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Environmental Protection Technology Series

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EPA Program Status Report

Synthetic Fuels Program

Office of Research and Development

U.S. Environmental Protection Agency

Washington, D.C. 20460

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This report has been reviewed by the Office of Research and Development.

October 1975

EPA PROGRAM STATUS REPORT
SYNTHETIC FUELS PROGRAM

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TABLE OF CONTENTS

1. INTRODUCTION AND SUMMARY

The Environmental Protection Agency (EPA) Synthetic Fuels Program is one of several technology advancement programs directed toward providing the necessary technology for meeting near-term and long-term energy requirements in an environmentally acceptable manner. The primary concern of the program is the control and prevention of environmental pollution from the conversion of coal and other fossil fuels to synthetic fuels, and from the utilization of synthetic fuels. The program is an outgrowth of EPA's Fuel Cleaning Program, and has been in operation since 1972. It has developed a substantial data base on the pollution potential of fossil fuels used as raw material for production of synthetic fuels, and a broad expertise that can now be focused on the task of assisting energy producers and consumers in meeting energy needs and environmental goals.

The Synthetic Fuels Program has two principal thrusts. One is the establishment of control requirements to prevent or minimize environmental pollution from the production and utilization of synthetic fuels. The second is the development of advanced technology for controlling the release of pollutants. Initial efforts in the program are concentrated on assessing the potential environmental effects of coal conversion. The assessment is based on the characteristics of coals and oil shale as well as the reactions and equipment characteristics of candidate conversion processes. To date, efforts involving the development of technology for controlling the release of pollutants have been directed primarily toward the desulfurization of hot, acidic gas streams in gasification processes and the demetallization and desulfurization of oils. The technology development effort was expanded in FY 1975 to include pollution controls for coal liquefaction, coal solvent refining, and oil shale processing.

There are, to date, a number of significant accomplishments of the program which have current or long-term impact on the Nation's energy problem. These include:

- Characterization of the pollution potential of over 100 U.S. coals likely to be used in conversion processes to make clean fuels
- Identification of the pollution potential and evaluation of available pollution control in five gasification processes and two liquefaction processes.
- Bench-scale demonstration of a highly effective method for desulfurization of high-temperature, acidic gases.

- Evaluation of catalysts for demetallization of oils.

- Analysis of the problems and opportunities of retrofitting industrial processes to use low-Btu synthetic gas.

- A symposium on environmental aspects of fuel conversion which provided a focal point for data dissemination and discussion of these factors.

Continuation of the Synthetic Fuels Program will involve assessing the environmental impact of additional conversion processes; a more in-depth data acquisition and assessment program; expanded effort in defining control requirements for conversion processes and developing necessary control technology; and new initiatives in defining control requirements. New initiatives are desirable in the areas of transportation and utilization of synthetic fuels, examination of specific water quality effects from conversion processes, and research into the control requirements for waste streams and the potential for recovery of valuable byproducts from wastes which would otherwise be environmentally hazardous. Timely accomplishment of the program will result in well-defined environmental control requirements and identification of control techniques in a time frame that allows process developers to incorporate the necessary control technology into their process design, thereby avoiding the costs and inefficiencies of retrofitting.

2. PROGRAM OVERVIEW

2.1 Background

The United States has a growing demand for fuels to meet increasing energy requirements in an environmentally acceptable manner. The Nation's largest fossil fuel resource is its coal reserves. Most U.S. coals, when burned in a conventional manner, introduce several types of pollutants into the environment in quantities that have proven to be unacceptable from the standpoint of environmental quality. Coal can, however, be converted to solid, liquid, or gaseous synthetic fuels of lower pollutant content. Under the mandates of the Air Quality Act of 1963, the Water Pollution Control Act Ammendments of 1972, and the Solid Waste Disposal Act of 1965, EPA initiated a program to reduce pollutant emissions and discharges from processes that produce synthetic fuels from coal, so that an adequate, reliable supply of fuels with low pollution potential would be available to meet future energy requirements.

The production of synthetic fuels from coal is not new, either in concept or practice. Early in this century, many American and European cities had "gas works" that produced manufactured gas from coal for both domestic and industrial use. With the advent of pipelines for transporting large quantities of natural gas and other improvements in the processing and shipment of liquefied petroleum gas, the use of manufactured gas from coal has been largely supplanted by petroleum-derived gases of higher heating value. More recently, coal-to-gas conversion has been performed on a commercial scale in plants currently in operation in Europe and South Africa.

The technology for producing liquid fuels from coal has also existed for several decades. During World War II, a fuel oil suitable for vehicle use was produced from coal on a commercial scale in Germany. The technology, which became available to the United States after the war, proved far too expensive to compete with petroleum fuels. Much of the current work on coal liquefaction is directed toward improved process efficiency and improved quality of the resulting fuel.

