hot oil generator.

Detailed Energy Displacement Plant Descriptions

The 3 MW + 48 MBtu/h Energy Displacement Plant

Figure 1 shows a 110 MBtu/h **EnvirOcycler** disposing of 14 tons/h of 46% wet wood waste, 24 hours a day, 7 days a week. The **EnvirOcycler**'s 2,000^{o}F products of combustion are conveyed in two "breechings" (horizontal, refractory-lined ducts) to the top of the "shell side" of a 33 MBtu/hot oil generator and to the top of the "shell side" of a 40 MBtu/h recuperator. Surplus products of combustion are dumped to atmosphere.

The inlet to the "tube side" of the recuperator is coupled to the compressor discharge of a 3 MW Centaur gas turbine generator set. The outlet from the tube side of the recuperator is coupled to the turbine inlet of the same gas turbine. The recuperator heats the 145 psia, 610^{o}F compressor discharge air up to 1,660^{o}F, the Centaur's turbine inlet temperature, before ducting it back into the turbine. In the event of a malfunction requiring gas turbine shut down - such as the generator having to suddenly shed load - a dump valve in the duct between the recuperator and the turbine inlet opens almost instantaneously. The 1,660^{o}F hot turbine air dumps to atmosphere allowing the turbine to come to a quick stop.

As can be seen in Figure 1, 2,000^{o}F **EnvirOcycler** products of combustion are drawn down through the shell side of the recuperator under the action of an 820^{o}F induced draft (ID) fan. Flow through the recuperator is controlled by an inlet vane damper on the ID fan. In most applications the gas turbine operates flat out in order to generate as much electric power as possible; therefore, there is no need for a variable frequency drive on the ID fan motor.

As shown in Figure 1, 4" minus hogged sawmill wood waste from the sawmill is conveyed, by a conveyor sized for a capacity of 50 tons/h - for surge purposes - to the **EnvirOcycler**'s one hour metering bin. The 7 unit metering bin (a unit is defined as 200 ft^3 of wood waste) supplies wood waste to the **EnvirOcycler** at the rate of 14 tons/h. At 46% moisture content, typical BC Interior sawmill wood waste has a density of 20.4 lbs/ft^3.

The 2,000^{o}F **EnvirOcycler** products of combustion ducted to the hot oil generator are drawn down through this heat exchanger under the action of a 600^{o}F induced draft (ID) fan. The products of combustion exit the hot oil generator and are routed to the main stack. The nominal hot oil temperature difference across the hot oil generator is 100^{o}F. The hot oil supply temperature is maintained at a 500^{o}F set point by varying the gas flow through the ID fan using a variable frequency drive.

The hot oil is circulated through the hot oil generator under the action of a 500^{o}F primary circulation pump. A diesel-motor-driven back-up pump parallels the primary circulation pump; it takes over in the event of a power failure and dumps the hot oil in the heat exchanger to a ground level storage tank.

A secondary hot oil circulation pump takes 500^{o}F oil from the main oil header and delivers it to the dry kilns. The dry kilns are supplied in parallel to each other. A kiln bypass is also installed in parallel with the dry kilns. Hot oil control to each kiln is achieved using constant volume, three way control valves. The nominal 400^{o}F hot oil exiting the dry kilns is returned to the hot oil generator for reheating.

As shown in Sketch 1, to generate 3 MW of power *and* to exit the recuperator at 820^{o} F, 63.2 MBtu/h of the **EnvirOcycler**'s total output must be drawn through the recuperator. If 110 MBtu/h are available in the "flue gas", and the gas turbine takes 63.2 MBtu/h, that leaves 46.8 MBtu/h available for hot oil heat. Because of the 600^{o}F stack losses this translates into 33 MBtu/h of hot oil heat available for the dry kilns. However, as shown in Figure 1, in true *co-generation* fashion an additional 15 MBtu/h is recovered from the combined turbine/recuperator exhausts; hence the 33 + 15 = 48 MBtu/h designation.

The 15 MBtu/h "waste heat" hot oil generator is fired by the 820^{o}F turbine exhaust air and by the 820^{o}F recuperator exhaust gas. The hot air/spent gas mixture discharges from the "waste heat" hot oil generator at 600^{o}F into the main stack. The waste heat hot oil generator has its own primary circulation pump. This pump delivers the waste heat 500^{o}F hot oil to the common hot oil header.

The ducts above the main 33 MBtu/h hot oil generator and the 40 MBtu/h recuperator are each fitted with a guillotine valve and an abort valve. The refractory guillotine valve, at the "inlet" to the heat exchanger top duct, serves as a shut off valve to isolate the heat exchanger from the **EnvirOcycler**'s 2,000^{o}F products of combustion. The refractory-lined abort valve is located on top of the duct, just slightly downstream of the vertical guillotine valve. The two valves are linked by a steel cable. When the guillotine valve drops down into the duct it automatically opens the abort valve. This allows fresh air to be drawn down through the heat exchanger to cool both the tubes and the liquid/gaseous fluids in the tubes under the action of the induced draft fan.

