

1 Introduction

This proposed study is to evaluate technical and economical feasibility of integrated biomass gasification and co-firing in an existing utility boiler. The project examined two different sites: Reid Plant boiler operated by Western Kentucky Energy and Monticello Plant operated by TXU Energy. Primary focus of the study was to utilize poultry litter as a fuel for external gasification and feed the resulting low Btu producer gas into the existing utility boiler at these sites. Specific objectives of this project are:

- To evaluate the technical and economic feasibility of gasification based co-firing on the existing class of fossil fuel fired boilers currently within range of animal waste and agricultural biomass sources of reliable consistency and delivery rates needed for economic operation
- To determine possible modifications, if any, required in either the proposed gasification or boiler technology, for effective utilization of the biomass sources proposed
- To evaluate these factors for two specific cases: for the Reid Plant operated by Western Kentucky Energy Corp. and Monticello Plant operated by TXU Energy.
- To develop detailed cost and schedule estimates for implementing gasification based biomass co-firing at these two facilities.
- Future implementation of such a facility if all of the estimates and evaluations indicate that a useful demonstration of the proposed biomass gasification and co-firing technology can be economically justified.
- To support commercialization of biomass co-firing technology that utilizes biomass, agricultural waste and farm animal wastes in an environmentally benign, technically practical application, provided it is economically viable.

1.1 Background Information

The technical and economic feasibility study was conducted for WKE's Reid plant located in Henderson County, KY, and for TXU Energy's Monticello plant located in Titus County, TX. Detailed background information on the Reid plant, Monticello plant and Primenergy's fixed bed updraft gasifier is provided in Section 3. For both cases Primenergy, LLC, KC-18 series gasifiers were selected, a single KC-18 for the Reid plant and twin KC-18 system for the Monticello case were considered. Nexant, Primenergy and Western Kentucky Energy (WKE) for the Reid case and Nexant, Primenergy and TXU evaluated a gasification system to be located in the vicinity of the existing boilers to provide

producer gas as a supplemental fuel and to displace a portion of the primary boiler fuel, coal and / or natural gas.

1.2 Gasification Based Cofiring Concept

The gasification based cofiring can best be represented by the following schematic in figure 1-1. As shown in the schematic, the primary boiler fuel and the biomass fuel are treated and utilized separately. This approach avoids the traditional problems associated with cofiring, where biomass is directly introduced in to an existing boiler, namely fuel handling and fuel delivery into the boiler, boiler slagging and altered ash characteristics and based on moisture content of the biomass an altered combustion pattern within the boiler.

