APPENDICES

APPENDIX TO CHAPTER 2

Typical Mining Characteristics: Tables 3-8
From Reference: "Technology Characterizations"
U.S. DOE, June 1980

ENERGY SYSTEM:

SIZE
- 20-year mine life
- 4 million tons per year
- 102.8×10^{12} Btu per year equivalent
- Eastern area mine, Northern Appalachian district

DESCRIPTION
- In the East, modified area mining is generally used in areas where the terrain is gentle (5° to 10° slope) and the overburden does not exceed about 100 feet. Typically, the thickness of the coal bed averages six feet and the efficiency of removal is about 80 percent (in terms of Btu recovered). Blasting with light charge is frequently needed to improve the mining. Overburden from each successive cut is placed in the previous one. Regrading to approximate the original land form is undertaken. Topsoil is replaced and revegetation is begun. Coal is transported to an offsite coal preparation plant.

COMPONENTS	Quantity
• power shovels	2
• trucks	7
• front end loaders	2
• scrapers	4
• coal shovel	2
• drilling equipment	4
• graders	2
• cable handler & reel	2
• bulldozers	8

ENVIRONMENTAL CONCERNS
- aesthetics
- acidic mine drainage contamination of surface and groundwater
- blasting damage and noise pollution
- vehicular emissions
- fugitive dust
- erosion
- altered land use

RESOURCES USED: (Per 10^{12} Btu Produced)	
RESOURCE DEPLETION	
in-place coal	48,638 tons
energy content	12,850 Btu/lb
COAL ANALYSIS	(by weight)
moisture	3.9
volatile matter	34.1
fixed carbon	52.4
ash	9.6
sulfur	2.1
nitrogen	1.1
ENERGY	
diesel fuel	6.0×10^9 Btu
electricity	5.9×10^5 kWh
LAND	Acres
fixed	0.3
incremental	6.1
WATER	Acre-Feet
consumption	1.7
COSTS	Dollars (1977)
construction	
total construction cost	1.24×10^6
other investments and fees	0.68×10^6
operation	
general mining cost	0.46 x 10[illegible]
reclamation and sediment control	3 x 10[illegible]
PERSONNEL	Workers
construction	
non-manual, technical	1.0
non-manual, non-technical	0.2
manual	4.7
operation	
non-manual, technical	0.8
non-manual, non-technical	1.1
manual	2.4

RESIDUALS (Per 10^{12} Btu Produced)	GROSS (tons)	NET (tons)
AIR POLLUTANTS		
particulates[1]	0.06	0.02
SO_2	0.1	0.1
NO	1.5	1.5
hydrocarbons	0.2	0.2
CO	0.9	0.9
WATER POLLUTANTS		
Total Dissolved Solids	35.6	20.8
Iron	0.4	0.0004
Manganese	0.4	0.1
Aluminum	0.6	0.03
Zinc	0.02	0.002
Nickel	0.006	0.002
Sulfate	16.1	14.3
Total Suspended Solids	4.8	0.4
Iron	0.02	0.004
Ammonia	0.06	0.02
SOLID WASTE[2]		
overburden removal	435	0
runoff treatment	390	0
ENERGY PRODUCT		
raw coal - 38,910 tons		

(1) Assumes a 60% reduction in fugitive dust emissions through dust suppression.
(2) Assumes all solid waste is returned to mining pits.

SOURCES: The MITRE Corporation, Annual Environmental Analysis Report, 1977.
University of Oklahoma, Energy Alternatives: A Comparative Analysis, 1975.
TRW, Meso Environmental Data Book, Volume IV, 1978.
Hittman Associates, Inc., Environmental Impacts, Efficiency, and Cost of Energy Supply and End Use, Volume I, 1974.
Bechtel Corporation, Energy Supply Planning Model, 1978.
Bureau of Mines, Basic Estimated Capital Investment and Operating Costs for Coal Strip Mines, 1976.
Energy and Environmental Analysis, Coal and Profitability, 1979.
Bureau of Land Management, Federal Coal Management Program, Final Environmental Statement, 1979.

ENERGY SYSTEM:

SIZE
- 6 million tons per year
- 1.1 x 10^{14} Btu per year equivalent
- 30 year mine life
- Western area mine, Powder River Basin

DESCRIPTION:

- In Wyoming and Montana, the two states which will account for most of the increase in production in the West, area strip mining is the dominant surface mining technique. After segregating the topsoil for subsequent reclamation purposes, and after blasting, the overburden (averaging 70 feet) is removed in long parallel cuts. The now exposed and blasted coal seam (averaging 25-30 feet) is removed (89 percent efficiency in terms of Btu recovered). With the exception of the first cut, overburden from each cut is placed in the previous one. Coal is loaded into trucks for transport to a coal cleaning area. Reclamation consists of grading the spoil, replacing the topsoil and initiating revegetation.

