

Southeastern Regional Biomass Energy Program

Fluidized Bed Combustion and Gasification: A Guide for Biomass Waste Generators

*Administered For
The United States
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TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
List of Figures	v
List of Tables	vi
1.0 INTRODUCTION	1
1.0.1 Biomass Fuels	1
1.0.2 Fluidized Bed Fundamentals	3
1.1 FLUIDIZED BED COMBUSTION SYSTEMS	7
1.1.1 Bubbling Fluidized Bed Combustion	8
1.1.2 Circulating Fluidized Bed Combustion	12
1.1.3 Systems and Equipment	16
1.1.3.1 Fuel Preparation	16
1.1.3.2 Feed Systems	18
1.1.3.3 Recycle Systems	19
1.1.3.4 Ash Disposal	23
1.1.3.5 Air/Gas System	23
1.1.4 Materials of Construction	25
1.2 FLUIDIZED BED GASIFICATION SYSTEMS	26
1.2.1 Bubbling Fluidized Bed Gasifiers	34
1.2.2 Circulating Fluidized Bed Gasifiers	35
1.2.3 Pressurized Fluidized Bed Gasifiers	36
1.3 BIOMASS FUEL PREPARATION EQUIPMENT	38
1.3.1 Processing Wood	39
1.3.1.1 Wood Drying	39
1.3.1.2 Wood Sizing	46
1.3.1.3 Metal Separation	51
1.3.2 Processing Agricultural Waste	53
1.3.3 Processing Refuse Derived Fuel	54
1.3.4 Densification	60
1.3.4.1 Briquetting	61
1.3.4.2 Pelletizing	62
1.3.4.3 Economics of Densification	64
1.3.5 Fuel Management	66
1.3.5.1 Fuel Blending	66
1.3.5.2 Inventory Management	66
1.3.5.3 Fire Prevention	68

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
1.4 APPLICATIONS USING FBCs	69
1.4.1 Process Steam	69
1.4.2 Power from Steam Turbines	70
1.4.3 Cogeneration	73
1.4.4 Other Combustor Applications	78
1.5 APPLICATIONS USING FBGs	79
1.5.1 Hot Gas Generation	79
1.5.2 Process Steam Generation	80
1.5.3 Steam Turbines	82
1.5.4 Gas Turbines	83
1.5.5 Combined Cycle	86
1.5.6 Cogeneration	88
1.5.7 Internal Combustion Engines	91
2.0 NON-TECHNICAL FACTORS	93
2.1 OVERALL SELECTION CRITERIA	93
2.2 OPERABILITY	96
2.3 RELIABILITY/AVAILABILITY	98
2.4 ECONOMICS	100
2.4.1 Capital & Installation Costs	100
2.4.1.1 FBC Steam Generators	100
2.4.1.2 Fluidized Bed Gasifiers	104
2.4.1.3 FBC Hot Gas Generators	107
2.4.2 Operating and Maintenance Costs	107
2.4.3 System Costs For Two FBC Steam Generators	108
2.5 ENVIRONMENTAL CONSIDERATIONS	111
2.5.1 Air Pollution Control Requirements	111
2.5.2 Air Permits	114
3.0 TECHNICAL FACTORS	117
3.1 PROCESS PERFORMANCE	117
3.1.1 Combustion Efficiency	117
3.1.2 Heat Rate	122
3.1.3 Heat Transfer	128
3.1.4 Cofiring	129
3.1.5 Emissions	129

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
3.1.5.1 Fluidized Bed Combustors	130
3.1.5.2 Fluidized Bed Gasifiers	131
3.1.6 Process Performance Summary	133
3.2 EQUIPMENT DESIGN ISSUES	135
3.2.1 Problems and Solutions	136
3.2.1.1 Erosion	137
3.2.1.2 Corrosion	142
3.2.1.3 Fouling	145
3.2.1.4 Mechanical Components	148
3.2.1.5 Operability	151
3.2.2 Flame Temperature	152
3.2.3 Air Flow	153
3.3 EMISSION LIMITS AND TEST RESULTS	157
3.4 FUELS AND ASH	162
3.4.1 Biomass Fuels	162
3.4.2 Fuel Characteristics	163
3.4.2.1 Wood Fuel Characteristics	163
3.4.2.2 Agricultural Waste Fuel Characteristics	167
3.4.2.3 MSW and RDF Fuel Characteristics	170
3.4.3 Fuel Delivery	178
3.4.3.1 Wood Fuel Delivery	178
3.4.3.2 Agricultural Waste Delivery	181
3.4.3.3 MSW and RDF Handling and Delivery	182
3.4.4 Feedstock Preparation Requirements	183
3.4.4.1 Fuel Size	183
3.4.4.2 Moisture Content	183
3.4.4.3 Elimination of Noncombustibles	184
3.4.5 Ash Characteristics	184
3.4.5.1 Wood Ash Characteristics	187
3.4.5.2 Agricultural Waste Ash Characteristics	190
3.4.5.3 MSW and RDF Ash Characteristics	190
3.4.6 Ash Handling Systems	191
3.4.6.1 Bed Drain Systems	191
3.4.6.2 Flyash Handling Systems	191
3.5 TURNDOWN	193
3.6 AVAILABILITY	196

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
3.7 SUPPLEMENTAL FUEL	198
4.0 REFERENCES	199
5.0 ACRONYMS/NOMENCLATURE	211
6.0 GLOSSARY	214
<u>APPENDICES</u>	
A. FBC and FBG Installation List	
B. Summary of Vendor Responses	
C. Fuel Preparation Equipment Vendor List	
D. Federal and State Environmental Offices	

6.0 GLOSSARY

Attrition - The fracturing of particles into smaller particles.

Availability - Mathematically, the number of hours that a unit is available for operation in a given time period, divided by the total number of hours in that time period. Availability is normally evaluated on a monthly basis, though it can be evaluated over any period of time.

Bagasse - The waste product from sugar cane processing.

Baghouse - A device in the flue gas path that removes particles from the flue gas. The flue gas passes through a fabric filter or bag which removes the particles from the gas much the same as a household vacuum cleaner bag removes dirt from the air stream. The particulate matter is then removed from the bags. Typically baghouses are separated into several compartments with many bags in each compartment.

Capacity Factor - Mathematically, the total gross unit generation over a time period, divided by the maximum possible generation assuming the unit produced full load over the entire time period.

Cetane rating - An index that measures the ignition delay of diesel fuels, i.e., the time between injection of the fuel and its ignition.

Char - The solid carbon left when volatiles are driven off of a combustible material.

Combustion Efficiency - A measure of how completely well the fuel is burned. The combustion efficiency compares the amount of carbon utilized in the combustion process to the amount of carbon present in the fuel before combustion.

Conventional Units - Non fluidized bed units such as pulverized fuel units, cyclone burner units or stoker units.

Electrostatic Precipitator, ESP - A device in the flue gas path that removes particles from the gas. This device eliminates dust or other fine particles from the flue gas by charging the particles with an electric field and then attracting them to highly charged collector plates. The particles are then removed from the plates and sent to disposal.

Elutriated - As used with regard to fluidized bed technology, the carrying of particles out of the bed or combustor by the flowing gases.

Endothermic - A reaction that absorbs heat.

Entrained - Particle are considered entrained when they are moving with and being carried by a flowing gas or liquid.

Equivalence ratio - The ratio of air supplied divided by the stoichiometric amount of air required.

Eutectic - Combination of compounds which produce low melting points.

Exothermic - A reaction that releases heat.

Fines - Generally materials which are of a size and density to be elutriated from the bed are considered to be fines. This size and density will vary with unit design and operating parameters. Material 30 mesh and smaller is a fair rule of thumb.

Freeboard - In a bubbling fluidized bed unit, the area above the bed. One of the functions of the freeboard is to allow particle ejected from the bed to disengage and fall back into the bed. It is common for combustion of small fuel particles to occur in the freeboard. Technically a freeboard does not exist on a circulating bed units, however the upper region of some circulating fluidized bed combustors, especially when staged, is sometimes referred to as the freeboard.

Heat Rate - The amount of fuel heat input required to produce a given amount of electrical power, commonly expressed in units of Btu/KWh.

Hog Fuel - A mixture of wood and bark, usually reduced to 2-3 inch chips and produced by a wood hog, from which it derives its name.

Isothermal - Occurring at constant temperature.

Mass flux - Pounds of material flowing per unit area.

Overbed Feed - Material which enters a fluidized bed unit at or above the top of a bubbling bed or the dense bed of a circulating unit.

Primary air - The air that is introduced for the purpose of providing the initial source of oxygen for the combustion or gasification process.

Producer gas - Low or medium Btu gas from a gasifier.

Recycle - The recirculation of material that is carried out of the unit and caught in a collection device (such as a cyclone) back into the unit, primarily for the purpose of increasing combustion efficiency and sorbent utilization.

Recycle ratio - Pounds of material that are recycled back to the unit per pound of fuel fed to the unit.

Residence Time - The time that the fuel molecules spent in the combustor.

Secondary air - The air that is introduced at a point above where the primary air is introduced for the purpose of providing additional air for the combustion or gasification reactions.

Solids gradient - A measure of the variation of the total quantity of solids in a fluidized bed unit over the height of the unit.

Sorbent - A material, such as limestone or dolomite, that is introduced for the purpose of removing unwanted gases, such as SO_2 , from the flue gas.

Specific weight loss - Pounds of material lost per pound of original material.

Splash Zone - The interface area between the dense fluidized bed and the freeboard, where the bubbling solids splash up from the bed, and fall back into the bed.

Splitter - A device used to separate the flow of one large pneumatic transport line into several smaller pneumatic transport lines.

Staged Combustion - A process applied to fluidized bed combustion, such that the in-bed combustion takes place in an oxygen lean environment and additional air is added above the bed where the combustion process is completed. This reduces the production of NO_x in the unit with some detrimental effect on sulfur capture.

Stoichiometric - The theoretical amount of air required to completely combust a given amount of fuel.

Superficial velocity - The volumetric flow rate of air or gas divided by the cross sectional flow area.

Underbed Feed - Material which enters a fluidized bed unit at the bottom of the bed or through the combustor floor just above the air distributor.

Volatiles - The gaseous combustible compounds released from a fuel when it is heated.

Water Wall - The inside wall of a unit formed by parallel boiler tubes welded together with a fin between the tubes to form a gas tight enclosure. Water is circulated through the tubes to absorb heat from the process and make steam.

