An Investigation of the Fuel Value of Indiana Peat

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Peat is a moist, spongy, partially carbonized vegetable matter. It is an incipient coal* containing the heat units stored up by the vegetation from which it is formed. This form of crude fuel has been used in Europe for centuries and today is used in Canada and in some places in the United States.

Hundreds of thousands of acres of peat beds exist in the lake region of Indiana embraced within the three or four northern tiers of counties. These deposits constitute a source of cheap and easily obtained fuel for local use. As the price of coal advances the use of peat for the manufacture of briquettes will increase and the time will doubtless come when the cities in that portion of the state will derive their fuel from the peat bogs of that region.

It has recently been my privilege to investigate the fuel value of a number of representative samples of Indiana peats which were collected by the State Department of Geology and Natural Resources. The relative fuel value of each of twenty-nine samples was determined by calorimetric test with the Parr Standard instrument and the results expressed in British Thermal Units. (B. T. U. = the amount of heat necessary to raise the temperature of one pound of water one degree Fahrenheit.) The results are also expressed in calories; a calorie being the amount of heat required to raise one gram of water one degree centigrade. The test was made on samples of peat dried at 105° Cent., which give a slightly higher thermal effect than would be obtainable in the practice with air dried peat, because of the moisture held by peat even after prolonged air

*The following table from Ost, Technische Chemie, 1903, p 12, indicates the progressive changes which peat might undergo in a possible conversion to anthracite coal:

	Wood.	*Peat.*	*Lignite.*	*Bituminous Coal.*	*Anthracite Coal.*
Carbon	50	60	70	82	94
Hydrogen	6	6	5	5	3
Oxygen	43	32	24	12	3
Nitrogen	1	2	1	1	Trace.

drying under favorable conditions. The advantage in using oven dried peat in the calorimetric test is that all samples may be accurately compared as to heating effect. The amount of moisture remaining after air drying is dependent upon local conditions.

TABLE SHOWING THE FUEL VALUE OF TWENTY-NINE SAMPLES OF PEAT FROM NORTHERN INDIANA.

Number.	County, Township, Range and Section.	B. T. U., Oven Dried 105°C.	Calories, Oven Dried 105°C.	Evaporative Effect Pounds Water per Pound of Oven Dried Peat.
1	Dekalb, Sec. 9 (33 N., 12 E.)	10232.77	5684.8	10.6
2	Steuben, Sec. 34 (37 N., 12 E.)	9422.87	5234.3	9.7
3	LaGrange, Sections 2, 11 and 12 (36 N., 8 E.)	8513.29	4729.5	8.8
4	LaGrange, Sections 4 and 9 (37 N., 9 E.)	8924.47	4958.0	9.2
5	Noble, Sections 28 and 29 (33 N., 9 E.)	10335.57	5741.9	10.7
6	Noble, Sec. 18 (33 N., 11 E.)	9217.28	5120.7	9.5
7	Whitley, Sec. 30 (31 N., 10 E.)	4541.67	2523.1	4.7
8	Kosciusko, Sections 11, 12 and 13 (31 N., 6 E.)	9715.68	5397.6	10.0
9	Kosciusko, Sections 32 and 33 (33 N., 6 E.)	6129.32	3405.1	6.3
10	Elkhart, Sec. 4 (36 N., 5 E.)	8637.89	4799.4	8.9
11	Elkhart, Sections 10 and 11 (36 N., 6 E.)	7211.22	4006.0	7.4
12	Elkhart, Sections 26 and 27 (35 N., 5 E.)	7613.06	4229.4	7.8
13	Elkhart, Sec. 18 (38 N., 6 E.)	9628.78	5349.3	9.9
14	St. Joseph, Sections 28, 33 and 34 (36 N., 2 E.)	9840.28	5466.8	10.1
15	St. Joseph, Sec. 3 (36 N., 1 E.)	9024.15	5013.4	9.3
16	St. Joseph, Sections 11 and 12 (37 N., 1 E.)	8503.95	4724.4	8.8
17	St. Joseph, Sec. 16 (37 N., 2 E.)	8236.06	4584.4	8.5
18	St. Joseph, Sec. 20 (37 N., 2 E.)	8491.49	4717.5	8.8
19	Marshall, Sections 10 and 11 (33 N., 1 E.)	9946.19	5525.6	10.3
20	Marshall, Sec. 1 (34 N., 2 E.)	8497.72	4720.9	8.8
21	Marshall, Sec. 10 (34 N., 1 E.)	10466.40	5814.6	10.8
22	Starke, Sec. 10 (32 N., 3 E.)	9905.70	5503.1	10.2
23	Pulaski, Sec. 9 (31 N., 1 W.)	9774.87	5430.4	10.2
24	Pulaski, Sections 7, 8 and 9 (31 N., 3 W.)	9064.65	5035.9	9.3
25	Pulaski, Sections 3, 9, 10 and 11 (31 N., 4 W.)	8472.80	4707.1	8.7
26	Porter, Sections 1, 2 and 3 (37 N., 5 W.)	5635.03	3130.5	5.8
27	Jasper, Sections 12, 13 and 14 (30 N., 6 W.)	8273.44	4596.3	8.0
28	Newton, Sections 32 and 33 (31 N., 8 W.)	9033.50	5018.9	9.3
29	Lake, Sections 34, 35 and 36 (35 N., 9 W.)	8731.34	4850.7	9.0

