Non-Treaty Storage Agreement

Technical Report: Appendices M - O

Bonneville
POWER ADMINISTRATION

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APPENDIX N

NEW RESOURCES

APPENDIX N

ENVIRONMENTAL IMPACTS OF GENERIC RESOURCE TYPES

Development of conservation and coal-fired resources is projected to be altered in the event the NTSA is used as a firm resource (See Technical Report Section 3.4.8). This appendix provides a summary of potential environmental impacts for these types of resources.

CONSERVATION

Indoor Air Pollution

One of the easiest and most economical ways to increase the efficiency of energy use in a home or business is to prevent loss of heated or cooled air from the building. Conservation programs often are based on tightening buildings; for example, caulking cracks and installing double- or triple-paned windows and storm doors in existing buildings. New buildings also may be built to standards that limit air infiltration. Efforts to tighten buildings may lead to problems of indoor air pollution and moisture problems caused by inadequate air flow into and out of the buildings. Inadequate air flow indoors can result in the buildup of pollutants produced in the building, such as gases and particles produced by combustion (for example, furnaces and people smoking); formaldehyde and other chemicals released by new building materials and furnishings; and chemicals used in cleaners and pesticides.

Pollutants in the outside environment also may seep into buildings. The effect of tightening in this case is not clear, however: a tight building may either prevent pollutants from escaping or prevent pollutants from entering. In some situations, house tightening has been shown to reduce indoor concentration of pollutants. Indoor air pollution may lead to adverse health effects given exposure for long periods or to high concentrations.

Particulates are particles or fibers in the air that are small enough to be inhaled. They are suspended in tobacco smoke and wood smoke; are produced by unvented gas appliances, kerosene heaters, and asbestos construction materials; and come from soap powders, pollen, lint, and house dust. When inhaled, particulates may cause nose, throat, and eye irritation. When they lodge in the lungs, particulates may cause lung cancer, emphysema, heart disease, bronchitis, and respiratory infections. Particulates also carry radon and its progeny (see below).

Combustion gases include carbon monoxide and nitrogen oxides. They are colorless and odorless gases that are produced by kerosene heaters, wood stoves, and unvented gas appliances. Carbon monoxide, also found in tobacco smoke, can cause lung ailments and impaired vision and brain functions. In high concentrations carbon monoxide can be fatal. Nitrogen oxides can cause lung damage and lung disease.

Formaldehyde is a component of urea-formaldehyde foam insulation and some glues used in plywood, particle board, and textiles such as furniture, drapes, and carpet. Formaldehyde has especially been a problem in mobile homes, with their relatively small living area and construction with more particle board and plywood than conventional houses. However, new board standards for manufactured housing have solved this problem. Relatively high levels of formaldehyde are likely to be found in new houses and businesses, where materials have not had time to release much of the gas. Levels also increase with higher temperatures and humidity. Formaldehyde, a strong-smelling, colorless gas, can cause nose, throat, and eye irritation; studies have shown that it can cause nasal cancer in animals.

Other chemicals that may provide indoor air pollutants include those in synthetic materials, pesticides, aerosol sprays, cleaning products, and paints. These chemicals may irritate skin, eyes, nose, and throat, and affect the central nervous system and metabolic processes. Interactions of two or more chemicals may be particularly harmful.

Moisture is produced by leaks; activities using water such as laundry, dishwashing, bathing, and cooking; people breathing and perspiring; and the soil beneath the building. Moisture can aid the growth of mildew, mold, bacteria, and viruses. It also can act as a solvent for formaldehyde and other pollutants, increasing the rate of release of harmful gases.

Radon is a colorless, odorless, radioactive gas, a decay product of uranium. Radon seeps into homes and other buildings from the soil beneath and from some building materials such as concrete and brick. Radon quickly decays into several types of "progeny" that can be carried by particulates in the air to lodge in the lungs. Increased levels of particulates thus increase the potential levels of exposure to radiation from radon emissions, although radon unattached to particulates has a greater chance of sticking in the lungs. As radon progeny decay, they emit alpha radiation that may damage lung tissue. Prolonged exposure to radon increases the risk of lung cancer: between 5 and 15 percent of all lung cancers may be caused by radon (the Surgeon General attributes 85 percent of all lung cancers to smoking). Exposure to radon also may cause birth defects and genetic damage.

Currently little information exists related to acceptable levels or direct health effects of these indoor air pollutants, and individual sensitivity to each pollutant varies. BPA has performed extensive monitoring and research on radon, however. About 3.5 percent of the Northwest houses monitored so far appear to have levels of radon higher than BPA's "action level." BPA's current residential weatherization programs for existing homes include the following steps:

1. Informing residents about the sources of indoor air pollution and about practical steps to reduce indoor pollutants.
2. Offering to monitor each participant's house for radon levels.

3. Paying 85 percent of the cost of an air-to-air heat exchanger (up to $850) if radon levels exceed 5 pCi/l (picoCuries per liter of air) inside the house. For low-income participants, BPA pays 100 percent up to $1000.

In the Record of Decision for BPA's New Energy-Efficient Homes Programs, BPA states that it has decided to offer four "pathways" to guide construction of energy-efficient new homes. BPA designed the pathway concept to provide builders and consumers with a menu of construction methods. The selection of the four construction pathways chosen was based on balancing five major factors: environmental, economic, technical, public concerns, and legal. The chosen pathways exhibit health effects close to those assuming current construction practices were continued without change; substantial energy savings; and maximum program flexibility at reasonable cost. The chosen pathways all include several environmental mitigation requirements: exhaust fans for kitchens and bathrooms; designated air supplies for combustion appliances; information on indoor air quality; Housing and Urban Development product standards for formaldehyde emissions from structural board materials; and the offer of radon monitoring and radon source control.

Several methods can mitigate the impacts of indoor air pollution. The most effective mitigation is prevention. Homeowners should avoid or isolate from the living area building materials and household chemicals that are sources of harmful gases. Smoking should be discouraged. Fireplaces and woodstoves should have tight-fitting doors and sources of outside air for combustion. Fires should not be allowed to smolder. Dehumidifiers may be used to remove moisture from the air. Air-to-air heat exchangers and other types of mechanical ventilation systems may be used to provide ventilation needed to dilute all types of indoor air pollutants.

Sources:

Bonneville Power Administration 1983 Wholesale Power Rate Final Environmental Impact Statement, September 1983, p. IV-49 - IV-51.

BPA, Issue Backgrounder: Energy Efficient New Homes & Indoor Air Pollutants, August 1987.

BPA, Backgrounder: Understanding Indoor Radon, June 1987.