APPENDIX A

LISTING OF FBC BIOMASS INSTALLATIONS

FLUIDIZED BED COMBUSTION FACILITIES

<u>FACILITY</u>	<u>LOCATION</u>	<u>TYPE/APPLICATION</u>	<u>CAPACITY</u>	<u>FUELS</u>	<u>MANUFACTURER</u>	<u>STARTUP</u>
KELLEY ENTERPRISES	PITTSFIELD, MA	PROCESS STEAM	10,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1975
WALNUT PRODUCTS INC.	ST. JOSEPH, MISSOURI	PROCESS STEAM	10,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1975
IOWA-MISSOURI WALNUT CO.	ST. JOSEPH, MISSOURI	PROCESS STEAM	10,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1975
VERMONT STATE HOSPITAL	WATERBURY, VERMONT	PROCESS STEAM	10,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1977
ROSSI CORPORATION	HIGGANUM, CONNECTICUT	PROCESS STEAM	10,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1979
BOISE CASCADE CORP.	CASCADE, IDAHO	PROCESS STEAM	10,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1980
H&B LUMBER COMPANY	MARION, NC	PROCESS STEAM	15,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1975
CITY OF ESKJO, SWEDEN	ESKJO, SWEDEN	HOT WATER SYSTEM	17,000 LB/HR	RDF, WOOD WASTE	GENERATOR AB	1979
CITY OF ESKJO, SWEDEN	EKSJO, SWEDEN	HOT WATER SYSTEM	17,000 LB/HR	RDF, WOOD WASTE	GENERATOR AB-BFB	1979
N. CHEYENNE PINE CO.	ASHLAND, MONTANA	PROCESS STEAM	20,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1974
MERRITT BROTHERS LUMBER	PRIEST RIVER, IDAHO	PROCESS STEAM	20,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1976
CHAPLEAU LUMBER CO.	CHAPLEAU, ONTARIA	PROCESS STEAM	20,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1977
GEORGIA PACIFIC CORP.	PHILLIPS, WISCONSIN	DRYER-PROCESS STEAM	20,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1977
ATLANTA VEBEER CIRO,	BEAUFORT, NC	PROCESS STEAM	20,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1977
WADE LUMBER COMPANY	WADE, NC	PROCESS STEAM	20,000 LB/HR	BARK	EPI-BUBBLING	1979
NAGEL LUMBER CO., INC.	LAND O'LAKES, WISC.	PROCESS STEAM	20,700 LB/HR	WOOD WASTE	EPI-BUBBLING	1977
OJI PAPER CO. TOMAKAMAI PLANT	HOKKAIDO, JAPAN	ELECTRIC POWER	22,046 LB/HR	PAPER SLUDGE & BARK BLEND WITH FUEL OIL	BABCOCK HITACHI-BFB	1985
KOGAP MANUFACTURING CO.	MEDFORD, OREGON	DRYER-PROCESS STEAM	24,000 LB/HR	HOG FUEL	EPI-BUBBLING	1979
DAW FOREST PRODUCTS	REDMOND, OREGON	DRYER-PROCESS STEAM	25,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1980
WEBSTER LUMBER CO.	BANGOR, WISCONSIN	PROCESS STEAM	26,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1977
BOISE CASCADE CORP.	EMMETT, IDAHO	PROCESS STEAM	26,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1977
WILLAMETTE INDUSTRIES	MONCURE, NC.	DRYER-PROCESS STEAM	26,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1977
WEYERHAEUSER COMPANY	LIVINGSTON, ALABAMA	DRYER-PROCESS STEAM	27,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1977
NORTHWEST MISSISSIPPI JUNIOR COLLEGE	SENATOBIA, MISSISSIPPI	PROCESS STEAM	27,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1980
IDAHO FOREST INDUSTRIES	COEUR d'ALENE, IDAHO	PROCESS STEAM	30,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1973
CITY OF LANDSKRONA, SWEDEN	LANDSKRONA, SWEDEN	HOT WATER SYSTEMS	2 X 34,000 LB/HR	RDF, WOOD, COAL	GENERATOR AB	1983

FLUIDIZED BED COMBUSTION FACILITIES

<u>FACILITY</u>	<u>LOCATION</u>	<u>TYPE/APPLICATION</u>	<u>CAPACITY</u>	<u>FUELS</u>	<u>MANUFACTURER</u>	<u>STARTUP</u>
CITY OF BOLLNAS, SWEDEN	BOLLNAS, SWEDEN	HOT WATER SYSTEMS	34,000 LB/HR	RDF, WOOD, PEAT	GENERATOR AB	1983
CITY OF VASTERVIK, SWEDEN	VASTERVIK, SWEDEN	HOT WATER SYSTEM	34,000 LB/HR	RDF, WOOD, PEAT	GENERATOR AB	1984
CITY OF BOLINAS, SWEDEN	BOLINAS, SWEDEN	2 HOT WATER SYSTEMS	34,000 LB/HR	RDF, WOOD, PEAT	GENERATOR AB-BFB	1983
CITY OF ESKJO, SWEDEN	EKSJO, SWEDEN	HOT WATER SYSTEM	34,000 LB/HR	WOOD WASTE	GENERATOR AB-BFB	
CITY OF VASTERVIK, SWEDEN	VASTERVIK, SWEDEN	2 HOT WATER SYSTEMS	34,000 LB/HR	RDF, WOOD, PEAT	GENERATOR AB-BFB	1984
JOBAN INDUSTRY	JAPAN	PROCESS STEAM	35,274 LB/HR	SLUDGE & WOOD WASTE	BABCOCK HITACHI-BFB	1989
DeARMOND STUD MILL	COEUR D'ALENE, IDAHO	PROCESS STEAM	40,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1978
WEYERHAEUSER CO.	RAYMOND, WASH.	BOILER RETROFIT PROCESS STEAM	40,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1975
LIDLAPING	SWEDEN	2 HOT WATER SYSTEMS	40,800 LB/HR	REFUSE, BIOMASS, COAL	GENERATOR AB-BFB	1985
CITY OF LIDLAPING, SWEDEN	LIDLAPING, SWEDEN	HOT WATER SYSTEM	40,800 LB/HR	RFD, BIOMASS, COAL	GENERATOR AB	
SUOMEN KUITULEVY OY	PIHLAVA, FINLAND	COGENERATION-RETROFIT	45,000 LB/HR	100% PEAT 100% WOODWASTE	AHLSTROM-CFB	1979
WESTERN LAKE SUPERIOR SEWAGE SANITATION DISTRICT	DULUTH, MINN.	PROCESS STEAM	2 X 45,000 LB/HR	RDF, DEWATERED SLUDGE OIL WOOD CHIPS	COPELAND	1982
BOISE CASCADE CORP.	KENORA, ONTARIO	BOILER RETROFIT- PROCESS STEAM	45,000 LB/HR	BARK, PAPER SLUDGE	EPI-BUBBLING	1977
DANTANI PLYWOOD CO., LTD. SHIMONOSEKI FACTORY	YAMAGUCHI, JAPAN	PROCESS STEAM	45,000 LB/HR	WOOD CHIPS	EPI-BUBBLING	1987
DANYA	JAPAN	PROCESS STEAM	46,297 LB/HR	WOOD WASTE	TAKUMA	1987
PARENCO PAPER	RENKUM, NETHERLANDS	COGENERATION	48,000 LB/HR	BARK, PAPER/WOOD, REFUSE PELLETS	THYSSEN ENGINEERING GMBH	1985
PARENCO PAPER	RENKUM, NETHERLANDS	COGENERATION	48,400 LB/HR	BARK, PAPER/WOOD, REFUSE PELLETS, DEINKING SLUDGE	THYSSEN ENGINEERING GMBH	1985
WLSSD	DULUH, MINN.	ORICISS STEAN	2 X 49,999 LB/HR	RDF, DEWATEREDSLUDGE, OIL, WOOD CHIPS	COPELAND-BUBBLING	1982
EHIME PLYWOOD INDUSTRIES MATSUIJAMA CITY FACTORY	EHIME, JAPAN	PROCESS STEAM	50,000 LB/HR	BARK CHIPS	EPI-BUFFLING	1988
ANGELHOLM ENERGIVERK	ANGELHOLM, SWEDEN	2 HOT WATER SYSTEM	51,000 LB/HR	WOOD CHIPS, PEAT	GENERATOR AB-BFB	1984
CITY OF SANDVIKEN, SWEDEN	SANDVIKEN, SWEDEN	2 HOT WATER SYSTEMS	51,000 LB/HR	WOOD, COAL, PEAT	GENERATOR AB-BFB	1983

FLUIDIZED BED COMBUSTION FACILITIES

<u>FACILITY</u>	<u>LOCATION</u>	<u>TYPE/APPLICATION</u>	<u>CAPACITY</u>	<u>FUELS</u>	<u>MANUFACTURER</u>	<u>STARTUP</u>
ENSO-GUZEIT OY	VARKAUS, FINLAND	COGENERATION-RETROFIT	55,000 LB/HR	100% WOODWASTE	AHLSTROM-CFB	1983
JAMES RIVER CORPORATION	BELLAMY, ALABAMA	PROCESS STEAM	55,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1980
KAINUUN OSUUSMEIJERI	SOTKAMO, FINLAND	COGENERATION	59,000 LB/HR	100% OIL 67% WOODWASTE	AHLSTROM-CFB	1982
MILUOT/MILOUMOR HAIFA BAY SETTLEMENT	MOBILE POST ASHRAT, ISRAEL	PROCESS STEAM	60,000 LB/HR	COTTON HULLS/WASTE	EPI-BUBBLING	1982
SOUTH VALLEY POWER JWP/EPI-WILLIAMS	CALEXICO, CAL.	ELECTRIC POWER	64,000 LB/HR	MANURE	EPI-BUBBLING	1989
SUNDSVALLS ENERGIVERK	SUNDSVALL, SWEDEN	COGENERATION	66,000 LB/HR	RDF, PEAT, WOOD WASTE	GOTAVERKEN-CFB	1984
CITY OF VASTERVIK, SWEDEN	VASTERVIK, SWEDEN	2 HOT WATER SYSTEMS	68,000 LB/HR	WOOD, COAL, PEAT	GENERATOR AB-BFB	1983
KATRINEHOLMS ENERGIVERK AB	SWEDEN	HOT WATER SYSTEM	68,000 LB/HR	COAL, WOOD	GENERATOR AB-BFB	1984
KIRBY LUMBER COMPANY	SILSBEE, TEXAS	PROCESS STEAM	70,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1980
NESTLE	KOBE, JAPAN	COGENERATION	88,200 LB/HR	COFFEE GROUNDS	IHI	1986
SANDE PAPER MILL AVS	NORWAY	PROCESS STEAM	88,000 LB/HR	COAL, WOOD WASTE, RDF	GOTAVERKEN-CFB	1985
NESTLE	JAPAN	COGENERATION	93,000 LB/HR	COFFEE GROUNDS	IHI	1983
KERRY COOP	LISTOWEL, IRELAND	COGENERATION	117,000 LB/HR	COALS, PEATS, WOOD CHIPS, SAWDUST	FOSTER WHEELER POWER PRODUCTS LTD.	1984
GENERAL ELECTRIC CO. CALIFORNIA AGRICULTURAL POWER CORPORATION	CHOWCHILLA, CALIFORNIA	ELECTRIC POWER	120,000 LB/HR	AGRICULTURAL WASTE	EPI-BUBBLING	1988
OJI PAPER CO. EBETSU HILL	HOKKAIDO, JAPAN	ELECTRIC POWER	121,254 LB/HR	COAL WASH TAILINGS, BARK, SAWDUST, COAL	BABCOCK HITACHI-BFB	1988
GENERAL ELECTRIC CO. CALIFORNIA AGRICULTURAL POWER CORPORATION	EL NIDO, CALIFORNIA	ELECTRIC POWER	122,000 LB/HR	AGRICULTURAL WASTE	EPI-BUBBLING	1988
KARLSKOGA KOMMUN & NOBEL CHEMATUR	KARLSKOGA, SWEDEN	ELECTRIC POWER	140,000 LB/HR	COAL, PEAT, WOOD WASTE	GOTAVERKEN-CFB	1986
CALEDONIAN PAPER	IRVINE, SCOTLAND, GB	PROCESS STEAM	143,653 LB/HR	100% BARK/COAL 100% COAL	AHLSTROM-CFB	1989
NORHTERN STATES POWER CO.	LaCROSSE, WISC.	ELECTRIC POWER-RETROFIT	150,000 LB/HR	WOOD WASTE	EPI-BUBBLING	1981
NORTHERN STATES POWER CO. FRENCH ISLAND POWER STATION	LaCROSSE, WISC.	ELECTRIC POWER-RETROFIT	2 X 150,000 LB/HR	RDF & WOOD	EPI-BUBBLING	1987
NORTHERN STATES POWER CO. FRENCH ISLAND POWER STATION	LaCROSSE, WISCONSIN	ELECTRIC POWER-RETROFIT	2 X 150,000 LB/HR	RDF & WOOD	EPI	1991
PATRIA PAPIER &	FRANTSCHACH, AUSTRIA	COGENERATION-RETROFIT	154,000 LB/HR	100% BARK	AHLSTROM-CFB	1983

