Carbona Corporation

Subcontractor:	Carbona Corporation 4501 Circle 75 Parkway Suite E 5300 Atlanta, GA 30339
Contracting Party:	Sandia National Laboratories
Subcontract Title:	"Small Modular Biopower Project"
Subcontract No.:	SNL BC-0002E
Period of Performance:	8 Jun 1998 through 30 Nov 1999
Subcontract Contact:	Mr. Jim Patel, Tel. (770) 956-0601

Introduction

This report has been prepared by Carbona Corporation as part of DOE's SMB project. The feasibility study is Phase 1 of a three-phase program that will result in a demonstration of a small-scale biopower system.

The study is based on Carbona's updraft gasification technology, which is an atmospheric, fixed bed gasifier. Several plants based on this technology operates in Scandinavia. The power plant consists of a fuel handling section, gasifier, boiler, and a steam turbine generator.

The study has considered the feasibility of three sizes of power plants: 1, 3 and 5 MWe. All the plants are combined heat and electric power (CHP) producers. The preferred biomass fuel is woody biomass and the preferred markets are timber sawmills or district heating plants. The feasibility study includes a market and resource assessment, a preliminary design of the power plant, an environmental and cost analysis, and an integrated business and commercialization plan. The specific design is based on a 3-MWe power and 19 MMBtu/h heat producing biopower plant.

The results of the feasibility study show that in the markets evaluated such a biomass-based power plant can supply all the energy to a sawmill or to district heating (CHP) at attractive economics. Carbona and its partners propose to build and operate an updraft gasifier biopower (USB) plant either at a sawmill in Ghana or at a district heating plant in Denmark under Phase II of the SMB project.

Potential Markets

The UGB system is a CHP plant. The biomass fuel for the UGB is wood waste either from forestry as wood chips or timber and sawmill operations. Therefore, the primary market for the UGB system is a sawmill or a community in a cold climate with a nearby forest industry or availability of wood residue. Both potential markets need electric power and some form of heat in the sawmill for drying and in the community for heating. Moreover, the planned size range of the UGB system—1, 3 and 5 MWe—is suitable for most of the market potential. Another requirement for the potential market for the community application is that it should be remotely located and therefore have no grid connection for electricity or that power price is very high. For both applications the price differential between wood waste and alternative fuels such as liquid petroleum and natural gas should be relatively large.

In the United States today the cost of electricity (COE) is very low (2-3 ¢/kWh), mainly because of low natural gas prices. Under these circumstances, the UGB system can not economically compete for new customers.

Remotely located communities near forestry industries are the only potential markets. However, several contacts with them have been unfruitful, mainly because of institutional barriers.

Therefore, the most attractive markets are international—in Scandinavia and the Baltic states and in developing countries within forest industries and where the alternative fuel prices are high. These countries are in Central and South America, West and East Africa, Asia-Pacific, Scandinavia, and the Baltic states. Some of the countries identified as promising potential markets in these regions are Brazil, Chile, Ghana, Kenya, India, China, Thailand, Denmark, Sweden, Latvia, and Estonia. The market and resource assessment in this study was for the two most promising areas: West Africa and Scandinavia.

The Danish government intends to continue the development of renewable energy at an average annual rate of 1%. This entails renewable energy increasing its share of the energy supply to about 35%. A gradual increase in the use of biomass at power plants should amount to 1.2 million tonnes of straw and 0.2 million tonnes of wood chips annually by 2000. Approximately 60 small towns should be converted to biomass-based district heating.

Data from the Food and Agriculture Organization of United Nations' database show that four African countries, which are all well-known for their large sawmill industries, have a market potential for at least 70 UGB plants of 3 MWe. These four countries are Ghana, Ivory Coast, Cameroon, and Nigeria.

The total investment cost of the 1, 3 and 5 MW UGB plants was estimated using standard costing practices. Because of the large size of the gasifier, for the UGB plant of 5 MW capacity two gasifiers will be assumed to supply gas to one gas boiler. The investment costs are summarized in Table 7.

Table 7. Investment Costs

Nominal capacity	Total investment cost
1 MW	$3.88 million
3 MW	$5.88 million
5 MW	$8.52 million

The COE is 5-7 ¢/kWh depending on price of biomass fuel and heat.

System Design

The power and heat generating power plant system described in this feasibility study is based on wood-based biomass. The fuel is gasified in an atmospheric pressure updraft gasifier. The low calorific value (LCV) product gas produced in the gasifier is burned directly in a boiler that generates high-pressure steam. Steam is utilized in a back-pressure steam turbine generating power and provides heat for district heating. The rest of the plant is a typical arrangement of conventional equipment.

The gasification plant (Figure 2) is to convert solid biomass fuel to product gas. The gasification plant is served by a fuel receiving station combined with covered fuel storage in addition to an open air fuel reclaim area. A conveyor transfers the fuel from the storage to the feeding system. The feeding system is piston type, gas-tight feeder located a top the gasifier. The gasifier is an air-blown updraft fixed bed gasifier. It comprises a refractory-lined shaft furnace and rotary grate. The fuel drops to the top of the fixed bed in the gasifier. First it will be dried by the upward product gas flow. In this drying process the product gas cools to about 480°-

660°F (250°-350°C), the exit gas temperature of the gasifier. The dried fuel then moves downward in the fixed bed, countercurrent with the product gas, through the gasification zone of about 1800°F (1000°C) temperature to the oxidation zone. The residual ash accumulates in this oxidation zone, near the grate. The gasifier ash is removed through the bottom of the gasifier by gravity through a valve systems into the ash containers and is then landfilled.