The earlier applications of coal conversion to liquid or gaseous fuels were intended primarily to produce more convenient forms of fuel for household, industrial, and vehicular use, rather than clean-burning fuels for reduction of environmental pollution. Nevertheless, the synthetic fuels generally burn cleaner than the original coal, and can be made extremely clean (low sulfur, low ash) by inclusion of pollutant removal steps in the conversion process. The pollution-causing substances must then be dealt with during conversion. Thus, the conversion process itself is a potential source of environmental pollution.

EPA's Synthetic Fuels Program began in 1972 as an effort of its Fuel Cleaning Program, which had been underway for several years. Both were directed toward development of technologies for producing clean (low-polluting) fuels from coal and other energy resources. The Federal Government's Synthetic Fuels Program was expanded and accelerated under the impetus of the 1973 energy shortage and attendant increases in the price of petroleum. This program now under the direction of the Energy Research and Development Administration (ERDA) addresses the production of solid, liquid, and gaseous fuels from coal and oil shale. EPA's portion of the Federal program is aimed toward insuring that clean fuels are available to meet standards and that adequate technology exists for controlling the release of environmental pollutants during production and utilization of these advanced fuels.

2.2 Program Objectives and Responsibilities

The overall objective of the Synthetic Fuels Program is to insure that adequate technology is available to control, within acceptable levels, the discharge of environmental pollutants from the production and utilization of synthetic fuels from coal or oil shale. Implicit in this objective is the schedule requirement that the necessary control technology be developed in time to permit its incorporation into planned commercial-scale conversion facilities.

To support this general objective, the following intermediate goals have been defined for the Synthetic Fuels Program:

- Determine the pollution potential of major fossil fuels (principally coal and oil shale) through analysis of domestic reserves.

- Assess pollution potential from storage and preconversion processing of fossil fuels; define control requirements and develop the necessary control technology.

- Assess the pollution potential of proposed coal conversion processes, including identification of pollutants occurring at major and secondary processing steps.

- Define the requirements for fuel product quality from the viewpoint of combustion pollutants and pollution due to accidental release during storage or transportation and develop the control technology where required.

- Encourage the development of adequate control technology by other governmental agencies and commercial firms involved in synthetic fuel production.

- Evaluate the adequacy of control measures presently available and proposed for use with future fuel conversion facilities.

- Assess the pollution potential of the transportation, storage and utilization of synthetic fuels. Define control technology requirements.

- Assess the pollution potential of disposal of wastes from synthetic fuel production. Define control requirements, and develop the required control technology.

- Investigate and assess the potential for recovery of wastes or pollutants as byproducts.

- Obtain a viable data base that can be used by EPA regulatory divisions in setting environmental standards for synthetic fuel production and utilization.

These intermediate goals have been used as the basis for defining and shaping the individual projects of the EPA Synthetic Fuels Program.

The definition of control requirements is being accomplished in conjunction with EPA's Environmental Effects Program and regulatory activity. Requirements are expected to be in the form of allowable limits (rates and concentrations) within which polluting substances might be released to the environment without imposing a health hazard or inflicting other environmental damage or degradation.

Primary responsibility for developing the in-process technology necessary to meet pollution control requirements resides with those organizations (government and private) who are developing the basic conversion process. If this responsibility is not met, EPA may be required to pursue in-process development in specific areas. EPA is undertaking the major responsibility for the development of any needed add-on control measures and will be evaluating the effectiveness and overall adequacy of all control methods proposed or developed either by EPA or by other organizations. EPA has also undertaken the coordination of all governmental research and development efforts for environmental control of synthetic fuel production and use.

2.3 Technology Involved: Its Importance, Advantages and Limitations

The principal raw materials to be used in the production of synthetic fuels will be coal and oil shale. Coal is by far the most important both in size of resource base and in its geographic distribution. Oil shale will contribute a smaller portion of synthetic fuels

but, because of its geographic concentration, could create severe waste disposal problems. Many of the problems of waste disposal are similar for coal and oil shale: both contain solid residues that must be disposed of in fixed landfills; both raw materials contain heavy metals, nitrogen and sulfur that can form pollutants during the conversion to fuels. Some liquefaction processes concentrate organic constituents (polycyclic aromatic compounds) that are known to be carcinogenic and are normally decomposed during combustion, in intermediate materials and possibly in the final products.

The magnitude of potential polluting substances present in or formed during the conversion of solid fossil fuels to clean usable forms of fuels is found to vary from several percent in the case of sulfur down to a few parts per million in the case of mercury or other trace components. To put the potential problem in perspective, a coal gasification plant capable of producing 250 million standard cubic feet per day of pipeline gas from Eastern U.S. bituminous coal will require about 26,000 tons per day of coal input. Assuming 3.5 percent by weight sulfur content in the feed, a typical value for eastern bituminous coal, 1,820,000 pounds of sulfur per day will flow through the plant and must be accounted for. If 95 percent of this sulfur is controlled, the plant could still emit 180,000 pounds of sulfur dioxide (SO_2) per day. If one part per million of mercury occurs as a trace element in the coal, the plant must account for 52 pounds per day of mercury in the products or waste streams.

