ENVIRONMENTAL REVIEW of SYNTHETIC FUELS

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INTRODUCTION

In response to the shift in the U.S. energy supply priorities from natural gas and oil to coal, the Environmental Protection Agency (EPA) has initiated a comprehensive assessment program. This program is evaluating the environmental impacts of synthetic fuel processes with a high potential for commercial application. It is directed by the Fuel Process Branch of EPA's Industrial Environmental Research Laboratory in Research Triangle Park, NC (IERL-RTP).

The primary objectives of the EPA synthetic fuels Environmental Assessment/Control Technology Development Program are 1) to define the environmental and health effects of multimedia discharge streams, and 2) to define control technology needs for an environmentally sound synthetic fuels industry. The synthetic fuels from coal technologies being studied in this program include low/medium-Btu gasification, high-Btu gasification, and liquefaction.

To achieve the overall program goals, EPA has defined six major task areas: current process technology background, environmental data acquisition, current environmental background, environmental objectives development, control technology assessment, and impact analysis. The contractors involved in the program, their EPA Project Officers, and the duration of each effort are tabulated on page 9.

This issue of the *Environmental Review of Synthetic Fuels* summarizes recent activities in EPA's synthetic fuels program. Activities of EPA contractors are covered in sections on current process technology background and environmental data acquisition. Highlights of technology and commercial development, major symposia, a calendar of upcoming meetings, and a list of major publications provide up-to-date information on national and international development in synthetic fuels technology. This issue also features a description of EPA's terminology for environmental impact analyses.

Comments or suggestions which will improve the content or format of these Reviews are welcome. Such comments should be directed to the EPA or Radian Corporation personnel identified on page 19 of this Review.

CURRENT PROCESS TECHNOLOGY BACKGROUND

General Topics

Environmental Assessment Reports (EAR's) — Several organizations have prepared EAR's of various synthetic fuels technologies. These reports are intended to provide EPA with a sound technical basis for the development of standards. Each EAR evaluates the multimedia waste streams, control/disposal options, regulatory requirements, and environmental effects associated with a specific technology.

For many processes such as Solvent Refined Coal (SRC), actual site-specific, commercial-scale data are not yet available; in these cases, the EAR's are valuable in obtaining preliminary data, evaluating assessment techniques, and recommending additional R&D activities to supply necessary data. The EAR's will be revised and updated as these data become available.

TRW, Inc.'s EAR of Lurgi Coal Gasification Systems for SNG has been published; results are described in the "Report Summary" section of this issue. Hittman Associates, Inc.'s EAR of Solvent Refined Coal (SRC) systems has also been recently published. Radian Corporation's EAR of Wellman-Galusha gasification systems will be available this winter. Detailed summaries of these EAR's will be presented in subsequent issues of the *Environmental Review of Synthetic Fuels*. (For more information, see Vol. 2, Nos. 1 and 2 of this publication.)

Gasification

Current Status of Low-Btu Gasification — Radian Corporation has prepared a summary of the status of low-Btu gasification facilities in the U.S. as of June 1979. The information compiled (see Table 1) includes type of gasifier, coal feed-

stock, and gas purification process as well as company/location, and number of gasifiers.

As indicated in Table 1, 36 gasifiers are installed or under construction at 16 facilities. Most of these facilities are located in the industrialized Northeastern United States. The predominant type of gasifier is Wellman-Galusha (21 total), although there are 12 Chapman gasifiers installed at one location in Tennessee. Other gasifiers used are Foster Wheeler/Stoic, Wellman Incandescent, and Riley Morgan.

The most common feedstocks at the facilities listed in Table 1 are low sulfur anthracite and bituminous coals. Gas clean-up generally involves only particulate removal via hot cyclones. Because coal feedstocks are primarily low sulfur, sulfur removal from the raw gas is practiced at only one facility.

TABLE 1. CURRENT STATUS OF LOW-BTU GASIFICATION

Gasifier Used	Coal Feedstock	Gas Purification Process	Company/ Location	Number of Gasifiers	Remarks
Wellman-Galusha	Anthracite, low sulfur (~0.7%)	• Cyclone	Glen-Gery Brick Co. — York, PA — Reading, PA — Shoemakersville, PA — Watsontown, PA — New Oxford, PA	8	• Currently in commercial operation • Product gas used to fire brick kiln
Wellman-Galusha	Anthracite, low sulfur	• Cyclone	Hazelton Brick Co. — Hazelton, PA	4	• One gasifier in use • Three other gasifiers inactive • Product gas used to fire brick kiln
Wellman-Galusha	Anthracite, low sulfur	• Cyclone	Binghamton Brick Co. — Binghamton, NY	2	• Gasifiers not currently in use
Wellman-Galusha	Bituminous, low sulfur (~0.7%)	• Cyclone	National Lime & Stone Co. — Cary, OH	1	• Currently in commercial operation • Product gas used to fire lime kiln • Lime will remove some of the sulfur species in the flue gas
Wellman-Galusha	Anthracite, low sulfur	• Cyclone • Gas quench	Can Do, Inc. — Hazelton, PA	2	• To be completed in 1980 • Product gas to be used in an industrial park • Possibility of adding two more gasifiers • Partial funding by DOE and DOC
Wellman-Galusha	KY Bituminous CO Subbituminous MT Bituminous ND Lignite	• Cyclone	Bureau of Mines — Fort Snelling, MN	1	• Commercial-size demonstration unit • Partial funding by DOI and DOE • First series of test runs completed in 1978 • Additional tests scheduled in 1979 • Product gas was used to fire an iron pelletizing kiln • Excess product gas was combusted
Wellman-Galusha	Bituminous, low sulfur	• Cyclone • Possibly gas quench, tar/liquor separation, wastewater treatment and sulfur removal (Stretford)	Pike County — Pikeville, KY	2	• To be completed in 1981 • Product gas used to fire boilers and process heaters • Partial funding by DOE

TABLE 1. CURRENT STATUS OF LOW-BTU GASIFICATION (CONT.)