The gasification air is fed through the rotating grate located in the bottom of the gasifier reactor to enable proper air distribution in the fixed bed. The air is preheated and humidified using steam before being fed into the gasifier. The steam is to control the gasification temperature (i.e., prevent ash sintering) in the lower bed area. The LCV product gas is generated in the gasification area. The product gas exiting the gasifier is directed to the gas boiler through the gas pipe. The gas pipe is short to minimize tar condensation. The gas is burned in a gas boiler equipped with a special gas burner suitable for LCV gas combustion.

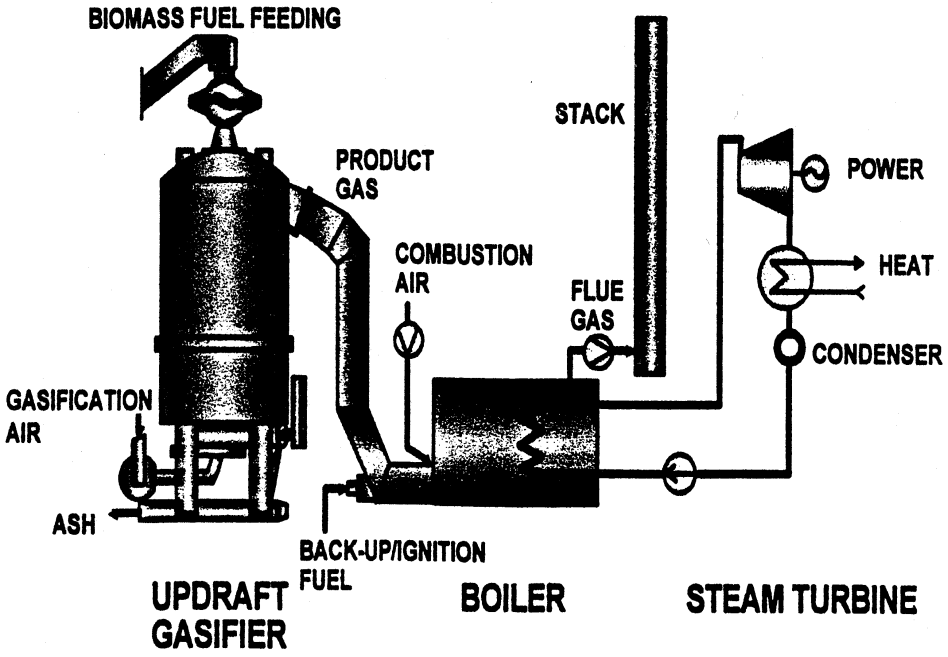

Figure 2. Updraft Gasifier Biopower System

The emissions of UGB plant as compared with emission limits required by the World Bank are listed in Table 8.

Table 8. UGB Plant Emissions

	Pollutant UGB plant	**Emission rate** World Bank limit
SO_2	0,009 tpd/MWe	0,2 tpd/MWe
NO_x	100 mg/MJ	260 mg/MJ
CO	25 mg/MJ	n/a
Particulate	10 mg/nm^3	50 mg/nm^3

The overall efficiencies of the three sizes of the UGB plants are shown Table 9.

Table 9. Overall Efficiencies of UGB Plants

Nominal Capacity MW	Electric Power MW	Heat MJ/s	Electric Efficiency (LHV)	Overall Efficiency (LHV)
1	1.0	3.66	18.6	82.0
3	3.0	8.37	21.9	82.7
5	5.0	13.6	22.4	83

Future Development

Carbona intends to supply the UGB systems in the identified markets on a turnkey basis. To achieve this, strategic partnerships will be formed with a local company in each country. Carbona has the basic engineering and knowhow of the UGB system and has the background from experience in supplying UGB systems in Scandinavian countries through its sister company in Finland. There are 10 operating plants based on UGB principles, located mostly in Finland.

For Scandinavia and the Baltic states Carbona has entered into an alliance with FLS miljø a/s. Ultimately Carbona will solidify this agreement for delivering UGB plants on a turnkey basis in Europe. For Ghana, Carbona has already formed a cooperation with a company called Waypoint Ltd. Similarly, Carbona has also formed a cooperation with a company called IBIL Tech Limited in India for that market. A potential customer has also been identified in India for a demonstration project.

The short-term goal is to build and operate a demonstration plant for each of the two primary applications of the UGB system—sawmill and local community. Two commercial plants should be sold based on the results of the demonstration plants. In the mid term the goal is to build UGB Systems in four of the main potential market countries to establish a broad base for future business. Also during this period efforts will be made to improve the efficiency and cost competitiveness of the UGB System. One approach will be to develop gas cleanup techniques so the steam turbine power block can be replaced by a gas engine. Also, the feedstock base for the system will be expanded to include agricultural waste and retrieve derived fuel. In the long term for the business to be successful, at least five UGB systems should be sold annually, and the U.S. market for biomass-based power must be established. This will require innovative approaches in financing, project development, and new partnerships.

As part of the commercialization of the UGB system, an aggressive marketing plan will be implemented. An initial step has already been taken by signing up partners for sales and marketing efforts on a local level in Scandinavia, the Baltic states, Ghana, and India. Also, quickly establishing the demonstration plants to aid in the marketing effort whereby customers can inspect and evaluate the results of an operating unit is essential. Therefore, the initial marketing efforts will be concentrated in Scandinavia, the Baltic states, Ghana, and India.