There is available technology for controlling the release of the major pollutants. In most conversion processes, much of the organic sulfur compounds is converted to hydrogen sulfide which can be reduced to elemental sulfur, a potentially valuable byproduct, by the Claus reaction which removes about 95 percent of the sulfur. An alternate, the Stretford process, removes about 99 percent. Polycyclic aromatic solvents can be retained in the process equipment for reuse or for conversion to clean fuel products, or can easily be decomposed by thermal oxidation. These and other demonstrated control measures have been incorporated into the design of many of the proposed plants. The removal of some of the pollutant-causing materials is, in fact, necessary for the efficient operation of certain conversion processes. Some pollutant removal processes are intricate and expensive, with expense increasing sharply with the degree of removal required. A major problem is the determination of where, in the overall conversion process, specific control measures should be applied to effect adequate control of pollutant discharges from major process streams and all secondary and waste streams.

The control of pollutant discharges may be far from complete, however. Approximately 300 compounds, many of which are potential pollutants, have been identified among the products of reactions involved in the conversion of coal to synthetic fuels. The relative quantities of these

compounds in the products and waste streams have not been fully determined for conversion processes. Some of these compounds are water soluble and, if they enter sources of water supply, would have detrimental effects on conventional water treatment systems. Attention has recently been focused on the chlorine content of coal and its effects on the types of pollutants that might be released. Significant levels of chlorine in coal could yield chlorinated hydrocarbons among the products of conversion, which are serious environmental pollutants.

The course of heavy metals from the raw material, some of which are known to be toxic and suspected of being carcinogenic, is not well understood for many conversion processes. Some processes require removal of heavy metals from the process stream to prevent poisoning of process catalysts. Removal can be accomplished in greater or lesser degree by a variety of demetallization processes, usually expensive, such as scavenging, oil extraction, chelation, or formation of eutectic slags. Portions of the heavy metal content may emerge in the synthetic fuels produced; other portions may be released to the environment in liquid or gaseous discharges or may be retained in the walls of the reaction vessels or tubing. Much of the heavy metal content will probably be concentrated in the ash and other solid wastes from the conversion process, where the metals can be stabilized for safe disposal or subsequent recovery. The adequacy of existing treatment methods requires further evaluation based upon developing information on the nature and quantities of metallic constituents of feedstocks.

Both gasification and liquefaction plants will have the opportunity to produce valuable organic liquid byproducts from waste streams. The process steps required to separate these byproducts from other plant streams affect the operation of the waste control units, such as wastewater treatment, as well as plant facilities, such as the recirculating water system. The existing control technology for sulfur and some organic pollutants, currently designed into major process streams for many of the proposed conversion plants, is probably adequate also for controlling discharges from this secondary byproduct production. It must, however, be carefully adapted to these applications in the light of emerging information on the content and concentrations of secondary-stream constituents.

Product quality will also affect ultimate emission of effluents into the environment. As an example, the nitrogen content of the product oils from coal liquefaction or oil shale is a problem. The removal of the nitrogen may be accomplished in the conversion process or in a properly designed combustion system neither of which is well developed technology.

2.4 Program Benefits

The major benefit of the EPA Synthetic Fuels Program will be to maintain a clean, healthful environment while providing the capability of utilizing the Nation's most plentiful fossil energy resource to form clean, convenient fuels for industrial and domestic use. An indirect benefit that will result from early identification of pollutants and control measures is the avoidance of problems of retrofitting existing equipment. Potential secondary benefits of environmental control lie in the recovery of sulfur, trace metals, phenols and valuable organic compounds as coproducts, and the recovery of ash and other solid products (for uses such as fill material or concrete aggregate) from the process wastes.

3. CURRENT PROGRAM STATUS

The Synthetic Fuels Program began at a modest level of effort in 1972 and was significantly expanded during FY 1975. The enlarged program currently includes the following activity categories:

1. Characterization of Feedstock (Pollution Potential and Energy Content)

2. Assessment of Environmental Effects of Conversion Processes

3. Development and Evaluation of Control Technology for Pollutant Removal from Conversion Plants

4. Demetallization, Denitrification, and Desulfurization of Oils (Shale, Petroleum, and Synthetic)

5. Determination of Pollution Potential of Synthetic Fuels Utilization; Definition of Control Needs

6. Assessment and Development of Technology for Removal of Pollutants and Their Recovery as Byproducts (Energy and Chemicals)

7. Assessment of Waste Management Problems (Solids, Liquids, and Gaseous).

Certain of the above categories (Numbers 1, 2, 3, 4, and 5) represent continuations of work initiated in the earlier years of the Synthetic Fuels Program. A number of solid accomplishments (identified in Section 4) were realized during this interim period of low budget effort. The remaining categories (Numbers 6 and 7) are just beginning (FY 1975), and the environmental assessment work in Number 3 is being greatly expanded under the FY 1975 budget. Under the current program, major funding is for environmental assessment and control technology development. Approximate funding levels for program elements are shown in Appendix A. The general content of major program elements is discussed below.

