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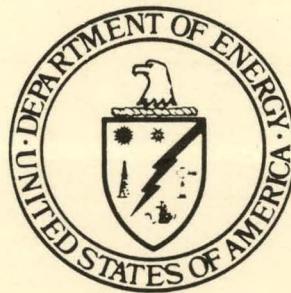
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FOURTH  
TECHNICAL CONTRACTORS'  
CONFERENCE ON PEAT

MASTER

PREPARED FOR



UNDER CONTRACT NO.  
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OCTOBER 22 & 23, 1981  
BETHESDA, MARYLAND



A JOINT VENTURE OF  
UOP INC. AND  
SYSTEM DEVELOPMENT CORPORATION

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## FOREWORD

The official proceedings of the October 22 and 23, 1981 Fourth Technical Contractors' Conference on Peat, sponsored by the U.S. Department of Energy and held in Bethesda, Maryland, are presented in this document. The conference brought together state and industrial peat researchers who are currently receiving DOE support. It also included the participation of government and industrial representatives from foreign governments.

The two day conference, hosted by UOP Inc./System Development Corporation, covered ongoing state peat resource estimation programs for fourteen states; peat gasification research by the Institute of Gas Technology, Gas Research Institute, Minnegasco, and Rockwell International; peat dewatering research by the Institute of Gas Technology, First Colony Farms, the University of Pennsylvania, and Wheelabrator-Frye; discussion of environmental and socioeconomic impacts by Radian Corporation; peat harvesting by Foster Miller Associates; and peat research and commercial activities in Finland and Sweden.

In addition to these proceedings, there are a number of other peat publications available from states, industry, and DOE. If you require further information concerning this and subsequent conferences or peat publications, please contact me.

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## CONFERENCE SCHEDULE

Thursday, October 22, 1981

Welcome

Melvyn J. Kopstein  
Manager, DOE Peat Development Program

Moderator -

Arden Walters  
Environmental Advisor  
UOP/SDC

### Morning Session - Peat Dewatering

Peat Water Retention Properties

David J. Graves  
University of Pennsylvania

Sod Peat Dewatering

Andrew Allen  
First Colony Farms

Peat Wet Carbonization PDU Studies

Dharam Punwani/Joseph Pagnessi  
Institute of Gas Technology

Peat, Wet Carbonization Commercialization Prospects

John Rohrer  
Wheelabrator-Frye

### Morning Session - Peat Exports

Export of Beneficiated Peat Pellets

Don Markle  
Alaska Division of Energy and Power Development

### Afternoon Session - International Peat Activity

Finland International Status

Jaakko Okkonen  
Finland

Peat R&D in Sweden

Birgitta Palmberger  
Swedish Embassy

Sweden International Status

Ollie Lindstrom  
Sweden

**CONFERENCE SCHEDULE (CONT'D)**

Afternoon Session - International Peat Programs (Cont'd)

Peat Harvesting

Peter DeBakker/Jonathan Ludlow  
Foster Miller Associates

Afternoon Session - Environmental and Socioeconomic

Environmental and Socioeconomic Impact Studies

Dennis Harner  
Radian Corporation

## CONFERENCE SCHEDULE

Friday, October 23, 1981

### Morning Session - Peat Gasification

Single Stage Fluidized Bed Gasification  
Francis Lau  
Institute of Gas Technology

Alternative Fuels Feasibility Study  
Al Radner/Paul Tomiczek (Dravo Corp.)  
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GRI Joint Program Involvement  
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Peat Hydrogasification  
Martin Garey  
Rockwell International

Peat Pilot Plant Studies  
Dharam Punwani/Richard Biljetina  
Institute of Gas Technology

Effect of Dewatering Methodology on Peat Gasification  
Francis Lau  
Institute of Gas Technology

### Afternoon Session - Peat Resource Estimation

Status of State Peat Resource Projects  
Frank Honea  
DOE, Grand Forks Energy Technology Center

Summary - Closing Remarks  
Melvyn J. Kopstein  
DOE, Peat Development Program Manager

OPEN FORUM

## **WELCOME**

DR. MELVYN KOPSTEIN, Manager, DOE Peat Development Program:

Good morning. On behalf of the Office of Fossil Energy, I am pleased to welcome you to the Fourth DOE Technical Contractors Conference on Peat. During the next two days each DOE-supported contractor will present a technical project status review. In addition, papers will be presented which demonstrate the interest and possible role of private industry in the conversion and utilization of peat in the United States.

