UTAH GEOLOGICAL AND MINERALOGICAL SURVEY
affiliated with
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University of Utah, Salt Lake City, Utah

TRANSPORTATION OF ENERGY FROM COAL, UTAH TO CALIFORNIA

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TABLE OF CONTENTS

FIGURES

TABLES

TRANSPORTATION OF ENERGY FROM COAL, UTAH TO CALIFORNIA

"A Symposium on the Transportation of Energy from Coal, Utah to California" was held by the Utah Section of the American Institute of Mining, Metallurgical and Petroleum Engineers on November 21, 1963. Three major transportation methods were discussed:

EXTRA-HIGH VOLTAGE TRANSMISSION
by Mr. E. W. DuBois, Sponsor Engineer
Electric Utility Systems Engineering
Westinghouse Electric Company
Pittsburg, Pennsylvania

COAL SLURRY PIPELINE TRANSMISSION
by Mr. Eric H. Reichl, Vice President - Research
Consolidation Coal Company
Pittsburg, Pennsylvania

RAILROAD TRANSPORTATION
by Mr. James R. McAnally, Vice President - Traffic
Union Pacific Railroad Company
Omaha, Nebraska

The purpose of the symposium was to define and establish the parameters within which Utah's coal reserves might become a major source of energy to the California markets, and each speaker based his remarks on the following assumptions:

Coal Sources - Wasatch, Kolob, Kaiparowitz Fields of Utah

Destination of Energy - Points in southern California in the range of 800 to 900 miles from Utah coal fields

Cost of Coal - $3.50 per net ton, f.o.b. mine site

Water Supply - There is neither a surplus nor an unappropriated source of water in Utah. For the purpose of this discussion it is assumed that water for pipeline use may be available, and that such bodies or flows as the Green and Colorado Rivers and Powell and Mead Lakes may be used.

Conversion Factors

Coal - 24,500,000 BTU per ton (net heat value)

Natural Gas - 975,000 BTU per MCF (net heat value)

Kwh - 9,000 BTU

Quantities of Power

Base - 1,000 mw

The quantity chosen by each speaker should be in multiples of 1,000 mw. The quantity deemed adequate for one mode of transmission may be inadequate for another; there should be no restrictions to those representing the separate areas. The quantity of coal required for each 1,000 mw (at 80 per cent load factor and 9,000 BTU heat rate) is 2.6 million tons per year.

Competitive Energy Costs - The present costs for natural gas and residual oil in California average between 33 cents and 35 cents per million BTU. This cost range appears to be a "best-guess" base for the next five years.

Suggestions — Each panel member is to select his base and his goals. The area requires the addition of 500 mw to meet annual growth needs.

Notation — The three modes selected for the panel appear today to be the most economical means of utilizing coal that are available.

The Utah Geological Survey expresses its appreciation to the Utah Section of the AIME, and to members of the symposium for permission to reproduce the papers of Messrs. Reichl and McAnally; the notes of Mr. DuBois; and the opening remarks of the symposium chairman, Mr. J. M. Ehrhorn, Industrial Development Director of the United States Smelting, Refining, and Mining Company.

INTRODUCTORY REMARKS

by J. M. Ehrhorn

The question is asked: Why tonight's program? Publicity suggests that coal in Utah may be on a threshold of expansion and profit.

By way of introduction and to give a perspective of this commodity, let me cite a few figures. The U.S. G. S. estimates Utah reserves as 14 billion tons recoverable, 16th among the states. Backed by Montana, Wyoming, Colorado, and New Mexico, this area contains 30% of U. S. reserves. How much is 14 billion tons? At today's market value this represents 50 billion dollars--over 100 times the average total production of all minerals in Utah on a yearly basis.

Coal is a fossil fuel energy, being, however, a solid rather than a liquid or gas. As with other fuels, population density and growth are keys to expansion. California with nearly 10% of the nation's population may be the focus of coal's future. Coal cannot and will not satisfy all of California's energy demands. Transportation is the key to the competitive position of coal in the State of Utah.

We are here to hear proponents of the three major methods of providing transportation that are economic and operational today. The future may bring others. The three methods to be discussed are: 1) Extra-High Voltage, 2) Coal Slurry Pipeline, and 3) Railroad Transmission.

