COAL SLURRY PIPELINES: THE ETSI PROJECT

by George R. Coffey & Virginia A. Partridge

Black Mesa Slurry Line during construction.

In the May, 1977 issue of **RIGHT OF WAY**, an article appeared on the coal slurry pipeline saga entitled, "History Repeats Itself as Railroads Block Coal Slurry Pipelines," by Ginny Partridge, Public Relations Representative of the ETSI Pipeline Project. This is a report of progress on the ETSI Pipeline Project system, the biggest single pipeline project ever undertaken in the lower 48 states. ETSI is a joint venture of Atlantic Richfield, Bechtel, Kansas-Nebraska Natural Gas, Lehman Brothers Kuhn Loeb, and Texas Eastern.

BACKGROUND

Slurry pipeline technology is established and proven. With the increasing demand for long distance transport of minerals and coal, this highly efficient and environmentally benign transport mode is sure to be used more and more. Original patents for the slurry pipeline concept were issued in 1891 and the first coal slurry pilot plant was built in a vacant lot at 58th Street and Madison Avenue in New York City.

The first operational coal slurry pipeline was built in 1914 in England, and used to transport coal from the Thames River docks into London.

America had to wait until 1957 for its first commercial coal slurry line. That's when the Consolidation coal slurry line was built in Ohio, connecting coal mines near Cadiz in the southern part of that state with a power generating station outside of Cleveland. This line, also known as the East Lake slurry line, successfully operated for six years before it was shut down after unit trains forced tariffs below the pipeline's rate. The pipeline could still operate if rail rates increased.

The Ohio pipeline was the precursor of over 15 long distance slurry pipelines built around the world in the 20-plus years since its startup. The 273-mile Black Mesa pipeline, which has been operating sucessfully since 1970, located in Kayenta, Arizona, was another major milestone in the development of slurry pipelines. This pipeline moved 5 million tons of coal per year across Arizona to the 1500 MW Mohave power station in Nevada. The Black Mesa Pipeline, a subsidiary of Southern Pacific railroad, has demonstrated the reliabily required by Electric utilities; and it has been able to deliver coal better than 90 percent of the time. Moreover, it has operated without any adverse effect on the environment.

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The entire length of the pipeline remains buried and the land above has been completely restored. Although it has been stopped for as long as six days, it has been restarted without removing the slurry.

The energy climate of the United States changed radically shortly after the Black Mesa line began operating. The 1973 OPEC oil embargo caused crude oil and petroleum product prices to quadruple. Although the embargo was lifted within two years, it drove home the point that we could no longer rely on foreign sources for a major part of our energy requirements. We turned to the vast reserves of American coal—reserves expected to last from 200 to 400 years and established a national policy designating coal as our country's primary energy source for the balance of this century and on into the next.

Because of this policy change, new coal-fired power stations have been completed or are under construction or planned at many locations around the country. Coal traffic on our railroads is increasing as we struggle to keep up with the rising demand for domestic steam coal and as we haul coal from our mines to our harbors for export.

It has become abundantly clear that there has never been a greater need for a coal slurry pipeline industry in this country. Coal slurry lines can supplement existing transportation systems, principally railroad and barges in domestic service and in transporting coal to harbors for export as well.

The ETSI coal slurry pipeline project is the pioneer coal slurry project being developed today. The main ETSI slurry pipeline will be about 1400 miles long and will move a half water, half coal slurry from mines in Wyoming's Powder River Basin to power stations in Oklahoma and Arkansas on the Mississippi River. From Cypress Bend, barges will be able to carry the dewatered ETSI pipeline coal down river to power stations in Louisiana. The pipeline is expected to cost about $3 billion transporting $30 million tons of coal per year. The pipeline's diameter will probably be 40 inches.

The ETSI system includes three coal slurry preparation plants at mine sites near Gillette, Wyoming. At these plants coal will be ground to the consistency of sugar and then mixed with water before entering the pipeline.