The results of the tests show the moss peats to have a much higher heat value than the peats of the grass and sedge variety. This fact is corroborated by numerous other tests on peats from other regions.

Five typical specimens of peat were subjected to a more complete chemical analysis, including the determination of the percentage of moisture, volatile combustible matter, fixed carbon, coke, ash, sulphur and nitrogen.

CHEMICAL ANALYSES OF FIVE SAMPLES OF PEAT FROM NORTHERN INDIANA.

Number.	County, Township, Range and Section.	Moisture 105°C.	Volatile Air Dried.	Fixed Carbon, Air Dried.	Coke Air Dried.	Ash Air Dried.	Nitrogen Air Dried;	Sulphur, Oven Dried
1	Dekalb, Sec. 9 (33 N., 12 E.).	17.16	73.31	22.53	26.67	4.14	2.56	0.74
14	St. Joseph, Secs. 28, 33 and 34 (36 N., 2 E.)	12.24	70.21	23.45	29.78	6.33	2.22	0.87
15	St. Joseph, Sec. 3 (36 N., 1 E.).....	11.40	65.52	20.65	34.47	13.82	3.31	1.33
19	Marshall, Secs. 10 and 11 (33 N., 1 E.)....	8.99	70.97	19.08	29.09	10.01	3.91	0.83
22	Starke, Sec. 10 (33 N., 3 E.).....	10.20	62.43	24.30	37.55	13.25	2.96	0.96

The value of any fuel depends upon the quantity of heat generated and the temperature which can be obtained. The influence of moisture and ash upon the heating power of peat is well shown in the following table*:

Dry peat without ash	6500 calories
Dry peat with 4% ash	6300 calories
Dry peat with 12% ash	5800 calories
Dry peat with 30% ash	4500 calories
Same peat with 25% water	4700 calories
Same peat with 30% water	4100 calories
Same peat with 50% water	2700 calories
Same peat with 0% water and 15% ash	5500 calories
Same peat with 25% water and 0% ash	4700 calories
Same peat with 30% water and 10% ash	3700 calories

It will be noticed that the difference between two samples of peat having a different content of moisture is greater than that due merely to the displacement of combustible matter. The loss represents the amount of heat consumed in vaporizing the moisture. This demonstrates the necessity of preparing peat for use as fuel so as to contain the least possible amount of moisture.

A comparison of the heating power of peat and various other fuels is given in the following tables†:

* Hausding, Handbuch der Torfgewinung, 1904, p. 333.