Finally, since the EDP must operate in conjunction with the **EnvirOcycler** in an *incineration* mode as well, provision is made to maintain the necessary flow of "flue gas" to the two heat exchangers by "back pressuring" the main supply breeching from the **EnvirOcycler**. This is done by means of a refractory-lined, flat valve, similar to the two heat exchanger abort valves, located on top of the main duct bypass stack.

The 6 MW + 30 MBtu/h Energy Displacement Plant

Figure 2 is a Flow Diagram of a 130 MBtu/h **EnvirOcycler** and a 6.6 MW EDP with 30 MBtu/h of "waste heat" 820^{o}F hot oil generation. It features two 40 MBtu/h recuperators and two Solar Centaur recuperative gas turbine generator sets. Because of the larger size **EnvirOcycler** required, a 9 unit wood waste metering bin is supplied.

30 MBtu/h of hot oil heat is, typically, only enough heat for 3 dry kilns. Accordingly, Figure 2 shows 3 dry kilns rather than the 4 kilns shown in Figure 1. As pointed out above, if a hot water generator is used in lieu of a hot oil generator, then approximately 60 MBtu/h of 250^{o}F hot water could be recovered: enough heat to operate 6 double tracked dry kilns, 120 feet long, whose maximum dry bulb temperatures do not exceed 185^{o}F.

Figures 3 and 4 show a Plan and an Elevation of a 6 MW Energy Displacement Plant which features a 130 MBtu/h **EnvirOcycler**, two recuperated 3 MW Solar Centaur gas turbine generator sets and a 30 MBtu/h "waste heat" hot oil generator. The Energy Displacement Plant occupies an area of 80 feet by 130 feet.

The "foot print" of the 130 MBtu/h **EnvirOcycler** is 26 feet x 26 feet. The top of the **EnvirOcycler**'s discharge scroll is 50 feet above ground level. The top of the main stack is 70 feet above ground. The "foot print" of the completely enclosed Centaur turbine is 29 feet by 8 feet. It is about 10 feet tall. The inlet air filter installed above the turbine generator increases the Centaur's overall height to about 20 feet.

Medium Density Fibreboard Option

In addition to effectively banning about half of British Columbia's sawmill beehive burners by the end of 1997 MoELP has also imposed a ban on landfilling the wood waste presently disposed in beehive burners. Faced with the pending beehive burner and landfilling bans, a number of forest products companies considered using their "white wood", i.e, their sawdust and shavings, in an MDF - a Medium Density Fibreboard - plant. There is a growing world-wide demand for MDF. Unfortunately, due to present MDF market conditions, of 7 MDF plants under active consideration in BC in 1994 only one plant has gone ahead at the present time. It is unlikely that another new MDF plant will be built in British Columbia before the year 2000.

While MDF is regarded in some quarters as the "answer" for the disposal of sawmill white wood, MDF does not appear to be the answer for the disposal of sawmill "brown wood", i.e., hog fuel. Rather than burn hog fuel in their energy systems, most MDF plants seem to prefer to burn sanderdust, scrap MDF and other MDF plant residue. The energy systems are used to heat hot oil for the board press and, in some cases, for the sawdust dryers.

In addition, at the present time the consensus seems to be that about 30% of MDF furnish must be made up of chips. Depending upon the state of the pulp and paper market, chips may or may not be an expensive MDF furnish. Furthermore, there appears to be some concern that not all sawdust from modern BC Interior sawmills - which employ thin kerf, water-cooled saws - is suitable for MDF. A figure used in some quarters today is that only 80% of such sawdust is suitable; the other 20% is considered too fine for MDF. BC sawmills might have to remove this fine, wet fraction and divert it to their hog fuel streams.

Also, as with all products marketed by the forest products industry, the MDF market is cyclical. Therefore, sawmills which depend on MDF plants to dispose of all their white wood may face a problem when the MDF market is in a slump. Will the MDF plant continue to operate or will it shut down until market conditions improve? If the MDF plant shuts down, how will the sawmill dispose of its wood waste, both white and brown?

One solution would be for the sawmills to install MoELP-compliant incinerators, such as the **EnvirOcycler**, sized to dispose of *all* the sawmill's wood waste, both white and brown wood. When the MDF market is bad the sawmill waste would be incinerated and the sawmill would recover whatever energy it decides to recover. When the MDF market is good then, because the **EnvirOcycler** has a turn down ratio of at least 5:1, the MDF plant takes the white wood and the **EnvirOcycler** consumes the remaining hog fuel and fine sawdust. Even without the white wood, the sensible heat in the hog fuel and the fine sawdust generated by a typical 120 Million fbm/y sawmill is normally sufficient to heat all the sawmill's dry kilns and buildings.