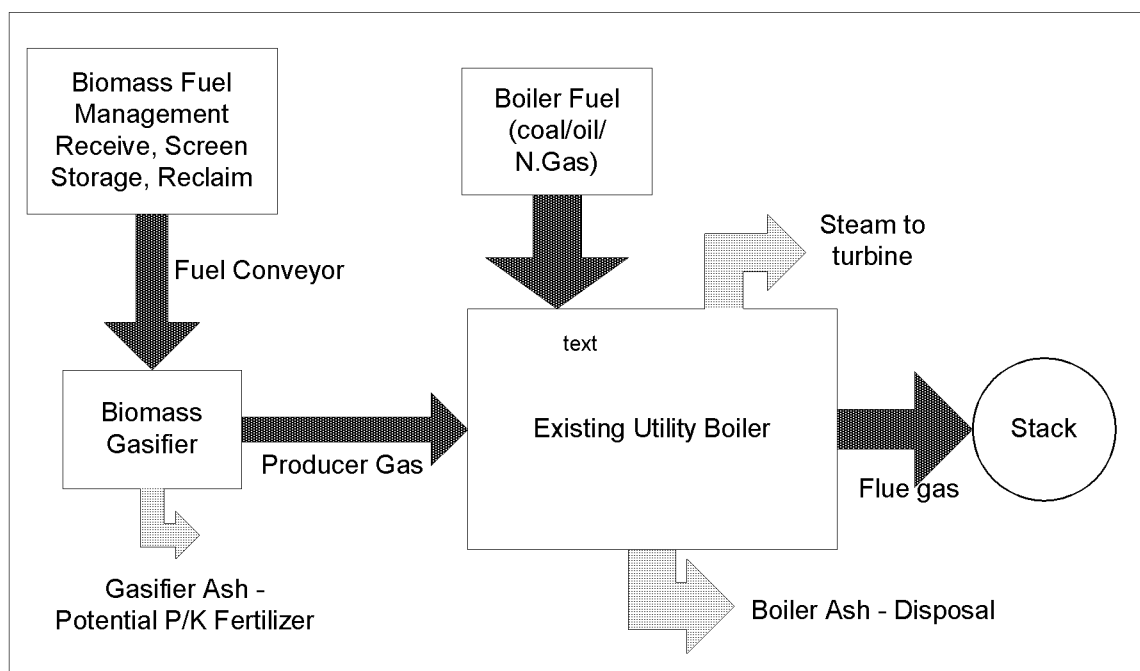


Figure 1-1 Gasification Based Biomass Co-firing System Diagram

1.3 Western Kentucky Energy Case

The WKE's Reid plant is located near Henderson, Kentucky. It is a 63 MWe coal-fired unit with a pulverized coal-fired Riley Stoker boiler. The boiler uses Western Kentucky coal. The boiler has maximum continuous capacity (MCR) of 313,000 kg (690,000 lbs) of steam/hr at 90.6 Bars and 513°C (1300 psig and 955°F) at the super heater outlet.

The Reid plant operated by WKE in Henderson County is in an ideal location for the proposed demonstration project since it is adjacent to a Tyson Foods chicken

processing plant and associated chicken farms. The total yield of poultry litter from the farmers in the vicinity is expected to be a greater than 75,000 tons per year. Figure 1-2 show concentration of poultry farmers within 50-mile radius in Western Kentucky, with center at McLean County, about 20 miles from the Reid plant.¹ The map shows that within 50-mile radius, there are 668 poultry houses. These poultry farmers are primarily associated with the Tyson Foods plant near the Reid plant in Robards, KY. Another poultry producer, Purdue Farms operate a large processing plant in Cromwell, KY, about 65 miles due southeast from the Reid Plant. Poultry farmers associated with Purdue Farms may overlap in this map.

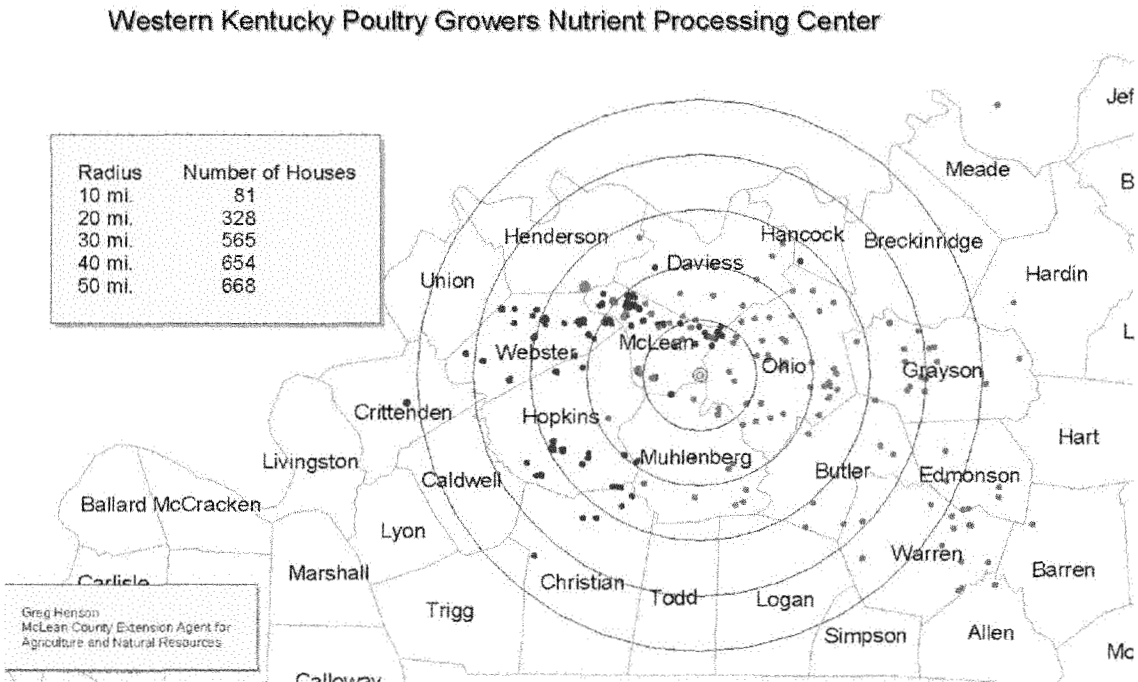


Figure 1-2 Poultry Supply in Vicinity of Reid Plant

For the Reid plant a single gasifier with 8 tons/h of litter (54,000 tons/year) was considered. This provided about 10% of the total boiler energy input from the gasification based cofiring. A detailed technical and economical analysis for this case is provided in Section 3.