Gasifier Used	Coal Feedstock	Gas Purification Process	Company/ Location	Number of Gasifiers	Remarks
Wellman-Galusha	Anthracite, low sulfur (~0.7%)	• Cyclone	Howmet Aluminum — Lancaster, PA	1	• To be completed in early 1980 • Product gas used to fire process furnaces • Possibility of adding up to 11 more gasifiers
Chapman (Wilputte)	Bituminous, low sulfur (~0.6%)	• Cyclone • Gas quench • Tar/liquor separation • Wastewater evaporation	Holston Army Ammunition Plant — Kingsport, TN	12	• Currently in commercial operation • Product gas used to fire process heaters • Only two gasifiers are operated at one time to meet current fuel needs • By-product tar used with coal to fire a steam boiler
Foster Wheeler/Stoic	Bituminous, low sulfur	• Cyclone • Electrostatic precipitator (ESP)	University of Minnesota — Duluth, MN	1	• Construction completed in 1978 • Partial funding by DOE • 100 hours of start-up tests completed • Full time operation scheduled for fall 1979 • Product gas to be used to fire steam boilers • By-product tar to be used to fire a steam boiler
Wellman Incandescent	Bituminous	• Cyclone • ESP • Sulfur removal (Stretford)	Caterpillar, Inc. — York, PA	1	• Start-up scheduled for summer of 1979 • Product gas to be used to fire process heaters
Riley Morgan	Several types tested.	• Cyclone	Riley Stoker Co. — Worchester, MA	1	• Commercial-size demonstration unit

Updated 6/79

ENVIRONMENTAL DATA ACQUISITION

Gasification

Test Results Indicate Process Modification for Emissions Control — In experiments with a laboratory gasifier, Research Triangle Institute (RTI) has performed parametric tests using bituminous coal, subbituminous coal, lignite, and these same materials treated with selected chemical substances. These runs were performed in the fixed-bed mode with semibatch feed to the gasifier.

Reactor operating conditions which were varied in the parametric test run sequence included coal particle size, reactor pressure, steam-to-air ratio, and such coal additives as potassium carbonate (K_2CO_3), sodium hydroxide (NaOH), and inert quartz. Alkaline additives are known to catalyze gasification and potentially enhance the retention of selected elements in the reactor residue. Quartz was added to modify the bed swelling, agglomeration behavior, and heat transfer characteristics.

Gasification of Illinois No. 6 coal treated with K_2CO_3 produced several effects compared to gasification of untreated Illinois No. 6:

- Higher carbon conversions (97 percent and greater).
- Higher sulfur residue retention.
- Higher chloride residue retention.
- Lower hydrogen sulfide (H_2S) levels in the aqueous condensate samples.

In addition, both K_2CO_3 and NaOH treatment techniques lowered the free-swelling index of the gasifier feed material.

Larger coal particle size (8 x 16 mesh vs 4 x 8 mesh) affected the yield of three major pollutants. H_2S levels in the aqueous condensate samples increased with the larger mesh size, while gas samples showed reduced ammonia and total organic carbon levels.

Operation at reduced pressure with North Dakota lignite coal decreased chloride levels in the aqueous condensate. The reduced pressure conditions also lowered the levels of ammonia in the product gas when gasifying standard lignite and Illinois No. 6 coal.

The varied coal types and operating conditions studied resulted in wide ranges of pollutant production in the product gas:

Pollutant	*mg produced/g carbon converted*
H_2S	3.70 to 36.0
COS	0.27 to 4.50
Thiophene	0.01 to 0.67
Benzene	3.60 to 17.0
Toluene	1.70 to 5.80
Phenol	0.06 to 0.92
Benzofuran	0.01 to 0.17

The wide ranges observed, usually greater than one order of magnitude, point to process modification (i.e., changes in coal type, pressure and mesh size) as an approach to emissions control.

Bioassay Studies Indicate Potential Mutagenicity of Tar Samples — RTI has conducted the Ames test for mutagenicity on crude tar samples and their fractions. The test organism for these bioassay studies was the TA-98 Salmonella bacteria strain, which tests for frame shift mutagens. Fractions were obtained from gasification test runs of Western Kentucky No. 9, Illinois No. 6, North Dakota lignite, and Wyoming subbituminous.

Bioassay test results are presented in Table 2. One significant finding is that tar base fractions from coal gasification tests with three coals — Western Kentucky No. 9, Wyoming subbituminous, and North Dakota lignite — showed more severe mutagenic effects on strain TA-98 than the crude tar samples from which they were obtained.

Gasification and Gas Cleaning Facility Provides Environmental Assessment Data — The Chemical Engineering Department at North Carolina State University (NCSU) has started to operate a coal gasification and gas cleaning facility designed and constructed by Acurex Corporation. The purpose of this facility is to provide environmental assessment data concerning both the gasification and gas clean-up processes.

The gasifier itself is a pressurized (0.8 MPa[100 psig]), fluidized bed reactor capable of gasifying a 6.3-g/s (50-lb/hr) coal feed stream. The raw product gas passes through a cyclone for particulate removal and is then routed to a venturi scrubber for quenching and removal of condensables, solubles, and finer particulates. Acid gas removal is accomplished downstream of the venturi scrubber in two packed towers (an absorber and a stripper) separated by a rich solvent flash vessel.

System start-up has been completed using high sulfur coke as the gasifier feedstock and a refrigerated methanol solvent for gas clean-up. Approximately 15 gasification runs have been accomplished along with an additional 5 runs of integrated gasifier-acid gas removal operation. Several runs have also been made using a synthetic feed stream to the acid gas removal system.

Future experiments will examine the influences of several gasification process parameters (i.e., temperature, coal feed rate, steam-to-carbon ratio) on pollutant production, with special attention to the yield of sulfur gases. Alternative solvents for acid gas removal will also be studied, such as hot potassium carbonate and monoethanolamine.

TABLE 2. BIOASSAY TEST RESULTS FOR CRUDE TAR SAMPLES AND FRACTIONS[1]

Sample	Coal	Potential Mutagenicity[2]
Base Fraction	W. Ky. No. 9	High
	Wyo. Subbituminous	High
	N.D. Lignite	High
	Ill. No. 6	Medium
Acid Fraction	W. Ky. No. 9	Negative
	Ill. No. 6	Negative
	Wyo. Subbituminous	Negative
	N.D. Lignite	Negative
PNA Fraction	W. Ky. No. 9	High
	Ill. No. 6	Medium
	Wyo. Subbituminous	Medium
	N.D. Lignite	Medium
Polar Neutral Fraction	Ill. No. 6	High
	W. Ky. No. 9	Medium
	Wyo. Subbituminous	Medium
	N.D. Lignite	Medium
Non-Polar Neutral Fraction	W. Ky. No. 9	Negative
	Ill. No. 6	Negative
	Wyo. Subbituminous	—
	N.D. Lignite	Negative
Crude Tar	W. Ky. No. 9	High
	Ill. No. 6	High
	Wyo. Subbituminous	Medium
	N.D. Lignite	Medium

[1]Two additional Western Kentucky No. 9 fractions (Insolubles and XAD-2) both showed negative potential mutagenicity. These same fractions from the other coal types were not tested.