Sawdust Digester Option

Some BC pulp mills use sawdust and shavings to make a lower grade pulp. BC pulp mills which do not are considering this option. However, as with MDF, the fact that BC sawmills produce a significant percentage of very fine sawdust concerns the pulp mills considering this option. Apparently, sawdust that is too fine cannot be used to make satisfactory pulp.

In addition, Interior pulp mills that do produce a strong, long fibre, chemical pulp from 90 year old trees are hesitant to degrade the quality of the pulp they make - which is prized by their European customers - by blending in pulp from sawdust and shavings. The alternative to blending in the lower grade pulp is to set up a completely independent, 100% sawdust, pulping line. Unfortunately, setting up such a line increases the cost of the sawdust digester option by a factor of 10 - from about $4 Million to about $40 Million - at a given pulp mill.

Finally, just as with the MDF option, the question arises: what will the sawmills do when the sawdust pulp market bottoms out? It is argued that the installation of sufficient incineration capacity to accommodate all a given sawmill's wood waste provides the only real insurance for this eventuality.

Economics of Power Generation

In addition to examining the MDF option and the sawdust pulping option, BC sawmillers have lobbied the provincial government to try to make it force BC Hydro (which is owned by the provincial government) to buy electric power generated in wood-fired steam power plants for between 5.54 and 6.04 per kW.h. 5.54 to 6.04 is the rate that Independent Power Producers (IPP's) need to profitably recover their investments. A 60 MW wood-fired steam plant built in Williams Lake, BC in the late 1980's - the largest wood-fired power plant in North America - is reported to receive 6.54/kW.h.

Unfortunately for both sawmillers and IPP's, today, BC Hydro is only willing to pay about 34/kW.h for its purchased power. BC Hydro has a surplus of hydro-electric power and, based on responses it received to a recent Request For Proposals, natural gas fired, combined cycle, power plant IPP's are willing to sell BC Hydro electric power for about 34. Sawmill wood waste burning IPP's, fortunate to receive as much as 34/kW.h for power, would have to charge a tipping fee of between $15/wet ton and $20/wet ton to recover their investments.

As indicated above, a 120 Million fbm/y sawmill must dispose of about 100,000 wet tons of total wood waste a year. A $20/wet ton tipping fee would cost this sawmill $2.0 Million/y to dispose of all its wood waste; a 150 Million fbm/y sawmill would have to pay $2.5 Million/y. BC sawmillers regard these costs as outrageous!

The $15 to $20 tipping fee per wet ton provides a convenient reference point when analyzing the economics of the two Energy Displacement Plants described above. The installed cost of the 3 MW + 48 MBtu/h Energy Displacement Plant shown in Figure 1 is about $13.8 Million. The installed cost of the 6 MW + 30 MBtu/h EDP shown in Figures 2 through 4 is about $18.8 Million.