BPA, Report No. 10: Radon Monitoring Results from BPAj's Residential Weatherization Program, January 1989, p. 2.

BPA, Final Environmental Impact Statement on New Energy-Efficient Homes Programs: Assessing Indoor Air Quality Options, Volume 1, August 1988, Summary.

BPA, New Energy-Efficient Homes Programs Record of Decision, February 1989.

Other Environmental Impacts

The most feasible types of conservation efforts include weatherization and other means of increasing the efficiency of energy use in buildings; increased efficiency of energy use by irrigation pumps and other machinery; and increased efficiency of transmission and distribution of electricity. Increasing the efficiency of energy use in buildings involves the production and transportation of insulation materials, weatherstripping, caulking, storm windows, infiltration barriers, and so on. It also could require the installation or replacement of machinery. Increasing the efficiency of irrigation pumps could require replacement of existing pumps wholly or in part. Increasing the efficiency of transmission and distribution also could require the replacement of equipment. All conservation efforts require personnel to audit and test existing buildings and equipment and to install or replace equipment and machinery.

Environmental impacts can be caused by the steps needed to provide the materials and machinery to the user. Such steps include: mining raw materials; manufacturing materials such as metals, glass, and insulation; fabricating the finished products; transporting the raw and finished materials; and installing the conservation measures at the point of use. Each step involves energy consumption and labor.

Sophisticated devices such as heat pumps and air-to-air heat exchangers require more raw material, manufacturing, and fabrication than construction materials such as insulation. They also may require more energy in transportation, more highly trained installers, and more maintenance.

Potential environmental impacts from manufacturing and transporting conservation devices and materials include increased energy use, air and water emissions, land use, employment, and other economic effects. Disposal of such devices and materials also could cause adverse impacts.

In general, however, the potential adverse environmental impacts that could result from the production and transportation of conservation materials are relatively insignificant. In addition, any adverse effects likely would be offset completely or partially by the environmental benefits of conservation. Because conservation measures result in increased efficiency of energy use, they could result in reduced operation and development of generation resources. Reduced operation and development of generation resources could result in less related environmental effects. A possible increase in employment for manufacturing, transporting, installing, and inspecting conservation measures could be a positive socio-economic effect.

Sources:

BPA, Final Environmental Impact Statement: The Role of the Bonneville Power Administration in the Pacific Northwest Power Supply System, December 1980, p. IV-123.

BPA, Environmental Assessment: Proposed Power System Changes to Implement the Water Budget, May 1983, Appendix C, p. C-1 - C-4.

COAL

The Northwest receives power from 13 coal-fired generation plants. Because coal generation is a proven technology, in recent years coal plants have been considered to be the baseload resources of the future. The Western U.S. has about half of the nation's coal reserves, most near the surface and with low sulfur content. Because of low production costs and low sulfur content, most of the nation's incremental consumption of coal is expected to be met from Western sources.

Increasing knowledge about the "greenhouse effect," the possible warming of the Earth caused by growing amounts of carbon dioxide in the atmosphere, has made future coal use for power generation less certain. Acid precipitation, caused by emissions of sulfur dioxide and nitrogen oxides, also has been linked to coal-fired generation plants. In addition, several factors may affect the development of coal reserves in the West: resource scarcity, especially of water; high transport costs to primary coal-use regions in the East; and ecological fragility of many western coal-producing areas. Coal mining and use are regulated by Federal and State laws that restrict water use and impact on water quality, preclude mining in certain areas including prime farm land, restrict air emissions, and require reclamation of mine sites.

Coal generation involves coal mining and preparation and plant construction and operation. Tables N-1 through N-8 show the natural resource use and environmental impacts of the steps in coal generation, which are discussed below. This section also discusses advanced technologies for electricity generation with coal, including coal gasification and fluidized bed combustion.

Fuel Mining and Processing

Mining. Coal is mined at several sites in and near the Pacific Northwest, including sites in the States of Washington, Montana, Wyoming, and Utah. The coal in the West generally has low energy value and low sulfur content. Almost all of the coal mines from which regional plants receive their coal are surface (strip) mines. In surface mining, topsoil is removed for later use in reclamation. The area is blasted and the overburden (earth overlying the coal seam) is removed in long parallel cuts. The exposed coal is removed and loaded into trucks for transport to a coal cleaning area and then to rail lines or mine-mouth plant. Reclamation consists of grading the soil, replacing the topsoil, and replanting vegetation. Federal laws require mining companies to reclaim mined lands by approximating the original topography and planting suitable vegetation.

Mining disrupts land uses, including agriculture and grazing. Even with reclamation, the land is not returned to its original form and may not resume its former productivity. The solid waste produced by mining can eventually be used as fill for reclamation. Coal mining to support a 1000-MW coal plant would permanently disturb about 251 acres and temporarily disturb about 52 acres each year. Aquifers in mined areas may be disturbed and may be contaminated by mining wastes. New and expanded mining operations may have significant socioeconomic impacts if many new workers are attracted to the area.

Air pollution results from emissions of the diesel-powered equipment that digs and hauls coal and overburden. It also arises from dust raised by the wind and by vehicular operation. Dust suppression practices, including spraying the area with water, can reduce the particulates caused by wind erosion and movement of vehicles. Water pollution may occur when suspended solids are produced by runoff from piles of overburden. Under controlled conditions, coal pile drainage and runoff are collected and treated prior to discharge, which reduces suspended solids and results in a zero acid content. Surface coal mining causes noise during drilling, blasting, and operation of equipment.

Table N-3 assumes that a preparation plant is sited near the coal mine. Coal preparation or beneficiation includes removing impurities from the coal, sizing the coal, and removing sulfur. The degree and type of beneficiation depends on the type of coal. Coal from the Western States generally is relatively clean and does not require washing. However, the coal goes through a "breaking and sizing" process that results in noise and requires small amounts of recycled water for dust control. The breaking and sizing operation and loading and storage require the long-term disturbance of about 63 acres of land for a 1000-MW plant. Table N-4 shows the resource use and environmental impacts of beneficiation. Beneficiation results in air and water pollution and solid wastes, as shown on the table.

Coal plants receive coal by truck or train, depending on the plant's distance from the coal mine(s) that supply it. Coal that must be transported long distances generally is moved by unit trains. Unit trains are dedicated to this purpose and operate regularly between two fixed points. Coal also may be transported by conventional trains, which carry cargoes of various types in addition to coal. Transporting coal by either type of train results in similar types and levels of pollutants. Table N-5 lists the environmental effects of coal unit trains.