COMPONENTS	Quantity
• trucks	31
• front end loaders	2
• scrapers	8
• draglines	2
• bulldozers	12
* drilling equipment	6
* graders	2
* coal shovel	2
° cable handler and reel	2

ENVIRONMENTAL CONCERNS
- fugitive dust and vehicular emissions
- reclamation
- alkaline mine drainage
- erosion
- noise
- aesthetics
- altered land use

RESOURCES USED:
(Per 10^{12} Btu Produced)

RESOURCE DEPLETION	
total in-place coal	59,449 tons
heat content	9,450 Btu/lb
COAL ANALYSIS	**% (by weight)**
moisture	21.5
volatile matter	34.5
fixed carbon	39.6
ash	4.4
sulfur	0.4
nitrogen	1.2
ENERGY	
fuel	0.8 x 10^{9} Btu
electricity	1.1 x 10^{5} kWh
LAND	**Acres**
fixed	0.4
incremental	1.8
WATER	**Acre-feet**
consumption	3.8
COSTS	**Dollars (1977)**
construction	
total construction cost	1.32 x 10^{6}
other investments and fees	0.23 x 10^{6}
operation	
general mining cost	0.28 x 10^{6}
reclamation and sediment control	2 x 10^{3}
PERSONNEL	**Workers**
construction	
non-manual, technical	1.1
non-manual, non-technical	1.2
manual	2.2
operation	
non-manual, technical	0.7
non-manual, non-technical	0.9
manual	1.9

RESIDUALS (Per 10^{12} Btu Produced)	GROSS (Tons)	NET (Tons)
AIR POLLUTANTS		
Particulates(1)	0.2	0.08
SO_2	0.2	0.2
NO	2.0	2.0
hydrocarbons	0.2	0.2
CO	1.2	1.2
WATER POLLUTANTS		
Total Dissolved Solids	90.9	23.9
Iron	0.005	0.005
Manganese	0.02	0.02
Aluminum	0.006	0.006
Zinc	0.005	0.005
Nickel	0.001	0.001
Sulfate	41.1	32.7
Total Suspended Solids	3.0	2.3
Iron	0.002	0.02
Ammonia	0.1	0.2
SOLID WASTE(2)		
overburden removal	745	0
runoff treatment	NA	0
ENERGY PRODUCT		
raw coal - 52,910 tons		

(1) Assuming 60% reduction in fugitive dust emissions through dust suppression.
(2) Assumes all solid waste is returned to mining pits.

SOURCES: The MITRE Co po on Ann Env onmen Ass
Un Ok homa [redacted] Com Ass, 1975.
Bd En Dn
, Environmental Impacts ency, and Cost of Energy Supply and End Use, Volume I, 1974.
fay Supply Planning Mod
1976.
Environmental Statement, 1979.

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TABLE 5 - Underground Coal Mining—Eastern

ENERGY SYSTEM:

SIZE
- 2 million tons per year
- 31.4×10^{12} Btu per year equivalent
- 20 year mine life

DESCRIPTION
- The mining involves driving main entries with production entries normal to the main entry on the right and left. As mining advances on one side of the main entry, rooms are excavated in the five foot coal seam. The strata above the seam is supported by pillars of coal. After an entire section is mined, part of the coal in the pillar is recovered (overall, about 57 percent recovery is possible) as a return to the main entry is made. With a mechanized continuous miner, many of the mining operations performed in the same section are executed simultaneously. An electric powered continuous miner either bores, digs or rips the coal from the working face. Coal is then loaded into a ratio feeder at the tail piece of a unit belt conveyor.