FLUIDIZED BED COMBUSTION FACILITIES

<u>FACILITY</u>	<u>LOCATION</u>	<u>TYPE/APPLICATION</u>	<u>CAPACITY</u>	<u>FUELS</u>	<u>MANUFACTURER</u>	<u>STARTUP</u>
ZELLSTOFF AG				100% OIL 67% BROWN COAL		
PAPYRUS KOPPARFORS AB	FORS, SWEDEN	COGENERATION	159,000 LB/HR	100% BARK 100% PEAT 100% COAL	AHLSTROM-CFB	1985
SITHE ENERGIES FEATHER RIVER PROJECT	MARYSVILLE, CA	ELECTRIC POWER	164,000 LB/HR	WOOD WASTE	B&W-CFB	1986
FORT DRUM	FORT DRUM, NY, USA	COGENERATION	3 X 175,000 LB/HR	100% COAL 100% ANTHRACITE 70% OIL WOOD CHIPS	PYROPOWER-CFB	1989
ULTRAPOWER	CHINESE STATION, CA	ELECTRIC POWER	208,600 LB/HR	WOOD WASTE ORCHARD PRUNINGS	EPI-BUBBLING	1985
METSALITON TEOLLISUUS OY	AANEKOSKI, FINLAND	COGENERATION-RETROFIT	220,000 LB/HR	90% WOODWASTE 90% PEAT 100% COAL 70% OIL	AHLSTROM-CFB	1985
ULTROPOWER	W. ENFIELD, ME	ELECTRIC POWER	220,000 LB/HR	WOOD WASTE	B&W-CFB	1986
ULTROPOWER	JONESBORO, ME	ELECTRIC POWER	220,000 LB/HR	WOOD WASTE	B&W-CFB	1986
ULTROPOWER	ROCKLIN, CA	ELECTRIC POWER	220,000 LB/HR	WOOD WASTE	ABB-COMBUSTION ENGINEERING-CFB	1989
ULTROPOWER	FRESNO, CA	ELECTRIC POWER	220,000 LB/HR	WOOD WASTE	ABB-COMBUSTION ENGINEERING-CFB	1988
THERMO ELECTRON ENERGY SYSTEMS	MENDOTA, CA, USA	ELECTRIC POWER	250,000 LB/HR	BIOMASS	GOTAVERKEN-CFB	1989
THERMO ELECTRON ENERGY SYSTEMS	WOODLAND, CA., USA	ELECTRIC POWER	250,000 LB/HR	BIOMASS	GOTAVERKEN-CFB	1989
CITY OF TACOMA DEPT. OF PUBLIC UTILITIES	TACOMA, WASH.	ELECTRIC POWER-RETROFIT	2 X 250,000 LB/HR	RDF, WOOD, COAL	EPI	1987
DELANO POWER PROJECT THERMA ELECTRON/SCHNEIDER	DELANO, CAL.	ELECTRIC POWER	255,000 LB/HR	AGRICULTURAL WASTE	EPI-BUBBLING	1989
CALIFORNIA AGRICULTURAL POWER COMPANY (CAPCO) FLUOR-DANIEL/ZUM	MADERA, CALIFORNIA	ELECTRIC POWER	260,000 LB/HR	AGRICULTURAL WASTE	EPI-BUBBLING	1989
P.H. GLATFELTER CO.	SPRING GROVE, PA, USA	COGENERATION	400,000 LB/HR	100% COAL/WOOD 55% OIL	PYROPOWER-CFB	1989
RUMFORD COGENERATION CO.	RUMFORD, ME, USA	COGENERATION	2 X 415,000 LB/HR	COAL, BIOMASS, OIL	PYROPOWER-CFB	1990
ENSO-GUZEIT OY	VARKAUS, FINLAND	COGENERATION	476,201 LB/HR	BIOMASS, COAL, OIL	AHLSTROM-CFB	1990
CITY OF TACOMA DEPT. OF PUBLIC UTILITIES	TACOMA, WASH.	ELECTRIC POWER-RETROFIT	536,000 LB/HR	RDF, WOOD, COAL	EPI-BUBBLING	1988

FLUIDIZED BED COMBUSTION FACILITIES

<u>FACILITY</u>	<u>LOCATION</u>	<u>TYPE/APPLICATION</u>	<u>CAPACITY</u>	<u>FUELS</u>	<u>MANUFACTURER</u>	<u>STARTUP</u>
OREBO ENERGI AB	OREBRO, SWEDEN	ELECTRIC POWER	562,000 LB/HR	COAL, PEAT, WOOD WASTE	GOTAVERKEN-CFB	1990
KAINUUN VOIMA OY	KHAANI, FINLAND	ELECTRIC POWER	794,000 LB/HR	100% PEAT, COAL, WOODWASTE, SLUDGE MIXTURE	AHLSTROM-CFB	1989
STUDSVIK	NYKOPING, SWEDEN	HOT WATER BOILER	.85MM Btu/hr	COAL, WOOD, PEAT	STUDAVIK-CFB	1979
CHALMERS UNIVERSITY	GOTHENBURG, SWEDEN	DISTRICT HEATING	5.5MM Btu/hr	BITUMINOUS COAL, BROWN COAL, PEAT & WOOD CHIPS	GENERATOR AB-BFB	1982
GENERATOR ENERGIPRODUKTION	TIDAHOLM, SWEDEN	HOT WATER SYSTEM	9MM Btu/hr	WOOD WASTE	GOTAVERKEN-CFB	1986
STUDSVIK ENERGI	SWEDEN	HOT WATER SYSTEM	10.5MM Btu/hr	PEAT, WOOD CHIPS, COAL	GOTAVERKEN-CFB	1981
BRUCK PAPER CO.	BRUCK, AUSTRIA	PROCESS STEAM	15 MWth	BARK, DEINKING SLUDGE	SIMMERING-GRAZ PAUKER AG-BFB	1984
AVESTA ENERGIVERK	AVESTA, SWEDEN	HOT WATER SYSTEM	52MM Btu/hr	COAL, PEAT, WOOD WASTE	GOTAVERKEN-CFB	1983
BODENS TORRVARME	BODEN, SWEDEN	HOT WATER SYSTEM	70MM Btu/hr	PEAT, WOOD CHIPS	GOTAVERKEN-CFB	1985
OSTERSUNDS FJARRVARME AB	OSTERSUND, SWEDEN	HOT WATER - DISTRICT HEATING	85 MM Btu/hr	100% BARK 100% PEAT 100% COAL	AHLSTROM, CFB	1985
NYKOPINGS VARMEVERK	NYKOPING, SWEDEN	HOT WATER SYSTEM	140MM Btu/hr	COAL, PEAT, WOOD WASTE	GOTAVERKEN-CFB	1984
MOINDALS, ENERGIVERK	MOINDAL, SWEDEN	HOT WATER SYSTEM	140MM Btu/hr	COAL, PEAT, WOOD WASTE	GOTAVERKEN-CFB	1984
UDDEVALLA ENERGIVERK	UDDEVALLA, SWEDEN	HOT WATER SYSTEM	140MM Btu/hr	COAL, PEAT, WOOD WASTE	GOTAVERKEN-CFB	1985
ESKILSTUNA VARMEVERK	ESKILSTUNA, SWEDEN	HOT WATER SYSTEM	170MM Btu/hr	WOOD WASTE, RDF	GOTAVERKEN-CFB	1986
ESKILSTUNA VARMEVERK	ESKILSTUNA, SWEDEN	HOT WATER SYSTEM	170MM Btu/hr	WOOD WASTE, RDF	GOTAVERKEN	1986

APPENDIX B

SUMMARY OF VENDOR SURVEY RESPONSES

Table B-1 (page 1 of 2)
Biomass Fluidized Bed Combustors Commercially Available

Vendor	ABB-CE	B & W	Energy Products	Gotaverken Energy
BFB Size	Not Available	10 Klb/hr & Up	12-360 MBtu/hr	100K-600Klb/hr
CFB Size	30-250 MW	35 Klb/hr & Up	Not Available	Not Available
Combustor Applications	Utility Boiler Industrial Boiler	Utility Boiler Industrial Boiler	Utility Boiler Industrial Boiler Hot Gas Generator	Industrial Boiler Pulp & Paper Industry
Commercial Guarantees Offered	Capacity Efficiency Emissions Aux Pwr Consumption	Capacity Efficiency Emissions	Capacity Efficiency Emissions	Capacity Efficiency Emissions Steam, Temp, & Press
Biomass Fuels	All Types	Any Biomass Coal & Waste Fuels	Wood Waste Paunch Manure Paper Sludge Municipal Sludge Agricultural Waste Plastics Demolition Waste RDF, Coal Shredded Tires	Wood Wood Waste Sludge Bark Waste Paper
Fuel Requirements				
Moisture	10 - 60%	60% max.	60% max.	60 - 65%
Size	1 - 2"	2" x 2"	4" minus	Determined by Feeder
Organics	No Limit			
Fuel Preparation Equipment Required				
Sizing	Hog & Screen		Shredder/Hammemill and Disc Screen	Screening only
Drying	None		Rotary Dryers or Screw Press	Not Required
Storage	Uncovered		Fuel & Plant Dependent	Uncovered
Fuel Feed Equipment Provided	Live Bottom Bin Variable Speed Screw Rotary Valve	Flipper Feeder or Air Swept Spout for Overbed Feed Screw Type In Bed Feeder for Fines	Storage Bins & Unloader Metering Bins Rotary Seal Valves Pneumatic or Mech Conveyors	Metering Screws Day Bin
Emission Equipment or Combustor Emission Levels				
Particulates	.015 lb/MBtu	Baghouse	Varies with Local Emissions Standards	ESP or Baghouse
SO ₂	90 - 95% removal	Inbed Capture or Dry Scrubber	Limestone Injection	None or Limestone
NO _x	<.15lb/MBtu	SNCR or SCR or None as Required for Project	Ammonia or Urea Injection	None or Staged Combustion
Other			Monitoring Systems	
Bed Temperature	1550-1650 F	1550-1650F	1200-1600 F	1500 F
Fly ash	70%	Varies with Fuel	Mostly Fly ash	95%
Bottom ash	30%			
Bed Material	Limestone Sand Dolomite	Sand Limestone	lone Grog	Sand
Boiler Efficiency		Varies with Fuel	70 - 75%	72 - 80%
Combustion Eff				99.5%
Energy Conv				
Equipment Lifetime and Maintenance				
Refractory	Variable		15 years	4 - 8 years
Inbed tubes	Not Used	See Survey	5 years	Not Used
Exp Jts & Seals	Variable	Not a Problem	20 years	
Sizing Eqpt		Out of scope	10 years	
Drying Eqpt		Out of scope	10 years	Not Used
Other			20 years	

Table B-1 (page 2 of 2)
Biomass Fluidized Bed Combustors Commercially Available

Vendor	Kvaerner	Pyropower	Tampella
BFB Size	10-150MBtu/hr	20K-600Klb/hr	Up to 1200Klb/hr
CFB Size	10-1000MBtu/hr	100Klb/hr - 400MWe	Open to Discussion
Combustor Applications	Utility Boiler Industrial Boiler	Utility Boiler Industrial Boiler Hot Gas Generator	Utility Boiler Industrial Boiler
Commercial Guarantees Offered	Capacity Efficiency Emissions	Capacity Efficiency Emissions	Capacity Efficiency Emissions See Survey
Biomass Fuels	Wood Peat Agriwaste Lignite	Mill Waste Forest Waste Energy Crops Sludge Peat	Wood Waste Pulp & Papermill Sludge Peat Agricultural Waste Fresh Wood Chips
Fuel Requirements			
Moisture	<60%	65% max	<65% - See Survey
Size	<6"	2"	<12" - See Survey
Organics	TBD	500 ppm max	
Fuel Preparation Equipment Required			
Sizing	Hog/shredder Screens	2' x 0	Screen, Crushing Metal Separation
Drying	Not typical	Sludge Dewatering Presses	Mech. Drying for Bark and Sludge
Storage	Site Dependent	Uncovered	Rain Dependent
Fuel Feed Equipment Provided	Overbed Spreader Stoker Feeder with Pressure Seal & Metering Bin Feed Conveyor	Gravimetric Feeder Drag Chain Conveyors Screw Conveyors	Feed Bin Metering Device Fuel Chutes Rotary Valves Air Swept Spouts Overbed Feeding
Emission Equipment or Combustor Emission Levels			
Particulates	Baghouse	ESP	ESP, Baghouse + Multicione & Scrubber
SO ₂	Limestone In Bed Dry Scrubber	None or Sorbent Injection	None or CaOH Injection
NO _x	Low Excess Air Staged Combustion Ammonia Injection	None or Ammonia Injection	Air Staging or SNCR or SCR
Other	See Survey		Active Coke Injection
Bed Temperature	1500 F	1400-1700 F	1350 - 1800 F BFB 1450 - 1700 F CFB
Fly ash	95%	10%	99%-BFB, 75%-CFB
Bottom ash	5%	90%	1%-BFB, 25%-CFB
Bed Material	Refractory Sand Limestone	Sand	Sand
Boiler Efficiency	72 - 80%	62 - 75%	
Combustion Eff	99.5%	98.5 - 99.9%	
Energy Conv		15K-19K Btu/Kwh	
Equipment Lifetime and Maintenance			
Refractory	4 - 7 years	BFB:10yr CFB:5yr	5 - 10 years
Inbed tubes	Not Used	Not Used	Not Used
Exp Jts & Seals		15 years +	NA-BFB, Varies-CFB
Sizing Eqpt		20 years	out of scope
Drying Eqpt	Not Used		out of scope
Other		20 years	See Survey