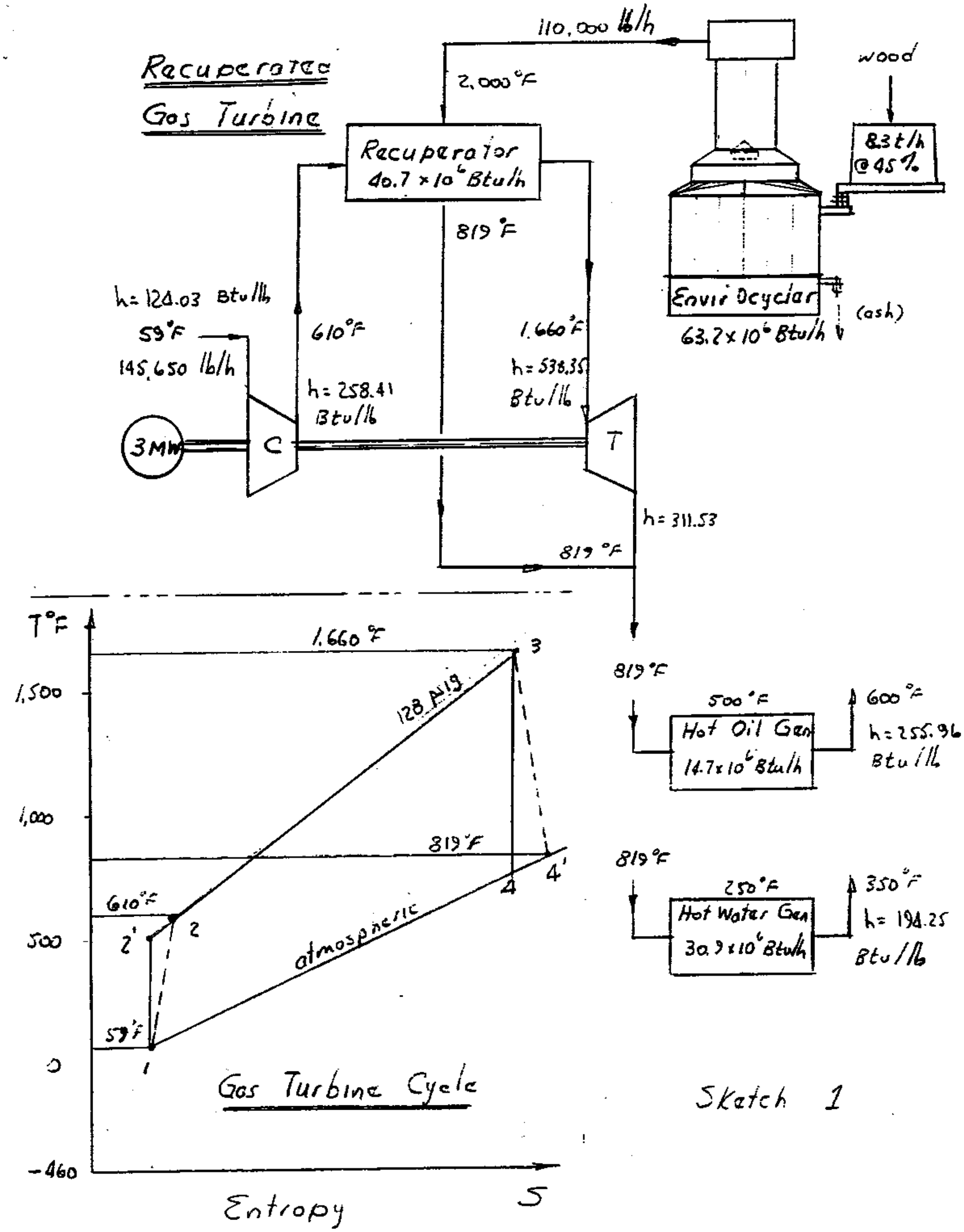
An analysis was conducted to determine what the sawmill's *Equivalent Disposal Cost* for each ton of wet wood waste would be assuming revenue streams from the *displacement* of natural gas (typical cost = $3.50/MBtu) and electricity (typical cost = 4.424/kW.h) and the *sale* of electricity @ 3.34/kW.h. A debt/equity ratio of 80:20 was assumed with debt amortization and capital payments based on a 15 year project life. The blended cost of capital was 11.2% based on debt interest of 9% and return on equity of 20%.

The analysis revealed that the Equivalent Disposal Cost - i.e., the "tipping fee" the sawmill would have to charge itself to realize a 20% return on its investment - for the 3 MW + 48 MBtu/h EDP is $3.50/wet ton. The Equivalent Disposal Cost for the 6 MW + 30 MBtu/h EDP is $3.00/wet ton. An analysis was also carried out to determine the "Cost of Compliance" with the new MoELP particulate requirements of 120 mg/Nm^3, when installing a stand-alone, 110 MBtu/h **EnvirOcycler** without any energy recovery. The Equivalent Disposal Cost in that case is $6.75/wet ton.

The conclusion to be drawn is that by installing an **EnvirOcycler** with appropriate heat recovery, a 120 to 150 Mbf/y BC sawmill can reduce its wood waste disposal cost from a maximum of $15/wet ton to $20/wet ton down to a low of $3/wet ton.

Recognizing that sawmills will not entertain projects with paybacks longer than 3 years, it would appear that opportunities exist for small independent power developers to install EDP's - such as those described above - and charge sawmills tipping fees of, say, $10/wet ton for a period of, say, 7 years. At the end of the period the sawmill would own the EDP.

Updated 1997 April 10th



Recuperated Gas Turbine
110,000 lb/h
2,000 °F
wood
Recuperator 40.7 × 10^6 Btu/h
8.3 t/h @45 %
819 °F
Envir Ocyclar
63.2 × 10^6 Btu/h
(ash)
h= 124.03 Btu/lb
59°F
145,650 lb/h
610°F
h= 258.41 Btu/lb
1,660°F
h= 538.35 Btu/lb
3MW
C
T
h= 311.53
819 °F
T°F
1,660 °F
3
1,500
1,000
500
0
-460
128 psig
819 °F
4
4'
610°F
2
2'
atmospheric
59°F
1
Gas Turbine Cycle
Entropy
S
819 °F
500 °F
Hot Oil Gen
14.7 × 10^6 Btu/h
600 °F
h= 255.96 Btu/lb
819 °F
250 °F
Hot Water Gen
30.9 × 10^6 Btu/h
350 °F
h= 194.25 Btu/lb
Sketch 1