COMPONENTS	Quantity
• mainline belt conveyor	1
• roof bolting machines	13
• ventilating fan	1
• continuous mining machines	11
• loading machines	11
• shuttle car	22
• ratio feeder	11
• rock duster	12
• supply motor	5
• mainline power center	5
• section rectifier	11
• auxiliary fan	13
• section belt power center	7

ENVIRONMENTAL CONCERNS
- solid waste disposal
- runoff from waste piles
- acid mine drainage
- subsidence of surface area
- noise

RESOURCES USED:
(Per 10^{12} Btu Produced)

RESOURCE DEPLETION	
total in-place coal	68,264 tons
energy content	12,850 Btu/lb
COAL ANALYSIS	(by weight)
moisture	3.9
volatile matter	34.1
fixed carbon	52.4
ash	9.6
sulfur	2.1
nitrogen	1.1
ENERGY	kWh
electricity	7.2×10^5
LAND	Acres
fixed	0.3
incremental	11.7
WATER	Acre-Feet
consumption	2.3
COSTS	Dollars (1977)
construction	
manpower	1.7×10^5
material	1.1×10^5
equipment	3.8×10^5
other investments and fees	7.1×10^5
operation	
manpower	4.9×10^5
material	0.8×10^5
equipment	1.4×10^5
other costs	3.6×10^5
PERSONNEL	Workers
construction	
non-manual, technical	1.3
non-manual, non-technical	0.1
manual	4.3
operation	
non-manual, technical	3.9
non-manual, non-technical	5.2
manual	12.4

RESIDUALS AND PRODUCTS:
(Per 10^{12} Btu Produced)

AIR POLLUTANTS
Air emissions from equipment are not considered a problem in underground extraction since most equipment is electric powered.

	GROSS (Tons)	NET (Tons)
particulates	negligible	
SO_2	negligible	
NO	negligible	
hydrocarbons	negligible	
CO	negligible	
aldehydes	negligible	
WATER POLLUTANTS		
Total Dissolved Solids	396.4	392.0
Iron	22.4	0.02
Manganese	0.6	0.2
Aluminum	3.6	1.7
Zinc	0.1	0.02
Nickel	0.06	0.02
Sulfate	197.8	174.9
Strontium	0.2	0.2
Chloride	0.6	12.7
Fluoride	0.1	0.1
Calcium carbonate*	101.7	138.3
Total Suspended Solids	19.0	1.7
Iron	7.0	0.2
Ammonia	1.0	0.3
SOLID WASTE		
from sinking the mine shaft	2.5	2.5
from treating mine water runoff	0	2,090
from extraction process	NA	NA

ENERGY PRODUCT
raw coal - 38,910 tons

*Calcium carbonate net emissions are greater than calcium c bons on ons be um bons ad ad we we as part of the treatment process.

SOURCES: The MITRE Corporation, Annual Environmental Analysis Report, 1977.
University of Oklahoma, Energy Alternatives: A Comparative Analysis, 1975.
TRW, Mess Environmental Data Book, Volume IV, 1978.
Hittman Associates, Inc., Environmental Impacts, Efficiency, and Cost of Energy Supply and End Use, Volume I, 1974
Bechtel Corporation, Energy Supply Planning Model, 1978.
Bureau of Mines, Basic Estimated Capital Investment and Operating Costs for Coal Strip Mines, 1976.
Bureau of Land Management, Federal Coal Management Program, Final Environmental Statement, 1979.

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TABLE 6 - Surface Oil Shale Mining

ENERGY SYSTEM:

SIZE
- 73,700 tons of raw shale per day
- 0.413 x 10^{12} Btu/day
- 2,800 Btu/pound of raw shale
- 30 gallons/ton shale oil content
- mine operates 328.5 days/year
- 24.2 x 10^{6} tons of shale mined/year
- total annual output is 136.67 x 10^{12} Btu
- mine life is 30 years

DESCRIPTION
- In surface mining, the overburden is removed exposing the underlying shale. Shale is mined using the bench technique. Shale is fractured through drilling and blasting and transported by trucks to primary crushing site.

COMPONENTS
- drilling equipment
- excavation equipment (cranes)
- crushers
- trucks

ENVIRONMENTAL CONCERNS
- air quality deterioration
- noise
- water requirement
- contamination of underground water supplies with saline mine water

RESOURCES USED:
(Per 10^{12} ● IM Produced)

FUEL	**Tons**
raw unmined shale	178,450
ENERGY	
electricity for operating drilling equipment and trucks	NA
COMPOSITION	**% (by weight)**
organic material	17.1
water	1.4
inorganic material	81.5
LAND(1)	**Acres**
mine development	0.8
disposal of permanent overburden	7.6
storage of spent shale	1.1
disposal of spent shale	1.1
WATER	**Acres-Feet**
mining and crushing	2.8 (2.2 - 3.3)
COSTS	**Dollars (1978)**
construction(2)	
manpower	226,033
materials	28,809
● Qutpmoat	339,649
● cher cost	14,792
total	609,283
operation & maintenance	NA
PERSONNEL	**Workers**
construction	NA
operation & maintenance	NA

RESIDUALS AND PRODUCTS:
(Per 10^{12} Btu Produced)

AIR POLLUTANTS	**Tons**
● artlcdolso	21.79
SO_2	0.21
NO_x	2.05
hydrocarbons	3.44
CO	1.00
WATER POLLUTANTS	
probability of ● l 1 O C contamination of underground water by mine water	
SOLID WASTE	
negligible (.00 Processing)	
ENERGY PRODUCT	**Tons**
mined shale rock	178,450

(1) This represents land committed to use over the lifetime of the plant, divided by the annual output of the plant, expressed in trillion Btu.
(2) This represents total cost of constructing the plant, divided by the annual output of the plant, expressed in trillion Btu.