Finally, we are indeed fortunate to have in attendance representatives from the Governments of Sweden and Finland. These individuals will discuss research and development activities in their respect nations and, where appropriate, they will also be talking about commercial peat use for energy applications.

I believe that the participation in this Conference by representatives from government, industry, and the international community reflect a broad-based interest in accelerating the development of economical and environmentally responsible technologies for large-scale peat conversion and utilization, as well as an interest in improving existing harvesting and utilization technologies.

At the last Conference I stated that the direction of the peat program was being modified to comply with administration goals for the Department of Energy. These goals are based on government involvement limited primarily to long-range research projects that have a potential for what is commonly referred to as high payoff.

An important role of DOE is to develop promising technologies to the scale of process development units and thus reduce the high initial risk that is often associated with long-range research projects. Accordingly, the peat program is evolving to address the technical, environmental, economical, and social issues associated with the harvesting, dewatering, conversion and utilization

of peat. While previous technology development has concentrated on converting peat to a substitute natural gas, subsequent research will be concentrated on laboratory and PDU-scale studies concerning harvesting, dewatering, beneficiation, and direct combustion.

In addition, a major effort will commence shortly to perform a programmatic environmental impact assessment for peat utilization in the United States.

The gasification element of the peat program is being phased out gradually. This is based upon the Department of Energy position that previous and ongoing studies have adequately demonstrated and quantified the high peat gasification reactivity and product selectivity.

The peat program has been transferred to the Office of Coal Utilization and Extraction which has the purview to implement the types of research and development studies alluded to. Mr. Tony Liccardi is the Program Director for this organization.

Once again, I bid you welcome to our Technical Contractors Conference on Peat.

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**WATER RETENTION BY PEAT:  
CENTRIFUGAL STUDIES OF CAPILLARY FRACTIONS**

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## INTRODUCTION

Since our last progress report in March 1981, we have concentrated our efforts on water drainage measurements under various centrifugal fields. In addition to low-speed centrifuge studies with commercial filter units, which have been described previously, we have now increased our capabilities by the construction of special filter units that can be used in a high-speed centrifuge at up to 10,000g forces.

The aim of this phase of the work has been to gain information on physically retained water in peat. The basic assumptions involved are that capillary forces give rise to a certain fraction of the retained water and that a series of incremental centrifugal forces can remove well-defined fractions of that water. According to a simplified theory, the forces required to empty a pore are inversely related to its diameter, so that a given population of pores is expected to empty at each centrifugal acceleration level. Large pores empty first and small pores last.

## DESCRIPTION OF EXPERIMENTS

The studies completed at this time are as follows:

- (1) Equilibrium water contents were measured at a series of forces up to 10,000 gravities.
- (2) Methanol, a fluid with much lower surface tension than water, was "solvent exchanged" into peat to replace the water, and studies similar to those in (1) were repeated.
- (3) Several water-miscible solvents, including dimethyl sulfoxide (DMSO), dimethyl formamide (DMF), tetrahydrofuran (THF), dioxane, and a strong solution of zinc chloride in water, were solvent exchanged into peat samples and allowed to remain for several days. Then, they were exchanged out again against distilled water. Finally, studies similar to those in (1) were

performed on the peat. The solvent samples were evaporated to collect any residue that might have been extracted. The rationale for this work was that the solvents might be expected to remove materials coating the pore walls, thus changing their water-wetting characteristics. The wetting characteristics (contact angle) are expected to influence the relative ease of capillary pore drainage in a gravitational or centrifugal field.