A 1000-MW plant requires, as an annual average, over 9000 tons of coal per day. Hauling by train results in noise, emissions from diesel fuel combustion, and wind-borne particulates. Air pollution consists chiefly of particulates, sulfur dioxide, nitrogen oxides, hydrocarbons, and carbon monoxide. Particulate emissions during transportation are estimated to be 2 percent of coal tonnage carried by conventional trains and 1 percent of tonnage carried by unit trains and trucks. Other methods of transport are barge, slurry pipeline, truck, and conveyer belt (used between the Jim Bridger mine and plant in Wyoming).

Plant Construction and Operation

Factors that must be considered when siting a coal-fired power plant include the current condition of the airshed and its ability to dilute the atmospheric discharges of the plant; availability of water for cooling; proximity to the transmission grid; proximity to and reliability of rail or water transportation for coal; and availability of land for disposal of ash and flue gas desulfurization products. About 156 acres of land must be dedicated to housing the plant and solid waste disposal for 30 years. Construction of a coal plant is similar to that of any large industrial facility.

Modern coal plants include pollution control devices including electrostatic precipitators or other devices to control particulate emissions; scrubbers to control sulfur dioxide emissions; onsite solid waste disposal to prevent loss during transport; and onsite water treatment so water may be recirculated to eliminate discharges. The Clean Air Act requires that power plants constructed after passage of the act include systems for control of nitrogen oxide, sulfur dioxide, and particulates. Coal plants are subject to Federal and State regulations regarding pollutants.

In a conventional generating plant, the coal is pulverized and burned in a boiler to generate steam to power a turbine. The turbine drives an electrical generator. Combustion of the coal produces a flue gas contaminated with several air pollutants, most notably sulfur dioxide, nitrogen oxides, and carbon monoxide. Emissions from coal plants result in acid precipitation, which corrodes building materials and harms aquatic and terrestrial life, including fish, forests, and food crops. Data on acid precipitation are being gathered to determine the long-term environmental effects.

In the eleven Western States, the second-largest source of sulfur dioxide and nitrogen oxide is electricity generation (non-ferrous metal smelting produces more sulfur dioxide, and motor vehicles produce more nitrogen oxide). Acid deposition tends to be concentrated around the sources of emissions, although pollutants are transported by storms and prevailing winds. Acid deposition is extremely variable over time, depending on localized weather conditions; snowmelt patterns (snowmelt causes "pulses" of acidic water); and existing acidity of soil and water.

The West has many areas that are potentially sensitive to acidity. The thin soil of the mountains is not sufficient to neutralize the acid from precipitation runoff. The flora and fauna of fragile mountain and desert areas, because of the relatively short growing season, can take years to recover from acid damage. The deep snows that fall on the mountains can provide pulses of acidity during spring snowmelt.

Sulfur dioxide must be largely removed from combustion gases before discharge. A wet scrubber to perform this function could produce over 1200 tons of limestone sludge daily at a 1000-MW plant. The limestone waste has no value, even for fill, and could leach into groundwater. Dry scrubbers now available produce a dry waste for which handling and disposal are easier.

Combustion of coal also releases large amounts of carbon monoxide and carbon dioxide, both of which contribute to the "greenhouse effect." Carbon dioxide blocks the escape of heat radiation from the Earth; increasing amounts of carbon dioxide are thought to be causing a warming of the Earth that could change the Earth's climate. No systems for control of carbon dioxide emissions are in current use on power plants.

Scientists disagree about the long-term implications of the "greenhouse effect" and, indeed, whether it exists at all. Study of these issues is underway, however. For example, EPRI-sponsored experiments are underway to evaluate the feasibility of using algae and other plants to absorb the carbon dioxide output of thermal plants. Laboratory results are promising.

A 1000-MW coal plant burning coal with a 10-percent ash content will produce an average 900 tons of ash each day. Some of the ash is slag (bottom ash) from the boiler, and some is fly ash captured by the air pollution control device. Fly ash may be sold for uses such as for road building material. The other solid wastes must be disposed of in landfills.

Advanced Technologies

Two advanced technologies, gasification and fluidized bed combustion, can generate electricity using coal more efficiently and with less harmful emissions than conventional coal burning.

Gasification. Coal gasification is the conversion of coal or coal char to gaseous products by reaction with steam mixed with air or oxygen. The product is a low- to medium-Btu gas. To provide heat to enable the chemical reactions, generally some of the coal is burned. The resulting gas would be used as a substitute for natural gas in a combustion turbine or combined-cycle generator (see section on Combustion Turbines, following).

Gasification was the original application of fluidized-bed combustion, discussed in the next section. A gasifier burns coal in a fluidized bed with less air than is required for complete combustion, resulting in a high concentration of combustible gases in the exhaust. Coal gasification is applied in several pilot plants in the U.S.; it is an option to be used if natural gas prices increase significantly. The environmental impacts of coal mining and transport are not eliminated by gasification, although generating electricity with synthetic gas would increase the efficiency of coal use.

Fluidized Bed Combustion. Fluidized bed combustion is a method of burning fuel in which the fuel is continually fed into a "bed" of particles supported by upflowing air. During fluidization, the bed of material expands (bulk density decreases); as the air velocity increases, the particles mix more violently. The proper air velocity, operating temperature, and bed material cause the bed to function as a chemical reactor.

For high-sulfur coal combustion, the bed may be composed of limestone. The limestone reacts with and absorbs the sulfur released during burning, reducing sulfur dioxide emissions. The alkali compounds in coal from the western U.S. can react with the sulfur dioxide to limit emissions, so the bed for low-sulfur coal could be simply coal ash. Fluidized-bed combustion also takes place at temperatures low enough (1400-1500°F or 760-840°C) that nitrogen oxide formation is inhibited. Fluidized bed combustion can meet Federal emission standards without the use of flue gas scrubbers, which improves the efficiency of fuel use and reduces capital and operating costs from standard coal generation.

Generation with fluidized-bed combustion involves immersing heat-transfer tubes within the hot fluidized bed. The high efficiency of heat transfer results in the need for relatively less tube surface area, reducing tube requirements and costs. This technology, and plants with pressurized fluidized-bed combustors, are being tested within the U.S.

<u>Sources</u>:

BPA, Environmental Assessment: Proposed Power System Changes to Implement the Water Budget, May 1983, Appendix C, pp. C-12 - C-15.

Bonneville Power Administration 1983 Wholesale Power Rate Final Environmental Impact Statement, September 1983, pp. IV-71 and IV-80 - IV-81.

Northwest Power Planning Council, 1989 Supplement to the 1986 Northwest Conservation and Electric Power Plan, Volume 1, pp. 57 and 61.