Table B-2 (page 1 of 2)
Biomass Fluidized Bed Gasifiers Commercially Available

Vendor	PRM Energy	Pyropower	Tampella
Gasifier sizes	8.5-300MBtu/hr		60-500MBtu/hr
Gasifier Type	MFBG	BFB & CFB	BFB
Gasifier Applications	Process Heat Maybe Gas Turbine	Process Heat Gas Turbine	Process Heat Gas Turbine IC Engines
Commercial Guarantees Offered	Capacity Efficiency Emissions	Capacity Efficiency Emissions	Capacity Efficiency Emissions
Biomass Fuels	Rice Husks Straw Wood Waste Peat Sludge Shells	Mill Waste Forest Waste Energy Crops Sludge Peat	Wood Chips Crushed Sod Peat Bark
Fuel Requirements			
Moisture	55% max	65% max	15 - 20%
Size	2"	2"	1/2" x 0
Organics		500 ppm max	
Fuel Preparation Equipment Required			
Sizing	Size to 2"	Size to 2" Max	Crusher or Chipper Screens
Drying	Dry to 55% Moisture	Sludge Dewatering Presses	FD Low Press Steam Dryer Heat Exc. & Cyclones
Storage	Uncovered	Uncovered	Covered Storage Silos for Dried Fuel
Fuel Feed Equipment Provided	Metering Bin Conveying Airlock Feeder Weigh Meter	Gravimetric Feeder Drag Chain Conveyors Screw Conveyors	Complete Feed Line Atms Weigh Hopper HP Surge Hopper HP Screw Feeder
Emission Equipment or Combustor Emission Levels			
Particulates	0.03Gr/NM3 - No Control Required	ESP	<5um, <.001gr/ft3 @O2 + 5%
SO2	11 ppm as SO3 Dependent on Fuel	None or Sorbent Injection	Negligible
NOx		None or Ammonia Injection	wSCR <.005lb/MBtu
Bed Temperature	1300 - 1800 F	1400 - 1700 F	1630 - 1740 F @ 290 - 370 psig
Fly ash		10%	60%
Bottom ash	99.9%	90%	40%
Bed Material	None	Sand	Dolomite
Boiler Efficiency	See Survey	62 - 75%	Overall 46.4%
Combustion Eff		98.5 - 99.9%	
Energy Conv		15K-19KBtu/hr	Carbon Conv 99.5%
Equipment Lifetime and Maintenance			
Refractory	12 yr proven	BFB:10yr CFB:5yr	Typical
Inbed Tubes	Not Used	Not Used	Not Used
Exp Jts & Seals	Not Used	15 years +	
Sizing Equipment	NA	20 years	Typical
Drying Equipment	NA		Typical
Other		20 years	

Table B-2 (page 2 of 2)
Biomass Fluidized Bed Gasifiers Commercially Available

Vendor	Battelle / Future Energy	Energy Products	Gotaverken Energy
Gasifier sizes	100-1K dry ton/day	48-300MBtu/hr	94-126MBtu/hr
Gasifier Type	CFB	BFB	CFB
Gasifier Applications	Process Heat Gas Turbine IC Engines	Process Heat	Process Heat
Commercial Guarantees Offered	Capacity Efficiency Emissions	Capacity Efficiency Emissions	Capacity Efficiency Emissions Steam, Temp, & Press
Biomass Fuels	All Types of Biomass Fuels	Wood Waste Paunch Manure Paper Sludge Municiple Sludge Agricultural Waste Plastics Demolition Waste RDF, Coal Shredded Tires	Wood Wood Waste Sludge Bark Waste Paper
Fuel Requirements			
Moisture	No Requirement	60% max.	60 - 65%
Size	2" minus	4" minus	Determined by Feeder
Organics	No Requirement		
Fuel Preparation Equipment Required			
Sizing	Coarse Chop to Yield 2" minus	Shredder / Hammemill and Disc Screen	Screening Only
Drying	None Required	Rotary Dryers or Screw Press	Not Required
Storage	No Requirement, Site Regulations Vary	Fuel & Plant Dependent	Uncovered
Fuel Feed Equipment Provided	Spread Feed System Lock Hoppers Feed to Base of CFB Gasifier	Storage Bins & Unloader Metering Bins Rotary Seal Valves Pneumatic or Mech Conveyors	Metering Screws Day Bin
Emission Equipment or Combustor Emission Levels			
Particulates	Water Scrubber on Product Gas	Varies with Local Emissions Standards	ESP or Baghouse
SO ₂	None Typically Required	Limestone Injection	None or Limestone
NO _x	None Typically Required	Ammonia or Urea Injection	None or Staged Combustion
Bed Temperature	1500-1600 F Gasifier 1800-1900 F Combustor	1200 - 1600 F	1500 F
Fly ash	100%	mostly fly ash	95%
Bottom ash			
Bed Material	Silica Sand	lone Grog	Sand
Boiler Efficiency	Cold gas 75%	70 - 75%	72 - 80%
Combustion Eff	Total thermal 90%		99.5%
Energy Conv			
Equipment Lifetime and Maintenance			
Refractory	Unknown	15 years	4 - 8 years
Inbed Tubes	Not Used	5 years	Not Used
Exp Jts & Seals	Not Used	20 years	
Sizing Equipment	Unknown	10 years	
Drying Equipment		10 years	Not Used
Other		20 years	

FBC/FBG VENDOR QUESTIONNAIRE
FLUIDIZED BED COMBUSTION AND GASIFICATION
A GUIDE FOR BIOMASS GENERATORS

1. Contact Information
Name: Edward F. Matthew, Business Development Manager Date: 4-Nov-93
Telephone: (203) 285-9957 Fax: (203) 285-5041
Company Name: ABB Combustion Engineering, Inc.
Address: 1000 Prospect Hill Road
Windsor, Connecticut 06095
2. Experience: Attach list of equipment sold with name of client, capacity, fuel types, current operating status (operating, mothballed, retired), and names and phone numbers of plant contacts.
3. Combustors offered (yes/no): BFB _____, CFB YES.
4. Combustor size range: BFB _____, CFB 30MW - 250 MW.
5. Combustor applications (yes/no): Utility Boiler YES, Industrial Boiler YES, Hot gas generator _____, Other (describe) _____.
6. Gasifiers offered (yes/no): BFB _____, CFB _____.
7. Gasifier size ranges: BFB _____, CFB _____.
8. Gasifier applications, i.e. fuel gas for (yes/no): process heating equipment _____, gas turbine _____, IC Engine _____.
9. Commercial guarantees offered (yes/no): Capacity YES, efficiency YES, emissions YES, other Aux. Power Consumption.
10. Acceptable types of biomass fuels systems designed for: _____
All types for CFB.

11. Required fuel characteristics: % moisture 10 - 60, size range 1 - 2" max, Organics (Na, K, ...) No Limit, Other _____

12. Fuel preparation equipment typically required:
Sizing: 1 - 2" Max. Hogging / Screening

Drying: Not Required

Yard storage: Covered _____, Uncovered X, Comment: _____

13. List fuel feed equipment normally provided (metering, conveying, pressure seal, distribution, under/over bed):
 Live Bottom Bin
 Variable Speed Screws
 Rotary Valve

14. Emission control and/or gas clean-up equipment typically specified or required for:
 Particulates: .015 lb/MM Btu
 SO2: 90 - 95% Removal
 NOx: <.15 lb/MM Btu
 Other:

15. Performance:
 Bed Temperature Range: 1550 - 1650 °F
 Typical ash distribution (flyash/bottom ash): 70 / 30
 Bed makeup material: Limestone, Sand, Dolomite, etc.
 Typical efficiencies (boiler, combustion, energy conversion):
 65 - 85%
 Other:

16. Typical equipment maintenance items and replacement frequencies (lifetimes):
 Refractory: Variable
 Inbed tubes: None
 Combustor/Gasifier expansion joints and seals: Variable
 Sizing equipment:
 Drying equipment:
 Other:

17. Costs: (Indicate approximate capital and installation costs for following equipment typically in your scope of supply, including instruments and controls. Select two different, but typical capacity systems.)

System Capacity	LOW CAPACITY 30 MW		HIGH CAPACITY 250 MW	
	Capital Cost (\$)	Install. Cost (\$)	Capital Cost (\$)	Install. Cost (\$)
Equipment				
FB Combustor *	~ 12 million	~ 4.6 million	~ 57.5 million	~ 17 million
Fuel Prep System	N. A.	N. A.	N. A.	N. A.
Emission Controls	N. A.	N. A.	N. A.	N. A.
FB Gasifier	N. A.	N. A.	N. A.	N. A.
Fuel Prep System	N. A.	N. A.	N. A.	N. A.
Gas Cleanup	N. A.	N. A.	N. A.	N. A.

* Complete scope from fuel silo outlet to stack.

FBC/FBG VENDOR QUESTIONNAIRE
FLUIDIZED BED COMBUSTION AND GASIFICATION
A GUIDE FOR BIOMASS GENERATORS

1. Contact Information
Name: David Gibbs Date: 10/25/93
Telephone: (216) 860-1029 Fax: (216)860-6590
Company Name: Babcock & Wilcox
Address: 20 S. Van Buren Ave PO Box 351
Barberton, Ohio 44203
2. Experience: Attach list of equipment sold with name of client, capacity, fuel types, current operating status (operating, mothballed, retired), and names and phone numbers of plant contacts.
3. Combustors offered (yes/no): BFB YES , CFB YES .
4. Combustor size range: BFB Min - 10,000 lb/hr Steam Flow _____, CFB Min - 35,000 lb/hr Steam Flow _____.
5. Combustor applications (yes/no): Utility Boiler YES , Industrial Boiler YES , Hot gas generator No , Other (describe) _____.
6. Gasifiers offered (yes/no): BFB No , CFB No .
7. Gasifier size ranges: BFB N/A _____, CFB N/A _____.
8. Gasifier applications, i.e. fuel gas for (yes/no): process heating equipment _____, gas turbine _____, IC Engine _____.
9. Commercial guarantees offered (yes/no): Capacity YES , efficiency YES , emissions YES , other _____.
10. Acceptable types of biomass fuels systems designed for: _____
Virtually Any Type Of Biomass Plus Coal & Waste Fuels Of All Types

11. Required fuel characteristics: % moisture _____, size range _____, Organics (Na, K, ...) _____, Other _____
Max. 60% Moisture Without Auxiliary Fuel Input

12. Fuel preparation equipment typically required:
Sizing: Nominal 2' x 2' For Wood/Bark

Drying: _____

- Yard storage: Covered __, Uncovered __, Comment: _____

13. List fuel feed equipment normally provided (metering, conveying, pressure seal, distribution, under/over bed):
 Typically Flipper Feeder Or Air Swept Spout For OverBed,
 May Be Screw Type In Bed Feeder For Very Fine Fuels.

14. Emission control and/or gas clean-up equipment typically specified or required for:
 Particulates: Baghouse
 SO2: Dry Scrubber Or In Bed Capture (Fuel Dependent)
 NOx: SNCR or SCR or None ; As Required For Project
 Other: _____

15. Performance:
 Bed Temperature Range: Generally 1550 F To 1650 F
 Typical ash distribution (flyash/bottom ash): Varies With Fuel
 Bed makeup material: Sand Or Limestone In Most Cases
 Typical efficiencies (boiler, combustion, energy conversion): Varies With Fuel
 Other: _____

16. Typical equipment maintenance items and replacement frequencies (lifetimes):
 Refractory: _____
 Inbed tubes: Do Not use In Bed Tube Bundles ; Do Use In Bed Panel Sections When Required to Remove Heat from Bed which have not req'd significant maintenance
 Combustor/Gasifier expansion joints and seals: Have Not Been A Problem
 Sizing equipment: Generally Not In Our Scope
 Drying equipment: Generally Not In Our Scope
 Other: _____

17. Costs: (Indicate approximate capital and installation costs for following equipment typically in your scope of supply, including instruments and controls. Select two different, but typical capacity systems.)

