Table 6. Movement of coal and lignite from port of New Orleans.

Year	Total New Orleans Movements (Short Tons (000 000s))	Foreign Imports	Foreign Exports	Domestic Coastwise Receipts	Domestic Coastwise Shipments	Domestic Internal Receipts	Domestic Internal Shipments	Domestic Local
1978	7.395	0.027	1.401	0.050	3.145	2.759	0.011	0.002
1977	9.452	0.142	1.438	-	3.587	4.274	0.010	-
1976	8.439	0.195	1.297	-	2.757	4.187	0.003	-
1975	8.711	-	1.236	-	3.096	4.375	0.004	-
1974	8.751	0.002	1.002	-	3.481	4.257	0.008	0.001

deepen the Southwest Pass through New Orleans from 40 ft to 55 ft. Preliminary environmental notifications have been submitted, and if timely congressional approval is obtained, the deepening could be accomplished by 1984.

In 1978, the port of New Orleans handled 7.4 million tons of coal and lignite [Table 6 (12)]. Of this total, 1.4 million tons were for export, 3.1 million tons were as coastwise shipments to other domestic points, and 2.8 million tons were receipts of domestic movements for local consumption.

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Impacts of Proposed Transshipment Facility on Price of Delivered Coal in New York

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Recent federal legislation has been directed toward reducing the use of imported oil, particularly by the utility sector. As a result, numerous oil-fired power plants have been targeted for reconversion to coal. Since transportation costs constitute a major portion of the total delivered-coal price to northeastern utilities, cost savings that might be achieved through efficient transportation methods will enhance the economic practicality of reconversions. The transportation cost savings that would accompany the construction of a large coal storage and transfer facility near the port of New York are estimated here. Total delivered-fuel costs are computed for plants that might reconvert to coal, assuming the use of coal from three supply regions and alternative mode and route configurations. Cost savings that would result from use of the proposed facility are estimated on a plant-specific basis. In addition, projections of annual throughput for a range of transshipment costs are estimated.

Development of intermodal transfer facilities follows logically in the general process of increasing the total efficiency of the national transportation system. Usually constructed at rail-water interfaces, transshipment terminals are designed to reduce the price of delivered bulk commodities.

Government policies currently being formulated will directly affect regional coal markets. The federally mandated program of reconverting oil-fired power plants to coal will increase the demand for coal by utilities in the New York region. Transportation costs will constitute a major portion of the delivered price to these users. Minimization of these costs will enhance the economic feasibility of the coal reconversion program. This paper examines the transportation cost savings that may be realized by New York State utilities through the development of a proposed coal-transfer and storage facility near the port of New York.

Estimates of delivered price from three alternative supply regions, assuming use of several mode and route configurations, are developed and compared to determine the cost savings that would accompany development and use of the proposed facility.

PROSPECT FOR INCREASED COAL USE

Use of coal to supplant imported petroleum products as a fuel for the generation of electricity has been the focus of the recent national energy policy. It has been estimated that coal reserves constitute 80 percent of our fossil-fuel energy reserves (1, pp.

176-180). These supplies can fulfill many of our energy requirements well into the next century. Though it is unreasonable to expect that coal will entirely replace oil, it is probable that an increasing percentage of the generation mix will be made up of coal-fired facilities.

Legislation enacted in the late 1970s has reflected the desire of the federal government to mandate the reconversion of oil- and gas-fired generating stations to coal. This program has met with widely varied opinion within the utility industry. Since the Nixon administration, every president has favored conversion as a major step toward reduction of overall imports of oil. However, conflicting objectives within government agencies have served to limit the effectiveness of these programs to date.

Most recently, the Carter administration sought to provide financial incentives to aid utilities with the capital costs of reconversion. An ambitious reconversion effort has proved difficult for utilities faced with rising fuel costs and an uncertain financial climate.

Though the Reagan administration has indicated a favorable stance toward conversion, financial incentives will most likely not include direct subsidies. In 1981, congressional review of the Clean Air Act of 1970 (P.L. 95-95, 91 Stat. 685) will serve as a bellwether of what may be a massive restructuring of environmental legislation. The decisions reached in this evaluation will, it is hoped, clarify the environmental regulations associated with any program to increase coal use. It seems likely that the 1980s will be an important decade, in which many fundamental questions associated with coal use will be addressed.