The water for the slurry will come from South Dakota's Lake Oahe, the largest reservoir on the Missouri River, and will be transported to the plant sites through the nearly 300 mile-long West River Aqueduct.

The main coal slurry line will have pumping stations every 80 to 100 miles and will cross Wyoming, the northeast corner of Colorado, and Kansas before reaching power stations in Oklahoma. The line will then cross into Arkansas serving power plants in that state plus the Cypress Bend barge terminal. At all delivery points, dewatering terminals will heat and spin the slurry dry and deliver powdered coal to the power stations and the barge terminal. The used slurry water will be clarified and be used for power station cooling and other industrial purposes.

ETSI COMPONENTS

There are four distinct elements comprising the ETSI slurry system. They are: 1) water supply system, 2) coal preparation plants, 3) coal slurry pipelines and pumping stations, and 4) coal dewatering plants.

1. Water Supply System

ETSI has negotiated rights to water from both the Oahe Reservoir in South Dakota and to Madison Formation in Wyoming. The Oahe Reservoir will be ETSI's primary source, and the Madison represents a backup source in the event Oahe water is not available. The total pipeline system requires up to 20,000 acre feet of water annually to transport a maximum of 37.4 million tons of coal.

Oahe Reservoir. Lake Oahe is one of six federal main stem reservoirs on the

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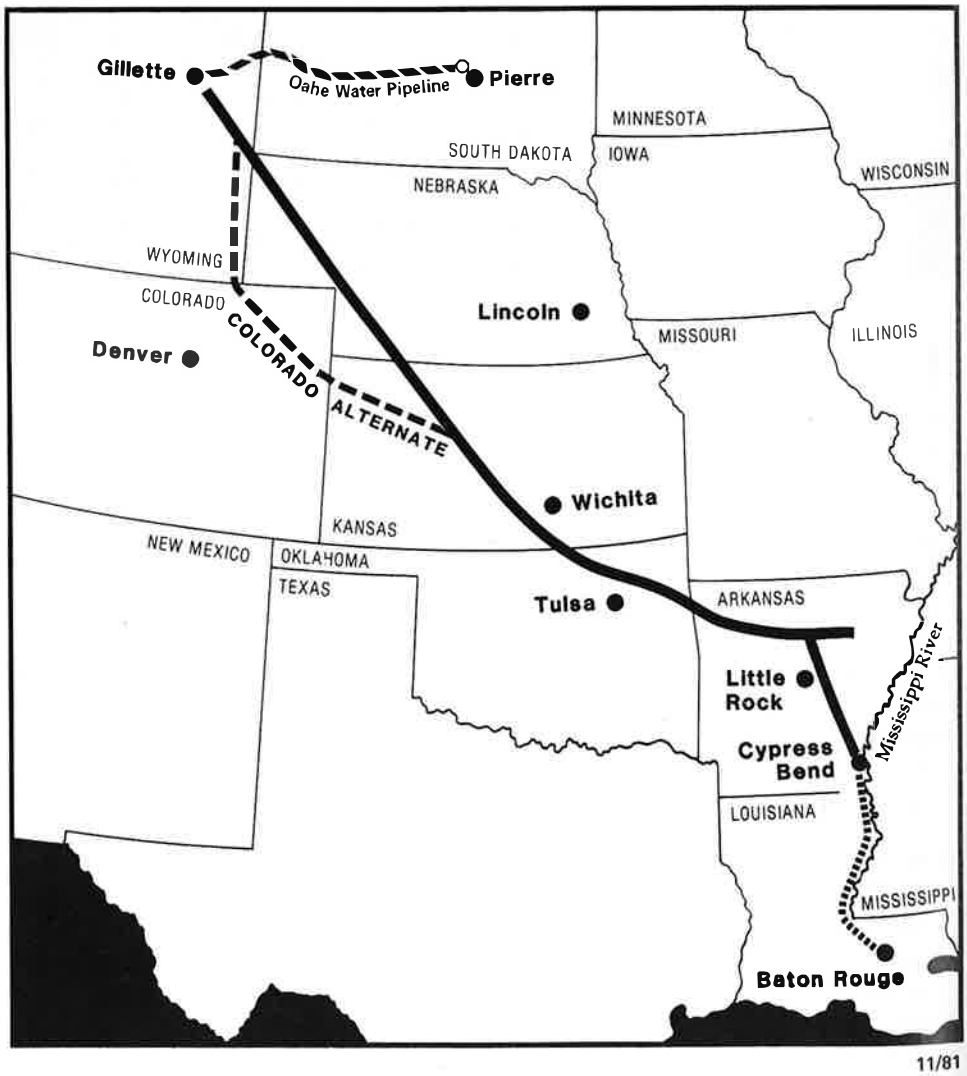
THE ETSI PIPELINE ROUTE