System Capacity	LOW CAPACITY		HIGH CAPACITY	
	Capital Cost (\$)	Install. Cost (\$)	Capital Cost (\$)	Install. Cost (\$)
Equipment	Fuel & Project Specific		Fuel & Project Specific	
FB Combustor				
Fuel Prep System				
Emission Controls				
FB Gasifier				
Fuel Prep System				
Gas Cleanup				

FBC/FBG VENDOR QUESTIONNAIRE
FLUIDIZED BED COMBUSTION AND GASIFICATION
A GUIDE FOR BIOMASS GENERATORS

1. Contact Information

Name: Thomas H. Daniels, Gen. Mgr. Marketing & Sales Date: 11/30/93

Telephone: (208) 765-1611 Fax: (208) 765-0503

Company Name: Energy Products of Idaho
Address: 4006 Industrial Avenue
Coeur d'Alene, Idaho 83814

2. Experience: Attach list of equipment sold with name of client, capacity, fuel types, current operating status (operating, mothballed, retired), and names and phone numbers of plant contacts.

3. Combustors offered (yes/no): BFB YES, CFB No.

4. Combustor size range: BFB 12 MM Btu/Hr - 360 MM Btu/Hr, CFB N/A.

5. Combustor applications (yes/no): Utility Boiler YES, Industrial Boiler YES, Hot gas generator Yes, Other (describe) Thermal Fluid Heating.

6. Gasifiers offered (yes/no): BFB Yes, CFB No.

7. Gasifier size ranges: BFB 48 MM Btu/Hr - 300 MM Btu/Hr, CFB N/A.

8. Gasifier applications, i.e. fuel gas for (yes/no): process heating equipment Yes, gas turbine No, IC Engine No.

9. Commercial guarantees offered (yes/no): Capacity YES, efficiency YES, emissions YES, other _____.

10. Acceptable types of biomass fuels systems designed for: Wood Waste, Paunch Manure, Paper Sludge, Municipal Sludge, Agricultural Waste, Plastics, Demolition Waste, RDF, Coal, Shredded Tires

11. Required fuel characteristics: % moisture 60, size range 4" Minus, Organics (Na, K, ...) _____, Other _____

12. Fuel preparation equipment typically required:

Sizing: Shredder Or Hammermill With Disc Screen For Sizing

Drying: Rotary Dryers Or Screw Press For Sludge Or Paunch Manure
Where Required Due To Excessive Moisture Content.

Yard storage: Covered X, Uncovered X, Comment: Depends On Fuel & Plant Location

13. List fuel feed equipment normally provided (metering, conveying, pressure seal, distribution, under/over bed): Storage Bins And Unloader, Metering Bins, Rotary Seal Valves,
Pneumatic Or Mechanical Conveyors To Under/Over Bed Feed Ports As
Dictated By Fuel Sizing.

14. Emission control and/or gas clean-up equipment typically specified or required for:
 Particulates: Cyclones, Multiclones, Baghouse, ESP's, ESB's, Wet Scrubbers (As
required to meet local emission requirements).
 SO2: Limestone Injection
 NOx: Ammonia Or Urea Injection
 Other: Continous Emissions Monitoring Systems

15. Performance:
 Bed Temperature Range: 1200 Deg. F - 1600 Deg. F
 Typical ash distribution (flyash/bottom ash): Fly Ash
 Bed makeup material: lone Grog
 Typical efficiencies (boiler, combustion, energy conversion): 70 - 75 %
 Other: _____

16. Typical equipment maintenance items and replacement frequencies (lifetimes):
 Refractory: 15 Years
 Inbed tubes: 5 Years
 Combustor/Gasifier Expansion joints and seals: Fabricated Stainless Steel & Fabric - 20 Years
 Sizing equipment: Shredders, Hammermills, Disc Screens, Trommels - 10 Years
 Drying equipment: Rotary Drum Dryers, Screw Presses - 10 Years
 Other: Fans, Boilers, Multiclones, Baghouses - 20 Years

17. Costs: (Indicate approximate capital and installation costs for following equipment typically in your scope of supply, including instruments and controls. Select two different, but typical capacity systems.)

System Capacity	LOW CAPACITY 24 MM Btu/Hr		HIGH CAPACITY 250 MM Btu/Hr	
	Capital Cost (\$)	Install. Cost (\$)	Capital Cost (\$)	Install. Cost (\$)
Equipment				
FB Combustor	\$1,200,000	\$300,000	\$10,000,000	\$3,500,000
Fuel Prep System	None	N/A	\$4,000,000	\$1,000,000
Emission Controls	None	N/A	Incl. In Above	Incl. In Above
FB Gasifier	\$1,200,000	\$300,000	N/A	N/A
Fuel Prep System	None	N/A	N/A	N/A
Gas Cleanup	None	N/A	N/A	N/A

13. List fuel feed equipment normally provided (metering, conveying, pressure seal, distribution, under/over bed): Metering Bin, Conveying, Airlock Feeder, Weigh Meter

14. Emission control and/or gas clean-up equipment typically specified or required for:

Particulates: 0.03 gr/NM³ – No Control Required

SO₂: 11 ppm as SO₃

NO_x: Depend On Fuel

Other: _____

15. Performance:

Bed Temperature Range: 1300 F – 1800 F

Typical ash distribution (flyash/bottom ash): 99.9 % Bottom

Bed makeup material: None

Typical efficiencies (boiler, combustion, energy conversion):
Conversion: Dry – 85 % of Input Btu To Boiler (65 % green)

Other: _____

16. Typical equipment maintenance items and replacement frequencies (lifetimes):

Refractory: At Least 12 Yr. Of Proven Life

Inbed tubes: None

Combustor/Gasifier expansion joints and seals: None

Sizing equipment: N/A

Drying equipment: N/A

Other: _____

17. Costs: (Indicate approximate capital and installation costs for following equipment typically in your scope of supply, including instruments and controls. Select two different, but typical capacity systems.)

System Capacity	LOW CAPACITY		HIGH CAPACITY	
	8 Mil Btu/Hr input		100 Mil Btu/Hr input	
Equipment	Capital Cost (\$)	Install. Cost (\$)	Capital Cost (\$)	Install. Cost (\$)
FB Combustor				
Fuel Prep System				
Emission Controls				
FB Gasifier	150,000	200,000 *	850,000	1,000,000 *
Fuel Prep System	N/A			
Gas Cleanup	N/A			

* Total Installed Costs.

FBC/FBG VENDOR QUESTIONNAIRE
FLUIDIZED BED COMBUSTION AND GASIFICATION
A GUIDE FOR BIOMASS GENERATORS

1. Contact Information
Name: John Barnes Date: 12/14/93
Telephone: (619) 458-3050 Fax: (619) 458-0653
Company Name: Pyropower Corporation
Address: 8925 Rehco Road
San Diego, Ca 92121
2. Experience: Attach list of equipment sold with name of client, capacity, fuel types, current operating status (operating, mothballed, retired), and names and phone numbers of plant contacts.
3. Combustors offered (yes/no): BFB YES , CFB Yes-with coal .
4. Combustor size range: BFB 20,000 lb/hr - 600,000 lb/hr , CFB 100,000 lb/hr - 400 MWe .
5. Combustor applications (yes/no): Utility Boiler Yes , Industrial Boiler Yes , Hot gas generator Yes , Other (describe) _____
6. Gasifiers offered (yes/no): BFB Yes , CFB Yes .
7. Gasifier size ranges: BFB _____ , CFB _____ .
8. Gasifier applications, i.e. fuel gas for (yes/no): process heating equipment Yes , gas turbine Yes , IC Engine _____
9. Commercial guarantees offered (yes/no): Capacity YES , efficiency YES , emissions YES , other _____
10. Acceptable types of biomass fuels systems designed for: Mill Waste, Forest Waste, Energy Crops, Sludge, Peat
11. Required fuel characteristics: % moisture 65 % Max , size range 2" , Organics (Na, K, ...) 500 ppm max , Other _____
With Higher Moisture Content - More Supplementary Firing Is Needed
12. Fuel preparation equipment typically required:
Sizing: 2" x 0
Drying: Dewatering 65% Max Moisture
Typical Pulp & Paper Mill Bark Presses And Sludge Dewatering System Can Reach 55 - 60 % Moisture.
Yard storage: Covered _____ , Uncovered X , Comment: No Comment.

13. List fuel feed equipment normally provided (metering, conveying, pressure seal, distribution, under/over bed): Gravimetric Feeders, Drag Chain Conveyors, Screw Conveyors

14. Emission control and/or gas clean-up equipment typically specified or required for:
 Particulates: ESP
 SO2: None Usually, Sorbent Injection If Required.
 NOx: None Usually, Ammonia Injection If Required.
 Other: None

15. Performance:
 Bed Temperature Range: 1400°F – 1700°F
 Typical ash distribution (flyash/bottom ash): 10/90
 Bed makeup material: Sand
 Typical efficiencies (boiler, combustion, energy conversion): Boiler 62 – 75 %
Combustion: 98.5 – 99.9 % Energy: 15,000 – 19,000 Btu/Kwh
 Other: _____

16. Typical equipment maintenance items and replacement frequencies (lifetimes):
 Refractory: CFB: 5 Years BFB: 10 Years +
With Annual Maintenance
 Inbed tubes: N/A
 Combustor/Gasifier expansion joints and seals: 15 Years +
 Sizing equipment: 20 Years with Annual Maintenance
 Drying equipment: _____
 Other: Sludge Dewatering: 20 Years With Annual Maintenance

17. Costs: (Indicate approximate capital and installation costs for following equipment typically in your scope of supply, including instruments and controls. Select two different, but typical capacity systems.)

System Capacity	LOW CAPACITY 50,000 Lb/Hr Steam		HIGH CAPACITY 300,000 Lb/Hr Steam	
	Capital Cost (\$)	Install. Cost (\$)	Capital Cost (\$)	Install. Cost (\$)
Equipment				
FB Combustor	4.5 Million	1.1 Million	16.8 Million	5.6 million
Fuel Prep System	1.0 Million	.3 Million	2.5 Million	.6 Million
Emission Controls	Included	Included	Included	Included
FB Gasifier	9.0 Million	2.3 Million	N/A	N/A
Fuel Prep System	2.0 Million	.5 Million	N/A	N/A
Gas Cleanup	Included	Included	N/A	N/A

FBC/FBG VENDOR QUESTIONNAIRE
FLUIDIZED BED COMBUSTION AND GASIFICATION
A GUIDE FOR BIOMASS GENERATORS

1. Contact Information
Name: Eric Wasson Date: 12/14/93
Telephone: (704) 541-1453 Fax: (704) 543-8172
Company Name: Gotaverken Energy Systems Inc.
Address: 8008 Corporate Center Dr.
Charlotte, NC 28226
2. Experience: Attach list of equipment sold with name of client, capacity, fuel types, current operating status (operating, mothballed, retired), and names and phone numbers of plant contacts.
3. Combustors offered (yes/no): BFB YES , CFB No .
4. Combustor size range: BFB 100,000 - 600,000 lb steam/hr , CFB N/A .
5. Combustor applications (yes/no): Utility Boiler No , Industrial Boiler Yes , Hot gas generator No ,
Other (describe) Pulp & Paper
6. Gasifiers offered (yes/no): BFB No , CFB Yes .
7. Gasifier size ranges: BFB N/A , CFB 30 - 40 MW (t) .
8. Gasifier applications, i.e. fuel gas for (yes/no): process heating equipment Yes , gas turbine No ,
IC Engine No .
9. Commercial guarantees offered (yes/no): Capacity YES , efficiency YES , emissions YES ,
other Steam Temp., Press.
10. Acceptable types of biomass fuels systems designed for: Wood, Wood Waste,
Sludge, Bark, Waste Paper
11. Required fuel characteristics: % moisture 60 - 65 , size range * , Organics (Na, K, ...)
, Other
* What Can Be Fed Can Be Fired.
12. Fuel preparation equipment typically required:
Sizing: Screening only.
Drying: Not Req'd.
Yard storage: Covered , Uncovered X , Comment: Wet Fuel Is O.K.

13. List fuel feed equipment normally provided (metering, conveying, pressure seal, distribution, under/over bed): Metering Screws, Day Bin.