LEGISLATIVE ACTIONS AFFECTING COAL USE

Two types of legislation, which often have conflicting goals, have served to create a somewhat ambiguous legal situation. Rising costs of compliance with environmental regulations have added greatly to the overall costs of electricity generation by using coal. Conversely, statutes passed since the oil embargo of 1973-1974 have been designed to encourage the substitution of coal for imported oil and natural gas, particularly for utilities.

Energy Legislation

The Energy Supply and Environmental Coordination Act of 1974 (ESECA) and the Power Plant and Industrial Fuel Use Act of 1978 (PIFUA) represent the major legislative efforts to mandate reconversion to coal. Although it grants the U.S. Department of Energy (DOE) broad powers to prohibit the use of oil or natural gas in utility plants and other major fuel-burning installations, the program has been stymied by a lack of financial incentives and an uncertain regulatory climate.

On June 24, 1980, the Senate passed the Oil and Gas Backout Bill. This legislation contained an appropriation of $4.2 billion to provide utilities with grants and loans for conversion efforts. For the 80 affected generating plants, $3.6 billion was earmarked for mandated conversions, $450 million was available for voluntary conversions, and $150 million was available to aid in development of coal-preparation systems (2). A utility may be eligible to receive up to 25 percent of the capital cost of conversion. If added financial need can be demonstrated, grants for an additional 25 percent or loans of up to 50 percent would be made available. Current indications are that such a subsidy program will not meet with widespread approval (New York Times, Nov. 20, 1980, p. 3).

Environmental Legislation

The significant environmental-related costs of coal combustion are attributable to air-pollution control and disposal of solid wastes generated in the combustion process. A balance must be achieved among these considerations, national goals of reducing dependence on foreign sources of fuel, and economic growth in order to effectively further coal use. The federal government will debate several significant environmental statutes in the 1980s, and the results of these reviews will, in large measure, shape the future for coal use.

The Clean Air Act of 1970 was the initial major legislative effort to significantly affect coal users. The act and subsequent amendments required the U.S. Environmental Protection Agency (EPA) to develop standards for primary and secondary ambient air quality. In December 1971, EPA responded through issuance of the new source performance standards. Utilities could comply with these standards by either (a) direct combustion of low-sulfur coal or (b) use of high-sulfur coal in conjunction with flue-gas desulfurization (FGD) systems.

A revision put forth in 1979 effectively removed the first option as a compliance strategy by requiring emission reduction through the use of so-called best-available control technology (BACT). This policy required that all new coal-fired generating stations--regardless of the sulfur content of coal--install and continuously operate FGD systems.

Previous regulations (Federal Register, June 1, 1978, p. 4; Dec. 18, 1978, p. 5) had established maximum allowable increments for SO_2 pollution in class 1, 2, and 3 areas within the United States. On approval of a state implementation plan (SIP), all regions in compliance with National Ambient Air Quality Standards would be defined as class 2. Areas could then be redesignated 1 or 3 at the discretion of the state and corresponding changes would be made in allowable SO_2 emissions. These regulations further required use of BACT at any new fossil-fuel source that had potential SO_2 emissions of 250 tons/year. Some coal industry representatives have attributed much of the complexity of compliance and evaluation of alternative strategies to these new regulations (3, pp. 117-129).

These new regulations were designed in part to restore competitive balance to the coal industry (4). The market for low-sulfur "compliance" coal had placed a strain on the coal industry in Eastern and Midwestern states that have high-sulfur coal reserves. Whether these regulations will achieve this objective remains open to question. The standards apply to plants constructed after September 18, 1978. FGD systems now remain the only technique that qualifies as BACT under these regulations.

Additional major environmental legislation that affects coal includes the Clean Water Act of 1970 (with subsequent amendments) and the Resource Conservation and Recovery Act of 1976 (RCRA). The latter is designed to improve disposal practices for hazardous waste materials. Classification of utility waste was postponed in recent regulations put forth under this act (Federal Register, June 1, 1978, p. 4; Dec. 18, 1978, p. 5). Determination of the nature of waste materials is based on physical and reactive characteristics of the substance. An alternative strategy, proposed by EPA, to develop a subcategory for "special wastes" could significantly affect costs of compliance for large generators of relatively low-hazard waste. Utility waste materials such as fly ash and scrubber sludge are expected to be included in the proposed classification.