† First table from Hausding. Second table from Thurston's Elements of Engineering

	Water Chemically Combined.	*Water Mechanically Held.*	*Ash.*	*Calories.*
Anthracite coal	2	3	2	8305
Charcoal, air dry	0	12	3	6868
Charcoal, kiln dry	0	0	3	7837
Wood, air dry	39	20	1	3232
Wood, kiln dry	49	0	1	4040
Peat	26	25	5	3950
Peat, manufactured	30	18	2	4430

	B. T. U.	*Evaporative Effect.*
Coal, anthracite	14833	14.98
Coal, bituminous	14796	14.95
Coal, lignite, dry	10150	10.25
Peat, kiln dry	10150	10.25
Peat, air dry	7650	7.73
Wood, kiln dry	8020	8.10
Wood, air dry	6385	6.45

From these tables it will be seen that unprepared peat has a higher heating value than wood, but is inferior to coal.

COMPARISON OF INDIANA BITUMINOUS COALS AND INDIANA PEATS.

I. Chemical Composition:

(A) The extreme percentages of the constituents considered in connection with the fuel value of twenty samples of Indiana coal, analyzed by Dr. W. A. Noyes*:

	Moisture 105°.	*Volatile Combustible Matter.*	*Fixed Carbon.*	*Coke.*	*Ash.*	*Sulphur.*
Maximum	13.82	45.16	52.77	57.22	9.76	4.01
Minimum	6.08	35.22	41.80	49.62	1.06	0.34

(B) Similar data from the analyses of Indiana peats (air dried):

Maximum	17.16	61.98	24.30	37.55	13.82	1.33
Minimum	8.99	52.23	19.08	26.67	4.14	0.74

*Report of State Geologist, 21, p. 105.

II THE HEATING AND EVAPORATING EFFECT AS SHOWN BY THE CALORIMETRIC TEST:

(A) Data from twenty samples of Indiana coal analyzed by Dr. W. A. Noyes*:

	B. T. U.	*Calories.*	*Evaporative Effect.*
Maximum	13219	7344	13.4
Minimum	11691	6495	12.1

(B) Data from twenty-nine samples of Indiana peat (oven dried):

Maximum	10466	5814	10.8
Minimum	4541	2523	4.7

SUMMARY.

	Calories.	*Evap. Effect.*
1 lb. best of 20 samples Indiana coal tested yields	7344	13.4
1 lb. best of 29 Indiana peat tested (oven dried), yields.	5814.6	10.8
1.26 lbs. best Indiana peat (No. 21) equals in thermal effect 1 lb. of the best Indiana coal (No. 17, Report State Geologist, 21, p. 106).		
1 lb. oven dry peat, average of 29 samples, yields	4288	8.0
1 lb. coal, average of 20 samples, yields	6860.8	12.8
1.6 lbs. average peat (oven dry) equals in thermal effect 1 lb. of average Indiana coal.		

The cost of preparing the peat, or pressing it into briquettes, must be considered in a comparison of peat with coal. Some peat briquetting plants are already in operation in Indiana, e. g. The Indiana Peat Co. of North Judson, Starke County. This firm estimates the operating expenses for a small peat plant of thirty tons capacity, as follows:**

1 foreman	$3 00
1 engineer	2 75
2 peat men	4 00
4 boys	5 00
1 man, hoisting engine	1 50
2 men at press	4 00

*Report of State Geologist, 21, p. 105.
**Report of State Geologist, 31, p. 99.

1 night man	$1 50
Office	5 00
Total	$26 75

According to this estimate the manufacturing of peat into briquettes costs about 85 cents per ton.

PEAT AS A SOURCE OF PRODUCER GAS.

In ordinary direct firing the object is to effect complete combustion in proximity to the fuel bed. Within the same chamber the fuel elements are vaporized, distilled, gasified and completely burned. The first two processes absorb heat only and there are advantages in separating them from the point where combustion of the gases occurs and where high temperatures are developed by the heat evolved. The gas producer or generator accomplishes this. Within it vaporization, distillation and gasification result in a combustible gas, which, led away to a separate combustion chamber, is there burned under conditions favoring a fuller realization of the fuel value and the attainment of temperatures otherwise impossible.