14. Emission control and/or gas clean-up equipment typically specified or required for:

Particulates: Electr. Precip. or Baghouse

SO₂: None / Limestone

NO_x: None / Staged Combustion

Other: _____

15. Performance:

Bed Temperature Range: 1500 °F +/-

Typical ash distribution (flyash/bottom ash): 95 % flyash

Bed makeup material: Sand

Typical efficiencies (boiler, combustion, energy conversion): Boiler, 72 – 80 %
Comb, 99.5 %

Other: _____

16. Typical equipment maintenance items and replacement frequencies (lifetimes):

Refractory: 4 – 8 yrs

Inbed tubes: N/A

Combustor/Gasifier expansion joints and seals: _____

Sizing equipment: _____

Drying equipment: N/A

Other: _____

17. Costs: (Indicate approximate capital and installation costs for following equipment typically in your scope of supply, including instruments and controls. Select two different, but typical capacity systems.)

System Capacity	LOW CAPACITY		HIGH CAPACITY	
	Capital Cost (\$)	Install. Cost (\$)	Capital Cost (\$)	Install. Cost (\$)
Equipment				
FB Combustor				
Fuel Prep System				
Emission Controls				
FB Gasifier				
Fuel Prep System				
Gas Cleanup				

FBC/FBG VENDOR QUESTIONNAIRE
FLUIDIZED BED COMBUSTION AND GASIFICATION
A GUIDE FOR BIOMASS GENERATORS

1. Contact Information
Name: Michael L. Murphy Date: 12-13-93
Telephone: (208) 664-4258 Fax: (208) 664-3615
Company Name: Kvaerner Environmental Tech
Address: 250 Northwest Blvd. Suite 203
Coeur d'Alene, ID 83814
2. Experience: Attach list of equipment sold with name of client, capacity, fuel types, current operating status (operating, mothballed, retired), and names and phone numbers of plant contacts.
3. Combustors offered (yes/no): BFB YES , CFB YES .
4. Combustor size range: BFB 10 - 150 MM Btu/Hr , CFB 10 - 1000 MM Btu/Hr .
5. Combustor applications (yes/no): Utility Boiler YES , Industrial Boiler YES , Hot gas generator No ,
Other (describe) _____.
6. Gasifiers offered (yes/no): BFB No , CFB No .
7. Gasifier size ranges: BFB _____ , CFB _____ .
8. Gasifier applications, i.e. fuel gas for (yes/no): process heating equipment _____ , gas turbine _____ ,
IC Engine _____ .
9. Commercial guarantees offered (yes/no): Capacity YES , efficiency YES , emissions YES ,
other _____ .
10. Acceptable types of biomass fuels systems designed for: _____
Wood, Peat, Agriwaste, lignite.

11. Required fuel characteristics: % moisture < 60% , size range <6" , Organics (Na, K, ...)
TBD , Other _____

12. Fuel preparation equipment typically required:
Sizing: Fuel Dependent - Hogging / Screening / Shredding typically.

Drying: Not Typical

Yard storage: Covered X , Uncovered X , Comment: Dependent on site conditions.

13. List fuel feed equipment normally provided (metering, conveying, pressure seal, distribution, under/over bed): Overbed spreader stoker feeder w/ pressure seal and metering &/or feed conveyor.

14. Emission control and/or gas clean-up equipment typically specified or required for:

Particulates: Baghouse

SO₂: Limestone in-bed plus dry scrubber, if req'd.

NO_x: Low excess air, staged combustion, ammonia injection

Other: Chlorides - lime injection dry scrubber
Mercury - Low temp, activated C injection

15. Performance:

Bed Temperature Range: 1550 °F +/-

Typical ash distribution (flyash/bottom ash): 95% flyash

Bed makeup material: Refractory sand or limestone

Typical efficiencies (boiler, combustion, energy conversion):
 Boiler - 72 - 80% (dep. on fuel), combustion - 99.5%

Other: _____

16. Typical equipment maintenance items and replacement frequencies (lifetimes):

Refractory: 4 - 7 yrs

Inbed tubes: None typically

Combustor/Gasifier expansion joints and seals: _____

Sizing equipment: _____

Drying equipment: N. A.

Other: _____

17. Costs: (Indicate approximate capital and installation costs for following equipment typically in your scope of supply, including instruments and controls. Select two different, but typical capacity systems.)

System Capacity	LOW CAPACITY		HIGH CAPACITY	
	CFB* 100 MM Btu/Hr in		CFB 250 MM Btu/Hr in	
Equipment	Capital Cost (\$)	Install. Cost (\$)	Capital Cost (\$)	Install. Cost (\$)
FB Combustor *	9.0 MILLION	2.5 MILLION	16.0 MILLION	5.0 MILLION
Fuel Prep System	.5 MILLION	.2 MILLION	1.5 MILLION	.5 MILLION
Emission Controls	inc.		inc.	
FB Gasifier				
Fuel Prep System				
Gas Cleanup				

*Costs for 100 MM Btu/Hr BFB about 10% less than CFB.

13. List fuel feed equipment normally provided (metering, conveying, pressure seal, distribution, under/over bed):
 Complete Biomass Feeding Line From
 Atmospheric Weigh Hopper To High Pressure
 Surge Hopper And Feeding Screw To
 Gasifier

14. Emission control and/or gas clean-up equipment typically specified or required for:
 Particulates: < 5 um < 0.001 gr/ft3 (O₂ = 5 %)
 SO₂: Negligible
 NO_x: (With SCR) < 0.05 Lb/MM Btu
 Other:

15. Performance:
 Bed Temperature Range: 1630 – 1740°F @ 290 – 370 psig
 Typical ash distribution (flyash/bottom ash): 60 % / 40 %
 Bed makeup material: Dolomite
 Typical efficiencies (boiler, combustion, energy conversion): Carbon Conversion > 99.5 %
 Overall Efficiency 46.4 %
 Other:

16. Typical equipment maintenance items and replacement frequencies (lifetimes): – only pilot plant experience
 Refractory: Typical
 Inbed tubes: N/A
 Combustor/Gasifier Expansion joints and seals:
 Sizing equipment: Typical
 Drying equipment: Typical
 Other:

17. Costs: (Indicate approximate capital and installation costs for following equipment typically in your scope of supply, including instruments and controls. Select two different, but typical capacity systems.)

System Capacity	LOW CAPACITY		HIGH CAPACITY	
	N/A		N/A	
Equipment	Capital Cost (\$)	Install. Cost (\$)	Capital Cost (\$)	Install. Cost (\$)
FB Combustor	N/A	N/A	N/A	N/A
Fuel Prep System	N/A	N/A	N/A	N/A
Emission Controls	N/A	N/A	N/A	N/A
FB Gasifier	N/A	N/A	N/A	N/A
Fuel Prep System	N/A	N/A	N/A	N/A
Gas Cleanup	N/A	N/A	N/A	N/A

* – 60 MM Btu/hr (Fuel Input) Pilot Plant Has Gasified > 1200 Tons of Biomass thru 12/93.
 Plant Contact: Enviropower Inc (Finland)/Risto Hokajarvi +358 31 241 3555 Fax: +358 31 241 3599

13. List fuel feed equipment normally provided (metering, conveying, pressure seal, distribution, under/over bed):

Feed bin, metering device, fuel chutes, rotary valves, air swept spouts – overbed feeding

14. Emission control and/or gas clean-up equipment typically specified or required for:

Particulates: ESP, baghouse + multiclone and scrubber

SO₂: Not usually needed due to low sulphur in fuel
limestone / CaOH – injection possible

NO_x: Primary method : Air staging
SNCR or SCR if needed

Other: Active coke injection before the baghouse (dioxins and HCl)

15. Performance:

	BFB	CFB
Bed Temperature Range:	1350 – 1800 °F	1450 – 1700 °F
Typical ash distribution (flyash/bottom ash):	99% / 1%	75% / 25%
Bed makeup material:	Sand	

Typical efficiencies (boiler, combustion, energy conversion): Comb. Efficiency 99.5%
(Boiler efficiency depends on fuel and selected exit gas temperature.)

Other: For CFB ~ 98% when coal is fired with biomass

16. Typical equipment maintenance items and replacement frequencies (lifetimes):

Refractory: > 5...10 years maintenance period

Inbed tubes: Not furnished

Combustor/Gasifier expansion joints and seals: NA for BFB / CFB: Depends on service

Sizing equipment: Normally out of our scope

Drying equipment: Normally out of our scope

Other: Fluidizing grid : nozzles don't need service, temperature probes 1 – 4 years

17. Costs: (Indicate approximate capital and installation costs for following equipment typically in your scope of supply, including instruments and controls. Select two different, but typical capacity systems.)

NA	LOW CAPACITY		HIGH CAPACITY	
	Capital Cost (\$)	Install. Cost (\$)	Capital Cost (\$)	Install. Cost (\$)
System Capacity				
Equipment				
FB Combustor *				
Fuel Prep System				
Emission Controls				
FB Gasifier				
Fuel Prep System				
Gas Cleanup				

**FBC/FBG VENDOR QUESTIONNAIRE
FLUIDIZED BED COMBUSTION AND GASIFICATION
A GUIDE FOR BIOMASS GENERATORS**

1. **Contact Information**
Name: Mark Paisley / Milton Farris **Date:** 12/16/93
Telephone: (614) 424-4958 / 404-612-5575 **Fax:** (614) 424-3321 / 404-612-5560
Company Name: Battelle Future Energy Resources
Address: 505 King Ave 3350 Cumberland Circle NW
Columbus, OH 43201 Suite 1500
Atlanta, GA 30339
2. **Experience:** Attach list of equipment sold with name of client, capacity, fuel types, current operating status (operating, mothballed, retired), and names and phone numbers of plant contacts. No commercial facilities
3. **Combustors offered (yes/no):** BFB _____, CFB _____
4. **Combustor size range:** BFB _____, CFB _____
5. **Combustor applications (yes/no):** Utility Boiler _____, Industrial Boiler _____, Hot gas generator _____, Other (describe) _____
6. **Gasifiers offered (yes/no):** BFB _____, CFB yes
7. **Gasifier size ranges:** BFB _____, CFB 100 to 1000 drs tons/day
8. **Gasifier applications, i.e. fuel gas for (yes/no):** process heating equipment yes, gas turbine yes, IC Engine yes
9. **Commercial guarantees offered (yes/no):** Capacity _____, efficiency _____, emissions _____, other Please obtain information from Future Energy
10. **Acceptable types of biomass fuels systems designed for:** All types of biomass fuels
11. **Required fuel characteristics:** % moisture no requirement, size range 2" minus, Organics (Na, K, ...) no requirement, Other no other fuel requirements
12. **Fuel preparation equipment typically required:**
Sizing: Coarse chop to yield 2" minus
Drying: None required
Yard storage: Covered x, Uncovered x, Comment: No requirement - storage as required by local regulations

13. List fuel feed equipment normally provided (metering, conveying, pressure seal, distribution, under/over bed): Spred feed system, lock hoppers, feed to base of CFB gasifier.

14. Emission control and/or gas clean-up equipment typically specified or required for:
 Particulates: Water scrubber on product gas
 SO₂: None typically required
 NOx: " " "
 Other: _____

15. Performance:
 Bed Temperature Range: Gasifier 1500 - 1600 F combustor 1800 - 1900 F
 Typical ash distribution (flyash/bottom ash): 100% fly ash
 Bed makeup material: silica sand
 Typical efficiencies (boiler, combustion, energy conversion): cold gas efficiency - 75%
total thermal efficiency including heat recovery - 90%
 Other: Produces 500 Btu/SCF product gas - does not use oxygen

16. Typical equipment maintenance items and replacement frequencies (lifetimes):
 Refractory: Unknown
 Inbed tubes: No in bed tubes
 Combustor/Gasifier expansion joints and seals: No expansion joints
 Sizing equipment: Unknown - expected maintenance equal to wood fired boiler systems
 Drying equipment: _____
 Other: _____

17. Costs: (Indicate approximate capital and installation costs for following equipment typically in your scope of supply, including instruments and controls. Select two different, but typical capacity systems.)

