

TABLE OF CONTENTS

	<u>Page</u>
EXECUTIVE SUMMARY.	1
TABLE OF CONTENTS.	i
LIST OF FIGURES	iv
LIST OF TABLES	v
LIST OF EXHIBITS	viii
CHAPTER 1: INTRODUCTION	1-0
1.1 Role of Synthetic Fuels	1-1
1.2 Scope of Study	1-2
CHAPTER 2: BACKGROUND	2-0
(I) Description of the Coal Conversion and Oil Shale Retorting Fuel Cycles	
2.1 Overview of the Coal and Oil Shale Fuel Cycles	2-1
2.2 Coal and Oil Shale Resources.	2-1
2.3 Exploration and Mining.	2-6
2.4 Beneficiation	2-9
2.5 Transportation.	2-10
2.6 Conversion.	2-10
2.7 Upgrading and Refining.	2-10
2.8 Distribution to End Users	2-13
(II) Characteristic Synfuel Technologies Parameters	
2.9 Common Elements	2-15
2.10 Physical Size	2-15
2.11 Complexity.	2-15
2.12 costs	2-17
2.13 Conversion Efficiency	2-18
2.14 Other Requirements and Concerns	2-18
CHAPTER 3: OVERVIEW OF SELECTED SYNTHETIC FUEL CONVERSION PROCESSES	3-0
3.1 General Synfuel Processes	3-1
3.2 Coal Gasification	3-2
3.3 Coal Liquefaction	3-8

	<u>Page</u>
3.3.1 General	3-8
3.3.2 Liquid Solvent Refined Coal (SRCII)	3-11
3.3.3 Exxon Donor Solvent	3-14
3.3.4 H-Coal	3-17
3.3.5 Fischer-Tropsch Process	3-21
3.3.6 Methanol Process	3-26
3.4 Oil Shale Retorting	3-31
3.4.1 General	3-31
3.4.2 Surface Retorting	3-31
3.4.3 Modified In Situ Retorting	3-36
3.5 Comparison of the Various Synfuel Systems With Respect to Resource Requirements	3-40
CHAPTER 4: SYNTHETIC FUEL PROCESSES CONVERSION COST AND PRODUCT ECONOMICS	4-0
4.1 Conversion Costs and Product Economics	4-1
4.2 Scale of Production	4-7
4.3 product Quality	4-8
4.4 Estimating Methods	4-11
4.5 product Upgrading	4-22
4.6 Refining Synthetic Liquids	4-28
4.7 Transportation and Other Infra- structure Costs	4-36
4.8 Addendum to Chapter 4: Basis for Cost Assumptions	4-43
1. Basic Conversion Plant	4-43
2. Assumptions of Product Upgrading	4-44
3. Refining Cost ⁰ Assumptions	4-46
CHAPTER 5: SUPPLY DEPLOYMENT SCENARIOS FOR SYNTHETIC FUELS	5-0
5.1 Factors and Constraints Affecting Synfuel Development	5-1
5.2 Constraining Factors in the Transi- tion period: 1980-2000	5-3

	<u>Page</u>
5.2.1 Equipment Problems	5-4
5.2.2 Critical Materials	5-6
5.2.3 Manpower	5-6
5.2.4 Coal Supply	5-9
5.2.5 Water Supply	5-13
5.2.6 Environmental Health and Safety	* 5-13
5.2.7 Siting	9 5-14
5.2.8 Transportation	* 5-15
5.2.9 Tradeoffs	9 5-15
5.3 Development of Supply Deployment Scenario and Comparisons With Other Estimates	 5-17
(A) Shale Oil Scenario	5-17
(B) Coal Gases Scenario	5-23
(C) Coal Liquids	5-32
(D) Summary Tables and Compari- sons	 5-38
5.4 Labor Requirements Associated With the Scenarios	 5-42
5.4.1 Operations Labor Needs	5-42
5.4.2 Construction Labor Needs	5-44
5.4.3 Regional Deployment of Synthetic Fuel Plants Work Force	 5-49
5.5 Additional Concerns and Impacts: Product Acceptability Concerns	 5-50
5.6 Foot notes to Chapter 5	5-53

APPENDICES

Appendix to Chapter 2: Typical Mining Characteristics	A-1
--	-----

Appendix to Chapter 5:

(A) Status of Process Development	A-1
(B) Existing U.S. and Foreign ^{LOW} and Medium-Btu Gasification Systems	B-1
(C) U.S. DOE Cooperative Agreements and Feasibility Study Grants for Syn- fuels	* * * * * C-1

GLOSSARY	G-1
--------------------	-----

BIBLIOGRAPHY	B-1
------------------------	-----

LIST OF FIGURES

	<u>Page</u>
Figure 1.1: U.S. Synthetic Fuels Production Goals 1985-2000.	1-3
Figure 2.1: Coal Conversion System	2-2
Figure 2.2: Oil Shale Retorting System	2-3
Figure 2.3: Coal Fields of the ^{conterminous-} United States.	2-4
Figure 2.4: Oil Shale Deposits of the United States.	2-5
Figure 2.5: Crude Oil Pipeline Network	2-14
Figure 3.1: Basic Coal Gasification Processes.	3-4
Figure 3.2: Schematic Diagram of Coal Gasification	3-5
Figure 3.3: Schematic Diagram of the Basic Liquefaction Processes	3-10
Figure 3.4: Schematic Diagram of the Solid Refined Coal (SRC-II) Process.	3-12
Figure 3.5: Schematic Diagram of the Donor Solvent Liquefaction Process	3-16
Figure 3.6: Schematic Diagram of the H-Coal Process.	3-20
Figure 3.7: Fischer-Tropsch Synthesis.	3-25
Figure 3.8: Synthesized Gasoline From Coal	3-27
Figure 3.9: Mobil Catalytic Process.	3-28
Figure 3.10: The TOSCO II Oil Shale Retorting System	3-32
Figure 3.11: Modified In Situ Retorting	3-37
Figure 3.12: Occidental Modified In Situ Retorting.	3-38
Figure 5.1: Comparison of Synthetic Fuel Production Estimates.	5-41

LIST OF TABLES

	<u>Page</u>
Table 2.1: U.S. by States--Resources-Reserve Base-Production--Bituminous- Subbituminous-Lignite Coal.	2-7
Table 2.2 : Potential Shale Oil in Place in the Oil Shale Deposits of the United States .	2-8
Table 2.3 : Process Summary	2-19
Table 3.1: Solvent Refined Coal II (SRC-II)	3-13
Table 3.2: Typical Properties of SRC Fuels Using Recycle SRC Process	3-15
Table 3*3: Donor Solvent Product Analysis.	3-18
Table 3.4: Estimated Heat Balance for a Commercial- Scale EDS Plant	3-19
Table 3.5 : Properties of H-Coal Distillates From Illinois No. 6 Coal Liquids	3-22
Table 3.6 : H-Coal.	3-23
Table 3.7: Overviews of SASOL I and SASOL 11	3-24
Table 3.8: Thermal Efficiencies--Methanol-to- Gasoline --Fischer-Tropsch	3-29
Table 3.9: Methanol-to-Gasoline Balances	3-30
Table 3 .10: Basic Material Balance for a TOSCO II Retort Module	3-33
Table 3 .11: Estimated Energy Balance for a TOSCO II Plant.	3-34
Table 3 .12: TOSCO II Oil Shale Retorting.	3-35
Table 3 .13: Modified In Situ Shale Retorting (Occidental).	3-39
Table 3 .14: Resource Utilization Efficiencies of Synthetic Fuel Energy Systems	3-41
Table 3 .15: Fossil Carbon Consumption of Synthetic Fuel Energy Systems	3-43

	<u>Page</u>
Table 3.16 : Water Consumption of Synthetic Fuel Energy Systems.	3-44
Table 3.17 : Manpower Requirements of Synfuel Energy Systems.	3-46
Table 3.18: Annual Feedstock Requirements for Synthetic Fuel Energy Systems	3-48
Table 3.19 : Annual Water Consumption of Synthetic Fuel Energy Systems	3-49
Table 3.20: Annual Manpower Requirements of Synthetic Fuel Energy Systems "	3-50
Table 5.1: Potentially Commercial Scale Projects-Shale Oil .."	5-18
Table 5.2 : Shale Oil Build-up Scenarios"	5-20
Table 5.3: Shale Oil Deployment Scenarios (and Comparisons).	5-21
Table 5.4: Estimated Typical Shale Oil product Slate 1980-2000 (For Scenarios)	5-22
Table 5.5: Potential Commercial Scale Projects--Low\Med Btu Gas	5-25
Table 5.6 : Potential Commercial Scale Projects--H-Btu Gas	5-28
Table 5.7: Scenario Deployment: H-Btu and Med\Low Btu Gas	5-30
Table 5.8: Synthetic Coal Gases Comparison	5-31
Table 5.9: Potential Commercial Scale Projects--Coal Liquids. * *	5-34
Table 5.10 : Coal Liquids Build-up Rate Scenario: Indirect and Direct . ..0. .***	5-35
Table 5.11: Coal Liquids Build-up Rate Scenarios.	5-36
Table 5.12: Coal Liquids Comparisons.	5-37
Table 5.13 : Summed Synthetic Fuel Deployment Schedules	5-39

