

Final Report

Task 002

Coal Conversion Comparisons

K.A. Rogers

R.F. Hill

The Engineering Societies Commission on Energy, Inc.
444 North Capitol Street, N.W., Suite 405
Washington, D.C. 20001

Date Published - July 1979

PREPARED FOR THE UNITED STATES
DEPARTMENT OF ENERGY

Under Contract No. EF-77-C-01-2468

PREFACE

The Engineering Societies Commission on Energy, Inc. (ESCOE) is a nonprofit corporation established by the five Founder Engineering Societies to provide independent, objective technical and economic assessments to the Department of Energy. The professional staff at ESCOE consists of Engineers in Residence who are on loan from their employers for approximately two years. Each Engineer in Residence has an outstanding record of experience and achievement related to fossil energy technology.

ACKNOWLEDGMENT

Our special thanks to Thomas J. Joyce, Tom Boyce, Dr. Charles McBeath, and Adrian Wilk, who all contributed directly to various portions of this report. Sincere appreciation also to the many engineers and scientists who gave their time and knowledge in an attempt to make this report as consistent and objective as possible at this point in time. Among the reasons for not naming this group is the wish to avoid any implication that responsibility for the report contents rests on anyone other than the authors.

K.A.R.
R.F.H.

EXECUTIVE SUMMARY

This ESCOE Report examines technologies for producing substitute fuels ("synfuels") from domestic coal. Techniques for comparison are developed and applied to fourteen coal conversion processes.

The conclusion is made that many processes are ready for commercial demonstration but at costs greater than for conventional petroleum fuels. All product costs in the report are based on the recently published ESCOE costing guidelines using both utility and private venture financing. All costs are in mid-1979 dollars.

There have been many studies by others covering the same conversion processes included in this report. The results of these other studies cannot usually be compared directly due to differences in size, economic and technical bases. This report puts the process data and costs on a consistent basis to achieve the comparison of product costs.

Most other studies report cost for derived products solely on an energy basis, \$/million Btu. However, because the actual fuels have different inherent values (a gallon of boiler fuel is not usually worth as much as a gallon of gasoline), an economic comparison method was developed to reflect the value differences of the different fuel products. The ESCOE value method assigns relative values to all products from a multi-product synfuel process. This method incorporates the preferences of the marketplace to arrive at the necessary selling prices for each product. This report also gives process costs on the conventional energy basis. Two methods of financing, using typical utility and private venture returns on investment, are included for all products.

The report divides the fourteen conversion processes studied into six groups: solid clean fuel, direct liquefaction, indirect liquefaction, synthetic natural gas, industrial gas, and electric power from a combined cycle-integrated gasifier system. Three of the processes are shown in an alternate mode of operation giving a total of seventeen sets of energy costs.

The prediction is made that no major technological advances are expected which will significantly decrease synfuel costs.

A discussion of impacts and commercialization barriers is included. The obstacles to establishing a viable coal conversion industry are chiefly lack of assured markets and high costs rather than technical uncertainties.

Table of Contents

	<u>Page</u>
Preface -----	ii
Executive Summary -----	iii
1.0 Introduction -----	1
1.1 Purpose of Study -----	1
1.2 Scope -----	3
1.3 Coal Resources -----	5
1.4 Mechanical Upgrading -----	5
1.5 Chemical Processes -----	6
2.0 Comparison Methods -----	9
2.1 Efficiency -----	9
2.2 Process Complexity -----	10
2.3 Economics -----	11
2.3.1 Cost per Unit of Energy -----	11
2.3.2 Energy Products Market -----	12
2.3.3 Product Value Technique -----	12
3.0 Process Descriptions -----	18
3.1 Solid Processes -----	18
3.1.1 SRC-I -----	19
3.2 Liquid Processes -----	20
3.2.1 SRC-II -----	21
3.2.2 EDS -----	22
3.2.3 H-Coal -----	22
3.2.4 Fischer-Tropsch -----	23
3.2.5 Methanol and M-gasoline -----	23
3.3 Gas Processes -----	24
3.3.1 CO ₂ Acceptor -----	25
3.3.2 Hygas -----	26
3.3.3 Bigas -----	27
3.3.4 Synthane -----	28
3.3.5 Lurgi Process, Dry Bottom -----	28
3.3.6 Slagging Lurgi Process -----	29
3.4 Other Processes -----	30
3.4.1 Combustion Engineering -----	31
3.4.2 Westinghouse -----	31
4.0 Technical Review -----	34
4.1 Process Complexity -----	34
4.1.1 Reactor Comparison -----	37
4.2 Process Comparisons -----	40
4.2.1 Efficiency -----	41
4.2.2 Process Development Status -----	41
4.3 Products -----	44
4.3.1 Solid Products -----	46
4.3.2 Liquid Products -----	46
4.3.3 Gaseous Products -----	46
4.3.4 By-Products -----	48
4.3.5 Power -----	48

	<u>Page</u>
5.0 Economics -----	49
5.1 Coal -----	50
5.2 Operating Cost -----	50
5.3 Capital Cost -----	51
5.3.1 Utility Financing -----	52
5.3.2 Private Financing -----	52
5.4 Products Amount -----	55
5.5 Product Cost -----	55
5.6 Cost Comparison -----	57
6.0 Commercialization Prospects -----	61
6.1 Commercial Compatibility -----	61
6.2 Social Compatibility -----	61
6.3 Utility Applications -----	62
6.4 Time Requirements -----	64
6.5 Constraints on Commercialization -----	64
6.6 Regulatory Prospects -----	67
6.6.1 SNG Regulation -----	67
6.7 Environmental Impact -----	69
7.0 Conclusions -----	72
References -----	74
Glossary -----	77
Appendix 1 - Product Specifications -----	78
Appendix 2 - Product Cost Calculation -----	81
Appendix 3 - Cost Sensitivity and Inflation -----	84
Appendix 4 - Coal Resources -----	86

List of Tables

Table 2.1: Value Factors for Energy Products -----	17
Table 4.1: Process Complexity -----	36
Table 4.2: Reactor Conditions -----	38
Table 4.3: Process Confidence Index -----	41
Table 4.4: Process Summary -----	42
Table 4.5: Products Summary -----	45
Table 5.1: Plant Capital Requirements -----	53
Table 5.2: Financial Data for Product Cost -----	54
Table 5.3: Product Cost - Energy Basis -----	56
Table 5.4: Products Cost -- Value Basis with Utility Financing -----	58
Table 5.5: Products Cost -- Value Basis with Private Financing -----	59
Table A : Cost Data -----	83