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Missouri River. The Oahe dam was constructed by the U.S. Army Corps of Engineers to control the flood waters of the Missouri. At the Dam's dedication in 1962, President Kennedy said:

> "Surely a continent so rich in minerals, so blessed with water, and a society so replete with engineers and scientists can make and must make the best possible use of the bounty which nature and God have given us, public and private, Federal and local, cooperative and corporate. We cannot prevent other people in this country from developing their resources. We look forward to the day when energy will flow where it's needed. We cannot permit railroads to prevent coal slurry pipelines conveying the resources of our mines."

A federal/state ad hoc committee, in 1974 report to the Assistant Secretary of Interior and the U.S. Department of the Army projected that three million acre-feet of water per year would be available from the upper Missouri River system for industrial use. This amount is in excess of all forecast needs, such as irrigation, municipal and domestic requirements, through the year 2060. Average annual flow of the Missouri River at Oahe is 18.5 million acre-feet. The Oahe Reservoir stores 23 million acre-feet.

Last December ETSI and the South Dakota Statewide Water Conservancy signed a contract for the purchase of up to 50,000 acre-feet of water a year from the Oahe Reservoir. This allocation, approved by the Bureau of Reclamation, totals less than the BLM's measurement tolerance when estimating the reservoir's total water supply.

Under the terms of this agreement, ETSI will build the 267-mile long West River Aqueduct between the reservoir north of Pierre, South Dakota and ETSI's coal slurry preparation plants south of Gilette, Wyoming. As part of the agreement, ETSI will transport 4,300 acre feet of Oahe water a year without charge to communities and rural water systems along the route of the aqueduct. ETSI will pay the state $10 million before water deliveries begin, and at least $9 million in annual payments that will be adjusted for inflation during the life of the pipeline.

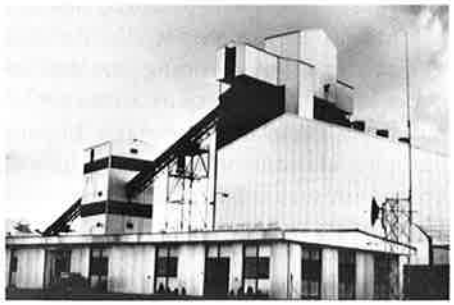
In addition, ETSI will provide up to $20,000 in technical assistance to study and propose solutions to the water supply problems of South Dakota communities which do not tie into the Oahe water line.

Madison Formation Seconday Water Source. This backup source of water is located in the Powder River Basin, Niobrara County, in Wyoming. The water would come from wells drilled to depths greater than 2,500 feet into the Madison Limestone Formation, a deep aquifer underlying the Northeastern Great Plains covering an area of over 180,000 square miles. Independent studies supervised by the Wyoming State Engineer in consultation with the U.S. Geological Survey, indicate that the Madison Formation contains one billion acre-feet of water. It's potential recharge is estimated to be from 150,000 to 400,000 acre-feet anually.

2. *Coal Slurry Preparation Plants*

Three preparation plants will be located adjacent to the related coal mines at Thunder Basin, North Rawhide and North Antelope mines. All land required will be leased by ETSI before construction begins.