[2]Brusick, D.J, "In Vitro Mutagenesis Assays as Predictors of Chemical Carcinogenesis in Mammals," *Clinical Toxicology*, 10(1):79-109, 1977.

Liquefaction

Source Test and Evaluation of Solvent Refined Coal (SRC) Pilot Plant — Hittman Associates, Inc., has performed two Source Tests and Evaluations (STEs) at Pittsburgh and Midway Coal Mining Company's SRC II pilot plant in Fort Lewis, Washington. The first STE, in March 1978, focused on preliminary environmental assessment (EA) data obtained from the wastewater treatment facility of the SRC plant and from the SRC-II products. In February 1979 the second STE was conducted to confirm earlier results and to perform complete Level 1 EA sampling on:

- All streams flowing into the wastewater treatment facility.
- All emissions to the atmosphere.
- The atmosphere surrounding the SRC plant.

Product streams consisted mainly of benzenes, phenols, and naphthalenes; considerable amounts of polynuclear aromatic hydrocarbons were also present. Many pollutants (phenols, naphthalenes, esters and such elements as aluminum, phosphorous, iron, zinc, and ammonia) were present in almost all effluent streams at levels greater than their respective health-based discharge multimedia environmental goal (DMEG) values. This is based on the assumption that the most environmentally hazardous form of the substance is present. (For an explanation of DMEGs and related terms, see "Terminology for Environmental Impact Analysis" in this issue.)

The SRC plant wastewater system consists of a surge reservoir, clarifier, dissolved air flotation unit, holding tank, sand and charcoal filters, and filter backwash tank. The first STE indicated that this treatment system achieved a removal efficiency of over 98 percent for total organics. During the second STE, however, this figure dropped to 95 percent due to a malfunction of the aeration system.

Emission streams monitored at various system vents showed high levels of organic species, especially in the boiling range of C_4 to C_5 normal hydrocarbons. In spite of the operating Stretford sulfur recovery process, the feed stream to the existing flare system contained high levels of sulfur species. Airborne particulate emissions, collected by eight high-volume air samplers at various locations, were below the Washington State standard of 60 $\mu g/m^3$ for air quality.

ENVIRONMENTAL OBJECTIVES DEVELOPMENT

General Topics

Terminology for Environmental Impact Analyses — EPA/IERL-RTP has developed a terminology for environmental impact analyses. It includes three categories of terms — primary, secondary, and component — that can be applied to judge the environmental acceptability of waste stream or product/by-product discharges from industrial processes or energy systems.

Primary terms, which have been used frequently in IERL-RTP environmental assessment projects, are:

- *Discharge Severity (DS),* a simple index of the potential harmful health or ecological effects of a single substance in a discharge. The DS does not require modelling or assumptions as to how the substance might disperse in the receiving medium.
- *Weighted Discharge Severity (WDS),* a simple index that reflects both the potentially harmful health or ecological effects of a single substance as well as the quantity of the total discharge. The WDS is similar to the DS except that it is intended for comparative evaluations of streams having significantly different discharge rates.
- *Total Discharge Severity (TDS),* a simplified index of the overall potential health or ecological impact of a discharge. The TDS is the sum of the individual human health or ecological DS values of a given stream; in terms of human health effects, the TDS covers a broad range of physiological responses, and when applied in terms of ecological effects it includes both species and biological ramifications.
- *Ambient Severity (AS),* an indicator of the potential harmful health or ecological effects of substances on the basis of estimated long-term ambient concentrations resulting from stream discharges.
- *Total Ambient Severity (TAS),* the ambient analog of TDS. Its uses are similar to those for TDS; in addition, it may be applied to compare impacts of two or more waste streams.

The secondary terms of the IERL-RTP terminology are still being developed and have been used infrequently to date. However, they may gain prominence as risk assessment becomes more widely practiced in environmental assessment programs. Secondary terms include:

- *Impact factor,* a representation of the number of receptors (plants, animals, or humans) exposed to ambient severities (or total ambient severities) greater than some critical value.
- *Ambient concentration profile,* a tabular or graphic display of estimated ambient concentrations shown as a function of distance from the point of discharge.
- *Exposure concentration profile,* a tabular or graphic illustration of the number of receptors exposed to estimated ambient concentrations of substances attributable to a discharge of concern.

Component terms are used in the specific definitions of primary terms, as shown in the equation for DS:

$$DS = dc/DMEG$$

where dc is the component term for the discharge concentration of a substance, and DMEG is the component term referring to the discharge multimedia environmental goal for the same substance. Individual DMEG values for a substance are related to health or to ecological effects and specify the substance concentration estimated to cause minimal adverse effect in a healthy receptor (man, plant, or animal) exposed once or intermittently for short time periods.

Component terms for the WDS are used in the equation:

$$WDS = DS \bullet mr$$

where mr is the total rate of stream discharge; i.e., the quantity (g, m^3, or l) of the total stream discharged per unit of time.

Component terms for the TDS appear in the equation:

$$TDS = \Sigma DS = \Sigma(dc/DMEG)$$

For AS the equation is:

$$AS = ac/AMEG$$

where the component term ac is the ambient concentration of a substance attributable to the discharge of concern, and AMEG is the component term for the ambient multimedia environmental goal for the same substance. The ac is estimated from mathematical models for environmental dispersion. AMEG values for specific substances are similar to DMEG values except that they are based on a continuous, rather than a single or intermittent, period of exposure.

For TAS the equation is:

$$TAS = \Sigma AS = \Sigma(ac/AMEG)$$

TECHNOLOGY AND COMMERCIAL DEVELOPMENT

U.K.'s National Coal Board Seeks European Economic Community Funding for Coal Liquefaction Project — The United Kingdom National Coal Board's proposal for a $6.4 million grant to fund a coal liquefaction project is being considered by the European Economic Community's (EEC's) Energy Commission. The EEC will commit some $130 million over the next 5 years to efforts for development of alternative energy sources. Some $68 million is earmarked for gasification or liquefaction processes, while geothermal and solar development will each receive $31 million.

While many of the proposals submitted in 1978 have already been selected for funding, financial support for other projects is still under consideration by the Commission. The National Coal Board's proposal seeks support for a supercritical-gas solvent extraction plant which will process 0.29 kg/s (28 tons/day) of coal feed. The process hydrogenates coal dissolved in a supercritical fluid to produce gasoline, diesel fuel, and chemical feedstocks.