System Capacity	LOW CAPACITY		HIGH CAPACITY	
	Capital Cost (\$)	Install. Cost (\$)	Capital Cost (\$)	Install. Cost (\$)
Equipment	400 wet TPD			
FB Combustor				
Fuel Prep System				
Emission Controls				
FB Gasifier	\$10 million incl. in cap.			
Fuel Prep System	\$4-6 million incl. in cap.			
Gas Cleanup	included in gasifier cost			

OWNER/OPERATOR QUESTIONNAIRE
 FLUIDIZED BED COMBUSTION AND GASIFICATION
 A GUIDE FOR BIOMASS GENERATORS

1. Contact Information

Name: W. S. Bulpitt

Telephone: (404) 392-7634 Fax: (404) 393-9871

Company Name: Southern Electric International, Inc.

Address: 100 Ashford Central N.
Atlanta, Ga 30338

2. Energy Forms Produced

		(yes/no)	capacity	
Steam for:	process heat			Btu or lb/hr
	electricity			kw
Gas for:	process heat	Y	200	MM Btu/hr
	electricity			kw

3. Plant Description

(Attach a block flow diagram and any brochures or written descriptive material, if available)

a. Fluidized Bed Combustor/Boiler or Gasifier (Check the appropriate spaces)

Bubbling Fluidized Bed (BFB) Combustor/Boiler or Gasifier .
 Circulating Fluidized Bed (CFB) Combustor/Boiler or Gasifier .
 Gasifier supplies fuel gas to Gas Turbine , Internal Combustion Engine , or other process heating equipment . If "other", state type: Lime Kilns, Boiler
 Outlet Steam or Fuel Gas Conditions: 1400 °F, 1 psig.
 Combustor or Gasifier Manufacturer: Power Recovery Systems

b. Fuel Preparation System

Does the fuel preparation system have the following (yes/no, and circle equipment you have):

1. Fuel sizing equipment (shredder, chipper, hogger, crusher, other)? Yes Is pre-sized fuel used? No
2. Fuel classifying equipment (vibrating or disc screen, air classifier, other)?
3. Fuel drying equipment (rotary drum, fluidized bed, flash, other)?
4. Pelletizing or briquet equipment? No
5. Fuel blending equipment? No

c. Fuel Gas Cleanup

Check spaces provided if special precautions or equipment are required for: fuel gas cooling , particulate control , alkali metals control , other controls for protection of gas turbine or internal combustion engine components. If "other" checked, list control equipment required: _____

d. Emission Control

Check spaces provided if control equipment is required for the listed pollutants in gases discharged from the combustor/boiler, gas turbine, internal combustion engine, or other process heating equipment:

Particulate matter , SO₂ , NO_x , CO , Other . If "Other" checked, list pollutants: NONE

What control equipment is used? baghouse , electrostatic precipitator , scrubber , other (list) _____

e. Ash Disposal

- 1. How is ash disposed: landfilled onsite , offsite , or used by another party .
- 2. Is equipment required for ash cooling , conveying , dust control .

4. Fuels, Sorbents, & Bed Makeup

Fuels used: wood chips , sawdust , bagasse , MSW , Straw , tree trimmings , other (list) BARK

Sorbents: limestone , dolomite , other (list) _____

Bed Material Makeup: sand , limestone , other (list) _____

5. Environmental Permits Required

Air (yes/no): Yes. Solid waste (yes/no): No. Other (list) _____

Air permit parameters limited: SO2 , NOx , CO , Particulate matter , Other (list) VOC's from dryer

Results of most recent emissions test (indicate appropriate units): SO2 _____, NOx _____, CO _____, Particulate matter _____, Other (list) _____
N/A - Startup not completed.

Solid waste parameters limited (list): _____

6. Performance

Typical net process efficiency or heat rate 72 % (% or Btu/KWH).
Typical availability 85 % and capacity factor _____ %.
Average annual production _____
How long has plant operated (years, months) 3.5 YEARS

7. Plant History

How long to design plant: 24 months. How long to construct plant: 12 months.
When did plant first operate: 12/86. Plant is operated on a continuous (yes/no) or intermittent (yes/no) basis since completion of shakedown. What is present operating plan for plant?
SHUT DOWN

What is expected life of plant: 20 years

8. Plant Economics

Capital cost: \$ 8,000,000.
Construction cost: \$ _____.
Annual operation and maintenance budget: \$ 1.5 million.
Annual fuel costs: \$ _____.
Annual sorbent costs: \$ _____.
Annual ash disposal cost \$ _____, or credit \$ _____.
Value or cost of energy produced: _____.

APPENDIX C

FUEL PREPARATION EQUIPMENT VENDORS

BIOMASS FUEL PREPARATION EQUIPMENT VENDORS

Page 1

<u>VENDOR</u>	<u>PRODUCT</u>
AEROSLIDE CORP. 7100 HILLSBOROUGH ROAD RALEIGH , NC 27602 919-851-2000	DRYERS
AGNEW ENVIROMENTAL PRODUCTS CO. P.O. BOX 1168 GRANTS PASS , OR 97526 503/479-3396	BRIQUETTOR
AIR-O-FLEX EQUIPEMENT CO. 3030 E.HENNEPIN AVENUE MINNEAPOLIS , MN 55413 612/331-4925	TRUCK DUMPS
AIR-TECH INDUSTRIES, INC. 85 MADISON CIRCLE DRIVE 3. RUTHERFORD, NJ 07073 201/460-9730	AIR BAGS
AMERICAN HOIST & DRRRICK CO. 63 S. ROBERT STREET ST. PAUL , MN 55107 612/228-4321	WOOD BAILING MACHINERY
AMERICAN SHEET METAL, INC. P.O. BOX 9 TUALATIN , OR 97062 503/638-9611	WOOD, WASTE, STORAGE & CONVEYING SYSTEM
ARCHER BLOWER, INC. 6200 SW VIRGINIA AVENUE PORTLAND , OR 97201 503/246-7755	WOOD WASTES, STORAGE & CONVEYING SYSTEMS
ATLAS SYSTEMS CORPORATION P.O. BO 11496 SPOKANE , WA 99211 509/535-7775	WOOD RESIDUE STORAGE SILOS, AUTO. DISCHARGE SYST
BAHCO SYSTEMS, INC P.O. BOX 48116 ATLANTA , GA 30362 404/427-9051	BARK CLASSIFIERS & DRIERS, DUST COLLECTORS
BIO-SOLAR RESEARCH & DEV. CORP. P.O. BOX 762 EUGENE , OR 503/686-0765	WOOD PELLETS, PELLET SYSTEMS
BLACK CLAWSON, INC. P.O. BOX 1028 EVERETT , WA 98206 206/258-3555	FUEL PREPARATION COMPONENTS AND SYSTEMS
BOCATS, INC. P.O. BOX 1021 GARDEN CITY , KS 67846 316/275-7167	LIVE BOTTOM AND CHIP TRAILERS

VENDORPRODUCT

THE BONNOT COMPANY
805 LAKE STEET
KENT , OH 44240
216/673-5829

DENSIFIED LOG EXTRUDERS

CALIFORNIA PELLET MILL CO.
1114 E. WABASH AVENUE
CRAWFORDVILLE, IN 47933
317/322-6000

PELLETIZER EQUIPMENT

CEA, CARTER DAY COMPANY
500 73rd AVENUE, NE
MINNEAPOLIS , MN 55430
612/571-1000

BULK STORAGE, WOOD RESIDUE
HANDLING EQUIPMENT

CLARK'S SHEET METAL, INC.
P.O. BOX 2428
EUGENE , OR 97402
503/343-3395

STORAGE HANDLING SYSTEMS FOR
WOOD CHIPS & DUST

CONSOLIDATED BALING MACHINE CO.
155D 7th STREET
BROOKLYN , NY 11215
212/625-0929

BALING PRESSES FOR WOOD
RESIDUE

CORNELL MANUFACTURING INC.
LACEYVILLE , PA 18623
717/869-1227

WOOD RESIDUE HANDLING EQUIP.,

DIVERSIFIED FUELS
975 OAK STREET
EUGENE , OR 97401
503/484-0371

PELLETIZED FUEL FROM WOOD
RESIDUE & EQUIPMENT

DYNAMIC INDUSTRIES, INC.
P.O. BOX 466
BARNESVILLE , MN 56514
218/354-2211

FRONT END LOADERS

EDERER INC.
P.O. BOX 24708
SEATTLE , WA 98124
206/622-4421

RAKE CRANES, CONVEYORS

ERIEZ MAGNETICS
ERIE , PA 16512
814/833-9881

METAL SEPARATORS

FERRO-TECH
467 EUREKA ROAD
WYANDOOTTE , MI 48912
313/282-7300

BRIQUETTING EQUIPMENT

FMC CORP.-MHS DIVISION
3400 WALNUT STREET
COLMAR , PA 18915
215/822-0581

FUEL HANDLING SYSTEMS

BIOMASS FUEL PREPARATION EQUIPMENT VENDORS

Page 3

<u>VENDOR</u>	<u>PRODUCT</u>
L.B. FOSTER CO. P.O. BOX 453 CARNEGIE , PA 15106 412/787-5500	ROOT EXTRACTORS
FULGRUM INDUSTRIES, INC. P.O. DRAWER G WADLEY , GA 30477 912/252-5223	TREE SHEARS - SAWMILL MANUFACTURER
ENERGY CONTROL ENGINEERING CORP. P.O. BOX 3064 CHARLOTTE , NC 704/375-1701	WOOD-FIRED BOILERS
GOODMAN EQUIPMENT CORPORATION 4834 SOUTH HALSTED STREET CHICAGO , IL 60609 312/927-7420	DOUBLE ANVIL WOOD HOG & CHIP MILLS
GRUENDLER CRUSHER & PULVERIER CO. 2915 N. MARKET STREET ST. LOUIS , MO 63106 314/531-1220	ROCK CRUSHING MANUFACTURER
GUARANTY FUELS, INC. P.O. BOX 748 INDEPENDENCE , KS 67301 316/331-0027	WOOD FUEL PELLETS
HALLCO MFG. CO., INC. 1001 1/2 MAINSTREE VANCOUVER , WA 98660 206/696-1170	LIVE BOTTOM TRAILERS
HARVEY ENGINEERING & MFG. CORP. RT.2, BOX 478 HOT SPRINGS , AR 71901 601/262-1010	FUEL SYSTEMS & WOODWORKING MACHINERY
HEIL COMPANY 3000 W. MONTANA MILWAUKEE , WI 53201 414/647-3101	DEHYDRATION EQUIPMENT
HOBBS ADAMS ENGINEERING CO., INC. 1100 OLLAND ROAD SUFFOLK , VA 23434 804/539-0232	FARM RELATED EQUIPMENT MANUFACTURER
S.W. HOOPER CORPORATION 211 POWER FERRY ROAD ATLANTA , GA 30339 404/955-4136	UNHOGGED FUEL RECLAMATION SYSTEMS
INDUSTRIAL BURNER 24 W. THIRD AVENUE SPOKANE , WA 99204 509/747-7965	FUEL PREPARATION, HANDLING SYSTEMS

<u>VENDOR</u>	<u>PRODUCT</u>
JACKSONVILLE BLOW PIPE CO. P.O. BOX 3687 JACKSONVILLE, FL 32206 904/355-5671	WOOD/BARK HOGS, BLOWER SYSTEMS
JEFFREY MFG. DIV., DRESSER INDUSTRI 500 E. MOREHEAD STREET/RM 221 CHARLOTTE, NC 28202 800/223-1954	FUEL HANDLING, PROCESSING EQUIP., HOGS
JOHN DEERE CORPORATION OTTUMWA, IA 515/684-4641	CROP RESIDUE DENSIFIERS
KINERGY CORPORATION 482 JENNINGS LANE LOUISVILLE, KY 40218 502/864-5901	SCREENS, FEEDERS & CONVEYORS
KOCKUMS INDUSTRIES P.O. BOX 108 TRUSSVILLE, AL 35173 205/655-3261	TOTAL TREE CHIPPERS
KOEHRING CANADA LTD. BOX 490 BRANTFORD, ON, N3T 519/752-6571	FELLER-BUNCHERS, FELLER-FORWARDERS
K-TRON CORPORATION P.O. BOX 548 GLASSBORO, NJ 08028 609/881-6500	METERING CONVEYORS
LAIDIG, INC. 1230 S. MERRIFIELD AVE. MISHAWAKA, IN 46644 219/256-02C4	WOOD REFUSE HANDLING SYSTEMS
LAMB INCORPORATED 851 BELTLINE HIGHWAY MOBILE, AL 36606 205/479-7401	HOGS, HAMMERMILLS
LANDERS MACHINE CO. 207 E. BROADWAY FT. WORTH, TX 79104 817/336-5653	PELLETIZING MACHINERY
LEHIGH FORMING CO., INC. P.O. BOX 799 EASTON, PA 18042 215/258-0830	PELLET SYSTEMS
MARDEE, INC. 3129 E, WASHINGTON AVE. MADISON, WI 53704 608/244-3331	FUEL PREPARATION, HANDLING STORAGE SYSTEM