	<u>Page</u>
Table 5 .14: Comparison of Synthetic Fuel Production Estimates	5-40
Table 5 .15 : Aggregate Operations Labor Needs.	5-43
Table 5 .16: Direct Coal Liquids--Incremental Construction Labor Requirements for Plants Coming On-Line in Period Ending. . .	5-45
Table 5.17: Indirect Coal Liquids--Incremental Construction Labor Requirements for Plants Coming On-Line in Period Ending. . .	5-46
Table 5.18: Shale Oil--Incremental Construction Labor Requirements for Plants Coming On-Line in Period Ending.	5-47
Table 5.19: Coal Gases--Incremental Construction Labor Requirements for Plants Coming On-Line in Period Ending.	5-48
Table 5.20: Regional Share of Incremental Con- struction Work Force for Plants Coming On-Line in Period Ending	5-49

LIST OF EXHIBITS

		Page
Exhibit 4-1:	Plant Capital Requirements	4-3
Exhibit 4-2:	Total Conversion Plant Investment	4-4
Exhibit 4-3:	Cost Data--Operating and Maintenance cost	4-5
Exhibit 4-4:	Annual Operating Cost	4-6
Exhibit 4-5:	Synthetic Plant Product Yields	4-10
Exhibit 4-6:	Synthetic Fuel Production Costs Original Estimates - Raw Liquids	4-12
Exhibit 4-7:	Cost Growth in Pioneer Energy Process Plants	4-14
Exhibit 4-8:	History of Shale Oil Capital Cost Estimates	4-15
Exhibit 4-9:	Synthetic Fuels Production Costs, Factored Cost Estimates, Raw Liquids	4-17
Exhibit 4-10:	Best Available Estimates - Typical Synfuel Processes	4-18
Exhibit 4-11:	Synthetic Fuels production Costs Factored Cost Estimates, Raw Liquids, Best Estimates	4-21
Exhibit 4-12:	Simplified Flow Diagram of Chevron First State Hydrotreater Refining of SRC-II Oil	4-23
Exhibit 4-13:	Direct Liquids Upgrading Costs	4-25
Exhibit 4-14:	Direct Liquids Upgraded Costs/Barrel	4-27
Exhibit 4-15:	Synthetic Fuels Production costs, Best Available Estimates, Upgraded Liquids*	4-29
Exhibit 4-16:	Process and Slate	4-31
Exhibit 4-17:	Synthetic Fuels Production Costs, Best Available Cost Estimates - Refined Liquid Fuels	4-33

	Page
Exhibit 4-18: Direct Liquids (SRC-II) Refining	4-34
Exhibit 4-19: SRC II Refined To Product Costs	4-35
Exhibit 4-20: Synthetic Fuel Liquids	4-37
Exhibit 4-21: Schematic Flow Diagram--Refining of SRC-II Oil by Hydrotreating and Hydrocracking--Case I	4-38
Exhibit 4-22: Schematic Flow Diagram--Refining of SRC-II Oil by High Severity Hydrotreating--Case II	4-39
Exhibit 4-23: Simplified Flow Diagram--Refining of SRC-II Oil by Moderate Severity Hydrotreating--Case III	4-40
Exhibit 5.1: Potentially Critical Materials and Equipment Requirements for Coal Liquids Plants and Associated Mines. . .	5-7
Exhibit 5.2: Selected Material and Equipment Items Required	5-8
Exhibit 5.3: Total Engineering Manpower Require- ments for Coal Liquids Plants and Associated Mines	5-10
Exhibit 5.4: Projected Peak Construction Labor Requirements	5-11
Exhibit 5.5: Regional Manual Labor for Construction and Maintenance for Coal Liquids Plants and Associated Mines	5-12
Exhibit 5.6: Tradeoffs in Shale Development	5-16