HRI's Fluid-Bed Gasifier Starts Up — Hydrocarbon Research, Inc. (HRI) (McLean, Va.), has successfully completed initial tests on a new fast fluid-bed coal gasifier at the company's research and development center in Lawrence Township, N.J.

The 0.07-kg/s (7-ton/day) pilot plant was designed, built, and operated by HRI under a $4-million DOE contract. It demonstrates an advanced gasification concept in which low- or medium-Btu gas is produced for industrial applications, including gas-fired turbine systems. Coal is fluidized at high velocities, and entrained material is recycled to build up bed density. Unique features of the system include independent control of bed density and fluidization velocity.

Coal De-Ashing Unit Commissioned at Solvent Refined Coal (SRC) Pilot Plant — Combustion Engineering Inc., a subsidiary of C-E Lummus (Bloomfield, N.J.), has successfully commissioned its proprietary coal de-ashing unit at DOE's SRC pilot plant at Fort Lewis, Washington. The plant which has nominal capacity of 0.52 kg/s (50 tons/day) of coal feed, is one of two coal liquefaction pilot plants in the U.S. Lummus' de-ashing technology incorporates a gravity settling process rather than conventional rotating mechanical filtration devices.

DOE Plans Incentives for Synfuel Use in Transportation — DOE's Policy Division is engaged in a 9-month study to develop a package of incentives that will stimulate production of synthetic liquid fuels for use in transportation. The incentives package would form the basis for legislation aiming at increased synfuels use in the sector by the mid-1980's. Coal-to-methanol conversion, coal liquefaction, shale oil production, and upgrading heavy oils are the technologies likely to receive most consideration in the study.

DOE Awards Contract for Synthetic Fuel Study — Exxon Research and Engineering Co., Linden, N.J., has been awarded a $61,800 contract by DOE to study the stability of synthetic fuels manufactured from coal and oil shale. The 1-year project will be administered by DOE's Bartlesville, Oklahoma, Energy Technology Center. It will include a review of existing literature and studies of the effects of trace elements and oxygen compounds on fuel stability.

Thirteen Utilities Expected to Participate in Kilngas Demonstration Project — According to process developer Allis-Chalmers, about three-fourths of the funding requirements for a kilngas demonstration plant have been tentatively pledged by a group including 13 utilities and the Illinois Energy Resources Commission. The Commission has allocated $18-million of the $100-million total requirement.

The 6.29-kg/s (600-ton/day) gasification plant will be located near Illinois Power's Wood River plant. Construction is to start in early 1980, with start-up in 1982. Other utility participants include Baltimore G&E, Central Illinois PS, Consumers Power, Iowa Power, Monongahela Power, Niagara Mohawk, Ohio Edison, Potomac Edison, PS of Indiana, PS of Oklahoma, Union Electric, and West Penn Power. The kilngas process gasifies coal by steam/air injection in a rotating, refractory-lined kiln.

CE Describes Energy and Cost Savings of Low-Btu Gas to Senate Subcommittee — In an effort to gain Congressional support for continued DOE funding of Combustion Engineering's (CE's) pilot scale gasifier, company officials have presented economic and energy consumption data to the Senate Subcommittee for Energy Research and Development. CE is seeking some $3 million from DOE for pilot scale tests of different coal types as part of a program to develop a gasification system for the electric utility market.

The program is directed toward providing replacement fuel for the existing 65,000 MW of gas- and oil-fired boilers. CE officials pointed out that conversion to direct coal firing with flue gas desulfurization (FGD) retrofits requires substantial derating and more extensive boiler modifications, while firing low-Btu gas requires little or no derating and less extensive boiler modifications. Cost savings of 2 mills/kWh were estimated for a boiler burning low-Btu gas compared to a conventional coal fired boiler equipped with an FGD scrubber. Use of a higher efficiency combined cycle system would produce savings up to 5.4 mills/kWh. Oil consumption could be reduced by an amount equivalent to 12 percent of present import consumption (1.8 m^3/s [1 million bbls/day]) by converting half the potential market to low-Btu gas firing.

DOE Proposes Multi-Purpose Coal Gas Facility — DOE proposed a $500-million multi-purpose facility in its FY80 budget as a replacement for the cancelled Powerton, Ill., combined-cycle coal gasification project. (For more on DOE's cancellation of the Powerton project, see the *Environmental Review of Synthetic Fuels,* Vol. 2, No. 2.) The newly proposed facility would be designed to test up to three different gasifiers simultaneously, thereby allowing DOE to move quickly toward the development of a system to produce methane gas from coal at costs less than those of current technology. Coal handling and other necessary systems would be contained in the facility and could be used by all gasifiers tested, saving the costs of separate ones. The FY80 budget for DOE included $10 million for the conceptual design of the facility with start-up in 1984 or 1985, according to DOE sources.

The facility will be 15 to 20 times larger than most coal gasification pilot plants and will have the production capacity of 16.4 m^3/s (50 million ft^3/day) of gas and 6.3 kg/s (600 tons/day) of liquid fuels.

Other details of the proposed facility were released for the first time, including a suggestion that it be used to test methanol synthesis and liquid fuels production via the Fischer-Tropsch process used in South Africa.

Exxon's Baytown Gasifier Ready for Testing — Exxon Project Manager Allen Barusch says the DOE-funded catalytic gasifier test program is ready for start-up. Tests on the 10.5-g/s (1-ton/day) system originally planned for January 1979 were delayed to ensure the adequacy of safety precautions. Initially, the three parts of the system will be tested separately, with integrated operation of the solids handling and reactor section, syngas recycle operation, and catalyst recycle expected in early 1980.

In the Exxon catalytic gasification process, ground coal is sprayed with a catalytic solution containing either potassium carbonate or potassium hydroxide. In the gasifier, the coal reacts with steam at about 704 °C (1300 °F) at a pressure of 3.5 MPa (35 atm). Low-Btu gas is recycled in successive upgrading steps and piped into a commercial system. The catalyst is reclaimed and recycled also. The process renders all coals non-caking, allowing use of a variety of coal types, and also reduces the temperature in the gasification step.

EPRI Investigates Coal Gasifier/Combined-Cycle Generating System — A recently completed EPRI study shows that conventional gas turbines can be used in combined-cycle generating applications with a Texaco coal gasification process in electric utility service. Capital requirements and thermal efficiency of the system were compared to those of a conventional coal fired steam generator equipped with flue gas desulfurization (FGD) scrubbers. Capital requirements are about the same for the two systems, but the coal gas/combined cycle system using a gas turbine operating at 1,093 °C (2,000 °F) has a thermal efficiency of 37-39 percent. Conventional steam generator/FGD system efficiencies are around 34 percent.