Coal is delivered by dump truck or conveyor from the mine to a working stockpile. The coal is first crushed by cage mills, then by rod mills to pipeline requirement (about the consistency of sugar). During the rod mill grinding, water is introduced to form the slurry mixture. Slurry from the preparation plant is pumped to agitated storage tanks as a buffer betweeen preparation operations to ensure maintenance of delivery scheduling.



Black Mesa Slurry Line Preparation Plant

3. Coal Slurry Pipelines and Pumping Stations

The transportation system begins at the pumping station adjacent to the Thunder Basin preparation plant. Coal from North Rawhide and North Antelope preparation plants is delivered by pipeline to the Jacobs Ranch station. The North Rawhide pipeline will be 55 miles long and 32 inches in diameter; the North Antelope pipeline will be 16 miles long and 24 inches in diameter. The main slurry pipeline, which may have a main trunk of up to 46 inches, extends approximately 1,300 miles from Jacobs Ranch to terminals in Oklahoma and Arkansas with a possible 200 to 300 mile extension into Louisiana.

The 19 slurry pumping stations en route propel the slurry at a rate of 3.6 miles per hour. The outage of one pumping station for a limited time will not require a shutdown of the system. A station can be bypassed, preserving 70 percent of capacity.

A private microwave telecommunications system provides voice and data transmission and supervisory control. There are three bases to support plant facilities and pipeline maintenance.

4. Coal Slurry Dewatering Plants

A dewatering plant is located at each delivery terminal to separate the coal from water by a process of centrifuging and drying. The extracted water is treated by "flocculation" to remove fine suspended coal particles. Residual water can either be used as a portion of the makeup water in the cooling system of the shipper's power plant, or be discharged into streams and rivers. If it is to be discharged, it is further treated for biochemical oxygen demand to meet environmental quality standards.

RIGHTS OF WAY

Obtaining a right of way to build a new transportation system should represent no significant problem in areas that already are well traversed by other pipelines. However, in the conceptual phases of the project, it became evident that the railroads whose existing tracks would have to be crossed by ETSI, would oppose the project, since they visualized it as dangerous competition. History shows that obstructions to competition have been a consistent reaction of the American railroad for the past 100 years.

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ETSI knew that for the project to succeed there would need to be absolutely incontrovertible proof of the availability of right of way. A concerted and successful effort was made to establish eminent domain for coal slurry pipelines in several of the states that must be crossed. Additionally, ETSI negotiated easement to land at a number of crossings or "windows" where the records showed that the railroads did not have fee ownership. Suit was then brought to quiet title. ETSI won 65 out of 65 cases and 6 out of 6 major appeals. The principle is well established that, at such locations, the railways do not have the right to deny or obstruct a crossing. At the beginning of 1981, ETSI began a program to acquire right of way between such railway crossings, and ETSI will not begin construction until it is satisfied that right of way is in hand. The terrain through which the pipeline project passes is generally very favorable. There is almost unlimited opportunity for choice of location except for certain anchor points, such as specific rail crossings, certain river crossings, the avoidance of cities, etc. About 75 percent of the ETSI project will be along established pipeline corridors. Therefore local citizens are already well acquainted with pipelines, and such precedent exists for determination of the terms, conditions, and prices for right of way.

General right of way acquisition is proceeding on schedule, except for Nebraska where resistence continues. ETSI has therefore acquired right of way along an alternative route through Colorado. If used this would add 30 miles to the line at an additional cost of $50 million.

An early effort was made to apply for permits from the railroads to cross their lines. The applications were consistently refused by the railroads, and it became evident that other forms of action were required. Over a five-year period, the following campaign was carried out.