Local environmental regulations will have a significant impact on plans for coal use in the study region. Combustion of coal within New York City is now prohibited by law. The Consolidated Edison Company was granted permission by EPA on August 7, 1980, for a one-year test burn of high-sulfur oil at three generating stations in New York as a prelude to reconversion (New York Times, Aug. 8, 1980, p. 5). Company officials expressed hope that this demonstration would illustrate the practicality of using low-sulfur coal without significant negative impact on the health and welfare of the region. The utility has been using 1.5 percent sulfur oil, approximately equivalent to a 1.0 percent sulfur coal. The decision by EPA to proceed with the test was reached over objections by surrounding states, which reflected a positive attitude toward demonstrating the environmental effects of reconversion.

POTENTIAL CONVERSIONS IN STUDY REGION

Questions related to future generation mix create an uncertain situation for future coal use by utilities that might be served by the proposed facility. In New York, coal use by utilities will remain the greatest percentage share of coal consumption in the state, as it has been historically (5). Potential increases in coal demand are related to the overall growth of electricity demand, any successful programs of voluntary or mandated conversions, and the future development of nuclear-generating capacity.

For this analysis, generating stations in the downstate region cited as candidates for reconversion were used to determine potential demand for coal that could be served by the proposed transshipment facility. Currently, the New York State energy master plan lists 20 generating units at 9 power plants as probable conversions (5). Utilities that have facilities included in this classification are Consolidated Edison (Con Ed) (three plants), Long Island Lighting Company (Lilco) (three plants), Central Hudson Gas and Electric (CHGEC) (one plant), Orange and Rockland (O&R) (one plant), and Niagara Mohawk (one plant). These facilities represent a generating capacity of 5982 MW. With the exception of the Niagara Mohawk plant at Albany, all stations mentioned above are included in the demand analysis; they represent a total generating capacity of 5582 MW. Table 1 (5, p. 174) presents the generating facilities included in this analysis. Completion of these conversions would increase coal consumption by 13.5×10^6 tons/year for coal from central Pennsylvania or southern West Virginia and 12.6×10^6 tons/year for coal from eastern Kentucky. Supply regions and quality characteristics used in this analysis are outlined in the following section. The plant-specific demand for coal from each supply region is outlined in Table 2. Coal demand for each generating station is computed based on total annual heat requirements to meet generating capacity and applicable heat content for each candidate coal.

COAL-SUPPLY REGIONS

Selection of a coal-supply source is generally based on the user's perception of quality characteristics necessary to achieve generating capacity and to ensure compliance with applicable regulations at a minimum cost. Characteristics such as content of British thermal units and percentage of sulfur content can vary widely from mines within a specific supply region. Such physical characteristics of the coal are determined through formational processes of heat, pressure, depositional history, and groundwater mineral content. As discussed earlier, environmental regulations have, to a large extent, shaped the current utility coal market.

In this analysis, coal-supply regions were selected based on discussions with utility representatives and approximate "typical" supply strategies. Supply nodes utilized here include Clearfield, Pennsylvania, for central Pennsylvania; Beckley, West Virginia, for southern West Virginia; and Thacker, West Virginia, for eastern Kentucky.

Quality characteristics and free-on-board (FOB) mine prices are presented in Table 3 (6). Implicit in selection of the supply sources is the assumption that Eastern coal will remain the minimum-cost alternative over Western coal for the converted plants. Transportation alternatives evaluated correspond to logical patterns of transportation from supply regions noted.

TRANSPORTATION ALTERNATIVES

Utility officials have stressed the importance of evaluating alternative strategies both for supply and for transportation to avoid the development of a "captive" market for Eastern coal movements. Five mode and route configurations were compared in this analysis (EGS stands for electric-generating station; NYCCHF stands for New York City coal-handling facility):

For central Pennsylvania coal:

ALLRAIL

RAILBARGE 1: rail to Philadelphia, barge to EGS

RAILBARGE 4: rail to Port Reading, NJ; barge to EGS

Table 1. Power plants for probable conversion to coal.

Electric-Generating Station	Operating Company	Conversion Service Date	Capacity (MW)
Arthurkill (nos. 2 and 3)	Con Ed	1984	851
Ravenswood (no. 3)	Con Ed	1984	928
Port Jefferson (nos. 3 and 4)	Lilco	1984	380
E. F. Barrett (nos. 1 and 2)	Lilco	1988	380
Northport (nos. 1 to 4)	Lilco	1989	1532
Danskammer (nos. 3 and 4)	CHGEC	1982	342
Lovett (nos. 4 and 5)	O&R	1986	399
Ravenswood (nos. 1 and 2)	Con Ed	1987	770

Table 2. Coal demand potential from supply region.