The study characterized the Texaco gasification process as "ready for commercial scale demonstration" on the basis of "very significant achievements in the past year." Such a gasifier/combined cycle installation is planned at Southern California Edison's Coolwater site with a target start-up date in 1983 or 1984. The 10.5-kg/s (1000-ton/day) gasifier, which will be linked to a 100 MW combined cycle power plant, is now in the detailed design phase.

The EPRI study answered several questions about the utility of conventional 1,093 °C (2,000 °F) gas turbines in gasifier/combined cycle applications. Development of all these systems had been slow in the past for two reasons. One was the misconception that advanced, high temperature (1427 °C [2600 °F]) combustion turbines would be required. Another was hesitancy based on poor historical evidence of turbine reliability. The EPRI study showed that poor reliability has been associated with peak-load duty cycles, but turbines in base-load duty at Dow Chemical's Salt Grass Power Project have performed with an average reliability of 98.7 percent in 130,000 operating hours.

High Sulfur Pelletized Coal Developed for Gasification — Low-Btu gas has been successfully produced using a pelletized fuel made from a high sulfur coal feedstock. The coal pelletizing process, which removes sulfur, ash, and other coal contaminants, includes such operations as mixing with limestone and thermal fixation. The "Helifuel" pellets are produced in a proprietary process by McDowell-Wellman, a subsidiary of Helix Technology Corp. Commercial-scale gasification tests employing about 90.7 Mg (100 tons) of the coal-based feedstock showed that continuous gas production could be maintained with no equipment modifications. The Ohio Department of Energy is providing part of the funding for further development which includes a feasibility study for a 2.9-kg/s (275-ton/day) plant.

West Germans Develop High Temperature Winkler Process for Reactive, High Ash Coals — The Winkler process, developed in the 1920's, gasifies fine-grained coal in a fluidized bed. Subsidiaries of Rheinische Braunkohlenwerke AG of Cologne, West Germany, have considerable operating experience with the conventional Winkler gasification process, and the company has started a major development program to define economic requirements for large scale gasifiers using the high temperature Winkler (HTW) process.

An HTW pilot plant has been designed and commissioned by the Uhde GmbH of Dartmund, the construction and engineering member of the Hoechst Group. This version of the process operates below the ash fusion temperature using less oxygen than other processes and produces a clean gas with no liquid by-products. Pilot plant operations at Wachtberg, West Germany, using lignite and other reactive and high ash coals have been conducted since mid-1978. The plant capacity is about 0.28 kg/s (26.5 tons/day).

FERC Recommends Denial of Certification of First Commercial Coal Gasification Plant — Federal Energy Regulatory Commission Administrative Law Judge Raymond M. Zimmet has recommended denial of a certificate of construction or sale of high-Btu gas from a prototype commercial high-Btu gasification plant proposed for Mercer County, North Dakota. The plant would produce 40.9 m^3/s (125 million ft^3/day) of gas with a minimum heating value of 38 MJ/Nm^3 (970 Btu/scf) using the Lurgi process and North Dakota lignite. Effective integration of a relatively new methanation step with the well established Lurgi process is a major goal of the project.

Judge Zimmet's recommendation, which is subject to voluntary review by the full Commission, would become final after 40 days if no exceptions are filed. Denial of the permit came as a result of Zimmet's disapproval of the financing plan proposed by the sponsor, Great Plains Gasification Associates, a general partnership of five corporations which are all affiliates of major interstate pipelines. The $1.5 billion plant would be built and operated by American Natural Gas Coal Gasification Co. The financing mechanism under contention is the sponsor's request that its rate payers absorb the debt portion of the financing in the event the project fails. Zimmet's opinion is that the cost of the product gas, from $0.20 to $0.29/$m^3$ ($5.56 to $8.29/thousand ft^3), should not be borne solely by the sponsor's customers who represent only a third of the Nation's rate payers. Since the country as a whole would benefit from learning whether it is practical to manufacture and marke' coal gas, Zimmet recommended that the President and Congress consider federal financing.

As this edition goes to press, it is understood that the FERC is in the process of reversing this decision.

DOE Cost Estimates of Energy Alternatives Favor Medium-Btu Coal Gas, Enhanced Oil, and Enhanced Gas Recovery — According to DOE estimates, medium-Btu coal gas is fast becoming cost competitive with Alaskan natural gas and may already be competitive with Alaskan offshore oil. DOE also indicated that the commercial viability of shale oil production is also closer to reality than that of high-Btu coal gas and synthetic gas from naphtha. But shale oil production still cannot compete with medium-Btu coal gasification, enhanced oil, and enhanced gas recovery. DOE submitted its cost estimates to the Interior Department as a part of production goal estimates for offshore oil and gas leasing. A methodology was developed by DOE to compare each technology on a per million Btu basis and on its potential contribution to the overall energy supply.

Soviet Coal Complex Under Construction — After successful pilot scale tests of processes that convert coal into products ranging from briquettes to fuel oil, the Soviet Union is proceeding with construction of its first coalcom. Both the acronym and the idea are borrowed from the South African coal, coke, oil, and megawatts complex that produces both fuel products and electric power at one installation. The Soviet plant is being built in Krasnoyarsk to process some 0.04 Mg/s (151 tons/hr) of coal from the Siberian Kansk-Achinsk field.

Processing technology will follow the principles of several coal pyrolysis processes (FMC COED, Lurgi Ruhrgas, Toscoal, and Garrets) which produce coal liquids that can be upgraded to liquid fuels. The potential product slate includes low sulfur coal for metallurgical use, coke briquetted from low ash char and pitch, medium ash char for fluidized bed boiler fuel, and fuel liquids from pyrolysis of low- and medium-ash coal fractions.

Coal Liquids for Turbine Fuel — According to a paper by Westinghouse Electric Corp., recent tests sponsored by the Electric Power Research Institute (EPRI) prove that large combustion turbines can run on liquids made from coal. Little or no modification is needed for the switch from petroleum fuels. The tests apparently offer new hope for the use of coal liquids for combined-cycle power plants.

Solvent Refined Coal (SRC) Demonstration Plant Design Subcontract Awarded — Pittsburgh and Midway (P&M) Coal Mining Company, a Gulf Oil Corporation subsidiary, is planning construction of a SRC demonstration plant under a contract with DOE. P&M has awarded a subcontract to Scientific Design Company for conceptual design and cost estimate support.