1.4 TXU Energy Case

TXU Energy's Monticello Plant is located near the cities of Mount Pleasant and Pittsburg in Titus County, TX. The Monticello is a 3-unit coal/ Texas lignite fired plant. For this study, Monticello Unit 1 was selected. The unit 1 Monticello boiler is a Combustion Engineering tangentially fired reheat boiler. The boiler is rated at 1,451,500 kg (3,200,000 lbs) of steam/hr at 250 Bars (3600 psig) and 540°C (1005°F) at the super heater outlet. The reheat flow is 1,270,000 kg (2,800,000 lbs) of steam/hr at 540°C (1005°F) and 40 Bars (550 psig). The boiler is fueled by 60% Texas lignite from the nearby mine and 40% low sulfur Powder River Basin (PRB) coal from Wyoming.

The Monticello plant is also an ideal location for poultry litter supply. Table 1-1 below shows estimated poultry, broiler, and pullets production within six county regions around the Monticello plant.²

Table 1-1 Poultry production estimate by Texas Agricultural Department (1997)

County	Camp	Titus	Franklin	Morris	Wood	Total
Total broilers/pullets and other chickens	50,359,409	18,223,679	15,081,030	5,783,000	14,183,669	103,630,787

Estimating about 1 kg (2 lbs.) of litter and bedding material per bird, there is estimated 100,000 t/y (105,000 tons/year) of litter supply in the vicinity of the plant. Pilgrim's Pride, the large poultry processor in Mount Pleasant and Pittsburg, TX estimates that there is nearly 200,000 tons/year of litter supply in the 80 km (50-mile) radius of the plant.

For TXU case, we designed gasifier for a feed rate of 14,350 t/h of litter or about 115,000 t/year of litter consumption. This rate produces about 2% of the total energy input to the Monticello Unit 1 boiler.

1.5 Primenergy Gasifier

The Primenergy gasifier is a fixed-bed updraft system. Because this gasifier is a sub atmospheric and an updraft device, it is a comparatively lower cost system than other types of gasifiers. In the updraft system most of the tars are cracked by partial oxidation of the product gas, which increases the temperature of the product while reducing the condensable long chain and cyclical hydrocarbons to fragments. Figure 1-3 is a schematic of the Primenergy gasifier.

The Primenergy gasifier has already been used for electricity generation in stand-alone plants. Typically it is installed to gasify biomass, with the gas being combusted immediately and ducted to a heat recovery steam generator (HRSG). The HRSG then generates the steam for use in a turbine. The largest design for a single Primenergy gasifier is 100x10⁶ kJ/h (100x10⁶ Btu/hr). Multiple gasifiers

can be installed to increase overall system capacities. Typical capacities of the electricity generating systems based upon the Primenergy gasifier are less than 15 MWe, and the typical HRSG steam conditions have been at or below 60 Bars (850 psig).

These stand-alone plants have been installed to manage rice hulls and rice straw, wood waste, switchgrass, and other feeds. The gasifier has shown that it can successfully handle materials up to 50-55 percent moisture, although the product gas quality suffers with high moisture feedstock. Testing for the Southeast Regional Biomass Energy Program (SERBEP) has demonstrated the substantial feedstock flexibility of this system.

Among the Primenergy gasification applications is the 300 t/d (330-ton/day) rice hull gasifier installed for Cargill Rice Milling of Greenville, MS. This installation delivers sufficient heat to a HRSG to generate 5 MW of electricity, and 6,800 kg/h (15,000 lb/hr) of process steam. Key to this installation are methods for removing virtually all of the ash as bottom ash while generating a gas that is substantially free of tars through partial oxidation of the gas exiting the gasifier itself. Other applications of this system with different fuel exhibit similar characteristics.