	Supply Region		
Electric-Generating Station	Central Pennsylvania	Southern West Virginia	Eastern Kentucky
Arthurkill (nos. 2 and 3)	2 093 684	2 093 684	2 013 158
Ravenswood (no. 3)	2 277 629	2 277 629	2 190 028
Port Jefferson (nos. 3 and 4)	883 577	883 577	849 593
E. F. Barrett (nos. 1 and 2)	954 287	954 287	917 584
Northport (nos. 1 to 4)	3 558 371	3 558 371	3 421 510
Danskammer (nos. 3 and 4)	824 585	824 585	792 870
Lovett (nos. 4 and 5)	1 017 541	1 017 541	978 405
Ravenswood (nos. 1 and 2)	1 881 600	1 881 600	1 809 231
Total	13 491 274	13 491 274	12 672 379

Table 3. Coal-quality characteristics and FOB mine prices.

			FOB Mine Price ($)	
Supply Region	Heat Content (Btu/lb)	Sulfur Content (% by wt)	Term	Spot
Central Pennsylvania	12 500	1.0	31.00	29.00
Southern West Virginia	12 500	1.5	29.50	26.00
Eastern Kentucky	13 000	0.7	37.00	33.00

RAILBARGE 5: Rail to NYCCHF, barge to EGS

For southern West Virginia coal:

- ALLRAIL
- RAILBARGE 2: rail to Norfolk, barge to EGS
- RAILBARGE 4: rail to Port Reading, NJ; barge to EGS
- RAILBARGE 3: rail to Newport News, barge to EGS
- RAILBARGE 5: rail to NYCCHF, barge to EGS

For eastern Kentucky coal:

- ALLRAIL
- RAILBARGE 2: rail to Norfolk, barge to EGS
- RAILBARGE 4: rail to Port Reading, NJ; barge to EGS
- RAILBARGE 5: rail to NYCCHF, barge to EGS

Lengths of haul from each supply region to generating stations were obtained from state transportation maps of New York, New Jersey, Pennsylvania, Virginia, and West Virginia. Tidewater distances were obtained from the U.S. Coast and Geodetic Survey (7).

Unless otherwise noted, all estimates of unit-train rates used in this analysis were derived from a regression model that expresses rates in dollars per ton as a linear function of the length of haul. Single-car rates were computed in a similar manner. Data regarding existing rate structures between supply regions and tidewater ports were obtained through discussions with personnel of the Consolidated Rail Corporation (Conrail), the Chessie System, and the Norfolk and Western Railway Company.

Unit-train rates apply for shipments in excess of 7000 tons for one origin. Calibration of quoted rail rates to length of haul yielded the following relationships:

For unit-train rates:

$$U = 6.65 + 0.015X \qquad R^2 = 0.89 \tag{1}$$

where

- U = unit-train rate ($/ton),
- X = rail-line distance between supply region and generating facility, and
- R^2 = proportion of variation in quoted rate accounted for by length of haul.

For single-car rates:

$$S = 9.97 + 0.017X \qquad R^2 = 0.67 \tag{2}$$

where S is the single-car rate in dollars per ton and X and R^2 are as in Equation 1.

In evaluating RAILBARGE alternatives, transshipment costs are assumed to be included in the rail rate. This was found to be the standard practice of railroads that retain ownership of coal-transfer facilities at tidewater ports. For the proposed transshipment terminal, varying levels of costs were evaluated. This sensitivity analysis yields insight into the cost levels necessary to achieve positive benefits for users.

Costs for waterborne movements are based on similar intercoastal shipments to a recently converted power plant in Massachusetts. These costs are recognized to be highly variable and based on factors such as vessel size, ownership, and the length of haul. Vessel sizes range from 2400-ton coastal barges to large ocean-going colliers in the 20 000-ton range. Comparative ton-mile transportation costs are shown below:

Mode	Cost ($/ton mile)
Rail	0.02-0.03
Barge	0.01-0.02

ANALYTICAL STRUCTURE

Delivered-coal prices were developed for each supply region and applicable transportation configuration. Estimates are based on FOB mine prices (Table 3) and modal rate estimates for each movement. The least-cost alternative for each generating facility is given in Table 4. Delivered-price estimates developed for RAILBARGE alternative 5 were, as discussed earlier, developed for various levels of per-ton transshipment cost. These estimates are fully explained in Table 5 and are compared directly with the least-cost alternative to determine transportation cost savings. Evaluation of these estimates based on plant-specific coal demand yields total benefits, shown in Table 6. The structure of the analytical methodology that was used is shown below:

1. FOB mine prices for three types of coal: central Pennsylvania, southern West Virginia, and eastern Kentucky;
2. Transportation costs:
   a. For four route options for central Pennsylvania coal: ALLRAIL, RAILBARGE 1, RAILBARGE 4, and RAILBARGE 5;
   b. For five route options for southern West Virginia coal: ALLRAIL, RAILBARGE 2, RAILBARGE 3, RAILBARGE 4, and RAILBARGE 5;
   c. For four route options for eastern Kentucky coal: ALLRAIL, RAILBARGE 2, RAILBARGE 4, and RAILBARGE 5;
3. Least-cost alternative for three types of coal;
4. Comparison with RAILBARGE 5; and
5. Evaluation of benefits.

EVALUATION

In terms of total benefits (per-ton transportation cost savings on a plant-specific basis multiplied by the demand potential of that plant), it would appear that ALLRAIL remains the minimum-cost alternative for plants at which rail infrastructure exists. Rail service extends to four plants used in this analysis: Lovett, Danskammer, Arthurkill, and E.F. Barrett. It is unreasonable, we believe, to assume that rail service will be extended to additional facilities due to attendant high construction costs and impacts on existing land use patterns.

Coal shipments bound for the E.F. Barrett station must be routed via Poughkeepsie or in some cases even further up the Hudson Valley. This excessive rail mileage militates against the ALLRAIL alternative for this facility.

At lower transshipment costs, use of the facility yields benefits in comparison with other RAILBARGE alternatives. For movements of central Pennsylvania coal, the proposed facility remains competitive at transshipment costs of $2.00/ton. For southern West Virginia coal, the facility yields benefits up to cost levels of $1.50/ton. Movements of more-expensive low-sulfur eastern Kentucky coal would not achieve savings at cost levels greater than $1.00/ton.

It is important to note that these benefits are low-end estimates. No provision is made for savings to users for additional storage capacity or savings in on-site coal-handling systems related to the facility. Table 7 lists the total annual benefits attributable to the proposed facility in terms of aggregate transportation cost savings. Estimates of annual throughput also vary with cost for transshipment. At $1.00/ton, throughput ranges from 9.6 million tons of central Pennsylvania or southern West Virginia coal to 4.4 million tons from eastern Kentucky. Cost levels of $2.00/ton result in a decrease in throughput to 8.6 million tons from central Pennsylvania and 4.4 million tons from southern West Virginia. (These throughput estimates assume that all plants will use the same coal supply source.)

The large backlog of loadings at the port of Norfolk adds greatly to the cost of transporting coal from that region. In developing an alternative scenario we have assumed that such congestion creates an unacceptable or overly costly service for utilities that results in an altered transportation strategy. To evaluate the effects of this situation, it was assumed that shipment via Norfolk was infeasible. Transportation cost savings were computed as in the base case.

Total benefits for this scenario are presented in Table 8. For the E.F. Barrett power plant, the use of the facility would yield benefits to transshipment cost levels of $1.50/ton compared with ALLRAIL. Generating stations not served by ALLRAIL are assumed to use RAILBARGE 4 (Port Reading, New Jersey). In general, use of the facility would yield savings throughout the range of cost levels for all three supply regions. Annual benefits for this alternative scenario are presented in Table 9.

For the alternative scenario, a throughput of 9.6 million tons of central Pennsylvania or southern West Virginia coal could be realized for transshipment costs as high as $4.00/ton. For eastern Kentucky coal, throughput is estimated to be 9.2 million tons/year at a similar cost level.

Table 4. Least-cost delivered-price alternatives.

Supply Region	Electric-Generating Station	Least-Cost Alternative	Delivered-Price Estimate ($)
Central Pennsylvania	Lovett	ALLRAIL	43.25
	Danskammer	ALLRAIL	43.52
	Arthurkill	ALLRAIL	42.53
	E. F. Barrett	RAILBARGE 1[a]	44.69
	Ravenswood	RAILBARGE 1	44.84
	Northport	RAILBARGE 1	45.63
	Port Jefferson	RAILBARGE 1	45.83
Southern West Virginia	Lovett	ALLRAIL	45.78
	Danskammer	ALLRAIL	46.05
	Arthurkill	ALLRAIL	45.06
	E. F. Barrett	RAILBARGE 2[a]	46.88
	Ravenswood	RAILBARGE 2	47.01
	Northport	RAILBARGE 2	47.70
	Port Jefferson	RAILBARGE 2	47.88
Eastern Kentucky	Lovett	ALLRAIL	54.45
	Danskammer	ALLRAIL	54.72
	Arthurkill	ALLRAIL	53.73
	E. F. Barrett	RAILBARGE 2[a]	54.59
	Ravenswood	RAILBARGE 2	54.72
	Northport	RAILBARGE 2	55.41
	Port Jefferson	RAILBARGE 2	55.59

[a]Assumes presence of transfer facilities at plant.