SOURCES: Environmental Protection Agency, Monitoring Environmental Impacts of the Coal and Oil Shale Industries, 600/7-77-015, February 1977.
Cameron Engineers Incorporated, Synthetic Fuels Handbook, 1975.
Department of Energy, Draft Environmental Impact Statement for the (updated) Prototype Oil Shale Leasing Program, 1979.
University of Oklahoma, Energy Alternatives: A Comparative Analysis, 1975.
Bechtel Corporation, Energy Supply Planning Model, 1978.

TABLE7 - UndergroundOilShale Mining

ENERGY SYSTEM:

SIZE
- 73,700 tons of raw shale per day
- 0.413 x 10^{12} Btu/day
- 2,800 Btu/pound of raw shale
- 30 gallons/ton shale oil content
- mine operates 328.5 days/year
- 24.2 x 10^{6} tons of shale mined/year
- total annual output is 135.67 x 10^{12} Btu
- mine life is 30 years

DESCRIPTION
- Underground mining uses room and pillar technique. The oil shale deposit is entered through a tunnel dug into the side of a valley where an outcrop appears. Pillars are left in place to provide roof support at appropriate intervals. Extraction is also accomplished by drilling and blasting. The broken shale is transported to portable crusher for primary crushing.

COMPONENTS
- drilling equipment
- excavation equipment (cranes)
- crushers
- trucks

ENVIRONMENTAL CONCERNS
- air quality deterioration
- noise
- water requirement
- contamination of underground water supplies with saline mine water

RESOURCES USED:
(Per 10^{12} Btu Produced)

FUEL	Tons
raw unmined ● halo	178,450

ENERGY	
electricity for operating drilling equipment and trucks	NA

COMPOSITION	% (by weight)
organic material	17.1
water	1.4
inorganic material	81.5

LAND(1)	Acres
mine development	0.15
crushing	2.93

WATER	Acre-Feet
mining and crushing	2.8 (2.3 - 3.3)

COSTS	Dollars (1978)
construction(2)	
manpower	164,224
materials	43,249
● qulpanc	254,842
other cost	82,341
total	544,655
● Nrttl= & maintenance	NA

PERSONNEL	Workers
construction	484
operation & maintenance	NA

RESIDUALS AND PRODUCTS:
(Per 10^{12} Btu Produced)

AIR POLLUTANTS	Tons
particulates	4.46
SO_2	0.012
NO_x	0.17
hydrocarbons	0.019
CO	0.10

WATER POLLUTANTS
probability of ● dIBO contamination ● r underground water with ● Im4 water

SOLID WASTE
negligible (see Processing)

ENERGY PRODUCT	Tons
● trod ● IM1O rock	178,450

(1) This represents land committed to use over the lifetime of the plant, divided by the annual output of the plant, expressed in trillion Btu.
(2) This represents total cost of constructing the plant, divided by the annual output of the plant, expressed in trillion Btu.

SOURCES: Environmental Protection Agency, Monitoring Environmental Impacts of the Coal and Oil Shale Industries, 600/7-77-015, February, 1977.
Cameron Engineers Incorporated, Synthetic Fuels Handbook, 1975.
Department of Energy, Draft Environmental Impact Statement for the (updated) Prototype Oil Shale Leasing Program, 1979.
University of Oklahoma, Energy Alternatives: A Comparative Analysis, 1975.
Bechtel Corporation, Energy Supply Planning Model, 1978

ENERGY SYSTEM:

SIZE
- Process 2,857,000 tons of run-of-mine (ROM) coal each year to produce 2 million tons of clean coal
- Hourly capacity 950 tons of ROM coal
- Operates 3,000 hours per year, representing ten shifts per week, 250 days per year
- 20 year plant life
- 87.5% efficiency (in terms of Btus)
- yield by weight is 70%

DESCRIPTION
- Coal beneficiation is a process for upgrading coal prior to its use for metallurgical or utility purposes. The purpose of beneficiation is to remove impurities (i.e. ash and/or sulfur) from raw coal. The degree of beneficiation depends on the type of coal and its ultimate use. The system described on this summary sheet (level E per Phillips et al.) is a relatively intense procedure. It removes more sulfur and ash than most other types of beneficiation, and it is also more costly. The resultant cleaned coal would be used for metallurgical purposes.

