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EAST KENTUCKY POWER COOPERATIVE

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HAND DELIVERED

June 9, 2000

Mr. Martin J. Huelsman, Jr.
Executive Director
Public Service Commission
P. O. Box 615
Frankfort, KY 40602

Re: PSC Case No. 2000-079

Dear Mr. Huelsman:

Please find enclosed for filing with the Commission in the above-referenced case, an original and eight copies of East Kentucky Power Cooperative, Inc.'s ("EKPC") responses to the Commission's Information Request No. 3 dated June 1, 2000. These responses are based on information provided by Kentucky Pioneer Energy, L.L.C.

Very truly yours,

Charles A. Lile

Charles A. Lile
Senior Corporate Counsel

cal/lhs
enclosures
c: Service List
David Brown – Kinlock

4775 Lexington Road 40391
P.O. Box 707, Winchester, Kentucky 40392-0707
Tel. (606) 744-4812
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EAST KENTUCKY POWER COOPERATIVE, INC.

PSC CASE NO. 2000-079

INFORMATION REQUEST RESPONSE

PUBLIC SERVICE COMMISSION REQUEST DATED JUNE 1, 2000

In response to the following Public Service Commission's third request for information, East Kentucky Power Cooperative, Inc. (EKPC) submits responses to the questions contained therein. Each response with its associated supportive reference materials is individually tabbed.

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COMMONWEALTH OF KENTUCKY

BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

APPLICATION OF EAST KENTUCKY POWER COOPERATIVE, INC. FOR APPROVAL OF A POWER PURCHASE AGREEMENT WITH KENTUCKY PIONEER ENERGY, L.L.C.	)))))	CASE NO. 2000-079

O R D E R

IT IS ORDERED that East Kentucky Power Cooperative, Inc. ("East Kentucky"), and Pioneer Energy, L.L.C. ("Pioneer") shall file the original and 8 copies of the following information with the Commission with a copy to all parties of record no later than June 9, 2000. Each copy of the data requested should be placed in a bound volume with each item tabbed. When a number of sheets are required for an item, each sheet should be appropriately indexed, for example, Item 1(a), Sheet 2 of 6. Include with each response the name of the witness who will be responsible for responding to questions relating to the information provided. Careful attention should be given to copied material to ensure that it is legible. Where information requested herein has been provided along with the original application, in the format requested herein, reference may be made to the specific location of said information in responding to this information request.

1. Provide the feasibility studies for the project.

2. Provide a copy of the Tender Specification Documents ("TSD") of the construction contractor. Provide the design and engineering of the process if it is not

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included in the TSD. Were the characteristics of Kentucky-produced coal considered in the selection of the type of process and equipment?

3. Provide the estimated budget for the project.

4. Provide the preliminary schedule for the project and estimated date of construction.

5. Provide the ratio of the coal to solid waste.

6. Will the solid waste be combined with coal to produce a briquette or will the solid waste be converted into gas and then processed with the coal? Explain the process to be used.

7. Will Kentucky coal be used exclusively for the briquettes? If yes, describe the term of contracts that are expected to be signed.

8. How much coal and how much solid waste are anticipated to be utilized on an annual basis?

9. Where will the solid waste and coal be stored and where will the briquettes be made?

10. Will all the solid waste originate in Kentucky or will out-of-state solid waste be imported?

11. What is the range of specifications for the coal that can be used in this gasification process? What are the specifications of the coal that will be used in this process?

12. Describe the type of purification system for the produced gas.

13. What is the estimated gas yield in Btu's gas per unit weight of coal and unit weight of solid waste?

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14. What is the estimated annual operating cost of the plant?

15. Explain the type of process that will be used for coal gasification.

16. Provide the operating manual, if available.

17. What is the gasification media (e.g., air, oxygen, steam)?

18. What is the estimated cost of the synthetic gas per million Btu?

19. If the proposed combustion turbine is operated exclusively on natural gas, what is the maximum gas consumption per hour and what is the maximum quantity of gas per hour available at the site for this combustion turbine?

Done at Frankfort, Kentucky, this 1st day of June, 2000.

By the Commission

ATTEST:

[signature]

Executive Director

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TAB 1

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PSC Request 1
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EAST KENTUCKY POWER COOPERATIVE, INC.
PSC CASE NO. 2000-079
INFORMATION REQUEST RESPONSE

PUBLIC SERVICE COMMISSION REQUEST DATED 6/1/00
REQUEST 1
RESPONSIBLE PERSON: **Dwight Lockwood**
COMPANY: **Kentucky Pioneer Energy**
(responding for East Kentucky Power Cooperative)

Request 1. Provide the feasibility studies for the project.