I will introduce the members of the panel and each shall present his subject without interruption or delay.

Paper 1 EXTRA-HIGH VOLTAGE TRANSMISSION *

by E. W. DuBois

Large scale usage of Utah coal resources for remotely located energy markets presents an interesting study of the principle of alternative costs. The principle is simple enough, but the application in this case is most complex because of difficulty in knowing and understanding the many variables sufficiently well. Accurate analysis depends upon knowledge in depth of important economic and technical factors related to the fields of resources evaluation, transportation, and electric power system design and operation. Comparisons made are severely influenced by initial assumptions. Careful consideration must be given to what valid economic comparisons can be made, how relevant and useful they are, and to what extent the costs represent an accurate basis for evaluation. New technology and good hard competition are bringing about great changes in the economic and technical facts associated with basic fuel cost, fuel transportation cost, and electrical generation and transmission costs. Such evaluations are beyond the scope of my discussion. My objective is to bring into sharper focus major factors reflecting on the potential use of extra-high voltage transmission (EHV) to transport power from remote resource areas to load centers.

Analysis of the technical and economic aspects of extra-long distance electrical transmission (longer than 400 miles) permits these observations:

1. Transmission distances in the extra-long distance (ELD) range of 400 to 1000 miles inherently imply the use of transmission voltages of 500 kv or higher on economic grounds when associated with resource utilization projects.

2. The technology exists today for transmission voltages of 500 kv and 700 kv AC.

3. In the range of 400 to 1000 miles, the economic selection of voltage level is a function of load level but is relatively independent of transmission distance.

* This reproduction has been compiled from Mr. DuBois' notes and abstract.

4. To achieve economic loading of facilities, large amounts of series capacitors are required. Dynamic voltages can be controlled by proper application of shunt reactors. Transient overvoltages can be controlled to reasonable levels permitting economical line design and equipment application.

5. The optimum economic load level for 500-kv ELD transmission is approximately 1200 mw per circuit.

6. The cost of transmitting 2400 mw for 800 miles at kv will be in the range of 2.2 to 2.5 mills/kwh at 90 per cent load factor.

   a. 50% to capital
   b. 29% for system losses
   c. 21% for operating maintenance and other cost items.

   Capital is chosen at 15%, the usual utility practice.

7. The concept of optimum economic loading of facilities is important in the selection of alternatives.

8. In general, simple mills/kwh comparisons of electrical transmission costs as compared to alternate energy transport methods are misleading and understate the benefits accruing to electrical facilities.

Paper 2 COAL SLURRY PIPELINE TRANSMISSION

by Eric H. Reichl

When I received Mr. Ehrhorn's invitation to speak here tonight, he also supplied some very precise instructions. He gave me 20 minutes to tell my story. I hope to be able to do it in less than that.

I am supposed to consider the possible supply of electric energy to Southern California based on Utah coal and specifically by way of pipeline transportation. Maybe this is as good a place as any to point out that as far as my company is concerned, we are primarily interested in the mining of coal. The means of transportation is, to us, essentially a secondary problem. While we are proud to have developed the pipeline system, I should, nevertheless, point out that we will be just as happy to deliver our coal via unit train or to a mine-mouth power station --the customer makes that decision.

The pipeline is our baby, of course, and in a way everyone likes his own children best. Indeed, we are rather proud of its potential and, quite frankly, we have really not found any other system which compares to it economically but there are many commercial considerations involved and economics alone do not necessarily govern the situation.

Getting back to my job, the first thing I would like to do is review for you the basis on which we might consider a pipeline case. First, a very brief comment regarding technology. As you know, the pipeline which we did operate has been shut down this summer. The reason was simple enough. The railroads decided to offer a rate to Cleveland which was well under the pipeline as we had set it up, and furthermore, it was applicable to almost four times the tonnage delivered by the pipeline so the mathematics were very simple. Besides, the railroads made the shutdown of the line a sine qua non for putting their new rate into effect.

However, it would be a real error to conclude that pipelining of coal is either a commercial or economic failure.

As a matter of fact, this line ran six years; we delivered over 7 million tons in it and we have developed ALL and I repeat ALL the technology required for the construction and operation of any size cross-country coal pipeline in terms of capacity and distance we might reasonably encounter in this country or for that matter, anywhere else.