- (4) One non-miscible solvent, carbon disulfide, was included in a series of tests identical to those described in (3). It was necessary to shake the sample vigorously to bring about some contact between the solvent phase and the peat. Separation of the wet peat phase and the solvent was quite simple in comparison to that in the prior case (3), however. As will be seen from the results, this hydrophobic solvent had a pronounced effect on water removal properties, in sharp contrast to results obtained with the water miscible solvents. Also of interest was the fact that whereas the solvents in (3) tended to darken in color to an orange or brown hue from the extractables,  $CS_2$  extracts had a pale color but deposited a considerable amount of waxy white substance upon evaporation. These results suggest that further studies involving "hydrophobic" solvents could be quite productive.
- (5) Three different enzymes were tested for their ability to modify water drainage characteristics. Peat was exposed to an aqueous solution containing cellulase from *Aspergillus niger* (Sigma Type II), or cellulase from *Trichoderma Viride* (Sigma Type IV), or hemicellulase from *Aspergillus niger* (Sigma). We reasoned that these catalysts, which are known to attack "loose ends" of cellulose or hemicellulose much more readily than the densely packed crystalline regions, would tend to remove "debris" that might be filling capillaries. According to this logic, enzyme-treated peat should demonstrate enhanced capillary water drainage in an experiment similar to (1). Although there was evidence of enzyme action, including partial clearing of the peat in water suspensions and darkening of the aqueous phase, the enzymes showed no appreciable positive effect on centrifugal pore water drainage. In fact, if anything, it was impeded.

(6) Another set of experiments that also bears directly on the question of physically-entrapped water has been completed. It has been known for some time that water loss from peat is partially irreversible. That is, once peat has been partially dried, it cannot be forced to imbibe water up to its initial native condition even by prolonged soaking in excess water. A capillary pore model of peat would explain such behavior by the fact that the menisci in submicron pores that result during drying create enormous hydrostatic pressures and tend to crush the pores out of existence. The effect is identical to that observed when common "white glue" become transparent as it dries. In this latter case, the individual spherical particles in the suspension merge into a solid mass under the same forces.

We have used the controlled electronic balance system described in our last report to dry peat samples to desired intermediate water contents. Each of these partially dried peats is then soaked in an excess of water until it will absorb no more. The drying hysteresis described by others has been confirmed and reduced to a much more quantitative basis. A series of planned tests will involve partial drying of peat samples, re-equilibration with removal under the protocol described in (1). Any pores destroyed by the partial drying should be readily apparent from the changed shapes of a retained water versus centrifugal force plot.

## **RESULTS**

The only peat samples that were available at the time these studies were initiated included an excellent virgin peat (about 86% moisture content) from North Carolina (supplied by First Colony Farms) and a sample of partially dried Minnesota peat (about 50% moisture content). This latter material was definitely not virgin peat and the results presented here should not be construed as representative of Minnesota peat. However, it was the only Minnesota peat initially available and has been included for comparison purposes. Excellent virgin peat samples from Minnesota and Maine have since been received but have not yet been evaluated.

Figure 1 shows the relative equilibrium of peat samples held at different centrifugal accelerations for prolonged times. Figure 2 is a similar plot but extends the range up to 10,000 gravities. Somewhat to our disappointment, we found that no additional populations of small pores were uncovered by the higher speeds. Figure 3 represents data taken to show that all of our centrifuge data really represents equilibrium values of moisture retention rather than simply plugging of the filter after a certain time. The filters were changed twice after an apparent equilibrium had been achieved, and no additional water removal was noted.

Figure 4 demonstrates the solvent removal from peat that is possible when methanol has been substituted for the water in peat. A close comparison between Figure 4 and Figure 1 reveals (as expected) that at all conditions the methanol is more easily removed from peat than is water.

Although the two peat samples were treated with all of the three enzymes previously mentioned, Figure 5 shows the results only for one of these, cellulase IV. This is the enzyme that demonstrated the most activity on peat (as judged by suspension clearing and solution darkening). Surprisingly, for all three enzymes, water removal was impeded by enzyme treatment. This figure demonstrates that up to 10 times the centrifugal force was needed to achieve the same water removal as from native peat samples.

The most interesting results (Figure 6) were those obtained by solvent-exchanging a substance into peat and then exchanging it back for water. Some solvents, such as dimethyl formamide, actually swelled the peat and caused it to retain much more water than it would otherwise. The peat became quite gummy and removal of the solvent was difficult. It is not known whether physical solubility, swelling of polymeric substances, or chemical alteration by the solvent caused this behavior. At the other extreme both in polarity of the solvent and action, carbon disulfide removed a waxy white substance from the peat and promoted water removal under a centrifugal field. Two possible explanations for this latter behavior come immediately to mind: (1) removal of the waxy substance altered the hydrophilic/hydrophobic character of pore walls or (2) pores

that were physically plugged became opened so that water could drain more rapidly. At this time, however, all explanations are speculative and require considerably more work to confirm.