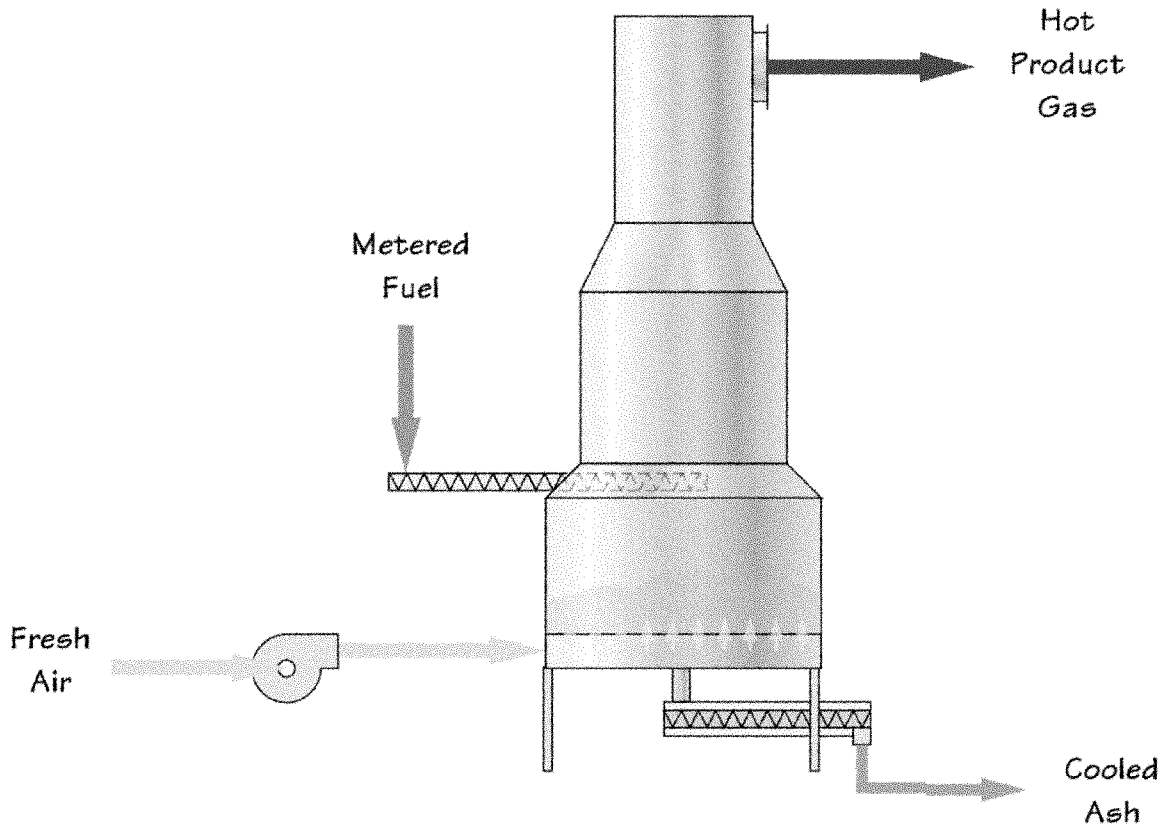


Figure 1-3 Primenergy Gasifier – simplified sketch

1.6 PHASE I Organization, Tasks and Schedule

The gasification based biomass co-firing project has reviewed and evaluated technical feasibility and economical viability of building and operating poultry litter gasifier at WKE's Reid plant near Henderson, KY, and TXU Energy's Monticello plant near Mount Pleasant and Pittsburg, TX. The project has reviewed the existing plant design and operation; evaluated available poultry litter supply, and prepared preliminary engineering design; specification and plant layout for construction and installation of the gasifier systems. The project also estimated impact on plant emissions due to cofiring. Based on the engineering design, plant layout, and fuel cost, project has prepared a pro-forma cost analysis for both WKE and TXU cases.

The overall project was planned for two phases. Under Phase I, the project has addressed feasibility and economic issues. If economically viable and if desired by the respective utility/ plant owners, a Phase II actual demonstration of the technology can be pursued. At present, due to unfavorable economics, the two participating utilities, WKE and TXU have not committed to the Phase II.

During the Phase I, the project team undertook a detailed feasibility study of integrating the existing utility boiler plant with Primenergy's gasifier unit utilizing poultry litter as primary feedstock. Project Organization for the Phase I study is shown here in figure 1-4.