The second equally important part of the system relates to the design of terminal facilities. The slurry preparation plant, of course, is our own problem and we learned how to simplify this much beyond the system we first used at Ohio. However, of even more importance is the utilization of the slurry. It is no secret that thermal drying is an undesirable step and that it was one of the real problems we had to wrestle with in Cleveland. Fortunately, we were able, with the help of the major boiler manufacturers, to demonstrate very much simpler and far more superior systems which are essentially based on use of coal in liquid form. This implies injection of highly concentrated slurry into the burner directly or use of mechanical dewatering prior to injection. To my mind the choice between them is a somewhat secondary consideration in the context of today's talk. The main point is that both systems have been demonstrated and are ready to be applied commercially.

The sum total of our experience can best be boiled down to a simple diagram. It represents the relationship between slurry properties, pressure drop, and all the results demonstrated in our extensive loop program plus 6 years of commercial experience.

Some of you may recall the graph which was presented about a year ago at the National Power Conference in Baltimore by Tom Thagard and myself. We showed there, as you see in this slide (Fig. 1) two curves which show the importance of capacity on operating cost and investment for coal pipelines. Be sure to note the logarithmic nature of these curves. In other words, as you go up in capacity, costs go down quite rapidly. For the record, I have now added a single point which falls below the curve on both operating cost and investment and which represents the actual results obtained in the Ohio line as they relate to these generalized curves. The important thing to note here is that the curves deal only with the main line system and include only the pumps and the pipeline proper; the terminals are not included here. The reason is simple. Terminals vary so much from case to case that there is no point to generalize on those. The main message from this slide is that our actual experience is substantially better than our generalized assumption which I am using for this discussion today.

Relating this now to the problem of Utah-California, the first consideration which we had to resolve was the capacity of the system. It is clear from the graph that pipelining does not offer any unusual