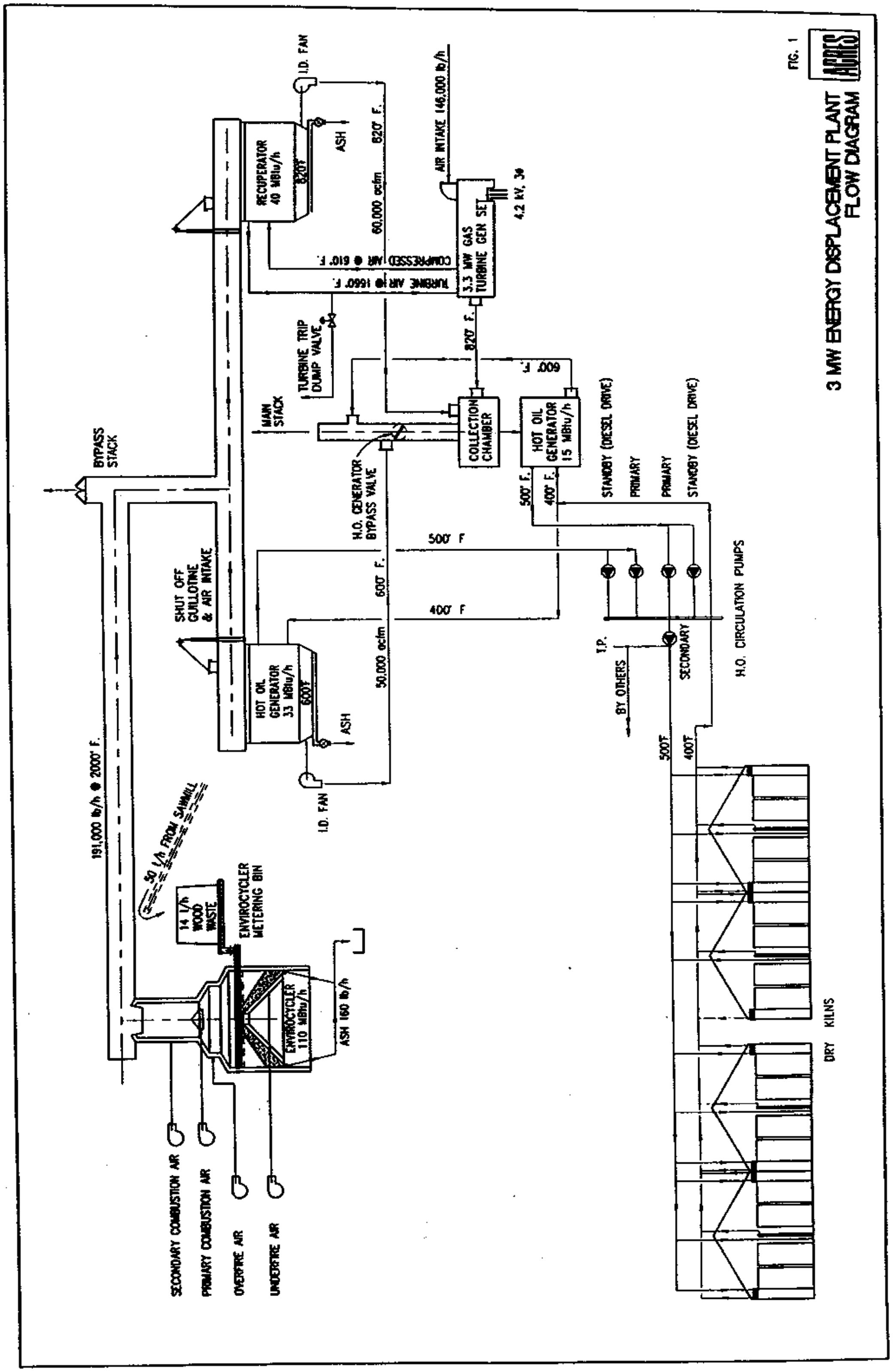
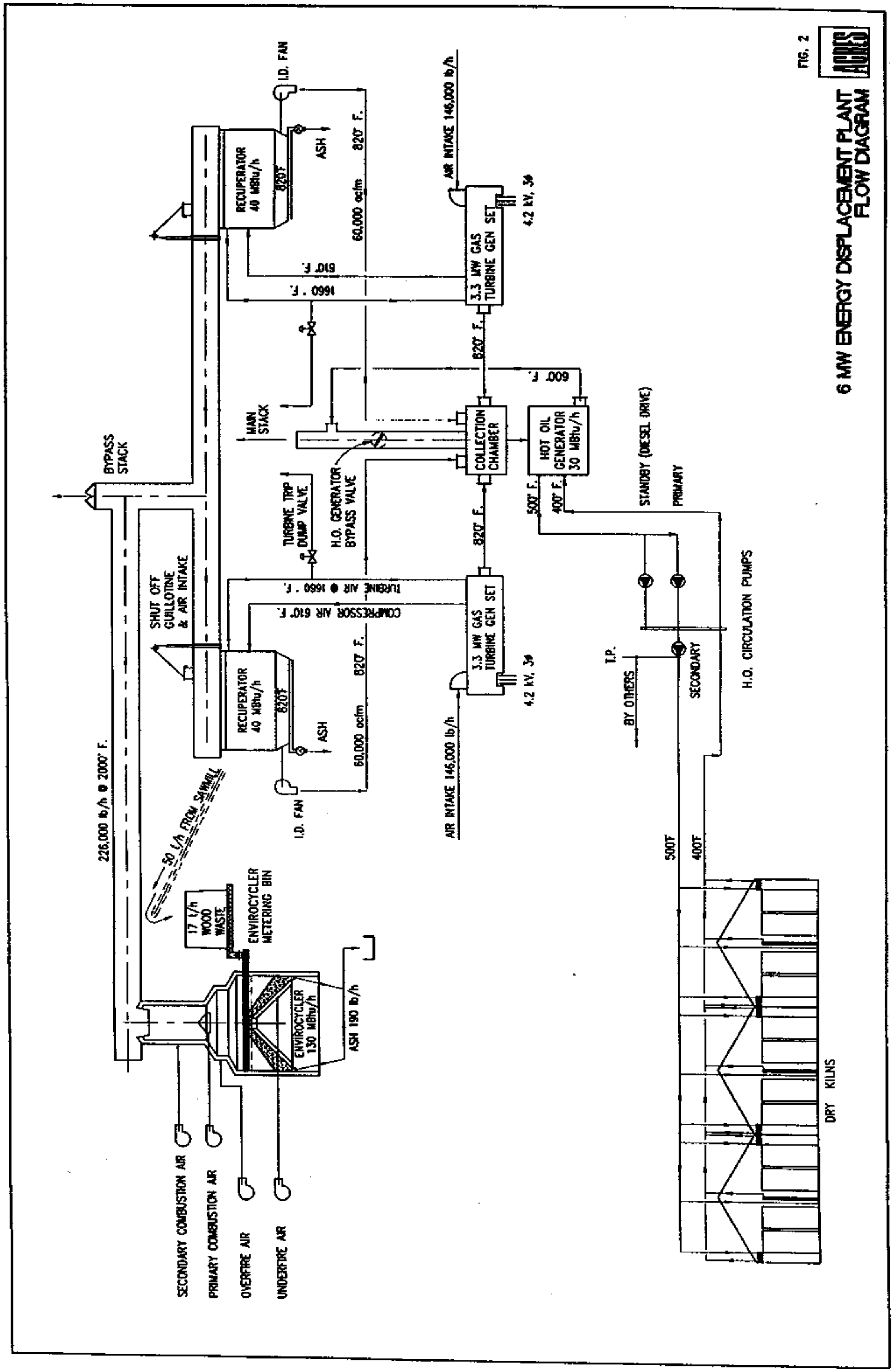