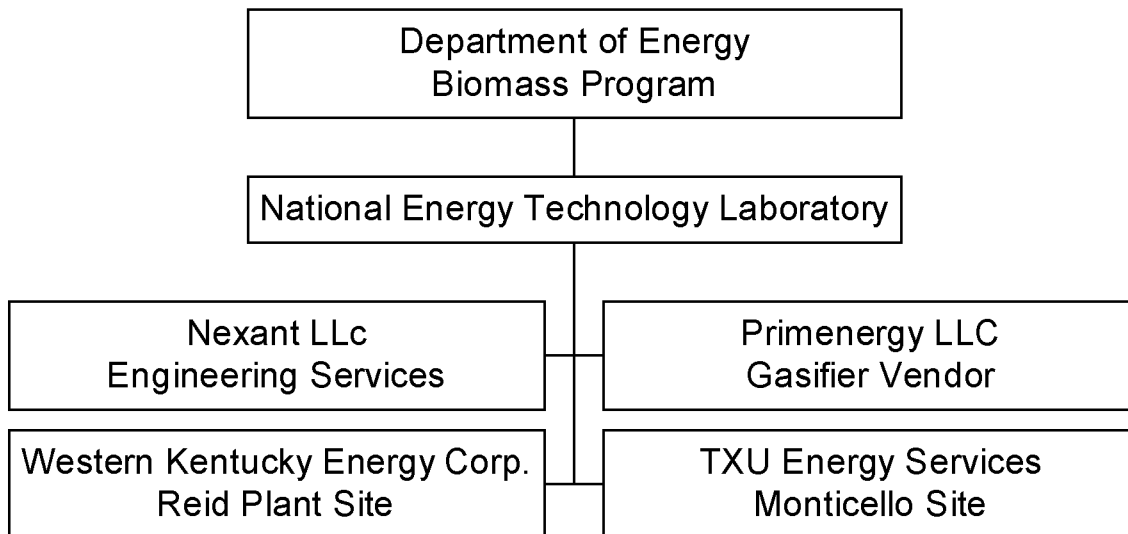


Figure 1-4 Project Organization Chart

The specific tasks that were performed under Phase I are:

- Conceptual engineering of the gasification facility, including the fuel handling aspects of the facility
- Equipment selection, integration with existing boiler and plant layout
- Fuel characterization, including proximate and ultimate analysis of the poultry litter, Btu content, moisture and size variation, ash characterization.
- Fuel availability assessments, focusing upon the availability of low, zero, and negative cost biomass. This effort is concentrated on locally available poultry litter, but project has also examined other biomass in the area.
- Modeling of the existing boiler to determine any de-rating issues

- Economic assessment of gasification-based co-firing evaluating the fuel cost implications on the overall cost of power generation

A detailed work plan by major tasks for Phase 1 is provided here. Figure 1-5 illustrates the logical flow of work undertaken in this program. At each of these stages, criteria for proceeding to the next stage were established. When the concept met all of the technical requirements than economical feasibility was assessed. The market analysis is based on both the technical and economic data developed by the project.

