DES MOINES POWER STATION OPERATING COMPARISON

	Old Station	*New Station*
Month	October, 1924	November, 1926
Name of fuel	Iowa	Iowa
Tons fuel burned	13,048	10,443
Average B.T.U. as fired	8,970	9,185
Average boiler efficiency	73%	83.3%
Average rating	127%	152%
Average combustible in ash	19%	7.1%
Average CO_2	11%	9.9%
Average uptake temp.	575°	200°
Steam pressure—gage	180 lbs.	382 lbs.
Superheat—average	90°	250°
Type of stoker	Natural draft chain grates	Forced draft chain grates
Air preheaters	None	12,420 sq.ft.
Superheaters	100° F.	250° F.
Economizers	None	10,000 sq.ft.
Furnace side walls	None	310 sq.ft. fin. walls

Fuel

At old station: from Pershing Coal Co., 9048 tons from Pershing Mine, and from Norwood White Coal Co., 4000 tons from No. 7 Moran Mine.

At new station: from Pershing Coal Co., Pershing and Tracy Mines, and from Norwood White No. 7 and No. 8 mines, Moran and Herrold, Iowa, respectively.

Quantities from different mines not known.

Boilers in Service

At old station, all boilers with exception of two in service.

At new station, all boilers in service much of month due to regulating superheat on new boilers No. 2 and No. 4. This lowered average CO_2 due to high banking H.P. hours.

New station average boiler rating is brought down due to above noted boilers in service, also due to low night loads which results in high banking H.P. hours.

The comparative results of these stations is of interest. The higher efficiency of the new station during this comparative period is due mostly to better heat absorption of boilers and economizers and air heaters. The load conditions, however, are unfortunate and the CO_2 and rating results do not represent the results obtainable from forced draft chain grates under more suitable load conditions and without such a large proportion of banked boiler hours.

POSSIBLE RESEARCHES IN IOWA COAL

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Among the many sources of wealth with which Nature has blessed Iowa are its coal measures. Dr. Lees has discussed the extent and characteristics of these deposits, and Mr. Marsh has shown what may be done to utilize this coal effectively in processes of combustion.

Iowa coal suffers from an inferiority complex due to the fact that its disagreeable and its poor qualities have been more persistently and widely broadcast than its good qualities. It also suffers from

severe economic handicaps. Take as an example the domestic use of Iowa coal in Iowa City. The freight rate on domestic sizes of a certain class of Iowa coal into this city is $1.80 per ton and on Western Kentucky, $3.52. If at the mine you pay $4.00 for Iowa coal and $1.65 for Western Kentucky you have immediately a difference of 63 cents per ton in favor of the Kentucky coal laid down in Iowa City. This discrepancy in price at mine is undoubtedly due to the greater difficulty in the securing of Iowa coal in its shallow beds and to general economic conditions affecting the cost of mining not necessary to be mentioned here. However this may be the fact that a coal considered superior to the Iowa coals which have been offered for sale here can be bought at a lower price places a handicap on the sale and use of Iowa coal which even better coals would have difficulty in surmounting. Both in domestic use and for industrial purposes Iowa coal shows certain qualities and properties which militate against its more general use. Let us catalogue a few of these disagreeable qualities.

First, a high moisture content. Aside from causing the purchaser to pay a good price for water, this moisture has the effect of causing the coal to crumble as it dries out so that for domestic purposes it is hard to stock it in any quantity in lump form.

Second, a high ash content. The ash content is due not only to inherent inorganic impurities but to deposits of earthy materials coincident with the formation of the coal bed such as partings, clay streaks, pyritic and shaly materials, as well as foreign materials such as fragments of roof and floor of the working, not removed in the cleaning processes at the mines. Unfortunately this ash is not only abundant, but it is of low fusibility, and thus clinkers readily and even may freeze to and into the air openings in grates. The low fusibility of the ash of Iowa coal along with and probably due to the high iron content of the ash may be said to be its worst characteristic and is mainly responsible for the low esteem in which it is held.

Third, sulphur content. Iowa coals in general are high in sulphur, combined of course with iron, and this characteristic not only adds to the disagreeable qualities of its smoke but makes the ash refuse particularly unpleasant to remove and handle.

Fourth, low heating value. Published calorimetric tests of Iowa coal seldom or never fall below 10,000 B.t.u. per pound. This is low as compared with many bituminous coals, but many combustion

engineers regard Iowa coal as possessing even less than this low figure in heat actually available in commercial conditions.

As a résumé of these counts against Iowa coal we may therefore cite the following:

High moisture, high ash of low fusion point and with high iron and sulphur content, high volatile content and low thermal value. It would seem that Iowa coal therefore has every quality that it should not have and few things to recommend it. These qualities, however, while characteristic of coal of the state as a whole, are modified in the coals of certain localities and certain veins.