FIG. 1

3 MW ENERGY DISPLACEMENT PLANT FLOW DIAGRAM


6 MW ENERGY DISPLACEMENT PLANT
FLOW DIAGRAM
FIG. 2
SECONDARY COMBUSTION AIR
PRIMARY COMBUSTION AIR
OVERFIRE AIR
UNDERFIRE AIR
ENVIROCYCLER 130 MBtu/h
ASH 190 lb/h
ENVIROCYCLER METERING BIN
17 t/h WOOD WASTE
50 t/h FROM SAWMILL
226,000 lb/h @ 2000° F.
SHUT OFF GUILLOTINE & AIR INTAKE
BYPASS STACK
RECUPERATOR 40 MBtu/h
820°F
ASH
I.D. FAN
60,000 acfm
820° F.
AIR INTAKE 146,000 lb/h
3.3 MW GAS TURBINE GEN SET
4.2 kV, 3ϕ
COMPRESSOR AIR 610° F.
TURBINE AIR @ 1660 ° F.
TURBINE TRIP DUMP VALVE
H.O. GENERATOR BYPASS VALVE
MAIN STACK
COLLECTION CHAMBER
HOT OIL GENERATOR 30 MBtu/h
600° F.
500° F.
400° F.
1660 ° F.
610° F.
STANDBY (DIESEL DRIVE)
PRIMARY
SECONDARY
H.O. CIRCULATION PUMPS
T.P.
BY OTHERS
500°F
400°F
DRY KILNS