Bonneville Power Administration, Final Environmental Impact Statement, Intertie Development and Use, April 1988, Volume 4, Appendix F, pp. F.1-1 - F.1-5.

World Resource Institute, "The American West's Acid Rain Test: Research Report #1," March 1985.

The Seattle Post-Intelligencer, "Power council contemplates 'greenhousing' of America," February 14, 1989.

James, Peter. <u>The Future of Coal</u>. Second Edition, 1984. MacMillan Press, London.

McGraw-Hill Encyclopedia of Science & Technology, 6th Edition, 1987. Volume 4, pp. 72-74 and Volume 7, pp. 198-200.

U.S. Department of Energy, Energy Technology Characterizations Handbook, Environmental Pollution and Control Factors, Third Edition, March 1983.

U.S. Department of Energy, Energy Technologies and the Environment, Environmental Information Handbook, October 1988.

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TABLE N-1

Pulverized Coal-fired Powerplants: Planning Characteristics

	Twin 250 MW Units	Twin 603 MW Units
Primary Fuel	Subbituminous Coal	Subbituminous Coal
Alternate Fuel	None	None
Fuel Inventory	90 days coal @ rated capacity	90 days coal @ rated capacity
Location	Hermiston, Oregon	Hermiston, Oregon
Rated Capacity (Net MW)	2 units @ 250 MW/unit	2 units @ 603 MW/unit
Peak Capacity (Net MW)	262 MW/unit	633 MW/unit
Heat Rate (Btu/kWh)	11,005	10,856
Availability (%)	77	75
Seasonality	Insignificant seasonal variation	Insignificant seasonal variation
Siting & Licensing Lead Time (mos)	48	48
S&L Shelf Life (yrs)	5	5
Construction Lead Time (mos to first unit/complete plant)	60/72	72/84
Siting & Licensing Cost ($/kW)	$32	$23
S&L Hold Cost ($/kW/yr)	$0.90	$0.80
Construction Cost ($/kW)[1]	$1,749	$1,211
Fuel Inventory Cost ($/kW)	$44	$35
Fixed Fuel Delivery ($/kW/yr)[2]	$8.60	$8.60
Variable Fuel Cost (mills/kWh)	16.4	16.2
Fixed O&M ($/kW/yr)	$32.80	$20.50
Variable O&M (mills/kWh)	2.3	1.9
Capital Replacement	Incl. in O&M	Incl. in O&M
Operating Life (yrs)	40	40

1 Construction costs exclude interest and escalation incurred during construction.

2 Annual unit cost of purchase and maintainance of unit train rolling stock.

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TABLE N-2

AFBC Coal-fired Powerplants: Planning Characteristics

	Single 197 MW Unit	Twin 509 MW Units
Primary Fuel	Subbituminous Coal	Subbituminous Coal
Alternate Fuel	None	None
Fuel Inventory	90 days coal @ rated capacity	90 days coal @ rated capacity
Location	Hermiston, Oregon	Hermiston, Oregon
Rated Capacity (Net MW)	1 unit @ 197 MW/unit	2 units @ 509 MW/unit
Peak Capacity (Net MW)	n/avail	n/avail
Heat Rate (Btu/kWh)	9,885	9,851
Availability (%)	81	74
Seasonality	Insignificant seasonal variation	Insignificant seasonal variation
Siting & Licensing Time (mos)	48	48
S&L Shelf Life (yrs)	5	5
Construction Time (mos to first unit/complete plant)	64	76
Siting & Licensing Cost ($/kW)	$41	$23
S&L Hold Cost ($/kW/yr)	$1.40	$0.50
Construction Cost ($/kW)[1]	$1,764	$1,268
Fuel Inventory Cost ($/kW)	$32	$32
Fixed Fuel Delivery ($/kW/yr)[2]	$8.60	$8.60
Variable Fuel Cost (mills/kWh)	14.7	14.7
Fixed O&M ($/kW/yr)	$37.10	$20.70
Variable O&M (mills/kWh)	4.8	3.1
Capital Replacement ($/kW/yr)	Incl. in O&M	Incl. in O&M
Operating Life (yrs)	30	30

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1 Construction costs exclude interest and escalation incurred during construction.

2 Annual cost of purchase and maintainance of unit train rolling stock.

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WESTERN SURFACE COAL MINING (WITH PREPARATION PLANT)

REFERENCE ENERGY SYSTEM

Western surface mine with seam thickness of 23.1 ft. The overburden thickness is 100 ft (stripping ratio) 4/1 (cover/coal). The overburden removal is done by dragline stripping shovels. Bulldozers are used for backfilling and regrading. There is an onsite preparation plant using a wet method of cleaning the coal, and unit trains are used for final shipment. The capacity and production of this mine are relatively close. Terrain, topography, and overburden thickness limit the mine capacity. The estimated production is 85-90% of capacity.

FACILITY OPERATING PARAMETERS

Size:	Coal mine: 9.7 × 10^6 tons/yr Preparation plant: 8.73 × 10^6 tons/yr
Annual Capacity Factor:	85-90%
Annual Energy Production:*	Coal mine: 170 × 10^{12} Btu Preparation plant: 152 × 10^{12} Btu
Efficiency:	90% (preparation plant)
Lifetime:	40 yr

*Heating value of coal = 8750 Btu/lb.

RESOURCES USED

	Quantities Used: Reference Energy System Annual Usage — English Units	Metric Units	Per 10^{12} Btu* Energy Produced	Remarks
Feed Materials				
Raw coal in place	9.7 × 10^6 tons	8.8 × 10^6 tonnes	64 × 10^3 tons	Assumed to be a 40-yr supply
Energy				
Electricity	0.9 × 10^6 kWh	0.9 × 10^6 kWh	6.0 × 10^3 kWh	For preparation plant
Fuel	3.8 × 10^6 gal	14.5 × 10^6 l	25.0 × 10^3 gal	
Ammonium nitrate Fuel oil mixture	1.25 × 10^3 tons	1.13 × 10^3 tonnes	8.2 tons	
Water	Unquantifiable			
	Total Usage			
Construction Materials	Not Determined			
Land				
Mine	20 × 10^3 acres	8.09 × 10^3 ha	130 acres	Facilities land includes land for preparation plant and railroad-associated land
Solid waste storage	102 acres	4.05 ha	0.07 acre	
Facilities	16.8 acres	68 ha	0.11 acre	
Mining operations	35 acres	14.2 ha	0.23 acre	
Personnel				
Mine	210 workers		1.4 workers	
Preparation plant	20 workers		0.13 worker	

*Entries computed on basis of output from preparation plant throughout the Summary Sheet.