It will be evident at once that in general Iowa coals are lower in fixed carbon and higher in volatile, sulphur, moisture and ash than are the coals from Illinois and Kentucky with which they are compared. On the other hand it will be noted that although high in moisture a sample of Appanoose county (Mystic vein) coal excelled in heating value even the best of the Illinois coals and was distinctly better in every way except moisture than the poorer Illinois coals. Thus we may say that while Iowa coals as a whole are distinctly inferior to the better Illinois and Western Kentucky coals they are no worse than the poorer grades of Illinois coals, and the better grades of Iowa coal are distinctly better than the inferior grades of Illinois coal. From this statement we may derive some comfort, but it is not a solution of the way to increase the use of Iowa coal. Iowa coal will continue to be used in the vicinities where it is mined, by industrial plants, power houses and domestic users who will put up with its poor qualities or go to large expense to overcome them so long as they can buy Iowa coal cheaper than they can buy better grades of coal brought into the state from surrounding fields. The difficulties in storage of Iowa coal can be avoided by delivering it from the mine to nearby users as it is needed, and for those who must have a guarantee against coal shortage the storage of coal under water will be practiced where economically feasible. These conditions mean, however, a limitation on demand which promises little growth for the coal mining industry of Iowa and a future dominated entirely by the growth of purely local markets. No amount of advertising, no amount of organization, no amount of appeal to state pride and loyalty will cause the average Iowa consumer to pay as much or more for Iowa coal as for a coal which he believes is superior in quality even though it comes from outside the state lines. If this is admitted then an extension of the uses of

Iowa coal outside of purely local markets must lie in the discovery of entirely new uses for it, in the discovery of new and better ways of burning it for power, industrial, and domestic uses, in the devising of possible ways of storing it cheaply without deterioration in size or quality and without spontaneous combustion, in the devising of treatments and processes which will enable it to be used in ways and for purposes now forbidden by its undesirable qualities.

In outlining possible fields of research having as their aim the extension of uses of Iowa coal we should not be deterred or discouraged at the outset by a feeling that the coal is so inferior that little expectation of success may attend our efforts. We might also be inclined to say that even though some encouraging laboratory methods are evolved, the general economic situation is such that there is little hope of extending the methods into actual commercial operations. We must remember, however, that we are not building entirely for the present, new discoveries and new applications may completely change the economic conditions of to-morrow, and who knows but that Iowa coals, despised and more or less discredited to-day, may become extremely important in the commercial and industrial life of the state in the next decade. Iowa coals present to the scientist practically an unexplored field. Little has been done in an investigation of their properties by the industrial chemist.

We are attempting to burn these coals in a raw state. What may be accomplished by attempts at purification we can merely surmise.

Possible researches on Iowa coal therefore may follow along these general lines.

1. An improvement in quality by removal of those impurities which most seriously impede successful or satisfactory combustion in industrial and domestic furnaces, and which interfere with successful ground storage. Can a method of washing or of dry cleaning of Iowa coal be evolved which will so far reduce the ash and sulphur content as materially to improve the qualities of the coal? There is here a very promising field of investigation which will involve a study of the most feasible methods of separation of the heavier impurities, whether by flotation in commercial sizes and grades, or air separation after grinding and subsequent briquetting of the purified product for the market.

2. We are attempting to burn Iowa coal in domestic heating appliances which for the most part were developed for eastern coals. It is entirely conceivable that such devices are ill adapted to the

burning of Iowa coal and that designs of furnace and combustion space, grates and smoke passages, heating surface shape and disposition could be evolved that would be a great improvement on devices in use. We may say safely that in general, house heating furnaces are undersized to promote the best conditions for combustion, and in such furnaces when using a high volatile, high ash and low heating value coal such as that of Iowa it is only to be expected that extreme difficulty will be encountered in securing satisfactory heating service and that the difficulties with smoke, soot and clinkers will be such as thoroughly to discourage the user. The determination by trial and experiment of the best shape and sizes of domestic heating furnaces for Iowa coals for a given set of conditions is a problem deserving attention.