3.1 Characterization of Feedstock

The Illinois State Geological Survey has examined the occurrence and distribution of trace elements in coal which potentially could become volatile in a high-temperature process. Coals are being analyzed by the Institute of Gas Technology to determine the quantity of pollution-causing substances in major fossil fuel reserves. The work to

date has involved analysis of the mineral content of eastern and mid-western coals, including trace metal residues.

Analyses of the mineral matter in coal is being continued at a low level of effort. Recently analyses have been performed on 101 whole coal samples and 32 separate fractions of washed coals, for 10 major and 23 trace elements. Previous tests were conducted on 1500 coal samples including some trace element analysis on 400 of them. A more comprehensive coverage of western coals and oil shale is planned for inclusion in subsequent years' programs.

3.2 Assessment of Environmental Effects of Conversion Processes

This program began about two years ago with an effort to identify and estimate quantities of potential pollutants released to the environment by specific conversion processes, to assess the effects of these substances on the environment, and to evaluate measures employed to control the release of certain pollutants. To date, reports have been issued for the following conversion processes:

- Koppers-Totzek Process (gasification)
- Synthane Process (gasification)
- Lurgi Process (gasification)
- CO_2 Acceptor Process (gasification)
- BIGAS Process (gasification)
- COED Process (liquefaction)
- SRC Process (liquefaction)

This work was done by Exxon Research and Engineering.

This effort is being expanded to include other processes for coal gasification (to both high-Btu and low-Btu products), liquefaction (including solvent refined solid products), and extraction of fuels from oil shale. Two important aspects of the expanded program are the acquisition of pollutant-discharge data from full-scale plants abroad and from pilot and demonstration plants funded by ERDA in the United States.

Arrangements for obtaining this kind of information from operational Lurgi gasification plants are in progress with four foreign countries. Negotiations are presently underway with ERDA to obtain similar data from existing and planned demonstration units in the United States.

EPA is currently negotiating separate contracts for environmental assessments of the production of low-Btu gas, high-Btu gas, oil from shale, and liquid fuels from coal. Also under negotiation is an environmental assessment of the probable future synthetic fuels industry utilizing systems analysis methods.

EPA has recently published a report on the Institute of Gas Technology assessment of the fate of trace constituents of coal during gasification. Trace metals in particular were found to be discharged by several different mechanisms, such as fumes and deposits on catalysts, in addition to remaining in the ash or being deposited within the reactor.

3.3 Control Technology Development and Assessment

While the environmental assessment work has been oriented toward overall systems for producing a given type of fuel (such as Lurgi gasification), the control technology effort is oriented toward unit processes, most of which find application in several types of overall systems.

The problem of removing sulfur and other pollutants from gas streams at high temperatures has received much of the early attention in this program. It is estimated that overall thermal efficiency of gasification processes is improved by 5 to 9 percent by cleaning the gas streams at high temperatures instead of cooling the stream before cleanup. Cleaning the hot, acidic gas streams continues to present major technical problems in several gasification processes. Considerable success has been achieved by Conoco Coal in the development of a desulfurization process for fuel gases at high temperatures. Bench-scale work has produced 97 to 99 percent desulfurized gas stream, and a pilot plant demonstration is being considered as a possible joint ERDA/EPA program. During FY 1975, the Synthetic Fuels Program is initiating additional R&D projects on fuel gas cleanup, including desulfurization and particulate removal of high-temperature/pressure process streams.

3.4 Demetallization, Desulfurization and Denitrification of Oils (Shale, Petroleum, and Synthetic)

The Synthetic Fuels Program includes research, development, and demonstration of procedures for removing metals, sulfur, and other potential pollutants from liquid fuels. Attention is currently focused on residual oils derived from petroleum, which are widely used as power plant fuels. Technology developed for this application is expected to be adaptable for removal of pollutants from shale oils and synthetic liquid fuels derived from coal. The program includes identification of potential pollutants in oils and development of methods for their removal.

A literature survey has assembled and analyzed available data on domestic and imported crude oils. These data provide the initial basis for an inventory of potential pollutants whose fate must be followed in further oil processing and utilization. This work was performed by Exxon Research beginning in 1972.

Much of the oil available to the United States is high-sulfur, high-metals-content residual oil. Currently, much residual oil cannot be desulfurized economically to meet environmental requirements because metals in the oil poison the desulfurization catalyst. Since vanadium and nickel are two of the major poisons, a program is underway to develop a low cost method for removing them prior to conventional desulfurization. The program is evaluating various scavenger and catalyst combinations. The residual oils being used in the investigations are vacuum bottoms with 3 to 3.5 percent sulfur and 400 to 1,000 ppm (parts per million) total vanadium and nickel. Successful completion of this project will result in a clean fuel for use in existing large installations. This work, begun in 1972, is being performed by Hydrocarbon Research, Inc. It should be noted that a large effort is being put into smaller areas of research by industry aimed primarily at methods for making quality products from poor feedstocks. In this regard it is necessary to purify the refinery feedstock by removing metals, sulfur and nitrogen before it can be upgraded to a high-octane gasoline. The EPA program complements this work.