<u>VENDOR</u>	<u>PRODUCT</u>
MAREN ENGINEERING CORP. 111 W. TAFT DRIVE SOUTH HOLLAND, IL 60473 312/333-6250	BALING PRESS, SAWDUST, HYDRAULIC BALING
McBURNAY CORPORATION P.O. BOX 47848 ATLANTA, GA 30362 404/448-8144	FUEL PREPARATION, HANDLING SYSTEMS
McCONNELL INDUSTRIES P.O. BOX 26210 BIRMINGHAM, AL 35226 205/942-3321	FUEL PREPARATION, HANDLING SYSTEMS, EQUIP. MFG.
M-E-C COMPANY P.O. BOX 330 NEODESHA, JS 66757 316/325-2673	DRYERS, WOOD RESIDUE FUEL PREP. SYSTEMS
MELROE DIVISION/CLARK EQUIP. CO. FARGO, ND 58102 701/293-3220	FELLER-BUNCHERS
MODOMEKAN, INC. 2175 PARKLAKE DR., NE/SUITE 300 ATLANTA, GA 30345 404/934/3151	WOOD RESIDUE STORAGE, HANDLING SYSTEMS
MORBARK INDUSTRIES P.O. BOX 1000 WINN, MI 48896 517/866-2381	FUEL HARVESTING MACHINERY, CHIP CLASS. HARDWARE
MUNSON MACHINERY CO., INC. 210 SEWARD AVENUE UTICA, NY 13505 315/797-0090	HOGS, HAMMERMILLS
NICHOLSON MANUFACTURING CO. 3670 E. MARGINAL WAY, SOUTH SEATTLE, WA 98114 205/682-2752	WOOD HANDLING AND PREPARATION
PEABODY GORDON-PIATT, INC. P. O. BOX 650 WINFIELD, KS 67156 316/221-4770	FUEL METERING BINS
PEERLESS ROYAL DIV. - ROYAL INDUSTRIE P.O. BOX 760 PARAGOULD, AR 72450 501/236-7753	& TRUCK DUMPS
PIEDMONT SILO COMPANY, INC. SOUTH DARING ROAD COVINGTON, GA 30209 404/786-3031	SILOS

<u>VENDOR</u>	<u>PRODUCT</u>
PRECISION CHIPPER CORP. P.O. BOX 360 LEEDS , AL 35094 205/640-5181	TOTAL TREE CHIPPERS
RADER PNEUMATICS, INC. P.O. BOX 20128 PORTLAND , OR 97220 503/255-5330	PNEUMATIC HANDLING & CONVEYING EQUIP. & TR
RADER SYSTEMS 2400 POPLAR AVE./ SUITE 312 MEMPHIS , TN 38112 901/761-3390	PNEUMATIC CONVEYORS, DISC SCREENS
RENS MANUFACTURING CO. P.O. BOX 337 CROSSWELL , OR 97426 503/895-2172	METAL DETECTORS
REXNORD, INC. - VIBRATING EQUIP. DIV. 3400 FERN VALLEY ROAD LOUISVILLE , KY 40213	VIBRATING CONVEYORS TO BOILER FEED
REYDCO TRADING P.O. BOX 3545 REDDING , CA 96001 916/347-5334	EXTRUDED LOGS & MACHINERY
ROME INDUSTRIES CEDARTOWN , GA 30125 404/748-7450	FELLER-BUNCHERS, SKIDDERS
ROYER FOUNDRY & MACHINE CO. KINGSTON , PA 18704 717/287-9624	CHIPPERS, SITE PREPARTION
SCHUTTE PULVERIZER CO., INC. 61 DEPOT STREET BUFFALO , NY 14240 716/855-1555	GRINDERS, CONVEYORS, ELEV. EQUIP., DUMPS, HOISTS
SCREW CONVEYOR CORPORATION 600 HOFFMAN STREET HAMMOND , IN 46237 219/931-1450	WOOD CONVEYORS, TRUCK DUMPS
SELEM HAMMERMILL CO. 2601 INDUSTRIAL DRIVE SELEM , VA 24153 703/389-8696	INDUSTRIAL HAMMERMILLS
SPM GROUP, INC. 14 INVERNESS DRIVE, EAST ENGLEWOOD , CO 80111 303/770-1201	BRIQUETTES, BRIQUETTING MACH., DESIGN ENGINE
SPROUT-WALDRON, DIV. OF KOPPERS CO., 130 LOGAN STREET MUNCY , PA 17756	PELLETIZING EQUIPMEN

<u>VENDOR</u>	<u>PRODUCT</u>
STEARNS-ROGERS, INC. P.O. BOX 5888 DENVER, CO 80217 303/578-1100	ROTARY FUEL DRYERS FOR HOGGED WOOD FUEL
STEELCRAFT CORPORATION P.O. BOX 12408 MEMPHIS, TN 38112 901/452-5200	HIGH/LOW PRESSURE CONVEYORS, FILTER
STRONG MANUFACTURING CO. 498 EIGHT MILE ROAD REMUS, MI 49340 517/561-2280	TOTAL TREE CHIPPERS
TENNESSEE WOODDEX P.O. BOX 10041 KNOXVILLE, TN 37919 615/588-7411	WOOD PELLET SALES
THERMAL WOODDEX 07 WILLOW SPRINGS ROAD LaGRANGE, IL 60525 312/747-6600	FLUIDIZED-BED BURNERS
TOTEM EQUIPMENT CO. P.O. BOX 3706 SEATTLE, WA 98214 206/762-9191	METAL DETECTORS
TRANSARTIC AIR, LTD. P.O. BOX 11573 VANCOUVER, B.C, 604/683-1123	WOOD BRIQUETTE SALES & SYSTEMS
TRIPPLE S DYNAMICS 1031 S. HASKELL DALLAS, TX 75223 214/821-9143	CONVEYORS, SIZING EQUIPMENT
UNION HEATING, INC. 7833 196 SOUTHWEST EDMONDS, WA 98020 206/725-4588	FUEL FEEDERS/DUTCH OVEN BOILERS, WASTE BURNE
WEAVER STAR SILO, INC. ROUTE 4 MYERSTOWN, PA 17067 717/866-5708	SILOS
WELLONS, INC. P.O. BOX 381 SHERWOOD, OR 97140 503/625-6131	WOOD FUEL STORAGE BINS, CONVEYORS
WESCO TRAILER MFG. 1960 E. MAIN STREET WOODLAND, CA 95695 916/662-9606	CHIP VANS

VENDOR

PRODUCT

WEST SALEM MACHINERY
665 MURLARK STREET
SALEM, OR
503/364-2213

HOGS, DISC SCREENS, SAWMILL
EQUIP. MFG.

GUARANTY PERFORMANCE CO., INC.
P.O. BOX 748
INDEPENDENCE, KS 67301
316/331-0027

ROTARY DRYERS, FUEL HANDLING
EQUIPMENT

APPENDIX D

FEDERAL AND STATE ENVIRONMENTAL AGENCY OFFICES
SOUTHEASTERN STATES

APPENDIX D

FEDERAL AND STATE ENVIRONMENTAL AGENCY OFFICES
SOUTHEASTERN STATES

1. U. S. ENVIRONMENTAL PROTECTION AGENCY REGIONAL OFFICES:

REGION III: Delaware, D.C., Maryland, Pennsylvania, Virginia, West Virginia

OFFICE: 841 Chestnut Street
Philadelphia, PA 19107
(215) 597-9814

REGION IV: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina,
South Carolina, Tennessee

OFFICE: 345 Courtland, NE
Atlanta, GA 30365
(404) 347-4727

REGION VI: Arkansas, Louisiana, New Mexico, Oklahoma, Texas

OFFICE: 1445 Ross Avenue
12th Floor
Dallas, TX 75270
(214) 655-2100

REGION VII: Iowa, Kansas, Missouri, Nebraska

OFFICE: 726 Minnesota Avenue
Kansas City, KS 66101
(913) 551-7000

2. SOUTHEASTERN STATE OFFICES:

ALABAMA

Alabama Department of Environmental Management, 1751 Federal Drive,
Montgomery, AL 36130 (205)271-7861

Air Division	(205) 271-7861
Industrial Water Division	(205) 271-7823
Land Division	(205) 271-7726
Permits Coordination Branch	(205) 271-7715

ARKANSAS

Arkansas Department of Pollution Control and Ecology, 8001 National Drive, P.O.
Box 8913, Little Rock, AR 72219-8913 (501) 562-7444

Air and Hazardous Materials Division	(501) 562-7444
Water Quality Division	(501) 562-7444
Solid and Hazardous Waste Division	(504) 562-7444

FLORIDA

Department of Environmental Protection, Air Resources Management, Twin Towers
Office Building, 2600 Blair Stone Road, Tallahassee, FL 32301 (904) 488-1344

Bureau of Air Regulations	(904) 488-1344
Bureau of Waste Water Management	(904) 488-0130
Bureau of Waste Management, Solid Waste Management Section	(904) 487-3299
Division of Environmental Permitting	(904) 488-0130

GEORGIA

Georgia Department of Natural Resources, Environmental Protection Division, 205
Butler Street, Suite 1152, Atlanta, GA 30334 (404) 656-4713

Air Protection Branch	(404) 363-7000
Water Protection Branch	(404) 656-4708
Land Protection Branch	(404) 362-2537

KENTUCKY

Kentucky Department for Environmental Protection, 316 St. Clair Mall, Frankfort,
KY 40601 (502) 564-3382 NOTE: Will be moving in April of 1994 - need to get new
address after that date.

Division of Air Pollution Control, Permit Review Branch	(502) 564-3382
Division of Water, Permit Review Branch	(502) 564-3410
Division of Waste Management, Permit Review Branch - Solid Waste	(502) 564-6716

LOUISIANA

Louisiana Department of Environmental Quality, 7290 Bluebonnet Road, (see below
for P.O. box nos.), Baton Rouge, LA 70810 (504) 765-0741

Air Quality Division -P.O.Box 82135	(504) 765-0219
Water Pollution Control Division P.O. Box 82215	(504) 765-0634
Solid Waste Division -P.O. Box 82178	(504) 765-0355

MISSISSIPPI

Mississippi Department of Natural Resources, Bureau of Pollution Control, 2380
Highway 80 West, P. O. Box 10385, Jackson, MS 39289 (601) 961-5171

Air Division	(601) 961-5171
Water Quality Division	(601) 961-5171
Solid and Hazardous Waste Division	(601) 961-5171

MISSOURI

Missouri Department of Natural Resources, Division of Environmental Quality, 205
Jefferson Street, 1st Floor of Jefferson Building, P.O. Box 176, Jefferson City, MO
65102
(314) 751-4819

Air Pollution Control Program	(314) 751-4817
Water Pollution Control Program, Permit Section	(314) 751-6825
Waste Management Program. Solid Waste Section	(314) 751-5410

NORTH CAROLINA

Division of Environmental Management, Department of Environment, Health and
Human Resources, 512 North Salisbury Street, Raleigh, NC 27626-0535 (919) 733-
3340

Air Quality Section	(919) 733-3340
Water Quality Section	(919) 733-5083
Solid & Hazardous Waste Branch	(919) 733-4996

SOUTH CAROLINA

Department of Health and Environmental Control, J. Marion Sims Building, 2600 Bull Street, Columbia, SC 29201 (603) 758-5406

Bureau of Air Quality Control	(803) 734-4750
Bureau of Water Pollution Control	(803) 734-5300
Bureau of Solid and Hazardous Waste Management	(803) 734-5200

TENNESSEE

Department of Environment and Conservation, L & C Annex Building, 401 Church Street, Nashville, TN 37243 (see below for floor number and telephone number for the Division)

Division of Air Pollution Control 9th Floor	(615) 532-0554
Division of Water Pollution Control, Permit Section - 6th Floor	(615) 532-0625
Division of Solid Waste Control Permit Section - 5th Floor	(615) 532-0780