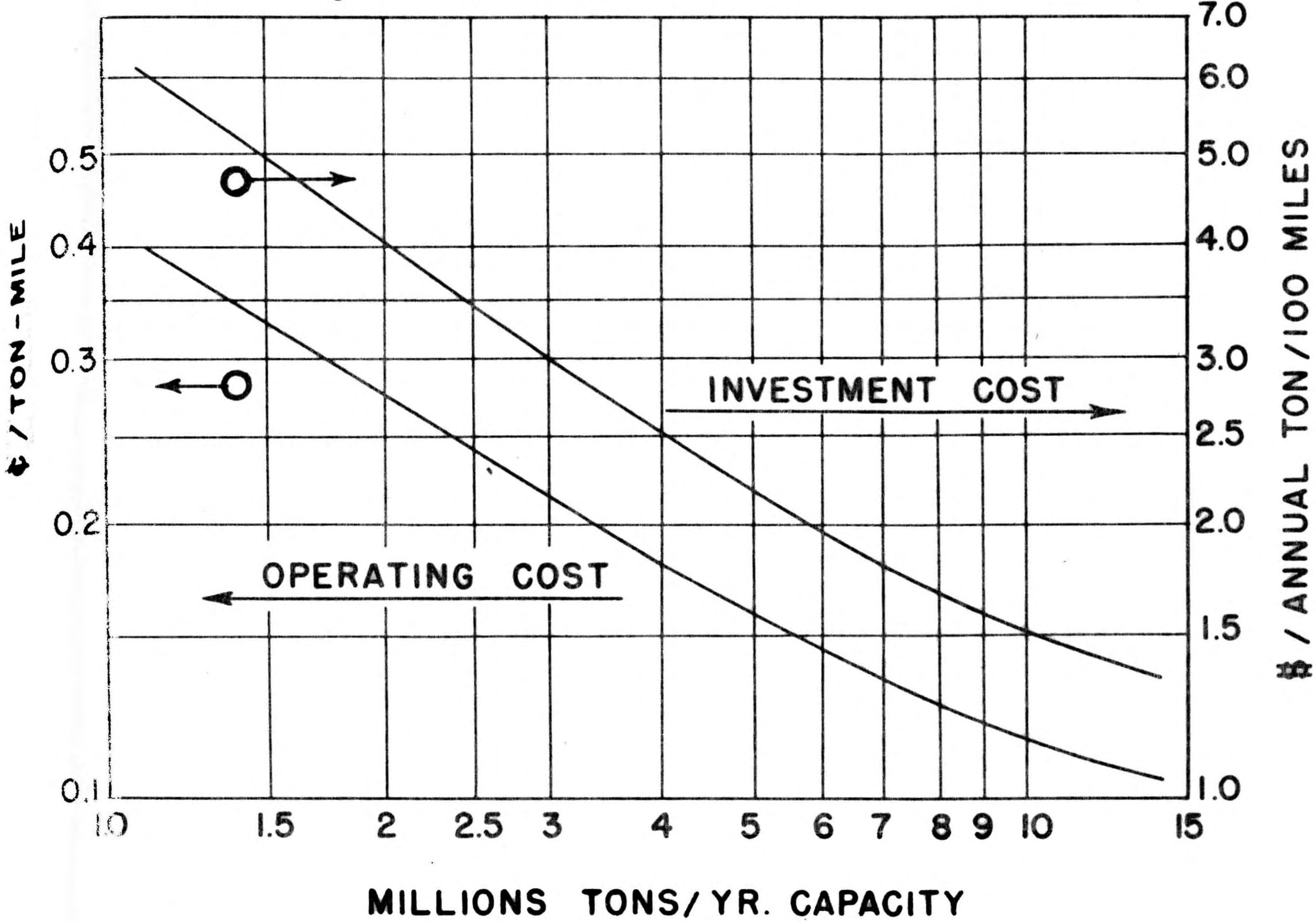
ECONOMICS OF COAL SLURRY PIPELINES

INVESTMENT & OPERATING COSTS

BASIS:

Short Tons of Coal At 3% Surf. Moisture

Operating Factor 90%



advantages for the transmission of small amounts of energy. We have always heard that the Californians pride themselves about the fact that they are able to think big. Well, in this instance, they have to think big. I think this is true for any new transportation system that is involved whether this is a gas pipeline, an electric transmission system, or a coal pipeline. It simply will not look attractive on a small capacity basis. When I say small, I mean one million kw, that's small in this context. I believe it is, indeed, small if you think that it represents less than two years' growth in the Southern California electric energy market. Surely a basic new source of energy such as coal in Utah could be considered for the supply of more than two years' growth. In order to come up with something specific, I have chosen a 2 million kw power station in the Southern California area to be supplied by a single coal pipeline from a single location in Utah.

As far as the necessary coal reserves is concerned, I am quite sure there are many people in this audience that know far more about Utah coal reserves than I do. I know, however, that there are several locations potentially available where we can set aside the reserves which must be set aside to justify such a line. At 80% operating factor, a 2 million kw system requires almost exactly a 5 million tons per year. If we assume that at least 40 years of reserve must be dedicated before anyone would commit his investment, we are, in other words, looking for blocks of coal exceeding roughly 200 million tons. There is no question but that these are available in this State.

In connection with pipelining, another question arises and that is the supply of water required to pipeline the coal. This has come up before. The amount involved in this instance happens to be about 7.0 acre feet per day and from our discussions with various authorities and the people in state and federal government, I am convinced that this water is available; not only in terms of being physically there but also legally available, which is far more important.

As we all know, a far more difficult problem exists in connection with the use of coal in California. As a coal producer, I would, of course, be delighted if the cheapest of all means of moving energy were clearly some form of EHV because we would then see all power stations located at the coal mine where the air pollution problems are, by and large, less stringent than at points near urban centers. But forgetting the comparison of transportation economics, my specific talk was to consider a system which requires the use of coal close to the market. This is not easy in the case of California. For one thing, there is out there what I would call almost a psychopathic objection to the use of coal and for any of you who have wiped a tear from your eyes in a good Los Angeles smog, this is not difficult to understand.

We have discussed this in great detail with people in the power business in Southern California and to my mind, there is simply no question: coal cannot be burned in Los Angeles proper. It becomes simply a question whether or not there is ANY location within reasonable distance where we could find sufficient cooling water to operate a 2 mm kw power station (incidentally, that is a lot of water) and in addition, where we can comply with the existing and probable future air pollution laws.