Response 1. Global Energy has concluded that the extensive operational history of both gasification in general and the BGL in particular, serves as an adequate demonstration of the feasibility of the technology. Commercial viability of the project is demonstrated by the Kentucky Pioneer Energy contractual commitments for the development and long-term operation of the facility.

The enclosed brochure "Gasification of Solid and Liquid Fuels for Power Generation", by Department of Trade and Industry in the UK, presents a comprehensive analysis of gasification in general and a discussion of the various versions of gasification technology. Information presented clearly demonstrates the technology is in place and operational.

Kentucky Pioneer Energy economic modeling and engineering work are subject to international contractual secrecy agreements and are therefore business confidential and not available.

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TECHNOLOGY
STATUS REPORT

CLEANER COAL TECHNOLOGY PROGRAMME

GASIFICATION OF SOLID AND LIQUID FUELS FOR POWER GENERATION

TSR
008

DECEMBER 1998

dti
Department of Trade and Industry

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Gasification of Solid and Liquid Fuels for Power Generation

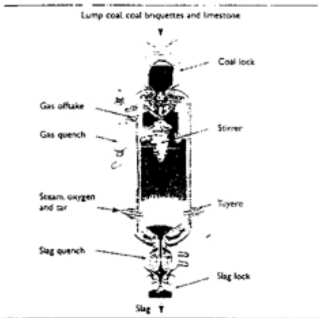

Figure 1 The BGL gasifier (courtesy of BG plc)

SUMMARY

Gasification is the conversion of solid and liquid materials (eg coal or oil) into a gas whose major components are hydrogen (H_2) and carbon monoxide (CO). Gasification has been employed for over a hundred years with the gas produced being used for various applications such as domestic heating and lighting ('Town Gas'), chemicals manufacture, eg ammonia (NH_3) or methanol, and the production of petrol- and diesel-substitutes.

In recent years, there has been interest in using gasification to generate electricity. The initial reason for this was the development of large, efficient gas turbines. It was soon realised that the gasification of coal, coupled with a gas turbine, could potentially generate power as efficiently as the most modern conventional coal-fired power plant, but with much lower emissions. The first experimental integrated gasification combined cycle (IGCC) power plant was built in the early 1970s in Germany, and today there are several coal-fired demonstration plant worldwide.

IGCC power plant can also be fired with oil-derived feedstocks such as heavy oils and tars. These products are formed during oil-refining processes. Traditionally, these products have been used to manufacture heavy fuel oils for use in power station boilers and as marine fuel. However, the market for heavy fuel oil has declined rapidly in recent years, and some refineries now have a surplus of such products. Gasifying these heavy oils can provide both power for the refinery, and for export, and H_2 which can be used within the refinery to upgrade and clean other products, such as diesel and petrol. There are at least four major oil IGCC projects active in Europe

Both biomass and wastes can be gasified; however, IGCC technology tends to favour large, centralised power plant whilst biomass and wastes are best exploited using smaller plant close to their source. An alternative, therefore, is to gasify the biomass or waste in a small gasifier adjacent to an existing power plant and use the gas produced to partially replace the coal or oil being fired. This allows an existing power station to utilise biomass and wastes as and when they are available. Some gasifier technologies allow biomass and wastes to be co-gasified with coal. Several biomass and waste gasification projects are currently going ahead, mostly in Europe, with several of the most important in the UK

IGCC plant are still at the demonstration stage and nearly all of the projects so far have required some form of Government support. The technology has three major deficiencies that need to be remedied before it becomes widely used

- i IGCC plant are expensive to build, costing significantly more than conventional coal-fired plant with environmental protection equipment.
- ii IGCC plant have so far suffered from relatively poor reliability.
- iii The operational flexibility of IGCC plant at least those with oxygen (O_2) plant - has yet to be fully proven; in particular, the start-up times for IGCC plant are measured in days rather than hours.

Further development work is required to overcome these obstacles to the uptake of the technology. When they have been overcome, IGCC plant should take a significant market-share of new coal-fired power plant worldwide

BENEFITS OF THE TECHNOLOGY

Gasification technologies offer the following benefits:

- highly-efficient and clean generation of power from coal
- clean generation of power from oil residues with substantial scope for integration with refinery activities
- environmentally-benign disposal of solid and liquid wastes with scope for further energy recovery
- utilisation of biomass for power production.