COSTS

	Reference Energy System (1981 $)	Per 10^{12} Btu Energy Produced	Remarks
Facility			
Capital			
• Mine	$251 × 10^6 total	$1.7 × 10^6 total	Reference year for cost is 1978; 1978 CCI average (I_p = 2776. See Explanatory Notes section and Append B.
• Preparation plant	($15.4-$148) × 10^6 total	($0.10-$1.0) × 10^6 total	
Operation and maintenance			
• Mine	≤$64 × 10^6/yr	≤$0.42 × 10^6/yr	
• Preparation plant	($8.9-$109) × 10^6/yr	($0.06-$0.71) × 10^6/yr	
Environmental Controls	Included in above costs		

WESTERN SURFACE COAL MINING (WITH PREPARATION PLANT)

ENVIRONMENTAL RESIDUALS

	Quantities Released: Reference Energy System Annual Levels — English Units	Metric Units	Per 10^{12} Btu Energy Produced	Remarks
Air Pollutants				Regulatory Compliance Standards* by component (air pollutants)
Carbon monoxide	147 tons	133 tonnes	0.97 ton	• Thermal Dryer
Hydrocarbons	47 tons	43 tonnes	0.30 ton	– Particulates: 0.031 gr/dscf
Oxides of nitrogen	734 tons	667 tonnes	4.8 tons	– Opacity: 20%
Sulfur dioxide	48 tons	44 tonnes	0.32 ton	• Pneumatic Coal Cleaning Equipment
Particulates	39 tons	35 tonnes	0.26 ton	– Particulates: 0.018 gr/dscf
Aldehydes	12 tons	11 tonnes	0.08 ton	– Opacity: 20%
Fugitive dust	107 tons	97 tonnes	0.70 ton	• Processing and Conveying Equipment – Opacity: 20%
Water Pollutants				
For the Western Surface Mine, all water used in the mine activity is recycled. Amount is unquantifiable.				
Solid Waste				
Preparation plant	970 × 10^3 tons	880 tonnes	6.38 tons	
Noise Pollution		Not Determined		

*CFR 40 Part 60, Subpart V: Coal Preparation Plants (41 FR2232).

PRODUCTS

	Quantities Produced: Reference Energy System Annual Production — English Units	Metric Units	Per 10^{12} Btu Energy Produced	Remarks
Primary				
Coal (cleaned)	8.73 × 10^6 tons	7.92 × 10^6 tonnes	57.4 × 10^3 tons	Represents approximately a 90% recovery from ROM coal output

OCCUPATIONAL HEALTH AND SAFETY

	Reference Energy System Annual	Per 10^{12} Btu Energy Produced	Remarks
Deaths			
Surface mine	0.05	0.29 × 10^{-3}	
Preparation plant	0.014	0.082 × 10^{-3}	
Injuries			
Surface mine	13.1	0.08	
Preparation plant	1.8	0.01	

COAL BENEFICIATION

REFERENCE ENERGY SYSTEM

The system is comprised of a number of wet circuit coal beneficiation devices including crushers, scalping screens, rotary breaker, vibrating screens, jigs, thickeners, concentrating tables, flotation circuits, and thermal drying. These devices are designed to remove unwanted components from the raw coal, such as ash to improve the energy content or sulfur to reduce the sulfur oxide emissions. The resultant cleaned coal can then be utilized in a manner essentially identical to other unprocessed coal that has not undergone this degree of beneficiation.

FACILITY OPERATING PARAMETERS

Size:	2.857 × 10^6 tons/yr
Annual Capacity Factor:	83% (based on 230 days/yr of operation)
Annual Energy Production:	55.0 × 10^{12} Btu
Efficiency:	87.5%
Lifetime:	20 yr

RESOURCES USED

	Quantities Used: Reference Energy System Annual Usage — English Units	Reference Energy System Annual Usage — Metric Units	Per 10^{12} Btu Energy Produced	Remarks
Feed Materials				
Coal (run-of-mine)	2.86 × 10^6 tons	2.59 × 10^6 tonnes	51.945 × 10^3 tons	
Energy				
Electricity	11 × 10^6 kWh	11 × 10^6 kWh	0.20 × 10^6 kWh	
Oil	32 × 10^9 Btu	34 × 10^{12} J	0.59 × 10^9 Btu	
Processing Materials		Not Determined		
Water				
Consumptive uses	200 acre-ft	250 × 10^6 l	3.7 acre-ft	
	Total Usage			
Construction Materials		Not Determined		
Land	240 acres	96 ha	4.3 acres	
Personnel				
Construction (1 yr)	440 workers		8.1 workers	
Operation and maintenance	82 workers		1.5 workers	

COSTS

	Reference Energy System	Per 10^{12} Btu Energy Produced	Remarks
Facility			
	(1981 $)		Reference year for costs is 1976. 1976 CCI average (I_R) = 2401. See Explanatory Notes Section.
Construction (1 yr)	\$35.3 × 10^6 total	\$0.63 × 10^6 total	
Operation and maintenance	\$26.5 × 10^6/yr	\$0.47 × 10^6/yr	
Environmental Controls	Not Determined		

COAL BENEFICIATION

ENVIRONMENTAL RESIDUALS

	Quantities Released			
	Reference Energy System Annual Levels			
	English Units	Metric Units	Per 10^{12} Btu Energy Produced	Remarks
Air Pollutants				
Particulates	50 tons	40 tonnes	0.9 ton	Regulatory Compliance Standards* by component:
Sulfur dioxide	0.3 ton	0.2 tonne	0.005 ton	
Oxides of nitrogen	33 tons	30 tonnes	0.6 ton	
Hydrocarbons	11 tons	10 tonnes	0.2 ton	
Carbon monoxide	11 tons	10 tonnes	0.2 ton	
Water Pollutants				• Thermal Dryer
Total dissolved solids	1.82×10^3 tons	1.65×10^3 tonnes	33 tons	— Particulates — 0.031 gr/dscf
• Iron	0.4 ton	0.3 tonne	0.007 ton	— Opacity — 20%
• Manganese	1.6 tons	1.5 tonnes	0.03 ton	
• Aluminum	2.2 tons	2.0 tonnes	0.4 ton	
• Zinc	0.3 ton	0.2 tonne	0.005 ton	• Pneumatic Coal Cleaning Equipment
• Nickel	0.16 ton	0.15 tonne	0.003 ton	
Total suspended solids	33 tons	30 tonnes	0.6 ton	
• Iron	3.3 tons	3.0 tonnes	0.06 ton	— Particulates — 0.018 gr/dscf
Ammonia	3.0 tons	2.0 tonnes	0.05 ton	— Opacity — 20%
Sulfates	990 tons	900 tonnes	18.0 tons	
Solid Wastes				• Processing and Conveying Equipment
Course cleaning	0.11×10^3 tons	0.1×10^3 tonnes	0.002×10^3 tons	— Opacity — 20%
Primary cleaning	559×10^3 tons	508×10^3 tonnes	10.16×10^3 tons	
Froth flotation	290×10^3 tons	260×10^3 tonnes	5.3×10^3 tons	
Breaking and sizing	0.11×10^3 tons	0.1×10^3 tonnes	0.002×10^3 tons	
Total	849×10^3 tons	768×10^3 tonnes	15.5×10^3 tons	
Thermal Discharge		Not Determined		
Noise Pollution				
May affect workers but not nearby receptors				