A research project is underway to investigate the kinetics of simultaneous hydrodesulfurization and hydrodenitrification of liquid fuels. These reactions are being studied to determine the conditions at which they compete for the same supply of hydrogen and at which they may be aiding each other. By removing such compounds from the fuel prior to combustion, part of the potential for producing air polluting oxides of sulfur and nitrogen is removed. Results of this type of work are aimed at long-term applications and may be useful in producing clean fuels from liquids derived from coal or oil shale. This work is being performed for EPA by the Massachusetts Institute of Technology.

3.5 Pollution Potential from Utilization of Synthetic Fuels; Definition of Control Needs

This program is to assess the potential pollution problems from the transportation and utilization of synthetic fuels, and to identify technological measures needed to control the associated release of pollutants.

The magnitude of potential pollution problems associated with the use or transport of synthetic fuels depends in large measure on the effectiveness of pollutant removal measures during production of the fuels. If sulfur in the raw material is removed during manufacture

of synthetics, there should be no problem of sulfur oxides in the combustion gases when the fuel is burned. Similarly, there should be no problem for trace metals or their compounds. But few pollutant removal measures are totally effective, and it is therefore necessary to examine the products of combustion (gaseous, liquid, and solid) for potential environmental pollutants. Since certain classes of synthetic fuels derived from coals (in particular, the liquids) contain different proportions of organic compounds than liquid fuels derived from petroleum, it is necessary to examine their combustion products to determine whether new and possibly hazardous compounds are formed by combustion reactions.

The problems and opportunities of retrofitting coal gasifiers to industrial plants was examined by Battelle for EPA. The study showed that such retrofitting would reduce emissions from existing coal fired plants as well as provide a nonpolluting fuel for plants now using gas or oil which may not be available for this purpose in the future.

Another potential problem relates to the nitrogen content of synthetic fuels obtained from coal. Nitrogen compounds are not removed by all processes that convert coal to synthetic fuels, and may, in fact, be concentrated in the synthetic fuel produced. These substances could cause formation of nitrogen oxides during combustion, producing unacceptably high concentrations of oxides of nitrogen (NO_x) in the combustion gases.

3.6 Technology for Recovery of Byproducts

This program will assess the pollution potential of byproducts from systems that produce synthetic fuels, to define technology needed for control of pollutants from byproducts, and to evaluate technology for environmentally acceptable separation and recovery of byproducts. This is a new part of the Synthetic Fuels Program, being initiated in FY 1975.

Earlier work in this area to identify most urgent needs and to provide a basis for indicating potential control methods included a study of the pollutants and potential byproducts in process streams of the P&M solvent refined coal process. Pittsburg and Midway Coal Company examined nitrogen, sulfur, and trace metals in the secondary (byproduct and product) processing steps. In April of 1975 a report on potentially hazardous emissions from the extraction and processing of coal and oil was published by Battelle. This was an extensive preliminary examination and cataloging of organic and organometallic compounds.

3.7 Assessment of Waste Management Problems

Wastes referred to here are both solids and liquids from coal conversion, oil shale retorting and upgrading and petroleum refining. In

oil shale retorting about 85 percent of the raw material must be disposed of as solid waste; in coal the solid wastes will vary from 5 to 20 percent of the feed material. In petroleum refining the quantity of solids to be disposed of is relatively small but may contain significant amounts of soluble materials. Both conversion and refining operations must dispose of spent catalysts, treatment sludges, blowdown streams and off-specification materials produced during plant start-up and upsets.

This program is intended to investigate impacts of specific waste products on the environment and to devise methods for controlling or disposing of such wastes to prevent environmental damage. Initial attention will be directed toward two problems: (1) the effects of liquid wastes from coal conversion and petroleum refining on the aquatic environment with emphasis on aquatic organisms, and (2) assessment of the effects of "rain-out" from coal conversion processes on aquatic ecosystems.

EPA is currently negotiating to have a single contractor identify problems and develop controls in the area of waste storage and disposal and byproduct utilization in advanced fuels processing plants.

Problems associated with atmospheric, groundwater or aquifer transport of pollutants from the vicinity of fuel processing plants to other areas are under investigation. Specifically, waste materials from coal or oil shale solids disposal may enter groundwater ecosystems. Atmospheric emissions from a fuel processing plant may enter lakes or streams through normal weather phenomena such as rain. Studies are underway to characterize the transport and fate of energy related pollutants in marine waters and to determine the effect of waste products on aquatic organisms. Other studies seek better methods for conserving water usage in fuel conversion processes and mitigating the effect of disposing of waste heat in the Great Lakes basin.