Under the agreement between P&M and DOE, two designs are called for, one for a demonstration plant processing 63 kg/s (6000 tons/day) of coal and producing 0.04 m^3/s (20,000 bbls/day) of oil equivalent products. Plans for expansion to a commercial-sized facility are also called for. In addition, the DOE contract includes a conceptual design for a commercial facility five times larger than the demonstration plant. Operation of the commercial scale facility is planned for the 1990's, with a product slate including fuel oils, naphtha, high octane gasoline, ethane-propane, and pipeline gas.

DOE's Low/Medium-Btu Coal Gasification Program Receiving "Excellent" Response — DOE's resource manager for low/medium-Btu coal gasification, Russell Bardos, says he has received eight proposals, been advised that 20 to 30 more proposals are in preparation, and has received over 200 inquiries about DOE's low/medium-Btu gasification program since it was announced on March 15. The program has accomplished its goals of stirring interest in coal gas and stimulating potential users to study the technology. Most of the responses received so far consider some type of combined-cycle operation, and, according to Bardos, many are using a gasifier developed by Texaco.

The program is currently limited to sharing the cost of assessing low/medium-Btu coal gasification technology with interested utilities and industries. DOE hopes to use about $4 million in partially funding 15 to 20 utility and industry studies. Although no funding is provided for construction of coal gasification plants, there may be some "incentives for construction" in the form of tax relief.

PROJECT TITLES, CONTRACTORS, AND EPA PROJECT OFFICERS IN EPA'S IERL-RTP FUEL PROCESS BRANCH ENVIRONMENTAL ASSESSMENT PROGRAM

Project Title	Contractor	EPA Project Officer
Environmental Assessment of Low/Medium-Btu Gasification (March 1979-March 1982)	Radian Corporation 8500 Shoal Creek Blvd. Austin, TX 78766 (512) 454-4797 (Gordon C. Page)	William J. Rhodes IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2851
Environmental Assessment of High-Btu Gasification (April 1977-April 1980)	TRW, Inc. 1 Space Park Redondo Beach, CA 90278 (213) 536-4105 (Chuck Murray)	William J. Rhodes IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2851
Environmental Evaluation of Coal Liquefaction (July 1979-July 1982)	Hittman Associates, Inc. 9190 Red Branch Road Columbia, MD 21043 (301) 730-7800 (Jack Overman)	William J. Rhodes IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2851
Acid Gas Cleaning Bench Scale Unit (October 1976-September 1981) (Grant)	North Carolina State Univ. Department of Chemical Engineering Raleigh, NC 27607 (919) 737-2324 (James Ferrell)	N. Dean Smith IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2708
Water Treatment Bench Scale Unit (November 1976-October 1981) (Grant)	Univ. of North Carolina Department of Environmental Sciences and Engineering School of Public Health Chapel Hill, NC 27514 (919) 966-1023 (Philip Singer)	N. Dean Smith IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2708
Pollutant Identification From a Bench Scale Unit (November 1976-October 1981) (Grant)	Research Triangle Institute P.O. Box 12194 Research Triangle Park, NC 27709 (919) 541-6000 (Forest Mixon)	N. Dean Smith IERL-RTP Environmental Protection Agency Research Triangle Park, NC 27711 (919) 541-2708

REPORT SUMMARY

Environmental Assessment Report: Lurgi Coal Gasification Systems for SNG

by

M. Ghassemi, K. Crawford, and S. Quinlivan
TRW, Inc.

The Lurgi "dry ash" high-Btu gasification process is especially suitable for substitute natural gas (SNG) production because the raw product gas has high levels of methane and hydrogen and requires less upgrading compared to many other commercial coal gasification processes. Although no commercial Lurgi SNG plants exist to date, several have been proposed for construction in the U.S. Cost estimates for commercial Lurgi SNG plants indicate that an 81 Nm^3/s (250 x 10^6 scf/d) facility will require a capital investment of around $2 billion (1978 dollars), and an annual operating cost of about $300 million.

The four basic operations of Lurgi SNG systems are coal preparation, coal gasification, gas purification, and gas upgrading. Associated auxiliary processes involve pollution control and utilities. These include the Lurgi-licensed pollution control processes: gas liquor treatment for tar and oil separation, Phenosolvan process for phenol recovery, and the Linz-Lurgi process for removing dissolved gases. Other environmentally significant auxiliary processes include sulfur recovery/tail gas treatment and on-site steam and power generation.

Table 3 lists the key process and waste streams as well as the associated constituents of environmental concern. Since only a few commercial Lurgi non-SNG plants are in operation (and none in the U.S.), many of these streams have not been well characterized from the standpoint of toxicity and trace constituents. Thus the nature and extent of their potential hazards are unknown.

Two gaseous waste streams of major environmental concern are the concentrated acid gases from the Rectisol process and flue gases from on-site combustion of coal or by-products for steam and power generation. The volumes of these streams are about 1.4 times and 3 times the volume of the product SNG, respectively. Essentially, all the sulfur originally present in the coal fed to the gasifier appears in the concentrated acid gases; these gases also contain hydrogen cyanide and hydrocarbons. The flue gases from on-site coal combustion at an 81 Nm^3/s (250 x 10^6 scf/d) plant are equivalent in volume to those produced by a 250-MW coal-fired power plant.

Wastewaters from U.S. commercial Lurgi SNG plants will be contained in ponds and either disposed of by solar evaporation or reclaimed for process use. The major environmental concerns in this case are (1) to provide suitable methods for containing and treating wastewater and (2) to dispose of the residues produced by such treatment.

Significant solid waste streams produced by a Lurgi SNG plant are wet ash from the gasifier and boiler ash quench systems, spent catalysts, and sludges from flue gas desulfurization (FGD) systems. The wet ash is produced in greatest quantity; an 81 Nm^3/s (250 x 10^6 scf/d) Lurgi SNG plant using 15 percent ash coal and on-site coal combustion for steam and power generation is estimated to produce an estimated 57 kg/s (5400 ton/day) of wet ash (20 percent moisture content). As with the utility industry, the disposal of such a voluminous quantity of waste can create a solid waste management problem.