*CFR 40 Part 60, Subpart V: Coal Preparation Plants (41 FR 2232)

PRODUCTS

	Quantities Produced			
	Reference Energy System Annual Production			
	English Units	Metric Units	Per 10^{12} Btu Energy Produced	Remarks
Primary				
Coal (cleaned)	2.00×10^6 tons	1.82×10^6 tonnes	36.4×10^3 tons	
Recoverables/Recyclables		Not Determined		

OCCUPATIONAL SAFETY AND HEALTH

Not Determined

TABLE N-5

WESTERN COAL UNIT TRAIN

REFERENCE ENERGY SYSTEM

Typical western unit train systems are comprised of 100 cars each holding 100 tons and four diesel locomotives of 3000 hp each. The train operates between two fixed locations on a dedicated basis. This example assumes a train traveling 700 mi one way and making 90 trips per year. Ten spare cars are reserved for each train system.

FACILITY OPERATING PARAMETERS

Size:	100 cars, 100 tons per car, 10×10^3 tons per train
Annual Capacity Factor:	Not determined
Annual Energy Production:	17.01×10^{12} Btu (coal transported)
Efficiency:	99.69% based on $\frac{\text{energy delivered}}{\text{energy loaded + energy expended}}$
Lifetime:	30 yr

RESOURCES USED

	Quantities Used: Reference Energy System Annual Usage – English Units	Metric Units	Per 10^{12} Btu Energy Produced	Remarks
Feed Materials				
Coal transported	900×10^3 tons	817×10^3 tonnes	52.9×10^3 tons	
Energy				
Diesel	221×10^9 Btu	233×10^{12} J	13.0×10^9 Btu	
	Total Usage			
Construction Materials				
Aluminum	43.2 tons	39.2 tonnes	2.54 tons	
Brass and bronze casting	17.4 tons	15.8 tonnes	1.02 tons	
Chromium	2.2 tons	2.0 tonnes	0.13 ton	
Copper	59.7 tons	54.2 tonnes	3.51 tons	
Iron		Not Determined		
Manganese	30.6 tons	27.8 tonnes	1.80 tons	
Nickel	0.51 ton	0.46 tonne	0.03 ton	
Steel	4.27×10^3 tons	3.88×10^3 tonnes	251 tons	
Land				
Land value has been excluded as it cannot be exclusively associated with coal transportation				
Personnel				
Construction		Not Determined		
Operation and maintenance	120 workers		7.02 workers	

COSTS

	Reference Energy System	Per 10^{12} Btu Energy Produced	Remarks
Facility	(1981 $)		
Construction	$\$9.80 \times 10^6$ total	$\$0.578 \times 10^6$ total	Reference year for cost is 1978. 1978 CCI average (I_R) = 2776. See Explanatory Notes Section.
Operation and maintenance	$\$8.74 \times 10^6$/yr	$\$0.513 \times 10^6$/yr	

WESTERN COAL UNIT TRAIN

ENVIRONMENTAL RESIDUALS

	Quantities Released: Reference Energy System Annual Levels — English Units	Metric Units	Per 10^{12} Btu Energy Produced	Remarks
Air Pollutants				
Particulates	2.38×10^3 tons	2.16×10^3 tonnes	140 tons	
Sulfur dioxide	90 tons	80 tonnes	5.0 tons	
Oxides of nitrogen	75 tons	68 tonnes	4.4 tons	
Hydrocarbons	61 tons	56 tonnes	3.6 tons	
Carbon monoxide	78 tons	71 tonnes	4.6 tons	
Aldehydes	14 tons	12 tonnes	0.8 ton	
Noise Pollution*				
In-cab noise level		≥ 112 dBA		Federal design levels:
100 ft from moving train		~ 95 dBA		55 dBA — residence
1000 ft from moving train		~ 75 dBA		75 dBA — open land
Whistle noise at 1000 ft		≤ 85 dBA		

*Noise cannot be expressed in terms of energy produced.

PRODUCTS

	Quantities Produced: Reference Energy System Annual Production — English Units	Metric Units	Per 10^{12} Btu Energy Produced	Remarks
Primary				
Coal transported	900×10^3 tons	817×10^3 tonnes	52.9×10^3 tons	

OCCUPATIONAL SAFETY AND HEALTH

Not Determined

TABLE N-6

WESTERN COAL CONVENTIONAL TRAIN

REFERENCE ENERGY SYSTEM

A conventional freight train is assumed to be made up of 85 freight cars, 17 of which carry 85 tons each of coal. The train may have multiple destinations and thus be made up of a mix of cars from many sources requiring more than one make-up and breakdown of the train during a single trip. This example assumes a 300-mi one-way trip using a diesel-powered locomotive. The train is assumed to make the equivalent of 20 round trips per year.