The final data (Figure 7) presented are on partial drying followed by soaking to cause reimbibement of water into the peat drying, which is partially irreversible, and these data serve to quantitate that observation. Above about 80% moisture, and below about 30% moisture, the peat tested seemed to be quite reversible in its moisture loss/regain properties. Within this range, however, a portion of the moisture that was lost could not be recovered, even by extensive soaking of the peat. The mid-point of the S-shaped curve is at about 60%, but contrary to what others have stated, this is not a sharp transition point from reversible to irreversible behavior.

### **CONCLUSIONS**

The studies of centrifugal liquid drainage from peat, while not yet completed, are already beginning to provide some important clues about water retention mechanisms. The results of pretreatment with carbon disulfide were unexpected and suggest several new series of experiments. Irreversible water loss on drying has been studied and quantitated for one representative peat. Work is continuing in all of these and several new areas.

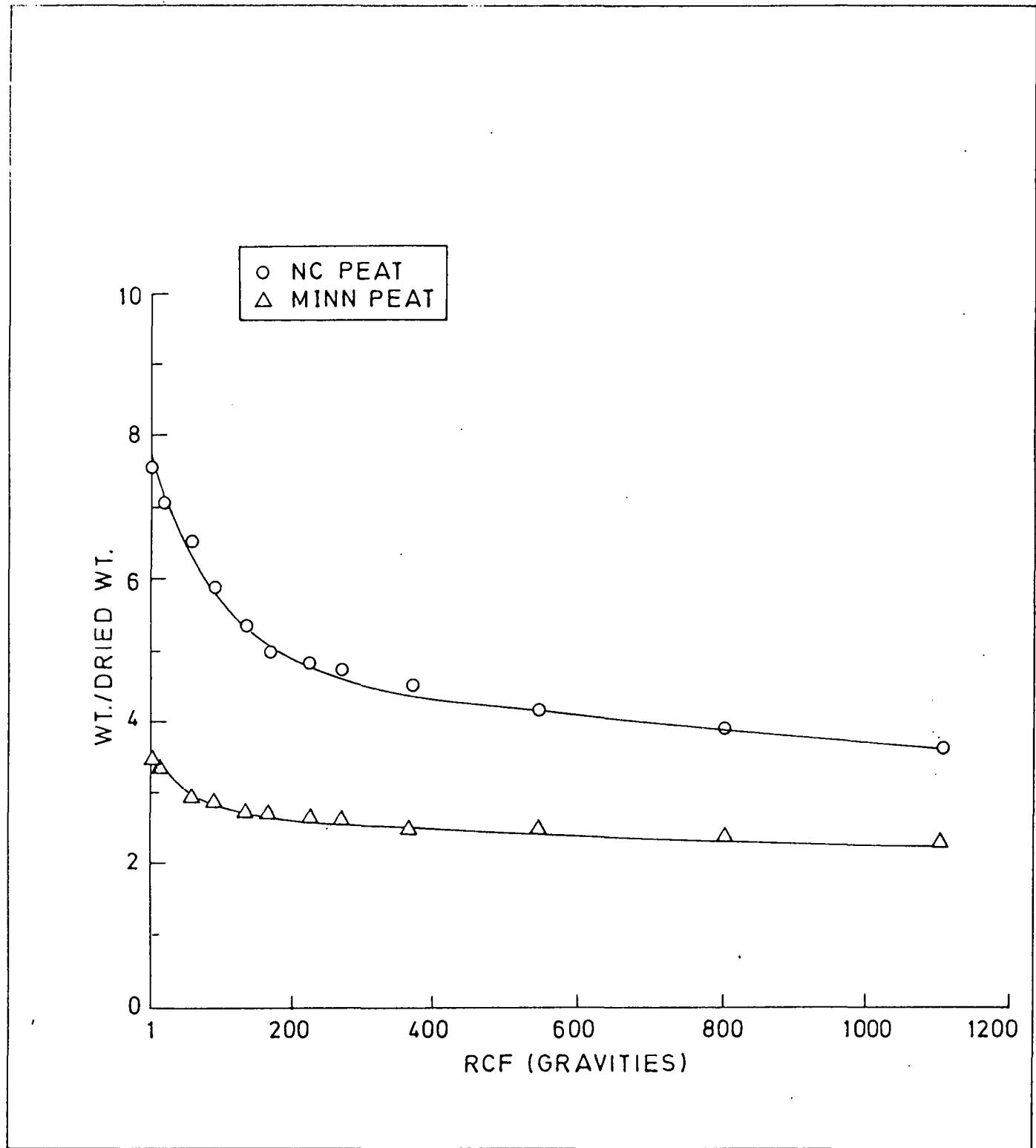


Figure 1 Relative Weights of North Carolina and Minnesota Peats After Equilibrium Centrifuging.

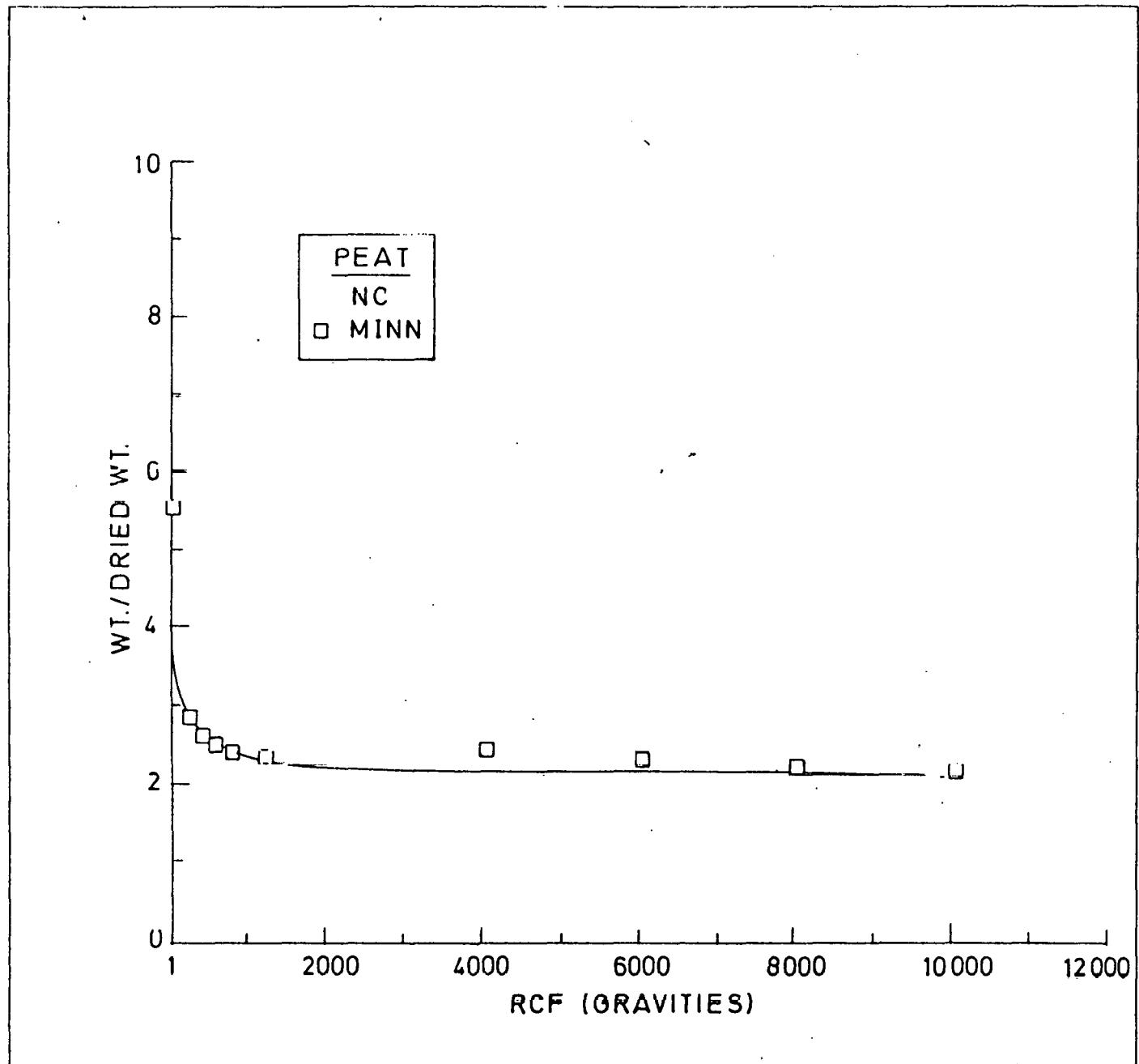


Figure 2 Relative Weights as in Figure 1 but at High Centrifugal Fields.