In this connection, I would like to make a brief comment on this problem of cooling water. There are probably many areas in this Western part of the United States where we have huge coal deposits with no cooling water anywhere nearby. Therefore, any power plant which could operate without it would be of real interest. Recently there have been attempts —and some of them quite large scale— to use air air cooling in lieu of water and there is, apparently, no question that such plants can be built. Of course they are less efficient and the drop in efficiency is quite substantial but I believe in many cases you will find that this drop in efficiency is far, far less in terms of dollars and cents than the cost of moving the coal to water or water to the coal.

In the California case, we believe an area exists outside the Los Angeles basin where cooling water is, in fact, available and for the purpose of this discussion, I will assume that the distance from the coal reserve will be 575 miles and that, in addition, a 50-75 mile distance would be involved for electric transmission of the power to the load center in L.A. proper where we must compete with natural gas.

Atomic energy has not yet been allowed closer to such a load center than about the same distance. As you know, this is another question but attempts are being made to build very large atomic plants right in the middle of cities whether the populace likes it or not and I have no way of predicting the outcome of that battle.

I don't intend here to discuss this question of air pollution and water reserves in California in any further detail because it is really not quite germane to the question of economics of coal transportation.

I have tried to set up the approximate economics of this case using coal pipeline and in the next slide (Fig. 2) this is summarized and I would like to discuss the various assumptions as we look at the table.

COST OF POWER IN LOS ANGELES

BASED ON UTAH COAL (VIA PIPELINE)

INVESTMENTS:	POWER PLANT (800,000 kw units)	\$96.0
	PIPELINE (575 miles) (2 million kw	\$33.0
	TOTAL	\$129.0 / kw

UNIT: mill/kwh

Capital Charges	@ 9.0%	@ 12.5%
@ 80% Op't'g factor	1.67	2.31
Direct Op't'g cost: power plt.	0.20	0.20
Direct Op't'g cost: pipeline	0.33	0.33
EHV to load center	0.25	0.25
SUBTOTAL (ex. fuel)	2.45	3.09

FUEL COST (Slurry @ mine)¢/mm BTU	18.0	20.0	18.0	20.0
In mill/kwh @ 8875 BTU/kwh	1.60	1.77	1.60	1.77
Slurry terminal	0.06	0.06	0.06	0.06
TOTAL COST: mill/kwh in L.A.	4.11	4.28	4.75	4.92

I have wrapped the pipeline and the power station together as one single investment and assume that the fuel will be supplied to this system in form of slurry at a coal mine.

First of all then, there is the power station proper and you see I have used \$96/kw investment. This figure, I believe, is safe. We have near Pittsburgh just now the design and construction of the Keystone Power Station which involves two 800,000 megawatt units near a coal mine district and these units, I understand, were estimated quite recently to be around \$97/kw. I have assumed the savings which are associated with the use of liquid fuel in form of slurry and have counterbalanced those with the increased cost for triple size electrostatic precipitators which might be required in California as compared to the Keystone plant. With this I have come up to \$96/kw. The pipeline investment is also expressed in terms of dollars per kw; the pump station and pipeline turn out to be \$33, for a total of \$129/kw. What you are really looking at here in a certain sense is a mine-mouth situation. It just turns out that there is a long straw in your mouth which reaches 575 miles into the milkshake in Utah.

As you well know, there are large utilities representing both private power and public power in Southern California and I simply have tried to show how the type of capital structure affects power costs in our case. I have calculated these in two columns here using 9% and 12.5% total capital charges respectively. If you disagree with this assumption, you can use the numbers on the slide and make your own calculations. I don't know what you prefer to apply.

As we calculate the power cost, the first item on the slide is the capital charge on this pipeline power station complex which I have calculated for an assumed 80% operating factor. I should add here by way of explanation that if we assume 80% operating factor, this gives us a tonnage of 5 million annually for the pipeline.

The direct operating cost for the power station proper in this instance excludes all handling of the coal ahead of the burner. It is as 2/10th of a mill and this again is based on the estimates made on the Keystone power project back East. The next items are the cash costs of the pipeline proper and if any of you care to check this, you can use the slide I showed first, the lower graph. In using the curve for direct operating costs, you will notice they are .16¢/ton mile and you multiply that by 575. This will give you 92¢ per ton. You divide that by the proper ratio of kilowatt to coal and it will give you .33 mills per kwh. If it doesn't, I've made a mistake. Incidentally, I used 12,500 BTU/lb. for the coal.