4. SUMMARY OF ACCOMPLISHMENTS

The Synthetic Fuels Program has thus far produced the following substantive results:

- Analyzed over 1500 coal samples from more than 100 Eastern and Midwestern coal sources and characterized them for pollution potential.
- Identified potential pollutant releases by five conversion processes:
  - Koppers-Totzek gasification
  - Synthane gasification
  - Lurgi gasification
  - CO_2 Acceptor gasification
  - BIGAS gasification
  - COED liquefaction
  - SRC liquefaction
- Developed and demonstrated highly effective desulfurization process for high-temperature gas stream (at bench scale).
- Developed design for pilor-scale unit to demonstrate desulfurization of high-temperature gas stream.
- Completed an analysis of high-temperature versus low-temperature cleanup of gas streams, with emphasis on application of combined cycles. (There was a difference in efficiency of about 5 percent in favor of cleanup at high temperature.)
- Produced an inventory of potential pollutants in crude oils from specific locations (domestic and foreign).
- Determined the fundamental characteristics of the reactions involved in simultaneous hydrodesulfurization and denitrification.

- Identified specific catalysts that tend to optimize demetallization of oils, and preliminary estimates of catalytic demetallization and desulfurization of specific Venezuelan and Iranian oils.

- Completed an analysis of problems and opportunities in retrofitting industrial processes to utilize low-Btu gas. (The analysis indicated that industrial processes representing a significant portion of energy use in industry could be adapted to low-Btu gas use.)

- Examined commercial-scale gasification plants in five foreign countries. Contracting for operational data and pollutant-emission measurement program on Lurgi units in several countries.

- Sponsored a symposium in 1974 that produced a comprehensive report on the state-of-knowledge on environmental effects on fuel conversion processes.

- Published a survey of potentially hazardous emissions from the extraction and processing of coal and oil.

5. APPENDICES

CONTENTS:

APPENDIX A - FUNDING LEVEL OF PROGRAM AREAS

EAP Identification Number	TITLE OR SUBJECT	$ THOUSANDS FY 72	FY 73	FY 74	FY 75	Total Through 1974
	FEEDSTOCK CHARACTERIZATION					
121NA-A-01-0	Input Material Characterization of Coal for Synthetic Fuel Process	———	———	———	150	475* Ill. Geol. Survey
121NA-A-01-0	Input Material Characterization of Coals and Liquids for Synthetic Fuel Process			120	450	
	ASSESS ENVIRONMENTAL IMPACT OF SYNTHETIC FUEL PRODUCTION					
021NA-B01-1	Evaluation of Pollution Potential and Pollution Control in Fossil Fuel Conversion Processes	———	———	———	50	400 (Exxon Research)
121NA-A01-0	Environmental Assessment and Data Acquisition - Low-Btu Gas Fuel			350	655	
121NA-A01-0	Ditto - High-Btu Gas Fuel			50	540	
322NA-A01-0	Ditto - Oil Shale			200	260	
122NA-A01-0	Ditto - Liquefaction			0	560	
0603E-A01-0	Environmental Assessment of ERDA Synthetic Fuel Facilities (Interagency--with ERDA)				860	

*Part of ongoing program since 1966.

FUNDING LEVEL OF PROGRAM AREAS (CONTINUED)

EAP Identification Number	TITLE OR SUBJECT	$ THOUSANDS FY 72	FY 73	FY 74	FY 75	Total Through 1974
220-2B-B01-0	Assess Environmental Impact of Oil Refining (Corvallis)				250	
220-2P-A01-0	Environmental Assessment and Data Acquisition for Oil Refining Water Problems (Usage/Contamination)				250	
	Trace Metal Discharges from (and Deposition within Gasifiers)	⟵		⟶		150 (IGT)
010NA-A01-0	Environmental Assessment - Systems Analysis and Support in Synthetic Fuel Area				255	
	DEVELOP CONTROL TECHNOLOGY FOR SYNTHETIC FUELS PRODUCTION PROCESS					
0103E-A01-2	Control Technology Development for Synthetic Fuels--Systems Analysis and Program Support				180	
0563E-A01-2	Control Technology Evaluation and Development--Conversion Process Output Gases			25	200	
0543E-A04-2	Develop HTP Particulate Removal from Gaseous Effluents (Evaluate Operation Parameters and Make Bench-Scale Evaluation				175	

FUNDING LEVEL OF PROGRAM AREAS (CONTINUED)

EAP Identification Number	TITLE OR SUBJECT	$ THOUSANDS FY 72	FY 73	FY 74	FY 75	Total Through 1974
0543E-A01-2	Raw and Acid Gas Cleanup Test Facilities: In-House Bench and Pilot Studies (RTP)				355	
0543E-A02-2	Raw Gas Cleanup by Dolomite (Consol)				1800	(Inter-agency with ERDA)
	High-Temperature vs. Low-Temperature Gas Cleanup--Relative Efficiencies	⟵	———	———	⟶	400 (United Aircraft Research)
	DEMETALLIZATION, DESULFURIZATION, DENITRIFICATION OF OILS (PETROLEUM, SHALE, SYNTHETIC)					
252-2E-A01-2	Develop Technology for Demetallization and Denitrification of Oil			⟵ ———	100 ⟶	100 (Hydrocarbon Research) 40 (MIT)
	BYPRODUCT RECOVERY AND POLLUTANT CONTENT					
054-3E-A03	Development of Controls for Products and Byproducts (Identify Most Urgent Needs; Survey Potential Control Methods)				180	