DEPARTMENT OF TRADE AND INDUSTRY SUPPORT

Since 1990, the Department of Trade and Industry (DTI) has supported 49 projects associated with gasification for power generation, contributing £10.9M to a total projects cost of £36.6M

INTRODUCTION

Gasification

Gasification is the conversion of a carbon-containing solid or liquid substance into a gas in which the major components are H_2 and CO. This gas can then be used as a fuel or as a chemical feedstock from which products such as NH_3 or methanol can be made.

The defining chemical characteristic of gasification is that it entails the partial oxidation of the feed material, in combustion, the feed is fully oxidised, whilst in pyrolysis, the feed undergoes thermal degradation in the absence of O_2.

The oxidants for gasification are O_2 or air and, usually, steam. Steam helps to act as a temperature moderator, as the reaction of steam with the carbon in the feed is endothermic (ie it absorbs heat) The choice of air or pure O_2 depends on a number of factors such as the reactivity of the feed material, the purpose for which the gas is to be used and the type of gasifier.

The first major application of gasification was to convert coal into a fuel-gas for domestic lighting and heating. This application has gradually died out in most places due to the availability of natural gas, although gasification is still used for this purpose in China (and until recently in Eastern Europe). For the last few decades, the main application of gasification has been in the petrochemical industry to convert various hydrocarbon streams into 'synthesis gas', eg for the manufacture of methanol, the supply of H_2 for NH_3 production or the hydrodesulphurisation or hydrocracking of oil streams. Other, more specialised uses of gasification have included the conversion of coal into synthetic motor fuels (as practised in South Africa) and the manufacture of substitute natural gas (SNG) (not practised commercially at present but given serious consideration in the late 1970s and early 1980s)

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GASIFICATION PROCESSES

Types of Gasification Process

There are many different gasification processes on offer. These differ considerably in terms of, for example, technical design, scale, reference experience and fuels handled. The most useful way of classifying them is by flow regime, ie the way in which the fuel and oxidant flow through the gasifier.

Just as conventional solid-fuel boilers may be divided into three basic types (namely pf-fired, fluidised bed and grate-fired), gasifiers fall into three groups: entrained flow, fluidised bed and moving bed (sometimes called, somewhat erroneously, fixed bed). Fluidised bed gasifiers are exactly analogous to fluidised bed combustors; entrained flow gasifiers are similar in concept to pf-firing, and moving bed gasifiers bear some resemblance to grate firing. Characteristics of each are compared in Table 2.

	Entrained flow	Fluidised bed	Moving bed
Fuel types	Solid and liquid	Solid	Solid
Fuel size (solid)	<500μm	0.5-5mm	5-50mm
Fuel residence time	1-10s	5-50s	15-30min
Gas outlet temperature	900-1400°C *	700-900°C	400-500°C

* [illegible]

Table 2 Comparison of gasifier types

Entrained Flow Gasifiers

In an entrained flow gasifier, pf or atomised oil flows co-currently with the oxidising medium (typically O_2). The key characteristics of entrained flow gasifiers are their very high and uniform temperatures (usually more than 1000°C) and the very short residence time of the fuel within the gasifier. For this reason, solids fed into the gasifier must be very finely divided and homogeneous, which in turn means that entrained flow gasifiers are not suitable for feedstocks such as biomass or wastes, which cannot be readily pulverised. The high temperatures in entrained flow gasifiers mean that the ash in the coal melts and is removed as a molten slag. Entrained flow gasifiers are well suited to gasifying liquids, and the primary application of such gasifiers today is in refineries, gasifying oil-feedstocks.

Entrained flow gasifiers have been selected for nearly all the coal- and all the oil-based GPPs currently in operation or under construction. Entrained flow gasifiers include the Texaco gasifier, the two variants of the Shell gasifier (one for coal, the other for oil), the Prenflo® gasifier and the Destec gasifier. Of these, both the Texaco gasifier and the Shell oil gasifier have over 100 units in operation worldwide.

Fluidised Bed Gasifiers

In a fluidised bed, solids (eg coal, ash) are suspended in an upwardly flowing gas stream. In a fluidised bed gasifier, this gas stream comprises the oxidant (normally air rather than O_2). The key feature of the fluidised bed gasifier (like the fluidised bed combustor) is that the fuel ash must not be allowed to become so hot that it melts and sticks together; if the fuel particles stick together, the bed will defluidise. The use of air as the oxidant keeps the temperature below ~1000°C. This in turn means that fluidised bed gasifiers are best suited to relatively reactive fuels, such as biomass.