CONSIDERATIONS IN SITE SELECTION

From the standpoint of practical planning, criteria for evaluating potential locations of intermodal transshipment facilities are relatively straightforward. Successful operation is dependent on the adequacy of rail service and access to adequate shipping channels. The unique harbor environment of the study region presents a somewhat more difficult situation for planners of the proposed facility. Discussions with the planning staff of the Port Authority of New York and New Jersey have indicated that the preferred site is located on the east bank of the Hudson River in the area between the Lincoln Tunnel and the Verrazano Narrows Bridge. This general location would make use of the existing rail system to minimize new track construction and would minimize necessary dredging.

For the general purpose of analyzing the economic impacts of the proposed facility, a site on the eastern shore of Staten Island was selected. The facility is assumed to be of sufficient size to handle the demand requirements of the reconversions examined in this analysis. Decisions regarding the exact nature of the proposed transshipment facility have not been firmly established. We have assumed a facility of size and configuration competitive with similar facilities on the East Coast.

Larger, more modern facilities such as the Superior Midwest Energy Terminal were designed for maximum efficiency and minimum environmental impact. It is expected that similar considerations will be paramount in the development of the proposed transshipment terminal in New York. To facilitate rapid turnaround, a loop track is preferred so that unit trains can be unloaded with little or no switching.

CONCLUSIONS

The current level of governmental interest in increased coal use will have significant impacts on

Table 5. Transshipment cost sensitivity.

		Delivered-Price Estimate ($)						
		Transshipment Cost ($/ton)						
Supply Region	Electric-Generating Station	1.0	1.5	2.0	2.5	3.0	3.5	4.0
Central Pennsylvania	Lovett	43.98	44.48	44.98	45.48	45.98	46.48	46.98
	Danskammer	44.18	44.68	45.18	45.68	46.18	46.68	47.18
	Arthurkill	43.79	44.29	44.79	45.29	45.79	46.29	46.79
	E. F. Barrett	43.87	44.37	44.87	45.37	45.87	46.37	46.87
	Ravenswood	43.67	44.17	44.67	45.17	45.67	46.17	46.67
	Northport	44.00	44.50	45.00	45.50	46.00	46.50	47.00
	Port Jefferson	44.12	44.62	45.12	45.62	46.12	46.62	47.12
Southern West Virginia	Lovett	46.52	47.02	47.52	48.02	48.52	49.02	49.52
	Danskammer	46.72	47.22	47.72	48.22	48.72	49.22	49.72
	Arthurkill	45.33	46.83	47.33	47.83	48.33	48.83	49.33
	E. F. Barrett	46.41	46.91	47.41	47.91	48.41	48.91	49.41
	Ravenswood	46.54	47.04	47.54	48.04	48.54	49.04	49.54
	Northport	46.54	47.04	47.54	48.04	48.54	49.04	49.54
	Port Jefferson	46.66	47.16	47.66	48.16	48.66	49.16	49.66
Eastern Kentucky	Lovett	55.19	55.69	56.19	56.69	57.19	57.69	58.19
	Danskammer	55.39	55.89	56.39	56.89	57.39	57.89	58.39
	Arthurkill	55.00	55.50	56.00	56.50	57.00	57.50	58.00
	E. F. Barrett	55.08	55.58	56.08	56.58	57.08	57.58	58.08
	Ravenswood	54.88	55.38	55.88	56.38	56.88	57.38	57.88
	Northport	55.21	55.71	56.21	56.71	57.21	57.71	58.21
	Port Jefferson	55.33	55.83	56.33	56.83	57.33	57.83	58.33

Table 6. Total benefits.