As I pointed out, the power station is not located at the load center. It has to be a certain distance away. From our discussions out there, I calculate the cost of transportation to be an extra .25 mills/kwh. Adding this will permit us then to compare the cost of power in the load center compared to other means of supplying it there.

The sub-total then shows the cost exclusive of fuel for the two capital structures to be 2.45 and 3.09 mills/kwh.

Now comes the fuel cost which must be added. I have simply shown this to range from 18¢-20¢/million BTU to show you the effect of this range on the power cost. This will probably seem a very high number to you because I understand that you can obtain coal here for less than 15¢/million. For the purpose of this review, we can assume that the difference is required to obtain the necessary water, storage facilities, and the preparation of the slurry which is all wrapped up together with the coal mine. It might be worthwhile here to point out that I am not writing any contracts or negotiating any pipeline but rather trying to give you some general feel for the economics of this case. Obviously there are many details which can show up, plus or minus, when you get to look at any specific case.

Anyhow, for the range of prices, assumed fuel adds 1.6-1.77 mills/kwh. In addition, I thought it would be worthwhile to bring out clearly the terminal cost. There is a specific charge associated with utilization of slurry in order to match up to the assumed investment and operating cost for the power station proper. This involves the pre-concentration or mechanical dewatering of the slurry whichever way you care to apply it which is required to wind up with a final efficiency, or equivalent efficiency, of 8875 BTU/kwh and this is taken as 6/100 mills/kwh.

Using the two capital structures and range of coal prices, you can see the delivered cost of power in L.A. ranges from 4-5 mills/kwh. Please remember this is now equivalent to power in the L.A. load center.

Incidentally, I believe this is approximately equivalent to 33-35¢/million BTU gas price in Los Angeles. Again using super-size modern gas-fired power station which would, of course, be cheaper than the coal station, this gas price would have to be firm to be comparable.

Possibly more important is the comparison of this cost structure with the possible cost of atomic power. It is very difficult to come to grips with this. As I understand it, the Pendleton (or Point Onofre) power station projected for Southern California Edison will produce power there at around 6 mills and to that must be added the cost of transmission to the load center which is about the same I had assumed for this coal plant, another 1/4 mill. What is not quite clear is the fact that this 6-mill figure requires substantial subsidies although there are a lot of people who don't like to hear this word or like to admit that subsidy is included. I have tried to calculate this once from the information that is available and if you add up the forgiving of interest for the first five years for fuel, the fact that the fuel is government owned and therefore obtained at a lower interest rate, the fact that design assistance is available for the design of this plant, the fact that plutonium is bought back at an artificial price - just these four items together pretty near add up to another mill per kwh.

The reason that the consumers or rather the utilities are still so much in favor of this is the argument that in the future the price will go down due to the massive research efforts of the federal government which, incidentally, are the largest subsidy of them all.

This point might be worth considering for a moment in connection with coal pipeline-based source of power for California. What is the likely outlook for the future cost of power in that instance? There are two components, one is the cost of fuel; the other the cost of transportation. The records show quite clearly that the price of coal has trended downward in this country. In the last six years alone it has dropped something in the order of almost 10%. There is all reason to assume that this trend will continue because it is the result of development and improved technology. And I might just mention that even in Washington there is now some concern regarding the imbalance of research funds which are being assigned to atomic energy versus other fuels. If only a very small fraction of atomic research dollars would find their way towards coal, this downward trend is undoubtedly going to speed up. I don't understand why people expect technology to reduce the cost of one type of fuel but expect it to have no bearing on any other.

As far as the pipeline itself is concerned, of course, the important thing to remember is that almost three-quarters of the cost of transportation are capital charges. After the initial period, what you might call the first core of this system, has been paid off, the cost would drop very dramatically.

If I may add up what I have said: it seems by way of a pipeline, coal can be delivered and converted into electric energy in Los Angeles at prices competitive with any now prevailing down there and furthermore, there is all reason to assume that this advantage will increase with time.