1. Eminent domain was sought at the state level. The results of this effort are as follows:
   - Wyoming and Arkansas had existing statutes that provide for acquisition of right of way for coal slurry pipeline purposes.
   - Oklahoma, Texas, and Lousisiana have since enacted eminent domain law for coal slurry pipelines.
   - The railroads now state that in general, their rights are limited to easements in Kansas, one of two ETSI states which do not have an eminent domain law for coal slurry pipelines.
   - Efforts to enact an eminent domain law in Nebraska for coal slurry pipelines have been frustrated, and such legislation seems unlikely in the near future.
2. Eminent domain was sought at the federal level in cooperation with other prospective coal slurry pipelines, who were encountering similar railroad resistance. There is strong evidence that, if pursued consistently, a federal eminent domain bill could be approved. However, ETSI no longer requires this authority.

Privately owned land represents about 92 percent of the total mainline route. There are approximately 3,500 easement parcel owners, plus about 1,900 secondary interest consents that must also be obtained. To date, more than 60 percent of the right of way needed through private land has been acquired in Wyoming, Colorado, Kansas, Oklahoma, and Arkansas.

Approximately 2 percent (33 miles) of the pipeline route lies across federal lands in Wyoming. Discussions have been held with officials of the Interior and Agriculture Department, with a

formal application granted by Department of the Interior for a right of way permit to cross these federal lands. The route through Oklahoma will cross restricted Indian lands. No particular problems are anticipated in negotiation and acquiring easements across this land and will be probably completed by the time this article is published.

About 3 percent (32 miles) of the right of way in Wyoming, Nebraska, and Oklahoma lies in state-owned lands. No difficulty is anticipated in acquiring these easements.

For the base route, there are some 1,500 crossings of highways, roads, rivers, streams, canals, pipelines, and utilities. Permission to cross is issued routinely if pipeline design and construction criteria meet the granting agencies' requirements. Preliminary acquisition of these permits is proceeding on schedule.

To cross federal land in Wyoming and Colorado, a $6 million three-year environmental impact study had to be completed to satisfy federal regulations.

This environmental impact study resulted in a very positive assessment of the ETSI system. The study called local slurry pipelines a safe means of transportation that cause little degradation of the environment. Moreover, according to the study, coal slurry lines cause the least possible risk to public health and safety of all coal transportation alternatives. Unlike other forms of transportation, coal slurry lines allow farming and other normal surface uses to continue along the pipeline route, and the ETSI line, the report said, will avoid damage to cultural and historical resources.

In addition, the study found that the ETSI line will benefit local economies along its route and provide energy to consumers at lower cost than other means of transportation. And, coal slurry pipelines were found to be energy efficient.

SUMMARY

Since ETSI was organized in 1973, $25 million dollars has been spent in the development phase alone. During this period, many challenges had to be met and milestones passed. First of all, engineering studies and laboratory testing programs had to be carried out to confirm that such a long distance slurry pipeline is indeed feasible. Determining that the pipeline would work, ETSI had to define market groups and the pipeline route.

Currently the project is in its definitive phase, a $70 million commitment toward achieving the objectives which will lead to the start of construction in 1983. Those objectives completed include the basic engineering design, definitive estimate of capital costs and construction and operation of a coal evaluation plant to test the characteristics of the specific Wyoming coals ETSI will ship and find out how they will behave in the slurry preparation and dewatering process. ETSI's tests have shown that with proper management, slurry-sized coal can be handled and stored safely, cleanly and efficiently.

Still needed are the various required federal and state permits necessary to allow construction of the ETSI system. These permits include:

- Air quality permits for coal preparation plants in Wyoming.
- Air quality permits for dewatering plants and the Cypress Bend Arkansas barge facility.
- Corps of Engineers river crossing permits.
- Other major federal permits, such as Federal Communication Commission license for the microwave system.

Acquisition of these permits is anticipated to be routine, though careful management is required to ensure that all permits are acquired before construction begins.

On the marketing front, ETSI is hard at work with transportation agreements. Market survey work indicates that potential business may be about 50 million tons a year, substantially more than the system's 30 million tons per year capacity.