Advantages of the fluidised bed gasifier include the ability to accept a wide range of solid feeds, including household waste (suitably pre-treated) and biomass such as wood. It is also to be preferred for very high ash coals, particularly those in which the ash has a high melting point, because other gasifier types (entrained flow and moving bed) lose significant amounts of energy in melting the ash to form slag.

Fluidised bed gasifiers include the High Temperature Winkler (HTW) and that developed by British Coal Corporation and now marketed by Mitsui Babcock Energy Ltd (MBEL) as part of the Air Blown Gasification Cycle (ABGC). There are relatively few large fluidised bed gasifiers in operation. Fluidised bed gasifiers are not suitable for liquid feeds.

Moving Bed Gasifiers

In a moving bed gasifier, the oxidant (steam and O_2) is blown into the bottom of the gasifier. The raw fuel-gas produced moves upward through a bed of solid feedstock, which gradually moves downwards as the feed at the bottom of the bed is consumed. The defining characteristic of moving bed gasifiers is therefore counter-current flow. As the raw fuel-gas flows through the bed, it is cooled by the incoming feed, which in turn is dried and devolatilises. There is therefore a very pronounced temperature profile in the gasifier, from 1000°C or more at the bottom to perhaps 500°C at the top. The devolatilisation of the fuel during the gasification process means that the outgoing fuel-gas contains significant amounts of tarry compounds and methane. This raw fuel-gas is therefore washed at the outlet with water to remove the tars. As a consequence of this, the fuel-gas does not require high-temperature cooling in a syngas cooler, as it would if from an entrained flow reactor. Moving bed gasifiers were designed for coal, but can accept other solid fuels, such as wastes.

There are two main moving bed gasifier technologies. The Lurgi dry-ash gasifier was originally developed in the 1930s and has been used extensively for Town Gas production and in South Africa for chemicals from coal. In this gasifier, the temperature at the bottom of the bed is kept below the ash fusion point so the coal ash is removed as a solid. In the 1970s, Lurgi and the then British Gas Corporation (now BG plc) developed a slagging version in which the temperature at the bottom is sufficient for the ash to melt. This gasifier is referred to as the BGL (BG-Lurgi) gasifier. Several BGL gasifiers are currently being installed into plant for gasifying solid wastes and co-gasifying coal and waste.

SPECIFIC GASIFIERS

Some of the most important and well-known gasification processes are described below in alphabetical order.

BGL Gasifier (Moving Bed)

The BGL gasifier was originally developed in the 1970s to provide a syngas with a high methane content in order to provide an efficient means of manufacturing SNG from coal. It was developed over about 15 years at British Gas' Westfield Development Centre in Fife, initially to test the process for applicability to SNG manufacture and later for IGCC.

Lump coal and a flux such as limestone are fed into a lockhopper which periodically discharges into the top of the gasifier (Figure 1). A slowly rotating distributor plate distributes the coal evenly over the top of the bed. For caking coals, the distributor is connected to a stirrer which also keeps the bed even and prevents the coal from agglomerating. As the bed descends the gasifier, it undergoes a number of reactions. These reactions can be grouped into three zones at different heights in the fuel bed: in the upper zone coal is dried and devolatilises; in the middle zone it is gasified, and in the lower zone it is combusted, the CO_2 produced acting as a gasification agent in the middle section. O_2 and steam are added at the bottom of the bed through nozzles (tuyères). The molten slag produced forms a pool in the bottom of the gasifier and is periodically removed.

The gasifier vessel is refractory-lined to prevent excessive heat loss from the bed. The refractory does not experience high temperatures as it is insulated from the hottest part of the bed (at the tips of the tuyères) by the coal bed itself.

The gas exiting the gasifier is at a temperature of 450-500°C and contains tars and oils produced by the devolatilisation of the coal, together with coal dust elutriated from the bed. This is removed by a quench vessel located at the gas exit. The gas is simultaneously cooled and cleaned by a water quench. The gas then passes to a further chain of exchangers that cool the gas to ambient temperature prior to being desulphurised. The tars and water removed from the gas pass to a separator, from which the tars and coal dust are recycled to the tuyères of the gasifier (a portion may be added to the top of the gasifier to suppress the elutriation of coal dust).