3. Iowa coals give great promise of being of value in pulverized form for industrial and boiler furnaces. We have had but little experience with this fuel in this form, however, and many questions remain unanswered as to the most efficient methods of preparation and its possible storage in the pulverized stage, whether its high moisture content is a detriment or an advantage, and what may be the effect of its high ash content. Are water screens necessary, or may their function be replaced by radiant heat water cooled walls; what is the best shape and size of furnace for a given set of conditions to produce most effective combustion and give least trouble with ash accumulation? How does the generally slow burning quality of Iowa coal affect burner and furnace design? These and many other questions will be answered in time by experimenters and pioneers in the use of Iowa coal as powdered fuel, and it will be necessary to spend much time and thought, doubtless, in full-sized experiments before a satisfactory technique will be evolved. The experiments and developments at Des Moines and Sioux City are very encouraging indeed, and it may be that in the unit pulverizer is the long sought answer to the problem of how to burn low grade coal for steam making in power boilers. If this is true for power boilers of large capacity what about similar devices for smaller heating or power installations?

4. Low and high temperature carbonization processes. Iowa coals because of their high sulphur and ash content have commonly been regarded as valueless for gas making and as a source of fuel coke or metallurgical coke. We are just beginning to realize, however, that we know very little about those curious and mysterious

substances in coal which give coking properties to one and deny them to another. It may indeed be quite possible by treatment or method to make out of Iowa coal coke of very superior quality when we learn the secret which underlies the coking property. Similarly the high volatile content of Iowa coal leads to an expectation that it should yield fuel gas and by-products of commercial value. All these matters, however, are now entirely in the field of surmise and conjecture. Much has been done in this country and in Europe in the investigation of other coals, but Iowa coals have been given practically no attention. What has been done elsewhere may be used to guide us here and stimulate our interest as well as confirm our belief in the possibility of finding ways and means of using Iowa coal for the production of marketable gas and coke.

There is an attractive possibility in power plant operation of converting low grade non-coking or indifferently coking coals by low temperature carbonization processes into a pulverized semi-coke more suitable for efficient power production than the original coal. If by such a process there may be secured by-products such as marketable gas, tars, and substances saleable to the chemical trades, the cost of power production from the standpoint of fuel only will be lowered materially by the revenue derived from sale of by-products. A combined property such as a gas and electric station would find many ways of saving in fuel costs if the carbonization process could be so far perfected as to afford the needed flexibility to meet the peak load conditions of both kinds of service. Will Iowa coal permit of such treatment, and is there any hope for the successful use of carbonization processes by plants in Iowa using our native Iowa coal?

5. A fascinating new field is that of producing oils from coal by methods distinct from distillation or carbonization. That Iowa coals should not yield to such treatment as well as those of other countries or other districts in our own country we certainly have no reason to believe. It is by no means certain of course that in our generation, coal gasoline will be manufactured at a price to compete with gasoline derived from crude oil, but if methyl alcohol made from coal can threaten the extinction in this country of an industry making the product by the older method, who shall say that a perfection of the coal process may not in a few years seriously affect the natural gasoline situation?

Of this much we may be fairly sure, and that is that the coals

which in a raw state are least valuable as primary fuels will be the logical sources of raw material for a synthetic product such as coal gasoline. Are Iowa coals suitable for this purpose, and will it be possible to build up in Iowa a future industry to supply from our coal measures liquid fuel for our 600,000 automobiles, trucks, and farm engines? This is a problem for the future perhaps, but at least it opens up interesting possibilities. Other more pressing problems of Iowa coal should be solved first, but it is comforting to believe that we have, at least potentially, sources of liquid fuel which a perfection of methods and the economic urge may some day make available.

While we at the University view with concern what seems to be a gradual decline in the production and use of Iowa coal we may be accused of doing little in a practical way to help out in the situation, for as a matter of fact little or no Iowa coal is used for domestic purposes in this locality, and, so far as the University is concerned, of the 15,000 to 20,000 tons used annually perhaps 25 per cent will be Iowa coal. This illustrates two common reasons why Iowa coal is not more used.

First, the economic reason. Iowa coal because of our geographic location in eastern Iowa cannot be sold here at prices which will meet the competition of coals coming from the East.

Second, the equipment now in use at the University is not adequate for the burning of Iowa coal. With a boiler plant working up to 200 per cent of rating it is next to impossible with the combustion equipment now in use to keep up steam with Iowa coal. Firemen do not like it, do not know and perhaps cannot learn how to handle it and find an abundance of reasons why they cannot maintain pressure when they are forced to use it.

In making up specifications for the combustion equipment of the new boiler plant of the University the fact that Iowa coal was to be used was particularly emphasized. Both the mechanical combustion equipment and the arch were let to one reliable and well known concern who assume responsibility for the entire furnace design, and we have the assurance of this concern that we shall be able to burn Iowa coal successfully at 150 per cent rating with a draft of 0.35 inch over the fire. The stokers are natural draft chain grate with water back, and the arch is of the concave convex type. The grates are 13 feet long and 11 feet wide, and the boilers, which are the vertical water tubular type, are rated at 612 H.P. set with mud

drum 8 feet above the floor. Thus it is apparent that we are doing what we can to make provision for the use of Iowa coal, subject of course to the limitation that when the market justifies it, coals from outside of Iowa will be bought and used when money can be saved by so doing.