Even with a close connection of producer to the furnace, and consequent utilization of the sensible heat of the gas, there is a loss of energy, but it should not exceed 15 to 18 per cent. of the calorific value of the fuel. Notwithstanding this loss, experience has demonstrated that producer gas accomplishes the same result with less fuel. It has made possible metallurgical operations which were impractical with direct firing, and materials quite unsuited for heating operations are made available by previous gasification in a producer. This is true of combustible substances containing much moisture, as wood, sawdust, peat, etc. The water may be removed from the gases, which can then be applied to operations requiring high temperature.

The yield of producer gas from different fuels varies within wide limits.*

Material.	*Gas Yield per Pound in Cubic Feet.*
Coke or charcoal	104
Bituminous coals	75
Brown coal	55
Turf	45
Wood	35

*R. D. Wood, Industrial Applications of Producer Gas, p. 25 and p. 26.

It has been demonstrated by test at the United States coal testing station in St. Louis that Indiana bituminous coal can be converted into producer gas and that when this gas is burned in a gas engine it yields 2 to 2½ times as much energy as could be obtained from burning the same coal under a boiler.

The advantages of burning coal gas pertain equally to using peat as a gaseous fuel. The use of solid peat fuel involves a loss of more than 25% of heat, which loss may be reduced to about 15% by first converting the peat into gas and then burning the gas.

Peat gas is valued above coal gas in the steel industry on account of its greater freedom from sulphur and phosphorus.

R. D. Wood & Co., of Philadelphia, have made experiments on the application of Texas lignite in gas producers and have demonstrated its value as a basis of gas production. This lignite is not far removed in its chemical composition from peat. Lignite showed moisture 21.86, volatile matter 31.81, fixed carbon 36.85, ash 9.48. The gas made from it is high in hydrocarbons, and, as a consequence, its flame produces an intense heat.*

A test of "machine peat" from Taunton, Mass., gave 4 cu. ft. of gas with a calorific power of 654 B. T. U. per cu. ft. from each pound of peat.† Gas from "cut peat" averages about 135 B. T. U.

‡One ton of compressed peat analyzing: moisture 15, ash 7, fixed carbon 21, volatile matter 57, will yield not less than 100,000 cubic feet of gas of not less than 150 B. T. U. per cubic foot.

Effort is now being made to utilize part of the peat deposits of Ireland by using peat for gas producer fuel in electric plants with recovery of ammonia and other by-products.‖ It is estimated that from 85 to 150 pounds of ammonia sulphate can be obtained per ton of peat with 1,780 cu. meters of gas. Acetate of lime, naphta, paraffin and volatile oils are also obtained. One hundred pounds of dry peat are calculated to yield 675,000 B. T. U. realizable as gas in a Mond producer, which would give 76 indicated horsepower hours in a gas engine, assuming a 30% thermal efficiency.

Caro¶ has recently improved the well-known Mond process for making producer gas in so far as he gasifies poor fuel in a mixture of air

*R. D. Wood, Industrial Applications of Producer Gas, p. 25 and p. 26.
†Norton: Report XV, Bog Fuel.
‡Twelfth Report Ontario Bureau of Mines, p. 231.
‖Jour. Gas Lighting, 100, p. 760.
¶Elektr. Zeitschrift, March, 1907.

and superheated steam. Extended experiments with this modified process in the Mond works at Stockton show that it is possible to treat directly wet peat, containing 50% to 55% water, with a simultaneous increase of ammonium sulphate. The chief result in the success of this undertaking is to render available the use of wet non-briquetted peat in gas producers, while the ammonium sulphate obtained as a by-product will assure in itself a fair interest on the capital invested.

Data concerning producer gas made from Indiana peat is not available at the present time. There is, however, no apparent reason why it should not be as satisfactorily used.

In the opinion of the writer, the greatest development of the peat fuel industry in Indiana will doubtless be as a source of producer gas.