Electric-Generating Station	Least-Cost Alternative	Supply Region	Benefits ($000 000s) Transshipment Cost ($/ton) 1.0	1.5	2.0	2.5	3.0	3.5	4.0
Lovett	ALLRAIL	CPA	-0.74	-1.3	-1.8	-2.3	-2.8	-3.3	-3.8
		SWVA	-0.75	-1.3	-1.8	-2.3	-2.8	-3.3	-3.8
		EKY	-0.72	-1.2	-1.7	-2.2	-2.7	-3.2	-3.7
Danskammer	ALLRAIL	CPA	-0.54	-0.96	-1.4	-1.8	-2.2	-2.6	-3.0
		SWVA	-0.55	-0.97	-1.4	-1.8	-2.2	-2.6	-3.0
		EKY	-0.53	-0.93	-1.3	-1.8	-2.1	-2.5	-2.9
Arthurkill	ALLRAIL	CPA	-2.6	-3.7	-4.7	-5.8	-6.8	-7.9	-8.9
		SWVA	-2.7	-3.7	-4.8	-5.8	-6.8	-7.9	-8.9
		EKY	-2.6	-3.6	-4.7	-5.6	-6.6	-7.6	-8.6
E. F. Barrett	RAILBARGE 1	CPA	0.78	0.31	-0.17	-0.65	-1.1	-1.6	-2.1
	RAILBARGE 2	SWVA	0.45	-0.00	-0.50	-0.98	-1.5	-1.9	-2.4
	RAILBARGE 2	EKY	-0.45	-0.91	-1.4	-1.8	-2.3	-2.7	-3.2
Ravenswood	RAILBARGE 1	CPA	4.9	2.8	0.71	-1.4	-3.4	-5.5	-7.6
	RAILBARGE 2	SWVA	3.3	1.3	-0.83	-4.2	-5.0	-7.0	-9.1
	RAILBARGE 2	EKY	-0.64	-2.6	-4.6	-6.6	-8.6	-10.6	-12.5
Northport	RAILBARGE 1	CPA	5.8	4.0	2.2	0.46	-1.3	-3.1	-4.9
	RAILBARGE 2	SWVA	4.1	2.4	0.57	-1.2	-3.0	-4.8	-6.6
	RAILBARGE 2	EKY	0.68	-1.0	-2.7	-4.5	-6.2	-7.9	-9.6
Port Jefferson	RAILBARGE 1	CPA	1.5	1.1	0.63	0.19	-0.26	0.70	-1.1
	RAILBARGE 2	SWVA	1.1	0.64	0.19	-0.28	-0.69	-1.1	-1.6
	RAILBARGE 2	EKY	0.22	-2.0	-0.63	-1.1	-1.5	-1.9	-2.3

Note: Supply regions abbreviated as follows: Central Pennsylvania, CPA; southern West Virginia, SWVA; eastern Kentucky, EKY.

Table 7. Total annual benefits, base case.

Transshipment Cost ($/ton)	Throughput by Supply Region (tons 000 000s) CPA	SWVA	EKY	Benefits ($000 000s) CPA	SWVA	EKY
1.0	12.98	8.95	0.90	9.6	9.6	4.4
1.5	8.21	4.34	0.00	9.6	8.6	-
2.0	3.54	0.76	0.00	8.6	4.4	-
2.5	0.65	0.00	0.00	4.4	-	-
3.0	0.00	0.00	0.00	-	-	-
3.5	0.00	0.00	0.00	-	-	-
4.0	0.00	0.00	0.00	-	-	-

Table 8. Total benefits, scenario 1.

Electric-Generating Station	Second Least-Cost Alternative	Supply Region	Benefits ($000 000s) Transshipment Cost ($/ton) 1.0	1.5	2.0	2.5	3.0	3.5	4.0
E. F. Barrett	ALLRAIL	PA	0.95	0.47	0.00	-0.47	-0.95	-1.4	-1.9
		SWVA	0.94	0.47	-0.01	-0.47	-0.96	-1.4	-1.9
		EKY	0.91	0.45	-0.01	-0.47	-0.92	-1.4	-1.8
Ravenswood	RAILBARGE 4	CPA	10.7	8.6	6.6	4.5	2.4	0.33	-1.8
		SWVA	12.8	10.8	8.7	6.7	4.6	2.5	0.42
		EKY	12.4	10.4	8.4	6.4	4.4	2.4	0.40
Northport	RAILBARGE 4	CPA	9.2	7.4	5.6	3.8	2.1	0.28	-1.4
		SWVA	11.0	9.3	7.5	5.7	3.9	2.1	0.36
		EKY	10.6	8.9	7.2	5.5	3.7	2.1	0.34
Port Jefferson	RAILBARGE 4	CPA	2.3	1.8	1.4	0.95	0.51	0.01	-0.37
		SWVA	2.7	2.3	1.9	1.4	0.97	0.53	0.01
		EKY	2.6	2.2	1.8	1.4	0.93	0.51	0.01

the market for coal and the transportation system that it will traverse. Increased use will certainly contribute to delays and congestion similar to those already being experienced at Norfolk. It is apparent that these problems decrease the overall efficiency of the transport network, which adds greatly to transportation costs. The development of a proposed transshipment facility in New York may serve to relieve some congestion at other ports through direct competition with similar facilities that yield only marginal economic benefits. Further expansion of coal traffic may tax existing terminals to the point of diminishing returns in cost savings, thus enhancing economic feasibility of the proposed facility.