One rather difficult situation here has been the storage of Iowa coal. It is no uncommon thing to see a carload of Iowa coal come into the yards on fire. To store on the ground any large reserve of Iowa coal without danger of fire is practically impossible. We hope in time to solve that problem by creating an underwater storage plant near the new power plant, the position of this plant on the river front and below the dam being unusually favorable for the development of underwater storage.

As I have said before although we here at the University recognize the problem which the miners and operators of Iowa's coal mines are now facing and are doing what little is possible, subject to practical limitations, to extend the use of Iowa coal locally, we feel that our real province and the way in which we can be of most service to the coal industry of the state is in utilizing our staff and facilities for promoting and carrying on research or investigation in the lines previously mentioned.

For some time the Department of Chemical Engineering here has been directing researches in the properties of Iowa coal by its advanced students, and some things are being learned which Dr. Olin can tell you more about than I. It is difficult, however, to conduct small sized laboratory experiments in the purifying of coal or in low temperature carbonization or in the preparation, storing, and utilization of pulverized coal from which results that may be useful in practice can be obtained or which will attract or merit the confidence of men in practice. Particularly is this true in arriving at conclusions with regard to the cost of a process. Experiments on a full sized scale are almost essential in work in combustion, carbonization, and purification.

Fortunately the University has some space and facilities which, modified to suit the requirements of the work, could be utilized in certain full sized experiments. Upon the completion of its program of providing new facilities for generating and distributing steam, the University will probably be able to retire from active service the existing main plant at the corner of Madison and Washington streets behind the Engineering Building. There is here a variety of

boiler and draft equipment some of which could be adapted to experiments with Iowa coal in pulverized form and in mechanical stokers of different types. There is also considerable space which could be devoted to equipment for coal purification treatment and low or high temperature carbonization. One advantage would be that steam formed could be turned into the high pressure system of the institution, in fact there would seem to be no serious problem as to what to do with the heat products of such a laboratory.

Thus we have the enthusiasm, the space, and some of the equipment. The matter of expense is the greatest stumbling block. Although our Graduate College has funds for research it will be by no means adequate to provide for so extended and expensive a program, even were this College disposed to support it. Consequently we must wait till either the coal industry, the manufacturers of combustion and other equipment, or the State itself becomes sufficiently interested to offer us support. Meanwhile we can only stand by helplessly wishing that Iowa coal were better but knowing that unless economic conditions change very materially the Iowa coal industry will continue to decline until it becomes merely of local importance in the vicinity of the few mines which can continue to be worked.

PROF. H. L. OLIN: The possibilities of research on the better utilization of the coals of the state are so great that I can outline here only some of the most important and urgent.

Professor Fleming has pointed out the major faults of a typical Iowa coal—high ash, volatile matter, and sulfur. Moreover, because of their physical structure some of them tend to slake rapidly on exposure to air and are therefore difficult to transport and store. A beginning at least should be made on a study of the classification of the different Iowa coals, for it is highly probable that certain seams in the state are lignitic in character while others are more highly devolatilized. Coördinated with such a study should be the testing of the rate of slaking and of deterioration in storage and of determining methods for improving storage conditions.

Elaborate studies should be made on the semi-plant scale of wet and dry washing methods for the elimination of ash and sulfur. Laboratory investigations covering a period of five years or more have been made in the Department of Chemical Engineering of the University, some of the results of which have been published in the latest volume of the Iowa Geological Survey. We are now ready for practical scale work in order to determine costs. It seems possible to eliminate a large percentage of undesirable constituents without undue loss of fuel matter. There seems to be no good reason why a washed domestic or steam grade of Iowa coals should not be produced and marketed so far as technical difficulties are concerned.

The need for research in the use of powdered coal has already been dis-

cussed. The most promising feature of this method is the apparent possibility of operating with fuels of high ash content with the attainment of high thermal efficiencies. Iowa coal with high volatile matter should be particularly susceptible to treatment in this way and thorough tests under a wide range of conditions should be made on carload lots from the various seams.

The possibilities of low temperature carbonization have been a matter of keen interest to fuel technologists for more than two decades, and much advancement has been made. We know little or nothing about the coking properties of Iowa coals at either high or low temperatures, nor about the yield and character of the by-products, gaseous or tarry. Industry is preparing for expansion along this line, and scientific studies should be made without delay to meet the needs as they arise.

Such a program as I have outlined would be in itself a large one, without considering other possibilities. The University stands ready to begin this work when funds shall have been provided for carrying it on.