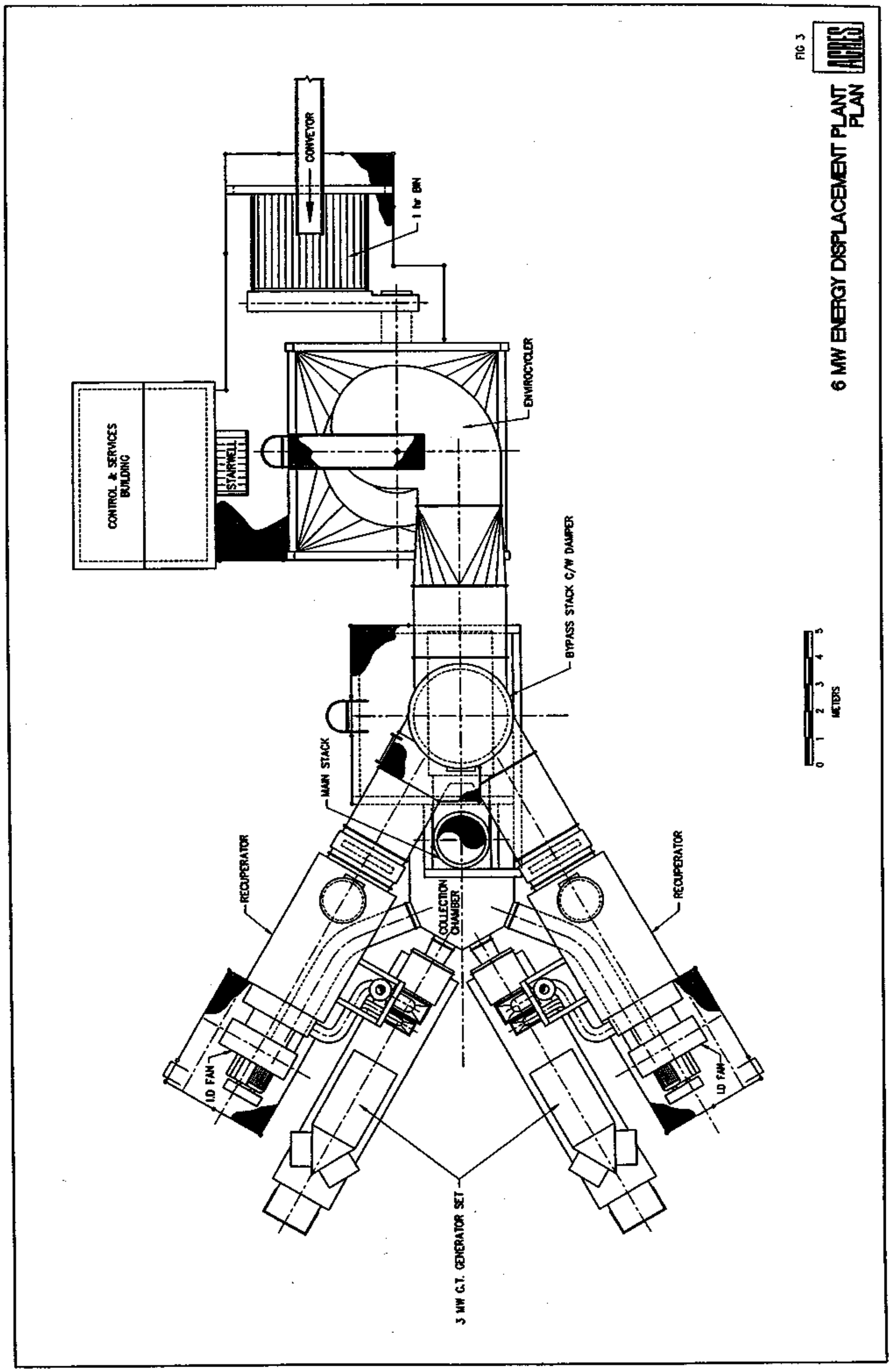
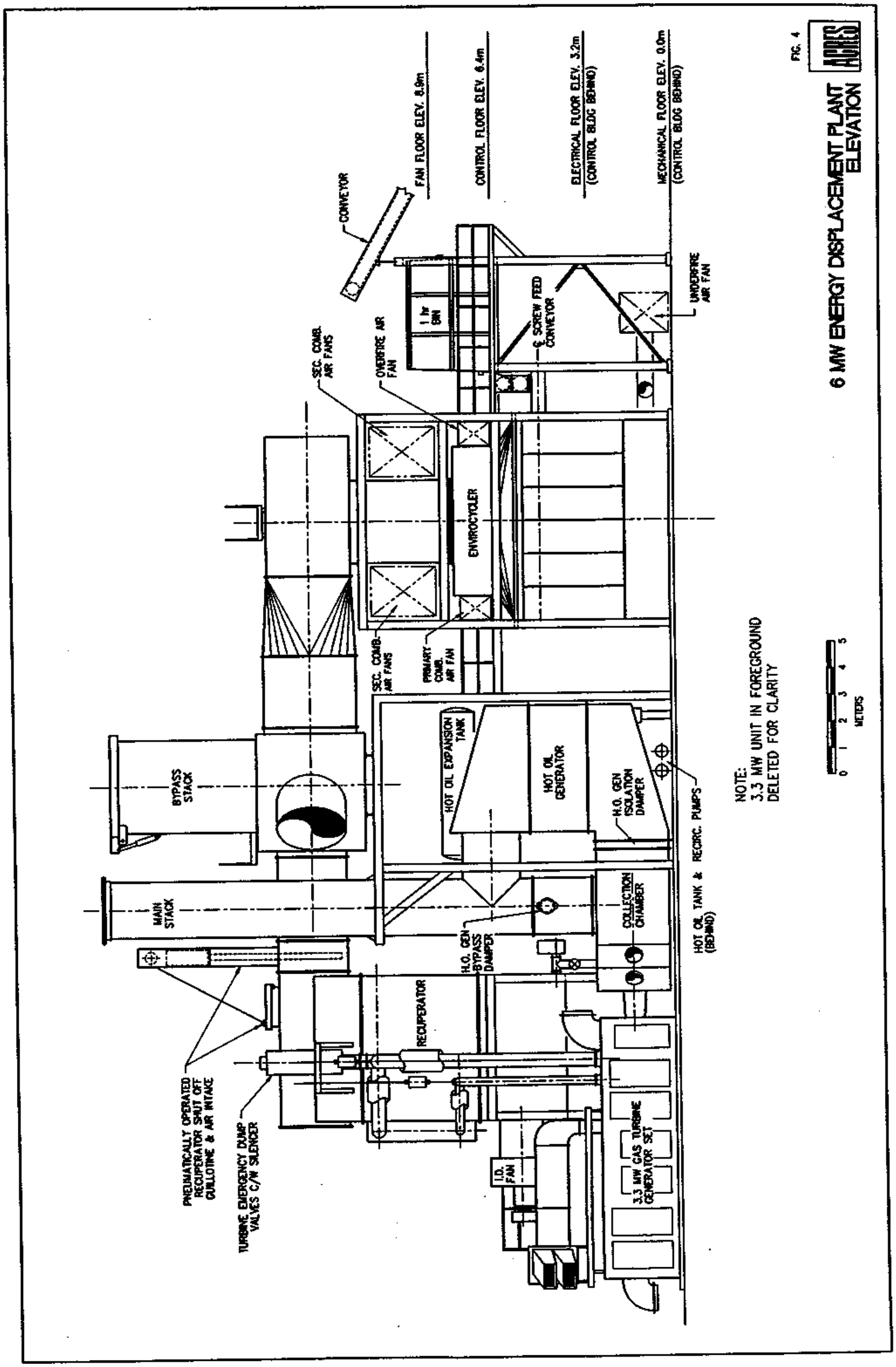