If transshipment cost levels examined in this analysis could be maintained, developers of the proposed facility could expect a throughput of up to 10 million tons/year. This estimate reflects only part of the potential demand. Further evaluation is necessary to determine the nature of the facility and the potential to serve roles different from those evaluated here.

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Table 9. Annual benefits, scenario 1.

Transshipment Cost ($/ton)	Throughput by Supply Region (tons 000 000s)			Benefits ($000 000s)		
	CPA	SWVA	EKY	CPA	SWVA	EKY
1.0	23.50	27.44	26.51	9.6	9.6	9.2
1.5	18.27	22.87	21.95	9.6	9.6	9.2
2.0	13.60	18.10	17.42	9.6	9.6	9.2
2.5	9.25	13.80	13.30	9.6	9.6	9.2
3.0	5.01	9.47	9.03	9.6	9.6	9.2
3.5	0.62	5.13	5.01	9.6	9.6	9.2
4.0	0.00	0.79	0.75		9.6	9.2

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Physical and Operating Characteristics of Ferry Vessels

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The state of the art of ferry-vessel technology, including conventional slow-speed ships and high-speed ships, is discussed. The latter models, although used regularly in Europe and Canada, have had limited operating experience in the United States. Important vessel features are highlighted, including passenger and vehicle capacity, engine and propulsion systems, hull design, speed and steering control, docking procedures, and passenger amenities. Conventional low-speed diesel-powered vessels consume less energy than their high-speed gasoline turbine counterparts. On the other hand, high-speed vessels offer service-quality capabilities that are highly competitive with automobile commutation. However, there has been little opportunity to demonstrate the advantages of high-speed vessels, mainly because of legislative restrictions.

Ferry systems operate within diverse environments and serve different types and levels of passenger, vehicle, and even freight demands. Consequently, there is a wide range of vessel types now in operation. However, one generalization can safely be made concerning vessels currently in operation in the United States and Canada: Most rely on long-established and conventional sources of power and propulsion and as such are not high-speed ships. That is, most cannot achieve a speed greater than 20 knots (23 mph). Despite the existence of hydrofoils, hovercraft, and surface-effect ships, which can achieve speeds greater than 40 knots (46 mph), use of these high-speed craft is confined to service in Europe and the Far East, as well as to American military programs. In fact, the Golden Gate Ferry in San Francisco is the only system in this country that relies on relatively high-speed vessels, and they achieve a cruising speed of only 25 knots (29 mph).

There are a number of reasons that American ferry systems do not use high-speed craft, some of which are listed below:

1. Many ferry-route distances are relatively short;
2. Longer ferry routes normally serve vehicle as well as pedestrian demand, which requires larger ship dimensions than most high-speed craft now offer;
3. Many ferries operate in heavily used waterways, often against the normal stream of ship traffic, which mandates lower operating speeds; and
4. Many high-speed craft (especially hovercraft) are foreign-built and thus prohibited from U.S. service by the Merchant Marine Act of 1920 (Jones Act).

However, a number of factors make it likely that high-speed vessels may see future domestic service. First, U.S. manufacturers have built and operated both hydrofoil and surface-effect ship prototypes, some of which are in operation elsewhere in the world. Second, planning objectives in urban areas may evolve, as they have already in San Francisco, from using ferries as bridge substitutes between key highway, transit, or pedestrian links into using high-speed craft to provide a competitive alternative commuter mode to the automobile between the central city and outlying areas. For such a plan to be feasible, the ferry would have to duplicate a number of automobile characteristics, among them speed (i.e., travel time). Third, the pedestrian-only feature of most high-speed craft fits in well with both urban (and recreational) area goals of reduction in automobile use, especially during peak-demand hours.

This paper presents a state-of-the-art exposition of ferry vessels available for current use. It discusses both conventional (slow-speed) vessels, which are widely used in this country, as well as high-speed ships, which, although their deployment is limited in the United States, represent products of available and fully tested technology. The objective of this paper is to provide a compendium of vessel information for the urban transportation