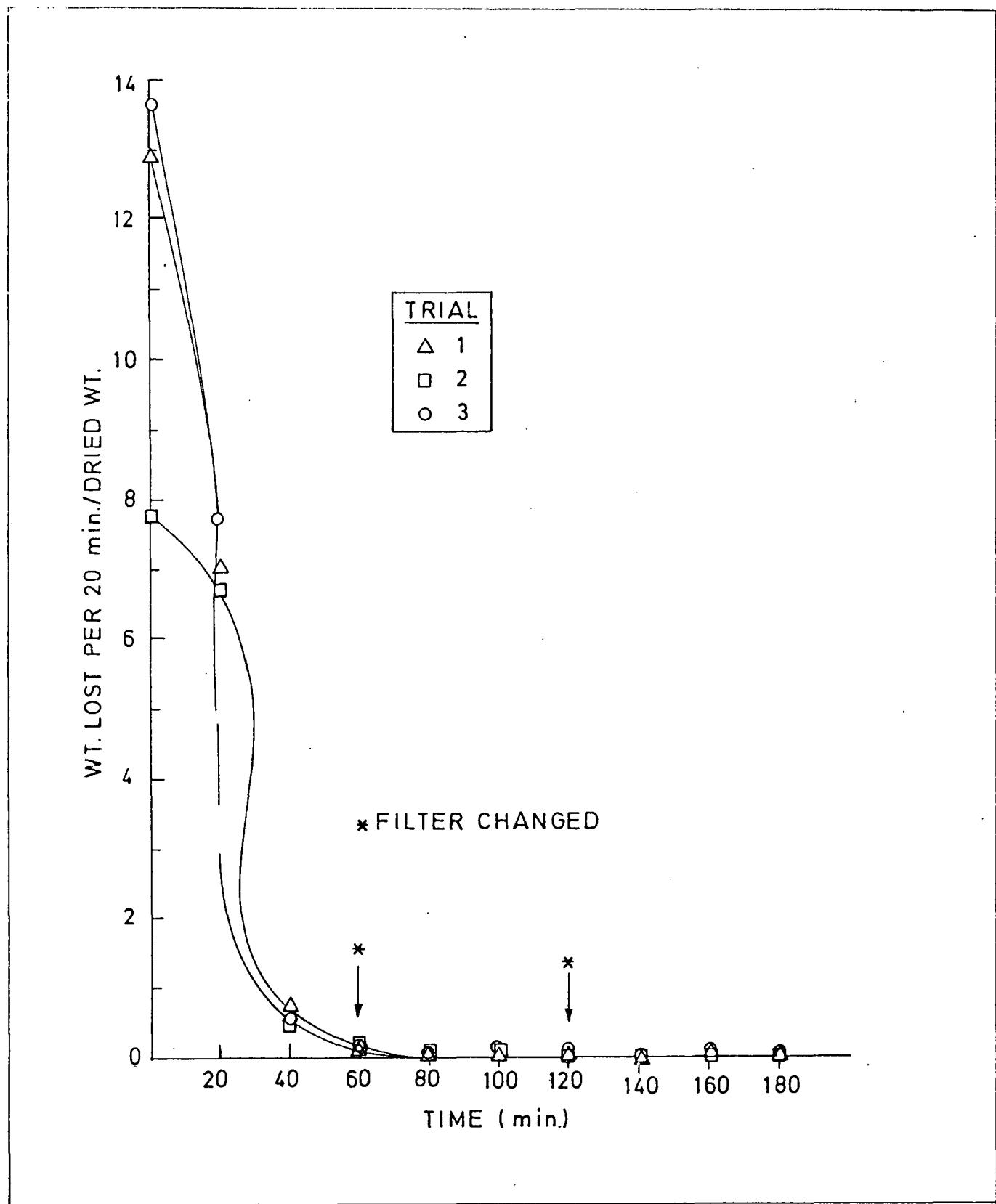


Figure 3 Demonstration that "Filter Plugging" is Not Responsible for Apparent Equilibrium Weights.