There is generally more than one control technology potentially applicable to a specific waste stream, as shown in Table 3. However, because of the lack of detailed information on waste characteristics and control technology capabilities, it is not possible at this time to identify and compare all the options for air, water, and solid waste management in a commercial Lurgi SNG plant. Preliminary studies of selected sulfur controls for concentrated acid gases and flue gases, the two most significant gaseous waste streams in an integrated plant, indicate that:

- The greatest reduction in overall sulfur emissions can be achieved (1) by using the Stretford process to treat concentrated acid gases and (2) by using desulfurized fuel gas for steam and power generation; however, these options are not the most cost-effective.

- The most economic control methods are (1) the Claus process with tail gas treatment for sulfur recovery from H_2S-rich acid gases, (2) the Stretford process for sulfur recovery from H_2S-lean acid gases, and (3) FGD systems for flue gases from coal fired boilers; however these options do not achieve the greatest reduction in overall sulfur emissions.

- Incineration of concentrated acid gases in the utility boilers and application of FGD systems to the combined flue gases do not appear to be competitive with other options both in terms of costs and sulfur emissions levels.

At present there are no specific EPA standards for Lurgi SNG plants, although, as shown in Table 4, several acts mandate that EPA promulgate regulations that will

TABLE 3. MAJOR POLLUTANTS/PARAMETERS OF CONCERN IN KEY PROCESS AND WASTE STREAMS AND APPLICABLE CONTROL TECHNOLOGIES

Product, By-Product or Waste Stream	Source	Constituents/ Parameters of Major Concern	Applicable Control Technology
Product/By-Product			
SNG	Final product	CO, $Ni(CO)_4$	In-plant process control
Tars, oils, and phenols	Raw gas liquor treatment	Aromatic hydrocarbons, polycyclic organics, phenols, trace elements, toxic properties	Prevention of leaks/spills, use of worker protection measures, combustion for steam/power generation, injection into gasifier
Naphtha	Rectisol process	Aromatic hydrocarbons and polycyclic organics, toxic properties	Prevention of leaks/spills, use of worker protection measures, combustion for steam/ power generation
Ammonia	Gas liquor treatment	Ammonia, trace contaminants	Prevention of leaks/spills, use worker protection measures
Gaseous Waste Streams			
Lockhopper and transient waste gases	Gasifier	Sulfur and nitrogen compounds, CO, organics, particulates, trace elements, toxic properties	Incineration and particulate control, proper operating procedures
Concentrated acid gases	Rectisol process	H_2S, COS, CS_2, HCN, CO, hydrocarbons, mercaptans	Sulfur recovery, incineration/FGD
Sulfur recovery tail gas	Sulfur recovery plant	Same as for concentrated acid gases	Catalytic reduction and H_2S recycle, incineration, incineration/FGD
Catalyst decommissioning/ regeneration off-gases	Decommissioning/ regeneration of shift and methanation catalysts	Metal carbonyls, CO, sulfur compounds, organics, toxic properties	Incineration and particulate control
Combustion flue gases	Onsite steam and power generation	SO_2, NO_X, particulates, trace elements	Electrostatic precipitators, fabric filters, FGD systems, and combustion modification
Aqueous Waste Streams			
Ash quench slurry	Quenching of gasifier ash	Dissolved and suspended solids, alkalinity, trace elements, components of the clean gas liquor used for quenching (see below)	Gravity separation, dissolved solids removal, disposal of solids in containment ponds/ landfills
Clean gas liquor	Ammonia recovery	Sulfide, thiocyanate, ammonia, dissolved organics, BOD, COD, pH, biotreatability	Biooxidation, use as cooling tower or quench water makeup
Waste sorbents and reagents	Pollution control units	Sulfur compounds, trace elements, dissolved and suspended solids, and other constituents (depending on specific source)	Resource recovery, oxidation, dissolved solids removal, use as ash quench
Combined plant effluent	Ash quench, FGD, and raw water treatment	Dissolved and suspended solids, COD, BOD, alkalinity, trace constituents, toxic properties	Forced or solar evaporation
Solid Waste Streams			
Gasifier and boiler ash	Ash quench systems	Leachability, compactability, leachate characteristics (including trace elements and organic contents and toxic properties)	Disposal in lined landfills and ponds, return to mines
Spent catalysts	Shift and methanation	Metallic compounds, accumulated trace elements/ organics, leachability and leachate characteristics	Resource recovery, encapsulation, disposal in lined landfills, return to mines
Tarry/oily and bio-sludges	By-product storage and wastewater treatment	Aromatic and polycyclic hydrocarbons, trace elements, toxic properties	Energy recovery, disposal in lined landfills, return to mines
Inorganic solids and sludges	FGD systems, miscellaneous sources	Same as for gasifier and boiler ash	Same as for gasifier ash

affect these sources in the future. However, many data gaps must be filled to provide a comprehensive technical basis for developing standards and defining control technology R&D needs. For example, data are almost totally lacking concerning the types and concentrations of organics and trace elements in all major waste streams listed in Table 3. These data are required to identify those streams and constituents to be regulated under the provisions of the laws presented in Table 4. In addition, few of the potentially applicable control technologies have actually been used on Lurgi gasification wastes. Data from other applications cannot generally be extrapolated to Lurgi SNG production because of differences in process design and waste stream characteristics.

EPA is conducting and planning several programs to fill these data gaps; the most important is the EPA-sponsored multimedia environmental sampling and analysis effort underway at the Kosovo Lurgi plant in Yugoslavia. Radian Corporation is conducting this program, which is the first multimedia environmental sampling and analysis effort to be undertaken at a commercial Lurgi synthetic fuels plant.

As the data gaps are filled, this EAR will be expanded, refined, and updated. These efforts will aid the EPA Program Offices in developing standards and defining control technology R&D needs.