FACILITY OPERATING PARAMETERS

Size:	29 × 10³ tons/yr (transported)
Annual Capacity Factor:	Not determined
Annual Energy Production:	0.548 × 10¹² Btu (coal transported)
Efficiency:	98.3% based on $\frac{\text{coal delivered}}{\text{coal loaded + energy consumed}}$
Lifetime:	30 yr

RESOURCES USED

	Quantities Used			
	Reference Energy System Annual Usage			
	English Units	Metric Units	Per 10¹² Btu Energy Produced	Remarks
Feed Materials				
Coal transported	29.1 × 10³ tons	26.4 × 10³ tonnes	53.04 × 10³ tons	
Energy				
Diesel fuel	8.06 × 10⁹ Btu	8.50 × 10¹² J	14.7 × 10⁹ Btu	
	Total Usage			
Construction Materials				
Aluminum	4.20 tons	3.82 tonnes	7.67 tons	
Brass and bronze	2.48 tons	2.25 tonnes	4.52 tons	
Chromium	0.30 ton	0.27 tonne	0.54 ton	
Copper	7.27 tons	6.60 tonnes	13.27 tons	
Iron		Not Determined		
Manganese	4.48 tons	4.07 tonnes	8.18 tons	
Nickel	0.066 ton	0.060 tonne	0.12 ton	
Steel	6.28 tons	5.71 tonnes	11.47 tons	
Land				
Land use value has been excluded as it cannot be exclusively associated with coal transportation				
Personnel				
Construction		Not Determined		
Operation and maintenance	2.92 workers		5.32 workers	

COSTS

	Reference Energy System	Per 10¹² Btu Energy Produced	Remarks
Facility	(1981 $)		
Construction	$1.24 × 10⁶ total	$2.27 × 10⁶ total	Reference year for cost is 1978. 1978 CCI average (I_R) = 2776. See Explanatory Notes Section.
Operation and maintenance	$0.837 × 10⁶/yr	$1.53 × 10⁶/yr	

WESTERN COAL CONVENTIONAL TRAIN

ENVIRONMENTAL RESIDUALS

	Quantities Released			
	Reference Energy System Annual Levels			
	English Units	Metric Units	Per 10^{12} Btu Energy Produced	Remarks
Air Pollutants				
Particulates	75.8 tons	68.8 tonnes	138.4 tons	Includes particulates from locomotives and fugitive emissions
Sulfur dioxide	1.9 tons	1.7 tonnes	3.5 tons	
Oxides of nitrogen	2.2 tons	2.0 tonnes	4.0 tons	
Hydrocarbons	1.5 tons	1.3 tonnes	2.7 tons	
Carbon monoxide	2.0 tons	1.8 tonnes	3.7 tons	
Aldehydes, etc.	0.33 ton	0.30 tonne	0.6 ton	
Noise Pollution*				
In cab of locomotive		>112 dBA		Federal design levels:
100 ft from moving train		~95 dBA		55 dBA – residence
1000 ft from moving train		~75 dBA		75 dBA – open land
Whistle noise at 1000 ft		≤85 dBA		

*Noise cannot be expressd in terms of energy produced.

PRODUCTS

	Quantities Produced			
	Reference Energy System Annual Production			
	English Units	Metric Units	Per 10^{12} Btu Energy Produced	Remarks
Primary				
Coal transported	29.0×10^3 tons	26.3×10^3 tonnes	52.9×10^3 tons	

OCCUPATIONAL SAFETY AND HEALTH

Not Determined

COAL-FIRED POWER PLANT — WESTERN COAL

REFERENCE ENERGY SYSTEM

The system is composed of a conventional steam electric power plant using typical western low-sulfur subbituminous coal supplied by a unit train operation. No cogeneration is included. Environmental control systems include electrostatic precipitators for particulate control, wet lime/limestone scrubbers for sulfur dioxide control, onsite solid waste disposal, and onsite water treatment for water recirculation to eliminate liquid discharges. The plant is assumed to be subject to current regulations.

FACILITY OPERATING PARAMETERS

Size:	500 MWe
Annual Capacity Factor:	80%
Annual Energy Production:	12×10^{12} Btu
Efficiency:	35%
Lifetime:	30 yr

RESOURCES USED

	Quantities Used: Reference Energy System Annual Usage — English Units	Metric Units	Per 10^{12} Btu Energy Produced	Remarks
Feed Materials				
Run-of-mine subbituminous coal	2.11×10^6 tons	1.92×10^6 tonnes	0.18×10^6 tons	Low-sulfur coal (0.63% sulfur)
Processing Materials				
Limestone to sulfur dioxide scrubber	32×10^3 tons	29×10^3 tonnes	2.7×10^3 tons	
Fly ash (sludge fixing)	34×10^3 tons	30.8×10^3 tonnes	2.9×10^3 tons	
Water				
Dust control and SO_2 control make-up	445 acre-ft	0.55×10^9 l	37 acre-ft	Quality not critical
Cooling tower make-up water	4.9×10^3 acre-ft	6.1×10^9 l	409 acre-ft	Wet cooling only
	Total Usage			
Construction Materials				
Concrete	87.5×10^3 tons	79.5×10^3 tonnes	7.29×10^3 tons	
Carbon steel	26.1×10^3 tons	23.7×10^3 tonnes	2.18×10^3 tons	
Alloy steel	1.39×10^3 tons	1.26×10^3 tonnes	116 tons	
Stainless steel	465 tons	423 tonnes	38.8 tons	
Copper	736 tons	669 tonnes	61.3 tons	
Aluminum	231 tons	210 tonnes	19.2 tons	
Manganese	204 tons	185 tonnes	17.0 tons	
Chromium	121 tons	110 tonnes	10.1 tons	
Nickel	18.8 tons	17.1 tonnes	1.6 tons	
Cast iron	341 tons	310 tonnes	28.5 tons	
Land				
Power plant and solid waste disposal (ash and sludge)	5.2 acres	2.1 ha	0.4 acre	Sufficient land needed for a 30-yr lifetime
Personnel				
Construction	Not Determined			
Operation and maintenance				
• Power plant	135 workers		1.7 workers	

COSTS

	Reference Energy System (January 1981 $)	Per 10^{12} Btu Energy Produced	Remarks
Facility			
Construction (5 yr)	$487 × 10^6 total	$40.6 × 10^6 total	Exclusive of fuel costs
Operation and maintenance	$5.4 × 10^6/yr	$0.45 × 10^6/yr	
Environmental Controls*			
Construction	$115 × 10^6 total	$9.6 × 10^6 total	Included in Facility Costs, above
Operation and maintenance	$2.8 × 10^6/yr	$0.23 × 10^6/yr	

*Includes baghouse, scrubbers, NO_x control, H_2O treatment, noise control, and solids handling.