The BGL gasifier has a very high cold gas efficiency; ie, compared with other gasifiers, a larger portion of the original calorific value (CV) of the coal appears as chemical energy in the gas as opposed to thermal energy. Thus, the BGL gasifier does not feature high-temperature heat exchangers as required by Shell and Texaco systems amongst others. The gasification island and CCGT unit is therefore less closely coupled as the gas-cooling train is not intimately integrated into the steam turbine cycle. In a BGL system more of the power is generated by the gas turbine and less by the steam turbine than in an entrained flow system.

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Fuel is pressurised in a lockhopper and then stored in a day- or charge-bin before being fed by screw into the gasifier. The bottom part of the gasifier itself comprises a fluidised bed, the fluidising medium being air or O_2 and steam. Gas plus elutriated solids flow up the reactor, with further air/O_2 and steam being added in this region to complete the gasification reactions. The crude syngas is then dedusted in a cyclone and cooled. The solids removed in the cyclone are returned to the gasifier base. Ash is removed from the base of the gasifier by means of an ash screw.

The temperature in the base of the gasifier is kept at about 800-900°C; this is controlled to ensure that the temperature does not exceed the ash softening point; the temperature in the freeboard above the bed itself can be significantly higher. The operating pressure can vary between 10bar (for syngas manufacture) and 25-30bar (for IGCC).

Lurgi Dry Ash (Moving Bed)

The Lurgi dry-ash gasification process was developed by Lurgi GmbH in the early 1930s as a means of producing Town Gas. The first commercial plant was built in 1936. Until 1950, the process was mostly restricted to lignites, but in the 1950s Lurgi and Ruhrgas collaborated to develop a process suitable for bituminous coals as well. Since then the Lurgi gasification process has been widely used worldwide for producing Town Gas and syngas for a variety of purposes (eg NH_3, methanol, liquid fuel production). In addition to plant supplied by Lurgi itself, Lurgi-type gasifiers have been built in Eastern Europe and the former Soviet Union.

The first ever GPP, at Lünen in Germany, used the Lurgi system (unusually, the gasifiers were air-blown). Other significant installations using the Lurgi system are the Great Plains SNG plant in North Dakota, USA, and the SASOL synfuels plant in South Africa.

The process itself is shown schematically in Figure 5.

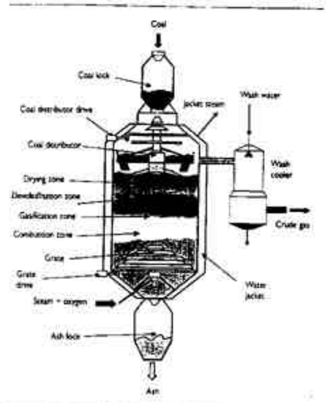

Figure 5 Lurgi dry-ash gasifier

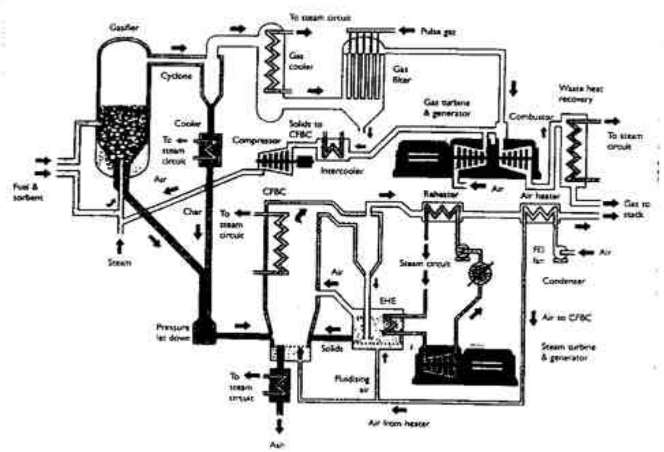

Figure 6 ABGC incorporating the ABGC gasifier

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Shell Coal Gasification Process (Entrained Flow)

Shell's experience with gasification dates back to the 1950s, when the first SGP units were commissioned. In 1972, Shell started development work on a gasification process for coal. Following experience with a 6tpd pilot plant in Amsterdam, in 1978 Shell started operation of a 150tpd demonstration plant operated by Deutsche Shell at Harburg near Hamburg, Germany. Shell used the experience gained to construct a plant at its existing petrochemicals complex at Deer Park in Houston, USA. This plant was sized to gasify 220tpd (250 US tons per day) of bituminous coal or 365tpd (400 US tons per day) of high-moisture, high-ash lignite. The Deer Park gasifier went into operation in 1987, and proved the ability of the SCGP to gasify a wide range of coals.