FIG 3
6 MW ENERGY DISPLACEMENT PLANT PLAN
CONVEYOR
1 hr BIN
CONTROL & SERVICES BUILDING
STAIRWELL
ENVIROCYCLER
BYPASS STACK C/W DAMPER
MAIN STACK
METERS
RECUPERATOR
COLLECTION CHAMBER
RECUPERATOR
I.D FAN
I.D FAN
3 MW G.T. GENERATOR SET


FAN FLOOR ELEV. 8.9m
CONTROL FLOOR ELEV. 6.4m
ELECTRICAL FLOOR ELEV. 3.2m (CONTROL BLDG BEHIND)
MECHANICAL FLOOR ELEV. 0.0m (CONTROL BLDG BEHIND)
FIG. 4
ACRES
6 MW ENERGY DISPLACEMENT PLANT ELEVATION
CONVEYOR
SEC. COMB. AIR FANS
OVERFIRE AIR FAN
1 hr BIN
SCREW FEED CONVEYOR
UNDERFIRE AIR FAN
ENVIROCYCLER
PRIMARY COMB. AIR FAN
HOT OIL EXPANSION TANK
HOT OIL GENERATOR
H.O. GEN ISOLATION DAMPER
BYPASS STACK
MAIN STACK
RECIRC. PUMPS
HOT OIL TANK & (BEHIND)
COLLECTION CHAMBER
H.O. GEN BYPASS DAMPER
RECUPERATOR
I.D. FAN
3.3 MW GAS TURBINE GENERATOR SET
PNEUMATICALLY OPERATED RECUPERATOR SHUT OFF GUILLOTINE & AIR INTAKE
TURBINE EMERGENCY DUMP VALVES C/W SILENCER
NOTE:
3.3 MW UNIT IN FOREGROUND
DELETED FOR CLARITY
0 1 2 3 4 5
METERS