COAL-FIRED POWER PLANT — WESTERN COAL

ENVIRONMENTAL RESIDUALS

	Quantities Released: Reference Energy System Annual Levels — English Units	Metric Units	Per 10^{12} Btu Energy Produced	Remarks
Air Pollutants				
Fugitive coal dust (unit train operation)	5.2×10^3 tons	4.7×10^3 tonnes	0.43×10^3 tons	
Sulfur dioxide	7.15×10^3 tons	6.49×10^3 tonnes	0.60×10^3 tons	(<0.6 lb/10^6 Btu*
Oxides of nitrogen	10.2×10^3 tons	9.26×10^3 tonnes	0.85×10^3 tons	0.50 lb/10^6 Btu*
Total suspended particulates	0.525×10^3 tons	0.48×10^3 tonnes	0.04×10^3 tons	0.03 lb/10^6 Btu*
Nonmethane hydrocarbons	0.32×10^3 tons	0.29×10^3 tonnes	0.03×10^3 tons	
Carbon monoxide	1.05×10^3 tons	0.95×10^3 tonnes	0.09×10^3 tons	
Carbon dioxide	3.7×10^6 tons	3.4×10^6 tonnes	0.31×10^6 tons	
Arsenic	128 lb	58.1 kg	10.7 lb	
Beryllium		Not Determined		
Cadmium	11.7 lb	5.3 kg	0.98 lb	
Manganese	0.6 lb	0.3 kg	0.05 lb	
Lead	32.1 lb	14.6 kg	2.68 lb	
Selenium	2.0 lb	0.9 kg	0.17 lb	
Uranium	718 lb	326 kg	59.8 lb	
Zinc	286 lb	130 kg	23.8 lb	
Radium-226	1.4×10^{-3} Ci	1.4×10^{-3} Ci	0.12×10^{-3} Ci	
Solid Wastes				
Coal preparation (at mine)	210×10^3 tons	190×10^3 tonnes	17.5×10^3 tons	
Boiler bottom ash (dry)	34×10^3 tons	31×10^3 tonnes	2.8×10^3 tons	
Boiler fly ash (dry)	101×10^3 tons	91.7×10^3 tonnes	8.4×10^3 tons	
Sulfur dioxide scrubber sludge (dry)	43×10^3 tons	39×10^3 tonnes	3.6×10^3 tons	
Total solid waste to onsite disposal	177×10^3 tons	161×10^3 tonnes	14.8×10^3 tons	
Thermal Discharge	21.0×10^{12} Btu	22.1×10^{15} J	1.7×10^{12} Btu	Cooling towers and stacks

*NSPS regulatory compliance level (70% reduction) for 0.63 percent sulfur coal with heating value of coal at 8100 Btu/lb.

PRODUCTS

	Quantities Produced: Reference Energy System Annual Production — English Units	Metric Units	Per 10^{12} Btu Energy Produced	Remarks
Primary				
Electricity	12×10^{12} Btu	13×10^{15} J	1.0×10^{12} Btu	
Byproducts				
Fly ash (for sale)	34×10^3 tons	31×10^3 tonnes	2.9×10^3 tons	
Recoverables/Recyclables				
Water to recycle	196×10^6 gal	742×10^6 l	16.3×10^6 gal	Zero-discharge design

OCCUPATIONAL SAFETY AND HEALTH

	Reference Energy System Annual	Per 10^{12} Btu Energy Produced	Remarks
Deaths			
Power plant	0–0.11	$0\text{–}9.5 \times 10^{-3}$	
Injuries			
Power plant	1.9–2.3	0.16–0.19	

TABLE N-8

ATMOSPHERIC FLUIDIZED BED COMBUSTION — WESTERN SUBBITUMINOUS COAL

REFERENCE ENERGY SYSTEM

Steam electric power generation facility utilizing a fluidized bed combustion system in which the small pieces of coal are suspended along with similarly sized bed material in a continuously moving mass of air. The bed material referred to as a sorbent and composed of crushed limestone or dolomite is responsible for the capture of a portion of the sulfur dioxide generated during combustion. Other environmental control systems include a baghouse filter with greater than 98% efficiency and conventional water treatment facilities as necessary. The lower combustion temperatures of the system also serve to minimize nitrogen oxide formation.

FACILITY OPERATING PARAMETERS

Size:	536 MWe
Annual Capacity Factor:	96%
Annual Energy Production:	15.2×10^{12} Btu
Efficiency:	34.4%
Lifetime:	20 yr

RESOURCES USED

	Quantities Used			
	Reference Energy System Annual Usage		Per 10^{12} Btu Energy Produced	Remarks
	English Units	Metric Units		
Feed Materials				
Coal (subbituminous western)	2.75×10^6 tons	2.50×10^6 tonnes	181×10^3 tons	8.06×10^3 Btu/lb
Processing Materials				
Limestone (sorbent bed material)	194×10^3 tons	177×10^3 tonnes	12.8×10^3 tons	
Water				
Consumptive uses	8.86×10^3 acre-ft	10.9×10^9 l	583 acre-ft	
	Total Usage			
Construction Materials				
		Not Determined		
Land	442 acres	179 ha	29.1 acres	
Personnel				
Approximately same as conventional power station of equivalent capacity				

COSTS

	Reference Energy System	Per 10^{12} Btu Energy Produced	Remarks
Facility			
	(1981 $)		Reference year for costs (facility only) is 1977. 1977 CCI average (I_R) = 2577. See Explanatory Notes Section.
Construction	$\$381 \times 10^6$ total	$\$25.1 \times 10^6$ total	
Operation and maintenance	$\$7.42 \times 10^6$/yr	$\$0.488 \times 10^6$/yr	
Environmental Controls			
Capital	$\$49.8 \times 10^6$ total	$\$3.3 \times 10^6$ total	

ATMOSPHERIC FLUIDIZED BED COMBUSTION – WESTERN SUBBITUMINOUS COAL

ENVIRONMENTAL RESIDUALS

	Quantities Released			
	Reference Energy System Annual Levels			
	English Units	Metric Units	Per 10^{12} Btu Energy Produced	Remarks
Air Pollutants				
Sulfur dioxide	26 × 10^3 tons	23 × 10^3 tonnes	1.7 × 10^3 tons	
Oxides of nitrogen	8.85 × 10^3 tons	8.03 × 10^3 tonnes	582 tons	
Particulates	2.22 × 10^3 tons	2.01 × 10^3 tonnes	146 tons	
Hydrocarbons	Approximately same values as conventional power station of equivalent capacity			
Carbon monoxide				
Water Pollutants				
Approximately same values as conventional power station of equivalent capacity				
Solid Wastes				
Dry weight	384 × 10^3 tons	349 × 10^3 tonnes	25.3 × 10^3 tons	
Thermal Discharge		Not Determined		

PRODUCTS

	Quantities Produced			
	Reference Energy System Annual Production			
	English Units	Metric Units	Per 10^{12} Btu Energy Produced	Remarks
Primary				
Electricity	4.45 × 10^9 kWh	4.45 × 10^9 kWh	0.293 × 10^9 kWh	
Byproducts		Not Determined		
Recoverables/Recyclables		Not Determined		

OCCUPATIONAL SAFETY AND HEALTH

Not Determined