In 1988 it was announced that the SCGP had been chosen for an IGCC plant at Buggenum, the Netherlands; this remains the only commercial plant using the SCGP.

The Shell gasifier is shown in Figure 8.

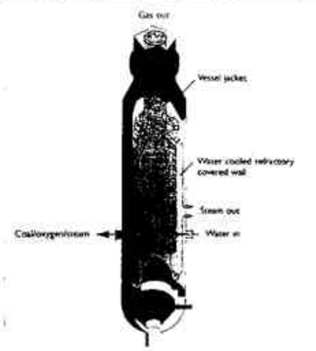

Figure 8 The Shell coal gasifier (courtesy of Shell)

The gasifier vessel consists of a carbon steel pressure shell, within which is a gasification chamber enclosed by a refractory-lined membrane wall. Water circulated through the membrane wall is used to control the temperature of the gasifier wall and raises saturated steam. Dried pf, O_2 and steam are fed through opposed burners at the bottom of the gasifier, which operates at ~25-30bar. Gasification occurs at temperatures of 1500°C and above, which ensures that the ash in the coal melts and forms a molten slag. The slag runs down the inner surface of the gasifier wall and is quenched in a water bath at the bottom of the gasifier. A portion of the slag adheres to the wall of the gasifier and cools, forming a protective layer.

Gasification of the coal forms a raw fuel-gas that is predominantly H_2 and CO with a little CO_2 and some entrained slag particles. At the gasifier outlet, the raw gas is quenched with recycled, cooled fuel-gas to lower the temperature to ~900°C; this cooling 'freezes' the slag particles, rendering them less sticky and less prone to fouling surfaces.

The fuel-gas is then cooled to ~300°C in the syngas cooler, raising high- and medium-pressure steam. In contrast to the syngas cooler for Shell's oil gasification process, the SCGP syngas cooler has the gas on the shell side. The syngas cooler thus has a complex tube bundle comprising various economisers, medium- and high-pressure evaporators and some superheaters.

The cooled syngas is filtered using ceramic filters. About 50% of the cooled syngas is then recycled to the top of the gasifier to act as the quenching medium for the gas. The remainder is washed to remove halides and NH_3 and then passed to the desulphurisation unit.

Texaco Gasification Process (Entrained Flow)

The key feature of Texaco's process is the very wide range of feedstocks that have been successfully gasified using the same basic technology. This range encompasses gases, oils, Orimulsion™, petroleum coke and a range of coals. Texaco is additionally working on pre-treatment processes that will allow waste plastics and scrap tyres to be gasified.

The Texaco Gasification Process was originally developed in the late 1940s. The initial focus of the work was to develop a process for reforming natural gas so as to make synthesis gas for conversion into liquid hydrocarbons. Soon, the emphasis shifted to producing syngas for NH_3 production. During the 1950s, work was carried out to extend the process to gasify oils and, to a lesser extent, coal. When the oil crisis occurred in 1973, work on coal gasification was re-commenced, and the first commercial plant gasifying coal began operation in 1983 at Eastman Chemicals' plant at Kingsport, Tennessee, USA. In 1984 the Cool Water IGCC plant went into operation. Currently operational GPPs using the Texaco process are El Dorado (petroleum coke) and Polk (coal); the Texaco process has also been selected for the majority of oil-residue IGCCs being built or planned.

There are two basic variants of the process, which differ in the method used to cool the raw syngas. In the quench variant, the raw syngas from the bottom of the gasifier is shock-cooled with water. In the full heat recovery variant, the raw syngas is cooled using a syngas cooler. The Texaco quench gasifier is shown schematically in Figure 9 and the full heat recovery version in Figure 10.

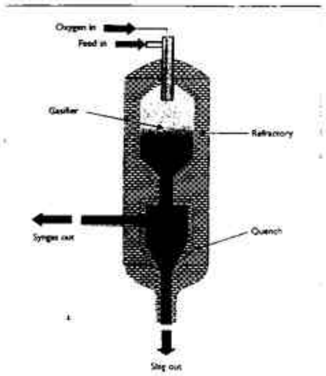

Figure 9 Texaco quench gasifier