FUNDING LEVEL OF PROGRAM AREAS (CONTINUED)

EAP Identification Number	TITLE OR SUBJECT	$ THOUSANDS FY 72	FY 73	FY 74	FY 75	Total Through 1974
	Nitrogen, Sulfur, and Trace Metal Balances in Secondary Processing of Synthetic Fuels (Begins with SRC)	⊢———	———	——⊣		40 (P&M)
	Review of Pollutants in Products		⊢——	——⊣		10 (Battelle)
	POLLUTION POTENTIAL FROM UTILIZATION AND TRANSPORTATION OF SYNTHETIC FUELS					
	Retrofit of Industrial Processes to Utilize Low-Btu Synthetic Gas	⊢———	———	——⊣		150 (Battelle)
	Utilization and Disposal of Wastes				180	
	WASTE MANAGEMENT					
0543E-A05-2	Develop Controls for Utilization and Disposal of Conversion Feed/Storage/ Preparation Wastes (Survey Methods and Control; Identify Problems)				200	
0103E-A02-2	Synthetic Fuels Control Technology Development Support from CINN re: Solid Wastes Management				50	

FUNDING LEVEL OF PROGRAM AREAS (CONCLUDED)

EAP Identification Number	TITLE OR SUBJECT	$ THOUSANDS FY 72	FY 73	FY 74	FY 75	Total Through 1974
021NA-A03-0	Environmental Assessment and Data Acquisition for Water-Related Problems/ Synthetic Fuels Study Support RTP/CRV				50	
1513K-A01-1	Evaluation of Water Conservation Alternative for Coal Gasification and Liquefaction (Corvallis)				200	
1443A-A01-3	Determine Effects of "Rain-Out" on Aquatic Ecosystems from Conversion of Coal (Corvallis)				300	
1443A-A02-2	Determine Effects of Power Plant Chemical and Waste Products of Coal Conversion on Aquatic Organisms (Corvallis)				40	

APPENDIX B - EPA REPORTS ON SYNTHETIC FUELS

The following reports were published before January 1975:

EPA No.	NTIS No.	
650/2-73-004	1AB013	"Fate of Trace Constituents of Coal During Gasification," Institute of Gas Technology, IIT Center, Chicago, IL. Order from: NTIS-PB 223 001/AS $3.75.
650/2-73-039	1AB013	"Chemically Active Fluid-Bed Process for Sulfur Removal During Gasification of Heavy Fuel Oil--Second Phase," Esso Research Company, Linden, NJ. Order from: Pending
650/2-73-041	1AB013	"Demetallization of Heavy Residual Oils," W. C. Rovesti and R. H. Wolk, Hydrocarbon Research Incorporated, Trenton, NJ. Order from: NTIS-PB 227 568 $10.25.
650/2-73-041a	PB 241-901/AS	"Demetallization of Heavy Residual Oils--Phase II," HRI (February 1975).
650/2-73-042	1AB013	"Gasification of Fossil Fuels Under Oxidative, Reductive, and Pyrolytic Conditions," Scientific Research Instruments Corporation, Baltimore, MD. Order from: NTIS-PB 228 668/AS $7.00.
650/2-73-049	1AB013	"Production of Clean Fuel Gas From Bituminous Coal," Consolidation Coal Company, Incorporated, Research Division Library, PA. Order from: NTIS-PB 232 695/AS $8.50.

R2-73-249	PB 225-039/AS	Potential Pollutants in Fossil Fuels, Esso Research Company, Linden, NJ (June 1973).
R2-73-272	PB 223-653/AS	Limited Oil Gasification Experiment, IMC (June 1973) 40 pages.
650/2-74-009a	1AB013	"Evaluation of Pollution Control in Fossil Fuel Conversion Processes--Gasification: Section I: Koppers-Totzek Process" by E. M. Magee, C. E. Jahnig, and H. Shaw, Esso Research and Engineering Company, Linden, NJ. Order from: NTIS-PB 231 675/AS $4.25.
650/2-74-009b	1AB013	"Evaluation of Pollution Control in Fossil Fuel Conversion Processes--Gasification: Section I: Synthane Process" by C. D. Kalfadelis and E. M. Magee, Esso Research and Engineering Company, Linden, NJ. Order from: NTIS-PB 237 113/AS $4.75.
650/2-74-009c	1AB013	"Evaluation of Pollution Control in Fossil Fuel Conversion Processes--Gasification: Section I: Lurgi Process," Exxon Research and Engineering Company, Linden, NJ. Order from: NTIS-PB 237 694/AS $4.75.
650/2-74-009d	1AB013	"Evaluation of Pollution Control in Fossil Fuel Conversion Processes--Gasification: Section I: CO_2 Acceptor Process," Exxon Research and Engineering Company, Linden, NJ. Order from: Pending.
650/2-74-009e	PB-240-371/AS	"Evaluation of Pollution Control in Fossil Fuel Conversion Processes--Liquefaction: Section 1; COED Process" (January 1975).
650/2-74-009f	PB 241-792/AS	"Evaluation of Pollution Control in Fossil Fuel Conversion Processes--Liquefaction: Section 2: SRC Process.