COMPONENTS
- scalping screen
- crusher
- rotary be-bar
- vibrator screens
- jigs
- 40uatorlagmtpt
- thickeners
- filters
- concentrating tables ● r hydroclones
- flotation circuits
- thermal drying

ENVIRONMENTAL CONCERNS
- ● artlcul.t. emissions
- solid waste disposal
- ● wrtaco water contamination from settling pond overflow and/or refuse pile runoff
- possible ground water contamination from ● octllq pond leaching
- noise

RESOURCES USED:
(Per 10^{12} Btu Produced)

FUEL	Tons
run-of-mine (ROM) or raw coal (assuming one ton of ROM coal has an energy content ● 1 11 ● Iltloa Btus per 800)	51,945

ENERGY(1)	
electricity	2.0×10^5 kWh
oil	5.9×10^8 Btu

LAND	Acres(2)
washing plant	0.2
loading facility	1.8
settling pond	2.3

WATER	Acre-Ft.
consumption	3.7

COSTS	Dollars (1976)
construction	6.3×10^5
operation and maintenance	3.2×10^5

PERSONNEL	Workers
construction (1 year)	8.1
operation and maintenance	1.5

RESIDUALS AND PRODUCTS:
(Per 10^{12} Btu Produced)

AIR POLLUTANTS	Tons (Gross)	Tons(3) (Net)
particulates	91	0.9
SO_2	2.7	0.005
NO_x	1.5	0.6
hydrocarbons	1.1	0.1
CO	5.4	0.2

WATER POLLUTANTS	Tons (Gross)	Tons(3) (Net)
total dissolved solids	143	33
iron	0.2	0.007
manganese	0.2	0.03
aluminum	1.1	0.04
zinc	0.04	0.005
nickel	0.01	0.00)
sulfates	98	18
total suspended solids	5,870	0.6
iron	4.6	0.06
ammonia	0.2	0.05

SOLID WASTE	Tons(4)
primary breaking	0
coarse cleaning(5)	2
raw-coal sizing	0
primary cleaning	10,157
froth flotation	5,341
thermal drying	0
breaking 004 ● ltlS@	2
total	15,502

HEAT
little Or none

NOISE
Noise may ● ffoct workers involved in cleaning coal, but there should be little or no adverse impact on receptors near beneficiation PIOO1O.

ENERGY PRODUCT	Tons	Heat Content
cleaned coal	36,360	13,750 Btu/lb

(1) These figures war. calculated assuming an energy content ● f 12,000 btu/lb ● t coal (Hittman, 1974). They ● . ● otlooal averages (assuming an energy ● ftlct=cr ● t 91.3%) and 40 oat ● PQ1? to elaborate (1.... level E) beneficiation in particular.

(2) These coefficients may b. ● ojoct to ● rsor ● laco the data source presented only the fixed amount of land used without ● pecifying the plant's ● n@*l output ● f cool. In calculating these coefficients, it woo ● aoad hero that plant output was the ● x . ● tbac ● paclflo4 in the "size" section ● f this sheet.

(3) These figures ● ro weighted ● oelciaal averages based upon regional coefficients projected by SEAS for 1979. The regional coefficients were weighted la terms ● t Btus used. Each ● f the coefficients shown on this sheet is ● qtrol to total national tons of residual divided by total national Btu output. These figures include residuals from refuse piles ● d the beneficiation process itself. They ● O O W 4 that 80% ● t coal ● r.porotloa plants ● r. closed cycle ● .4 that ● it refuse is treated. An ● tticloacy ● f 90% (in Btus) was ● oau004.

(4) Based on ● ottooal ● verages la ● lttmm.

SOURCES: Phillips, Peter and Paul DeRienzo, "Assessing the Economics of Steam Coal Preparation", Coal Mining and Processing, September, 1977.
DOE and EPA, Engineering/Economic Analysis of Coal Preparation with SO2 Cleanup Processes, 1978.
Hittman Associates, Environmental Impacts, Efficiency, and Cost of Energy Supply and End Use, 1974.
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McGraw Hill Mining Information Services, Keystone Coal Industry Manual, 1977.
Bureau of Land Management, Federal Coal Management Program, Final Environmental Statement, 1979.