Paper 3 RAILROAD TRANSMISSION OF COAL

by James R. MacAnally

I am indeed happy to take part in this panel discussion on coal energy transportation before the Utah Section of the American Institute of Mining Engineers, but at the outset I must confess to some misgivings in appearing before such a distinguished gathering of professional people; and especially after hearing the excellent presentations of Mr. DuBois and Mr. Reichl. Having learned my railroading the hard way through some 38 years of service, my discourse will necessarily be somewhat less sophisticated and less technical. Nevertheless, I hope it will add something of value to the discussion.

I consider it rather appropriate that, in this review of what really is a competitive transportation problem, the old iron horse has been reserved for the last. Since youth will be served and the railroads have been around so long they have the reputation, deserved or otherwise, of being something less than youthful in their outlook. I suppose this is a perfectly natural order of things. I would remind you, however, there's plenty of life in the old nag yet!

In setting the stage for presenting the railroad phase of this competitive transportation job, I want to emphasize one advantage we inherently possess over Extra-High Voltage Transmission or Coal Slurry Pipe-Line Transmission. That is in the area of fixed plant. We have most of what is needed already available. At times of low traffic density this can be a heavy burden; but in eras of expanding volume it is equally a blessing, since incremental costs for handling added traffic are sharply lower than out-of-pocket or fully-distributed costs for handling the base load.

With centralized traffic control, which we have all the way between Salt Lake City and Los Angeles, a single-track railroad approximates 80% of the capacity of a double-track railroad. Even in this situation, however, the actual physical carrying capacity can be further expanded by the use of improved techniques of operation, by increased size of individual car, or by the introduction and use of new sophisticated equipment especially designed for extremely heavy tonnage operations. In any event, we already have the fixed plant available to handle substantial increases in tonnage with but relatively modest increases in operating costs and in this situation, in contrast to newer and as yet inoperative transportation media requiring very substantial capital investments, in my opinion, does give the railroads an advantage of no mean proportions in approaching the expanding market for energy from coal.

Additionally, because of this fixed plant already in being, the railroads have the flexibility to expand or contract as supply and demand fluctuates without serious detriment to their investment structure. I seriously doubt this same flexibility can exist in other systems designed specifically for and devoted solely to transportation of the single substance of energy.

For the purpose of this discussion, your moderator very wisely established certain ground rules to insure a reasonably fair basis of measurement of any comparisons undertaken. Those ground rules contemplated the mine price of coal as $3.50 per ton; the coal to have a rating of 24,500,000 BTU's per ton; and a 1,000 megawatt annual production to require a 2,600,000 tons of coal. For my own purposes, I am also assuming the origin as a representative rail point in Carbon County, Utah, and the destination as Los Angeles, California involving a rail haul in round figures of 825 miles.

Until quite recently, most Utah miners held rather firmly to the philosophy that $5.00 per ton at the mine was about the right price for their coal. At this price and the presently effective frieght rate of $7.17 per ton, the cost per million BTU's delivered in Los Angeles would be almost 50¢. Reduce the mine price to $3.50 per ton as contemplated by the ground rules and at present freight rates the cost per million BTU's drops to 43.55¢. We can do this today regardless of whether the demand is for the energy equivalent of one car or a thousand cars. That's the flexibility I mentioned earlier.

Now quite obviously, with both gas and oil delivering BTU's in Los Angeles for 35¢ or less, coal by railroad at 50¢, or even 43¢, is not any great competitive factor today. That is no criterion for the future, however, because until quite recently there has been but little interest in coal for power purposes west of the mountains in California because of the air-pollution psychosis so prevalent there.

For the sake of further comparison, let us assume that coal energy, regardless of how transmitted, must meet a price of 30¢ per million BTU's in Los Angeles. That would mean a freight rate of $3.85 per net ton, and require a reduction of $3.32 per net ton, or just about 46%. On the basis of single-car shipments that is a greater reduction than I would care to undertake; but when we get into the area of substantial volumes an entirely different outlook appears.

It is this "substantial-volume" area I now want to explore with you. There is one transportation approach now described as unit-train operation which can be put together immediately and without difficulty. It simply involves use of existing power and cars, kept intact in trains, and handled with dispatch to maximize the carrying capacity by continuous use. We have such an operation already effectively handling iron ore pellets between Atlantic City, Wyoming, and Geneva, Utah. It is regularly handling approximately 9,000 tons of lading and making the round trip of 710 miles every other day, which time includes loading and unloading. An indication of the economy inherent in such unit-train operation is evidenced by the fact we are doing this transportation job with just about half the power and cars we had originally calculated would be required for operation in the conventional manner. This obviously also involves only half of the crew costs.