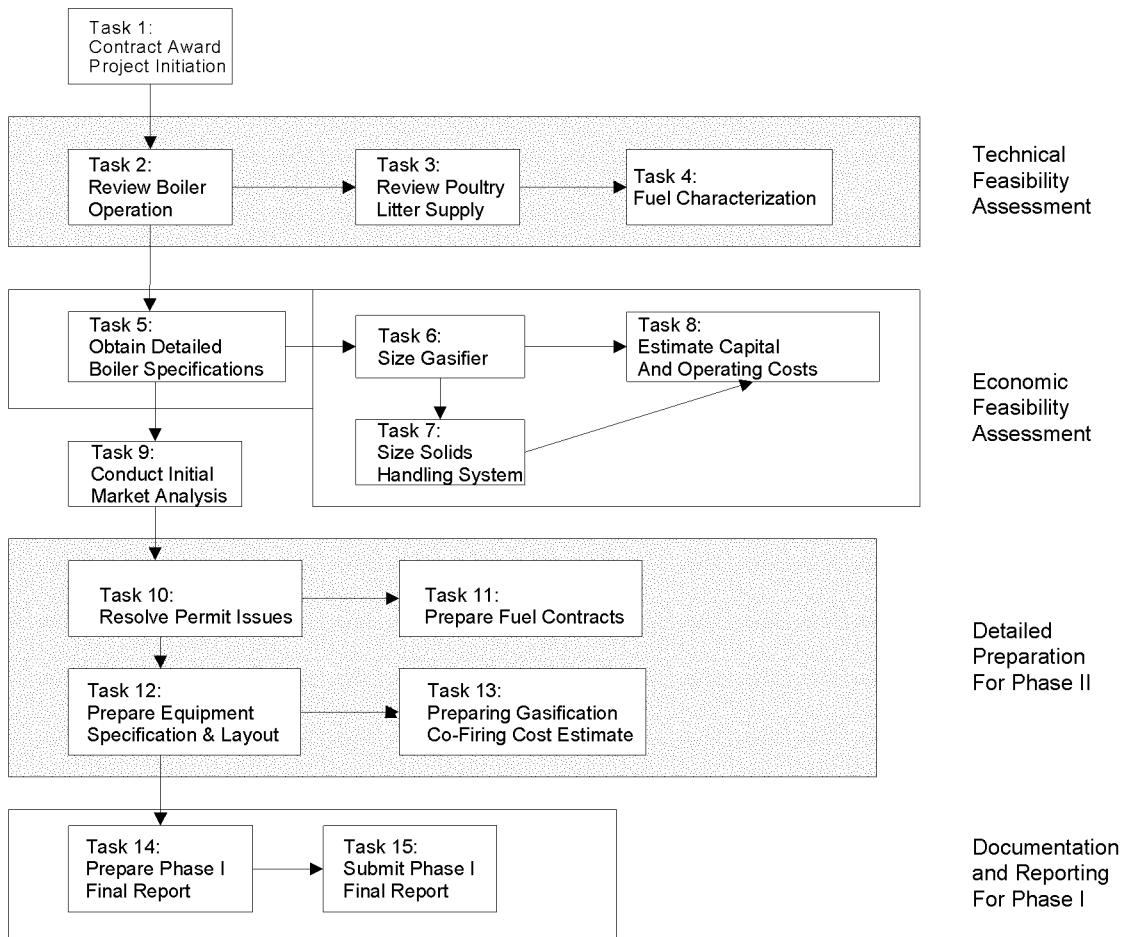


Figure 1-5 Interrelationships of Tasks in Phase I

The schedule for the proposed tasks is shown in 1-6.

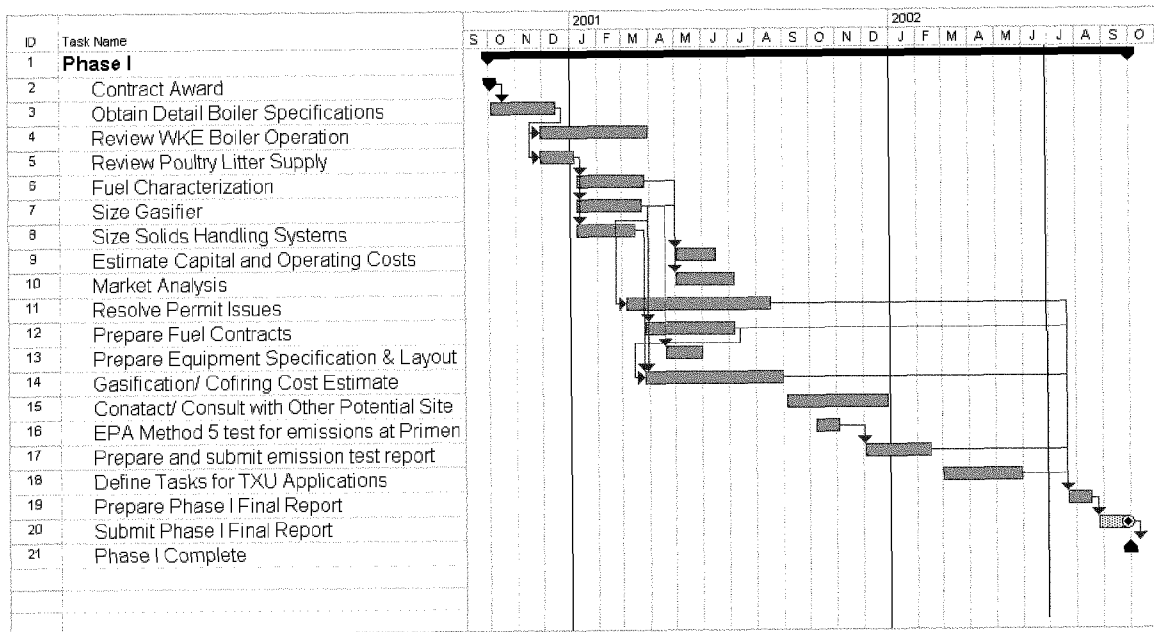


Figure 1-6 Project Milestone Schedule