As part of this effort, ETSI is working toward establishing a tariff level that provides lower costs to the shippers and electric power consumers. ETSI research shows that the pipeline tariff will be competitive with rail rates right from the start of pipeline operation, and as rail rates climb with inflation, ETSI's

economic superiority will become increasingly dominent.

A final—and a most important objective during the definitive phase—is to structure the financing for the ETSI pipeline project. The ETSI pipeline should take two years to build, operating fully by 1986.

CONCLUSION

If you are any way at all associated with coal and its transportation, you know that as demand for coal rises both in this country and worldwide, existing transportation systems will be hard pressed to provide the transportation capacity needed to move this coal to our power stations and seaports.

Coal slurry lines offer an additional, reliable transportation system to haul coal from mines to large power stations around the country and to industrial and export markets. They will ease the burden of the railroads, and they will make coal an even more economically attractive fuel.

Coal slurry pipeline will form a new industry, and it will be an industry based on a proven technology. The Black Mesa line in Arizona and the Consolidation Coal slurry line in Ohio, as well as the successful operation of iron ore and limestone slurry lines both here and overseas prove that the idea works.

Capital expenditures occur only once and are therefore not subject to inflation once the line is built. Therefore, coal delivered by slurry pipeline can help our public utilities hold the line on rising electricity costs, a major benefit that can be passed on to consumers in the form of lower power prices.

It's not surprising, therefore, to hear the report of an Oklahoma utility executive who in 1977 told the Oklahoma House Judiciary Committee that "if our company, other Oklahoma utilities, and the state's rural electric systems used the full capacity of a 25 million ton a year coal pipeline from Wyoming, we could save $12 billion over the next 30 years."

We believe in this project, and we believe in the development of a substantial coal slurry industry in the United States—an industry that will be a hard working partner providing substantial benefits for the coal mines, utilities, and ultimately the consumers of America.

The Working Precedent! Black Mesa Slurry Line

In 1969 and 1970 a 273-mile, 18-inch pipeline was constructed from Kayenta, Arizona, to the 1500 megawatt Mohave power plant at Davis Dam near Bullhead City, Arizona, for handling 5,000,000 tons of coal per year in slurry form. Black Mesa Pipeline is a subsidiary of Southern Pacific Pipe Lines, Inc. and acts as a subcontractor to Peabody Coal Company in providing transportation from mine to power plant under a 35-year contract. This is the world's largest and longest coal carrying pipeline with a total gross investment of over $39 million dollars.

In a liquids pipeline, pressure moves the product rather easily and from a static line startup the flow can be resumed without difficulty. In a solids carrying pipeline, the material to be transported must be finely ground in precise proportions before suspending in water in order to achieve similar liquid flow patterns. To reduce the friction and wear within the pipe, the velocity of flow must be kept to within narrow limits. This mixture of half water and half solids is called slurry.

Due to the rugged terrain, 4 pump stations are required, delivering the pressure required to lift the slurry over peaks higher than 6,500 feet. The most precipitous and difficult pressure requirement is that required to push the slurry up 1,600 feet in less than 25 miles.

Another unique feature of the pipeline concerns the drop of 3,000 feet from the top of the Black Mountains to the Colorado River. In order to control the rate of flow during the abrupt descent, the diameter of the pipe was reduced from 18 inches to 12 inches.

The pipeline responsibility does not begin until the coal reaches the Black Mesa slurry preparation plant. Here, the raw coal is crushed to ¼ inch and smaller particles. The rough ground coal mixed with water is fed into 1 of 3 rod mills in order to grind the coal to a very fine size producing the finished slurry. The slurry is retained in storage tanks and held in suspension by means of a large propeller preparatory to entry into the pipeline. Each storage tank holds 600,000 gallons, enough to supply the pipeline for a 2-hour period of maximum operation pumping at 660 tons of coal per hour.

At the end of the 273-mile journey, the pipeline's responsibility ends as slurry is delivered to one of many storage vessels designed for the slurry operation and the supply source for the

(see Black Mesa, pg. 17)

Rugged terrain traversed by the Black Mesa Slurry Line.