Another transportation approach and one which has been attracting considerable attention throughout the country is the so-called integral train. This involves new equipment especially designed to facilitate fast loading and unloading and to handle exceptionally heavy tonnages.

An interesting adaption of either the unit-train or integral-train operation involves the coal companies or the power companies obtaining their own railroad equipment and simply paying the railroad what, in effect, amounts to a "towing" rate. This innovation apparently has application in situations where, for one reason or another, the railroad involved does not care to undertake the capital investment necessary to acquire the needed equipment. As a practical matter, however, it would seem the economics of transportation would be identical regardless of who provides the equipment.

We have just recently received report covering an engineering study of integral-train operations undertaken for our account. I wish I were in a position to fully share the results of this survey with you. Unfortunately, it involves 292 pages of detailed data and 61 prints. Interested departments within the railroad are now studying this report and, until that study has been completed, I would be reluctant to adopt or embrace the projections it presents. As an example of the philosophy it proposes, however, the study involves entirely new and revolutionary concepts of train consists contemplating the handling of 50,000 tons of lading and suggesting a target market price in the Southern California area as low as 22¢ per million BTU's. As I said earlier, I am not adopting this projection as practical or feasible but it does demonstrate the extreme range within the contemplation of at least some people.

Until the practicability of the integral-train concept has been fully explored and proves acceptable, it is my own view the unit-train approach to the volume marketing of coal is the best currently available rail vehicle for exploitation. Obviously there are many factors to be considered in any given situation, such as the location, length of haul, loading and unloading facilities, to name but a few, which have a direct bearing on the transportation cost that can be projected for a given operation. Within this unit-train concept we already have two coal projects in active negotiation, in widely removed areas, which, in my opinion, indicates this concept is fully practicable. Without attempting a detailed analysis applicable to one area of consideration this evening, I have every confidence the railroads can provide the necessary transportation at a price that will assure coal energy being fully competitive with any other energy source.

Recent marketing surveys have indicated that the Mountain-Pacific area represents a potential market for energy equivalent to 31 million tons of coal per year. This is a challenging potential. Obviously there are many problems to resolve but I am completely satisfied that, with the improving technology constantly developing, coal can be a very real competitive factor in this energy market—and this notwithstanding any defensive price cuts of major commercial significance which may be undertaken by competitive fuels.

In the area of air pollution, it seems to me entirely possible that there are areas of joint efforts by at least two of the three competing methods of transmission represented here tonight. Obviously I am thinking of Extra-High Voltage Transmission where it might be possible to put the power plant east of the mountains, where air pollution is no problem but where transportation over the Cajon Pass does represent a substantial factor of transportation cost and use Extra-High Voltage Transmission lines to deliver the energy to the consuming plants in the densely populated area west of the mountains.

Since this panel was first organized, I understand there has been a new entry into the competitive field in the form of nuclear energy--the Atomic Energy Commission is considering a proposal to offer nuclear energy at 30¢ per million BTU's. Such a proposal undoubtedly involves a subsidy by government to some extent. It would appear such a subsidized undertaking is wholly unnecessary. Each of the proponents represented on this panel is an exponent of free competitive private enterprise and I certainly hope that we can continue to function as such without having to contend with subsidized competition from the government.

In conclusion, I want to leave with you one bit of philosophy. That is simply this. For coal to be competitive with other sources of energy regardless of the method used to transmit it to the point of consumption, it is going to require the closest cooperation and honest effort of all parties to the transaction. In short, you can't chisel a dime on the transmission rate to add it to the mine price of coal or vice versa. Both parties are entitled to a fair profit and unless they can have reasonable assurance of achieving such profit, the joint effort will collapse before it really gets started.

I am completely satisfied that we are on the threshold of an exciting new era in utilization of coal. I am also equally satisfied that the competition so obviously prevalent between the several transmission methods represented here tonight will challenge each other to do their level best toward the ultimate goal of realizing to the utmost the great challenge with which we are each confronted. From the railroad aspect, I can assure you we will be in there contending vigorously.