650/2-74-009g	PB 243-694/AS	"Evaluation of Pollution Control in Fossil Fuel Conversion Processes--Gasification: Section 5: Bi-Gas Process" (May 1975).
650/2-74-025	1AB013	"Applicability of the Meyers Process of Chemical Desulfurization of Coal: Initial Survey of Fifteen Coals" by A. A. Lee, J. W. Hamersma, M. L. Kraft, C. A. Flegal, and R. A. Meyers, TRW Systems Group, Redondo Beach, CA. Order from: NTIS-PB 232 083/AS $7.00.
650/2-74-048	1AB015	"Development of an Approach to Identification of Emerging Technology and Demonstration Opportunities," Battelle Columbus Laboratories, Columbus, OH. Order from: NTIS-PB 233 646 $8.50.
650/a-74-052	1AB013	"Study of Potential Problems and Optimum Opportunities in Retrofitting Industrial Processes to Low and Intermediate Energy Gas from Coal," Battelle Columbus Laboratories, Columbus, OH. Order from: NTIS-PB 237 116/AS $5.75.
650/2-74-054	1AB013	"Occurrence and Distribution of Potentially Volatile Trace Elements in Coal," Illinois State Geological Survey, Springfield, IL. Order from: NTIS-PB 238 091/AS $4.75.
650/2-74-069	1AA010	"Instrumentation and Methodology for the Assay of Polynuclear Aromatic Hydrocarbons," Exxon Research and Engineering Company, Linden, NJ. Order from: Pending.
650/2-74-072	1AB013	"Sasol Type Process for Gasoline, Methanol, SNG, and Low-BTU Gas from Coal" by F. K. Chan, Kellogg Company, Houston, TX. Order from: NTIS-PB 237 670/AS $4.75.

650/2-74-082	1AB013	"Refinery Catalytic Cracker Regenerator SO_x Control Process Survey," Monsanto Research Corporation, Dayton, OH. Order from: NTIS-PB 237 756/AS $7.50.
650/2-74-099	1AB013	"Environmental Considerations for Oil Shale Development," Battelle Columbus Laboratories, Columbis, OH. Order from: Pending.
650/2-74-109	1AB013	"Chemically Active Fluid-Bed Process for Sulphur Removal During Gasification of Heavy Fuel Oil--Second Phase," ESSO Research Centre, Berkshire, England. Order from: Pending.
650/2-74-118	1AB013	"Symposium Proceedings: Environmental Aspects of Fuel Conversion Technology," St. Louis, MO, Research Triangle Institute, Research Triangle Park, NC (May 1974). Order from: Pending.
660/2-74-050	1BB036	"Research Study of Coal Preparation Plant and By-Product Coke Plant Effluents" by E. F. Pearson, C. F. and T. Steel Corporation, Pueblo, CO. Order from: Pending.
660/2-74-052	1BB039	"Evaluation of Irrigation Scheduling for Salinity Control in Grand Valley" by G. V. Skogerboe, W. R. Walker, J. H. Taylor, and R. S. Bennett, Colorado State University, Fort Collins, CO. Order from: GPO-EP1.23/2:660/2-74-052 $1.30. NTIS-PB 235 633/AS.
660/2-74-067	1BB040	"Pollution Problems and Research Needs for an Oil Shale Industry," by F. M. Pfeffer, Robert S. Kerr Environmental Research Laboratory. EPA, Ada, OK. Order from: GPO-EP1.23/2:660/2-74-067 $0.85. NTIS-PB 236 608/AS.

660/2-74-077	1BA024	"Organic Compounds Entering Groundwater from a Landfill," by J. Robertson, G. R. Toussaint, and M. A. Jorque, University of Oklahoma, Norman, OK. Order from: GPO-EP1.23/2:660/2-74-077 $1.15. NTIS-PB 237 969/AS.
650/2-75-011		"Sulfur and Nitrogen Balances in the Solvent Refined Coal Process," PAMCO (January 1975).
650/2-75-038		"Potentially Hazardous Emissions from the Extraction and Processing of Coal and Oil," Battelle Columbus Laboratories, Columbis, OH. (April 1975), 162 p. Order from: NTIS-PB 241 803/6WP.

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15. SUPPLEMENTARY NOTES

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16. ABSTRACT

The status of EPA's Synthetic Fuels Program as of September, 1974 is presented in nontechnical language. This program is a part of EPA's work directed toward providing the necessary technology for meeting near-term and long-term energy requirements in an environmentally acceptable manner. The program is aimed at controlling and preventing environmental pollution when coal and other fossil hydrocarbons are converted to synthetic fuels and are utilized as products. Program objectives and responsibility are presented in relation to funding level. Significant accomplishments of the program are summarized, and the thrust of future research is discussed. A bibliography of R&D reports directly related to the synthetic fuel program is attached.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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