TABLE 4. STATUS OF EPA REGULATIONS UNDER EXISTING LAWS WHICH WOULD AFFECT LURGI SNG PLANTS

Law	Key Pertinent Regulatory Features	Status of Regulations
The Clean Air Act Amendments (PL 91-604)	• Develop New Source Performance Standards (NSPS) for industrial source categories. • Preconstruction review of major emission sources to prevent significant deterioration of ambient air quality ("PSD") regulations. • Establish emission standards for hazardous air pollutants from stationary sources.	• No NSPS have been developed for Lurgi plants. • Emissions guidelines have been developed for Lurgi SNG to assist states and EPA Regional Offices in setting plant-specific standards. • "PSD" requirements for SO_2 and particulates and regional air quality classification have been completed. • Hazardous emissions standards have been set for asbestos, mercury, beryllium, and vinyl chloride.
Federal Water Pollution Control Act Amendments (PL 92-500); Clean Water Act Amendments (PL 95-217)	• Establish effluent limitations and guidelines covering conventional, toxic and nonconventional pollutants for new industrial sources discharging into navigable waters.	• No effluent guidelines have been developed for Lurgi plants. • A list of 129 toxic substances/classes of toxic substances has been developed. • A list of industrial categories requiring standards has been developed. The list does not currently include Lurgi SNG plants.
Resource Conservation and Recovery Act (RCRA) (PL 94-580)	• Develop criteria for identification of hazardous wastes. • Develop regulations for handling, transportation, storage, treatment, and disposal of hazardous wastes.	• Identification criteria and hazardous waste handling, storage, treatment, and disposal regulations have been proposed. • Proposal has been made to classify coal ash and FGD sludges as "special wastes" and not as "hazardous wastes."
Toxic Substances Control Act (PL 94-469)	• Promulgate regulations for the manufacture, processing and distribution in commerce, and use or disposal of substances or mixtures of substances presenting unreasonable risk to health and environment. • Issue regulations on testing, premarket notification, and reporting/retention of information.	• A priority listing of chemicals for toxicity testing has been developed. • No substance-specific regulations have yet been developed.

MEETING CALENDAR

Energy Sources Technology Conference and Exhibition, February 3-7, 1980, New Orleans, LA. Contact: Paul Drummond, ASME, 345 E 47th Street, New York, NY 10017; telephone (212) 644-8074.

IUPAC 3rd International Congress on Industrial Wastewater and Wastes, February 6-8, 1980, Stockholm, Sweden. Contact: 3rd International Congress on Industrial Wastewater and Wastes, Box 21060, S-100 31, Stockholm, Sweden.

2nd Symposium on Process Measurements for Environmental Assessment, February 25-27, 1980, Atlanta, GA. Contact: Dr. Phillip Levins, Arthur D. Little, Inc., 15 Acorn Park, Cambridge, MA 02140.

179th ACS Meeting, March 23-28, 1980, Houston, TX. Contact: A. T. Winstead, ACS, 1155 16th St., N.W., Washington, D.C. 20036; telephone (202) 872-4397.

7th Energy Technology Conference and Exposition, March 24-26, 1980, Washington, D.C. Contact: Lauren Unzelman, Energy Technology Conference, Inc., 4733 Bethesda Ave., N.W., Washington, D.C. 20014; telephone (301) 656-1090.

RECENT MAJOR MEETINGS

5th Underground Coal Conversion Symposium

In situ coal gasification and liquefaction were the topics of a recent DOE-sponsored meeting, the Fifth Annual Underground Coal Conversion Symposium. Over fifty papers were presented during the 4-day symposium, held June 18-21 in Alexandria, Virginia. The symposium consisted of nine sessions:

- Minisymposium.
- DOE Field Programs.
- Industry Activity.
- Economics.
- Instrumentation and Control.
- Environmental Studies.
- Mathematical Modeling.
- General Topics.
- Laboratory Studies.

The Minisymposium included summaries of the National Underground Coal Conversion (UCC) Program, field implementation of UCC research, private sector involvement, and the role of UCC in the future. The session concluded with a panel discussion.

Field studies and data acquisition were the topics of the next two sessions. DOE-sponsored activities were described in Session II, while Session III concerned efforts of private industry.

Papers presented during the Economics Session examined UCC from several perspectives, including the chemical industry standpoint and alternative methods of drilling and linking.

The Instrumentation and Control Session dealt with conceptual and proven techniques. Several papers described field experience and the resulting data.

Environmental aspects of UCC were featured in Session VI, which focused on regulatory implications for UCC, related DOE activities, and results of environmental assessment studies performed at several sites.

The application of mathematical modeling to UCC was the topic of another session; papers summarized a variety of models which can be used to model such phenomena as water intrusion, combustion front instabilities, transport processes, reverse combustion linking, and structural and fracture mechanics.

The final sessions of the symposium covered general UCC topics and laboratory studies. General topics included R&D potential in the U.S., foreign UCC research, and commercial applications. Presentations of laboratory studies discussed investigations of coal properties and reaction kinetics as well as a review of supporting research at Oak Ridge National Laboratory.

The Symposium Proceedings (Conf. No. 790630, May 1979) are available from the National Technical Information Service (NTIS). Each printed copy is $15.00; microfiche copies are $3.00 apiece. Payment must accompany order. The address is:

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Rd.
Springfield, VA. 22161

For a complete listing of the symposium papers, see "Recent Major Papers and Publications" in this issue.

Tenth Biennial Lignite Symposium

The Tenth Biennial Lignite Symposium concerned developments in the technology and use of low rank fossil fuels. Since 1961, these meetings have been cosponsored by the

Grand Forks Energy Technology Center of the U.S. Department of Energy (DOE) and the University of North Dakota. This tenth symposium, held May 30-31 at the University of North Dakota in Grand Forks, was an opportunity to review developments in combustion, gasification, liquefaction, mining, environmental control, and future use.

The extensive domestic reserves of low-rank fossil fuels provide a major energy resource. Properties of these fuels differ considerably from those of higher rank and require different techniques for mining, utilization, and conversion processes. Generally, low-rank coals have low sulfur content, can be surface mined at relatively low cost, and are suitable raw material for liquefaction and gasification as well as electrical generation. Significant progress in the development of these fuels has been made; however, many technical, social, economic, and environmental problems remain to be solved.

The symposium addressed many of these problems and covered activities in the major lignite-producing areas of the U.S. Also featured were presentations from Australia and West Germany, two major lignite-producing nations. Several solid fossil fuels were considered, ranging from peat to subbituminous coal. Specific topics included gasification, liquefaction, combustion, power generation, stack gas clean-up, mining, and plans for utilization.

Preliminary plans have been made to include expanded international low-rank coal coverage at the Eleventh Lignite Symposium in the spring of 1981. This meeting, to be held in Texas, will be cosponsored by DOE and the Texas Energy Advisory Council.

For a complete listing of the papers presented at the Tenth Biennial Lignite Symposium, see "Recent Major Papers and Publications" in this issue. The Proceedings of the Symposium are available by contacting:

U.S. Department of Energy
Technical Information Center
P.O. Box 62
Oak Ridge, TN 37830

RECENT MAJOR PAPERS AND PUBLICATIONS

Gasification Technology

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Bombaugh, Karl J., and William E. Corbett, "Kosovo Gasification Test Program Results — Part II: Data Analysis and Interpretation," *Proceedings of the Fourth Symposium on Environmental Aspects of Fuel Conversion Technology,* Report EPA-600/7-79-217, September 1979.

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