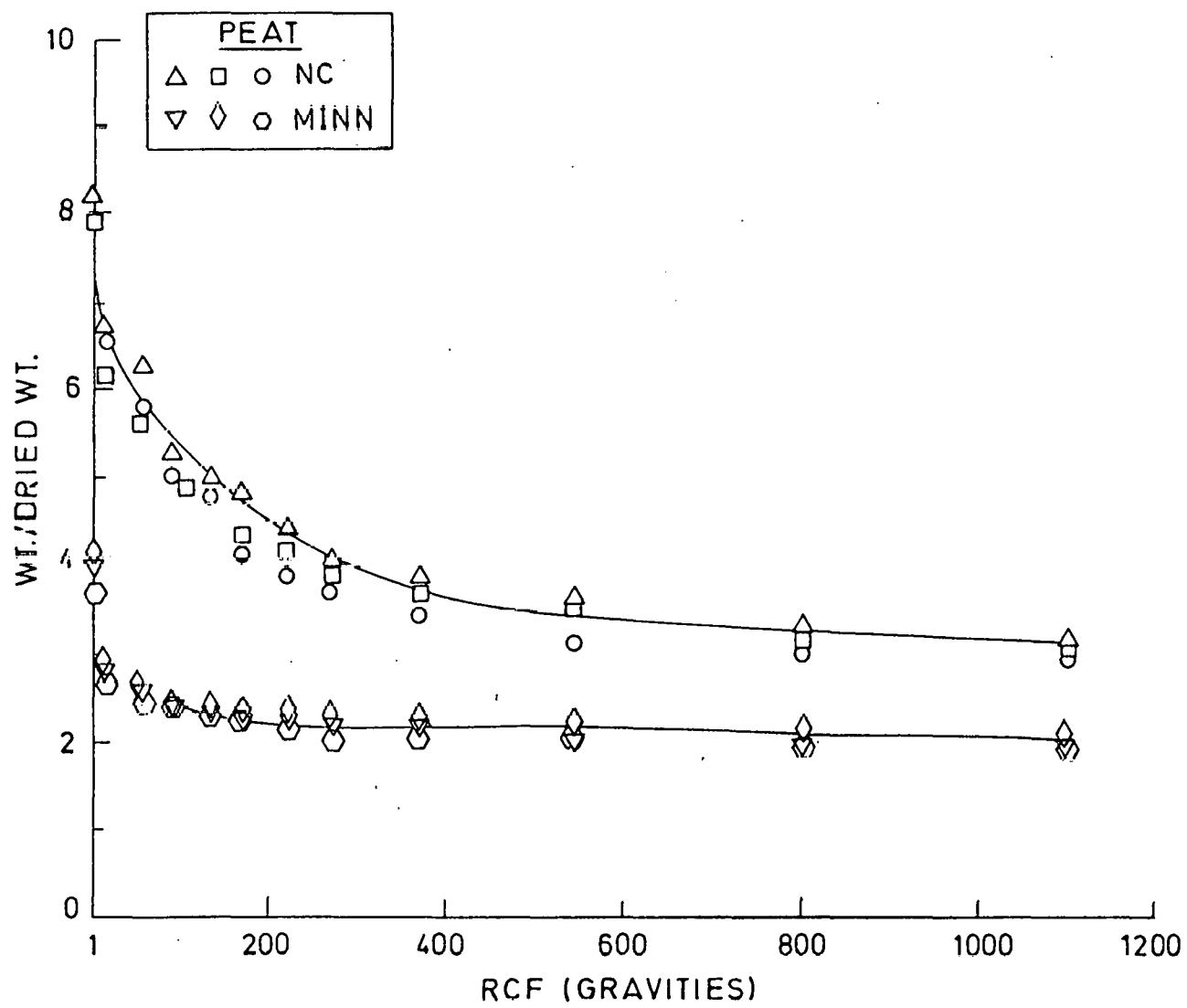


Figure 4 Relative Weights of Peats After Centrifuging When Methanol Rather than Water is the Entrained Fluid.

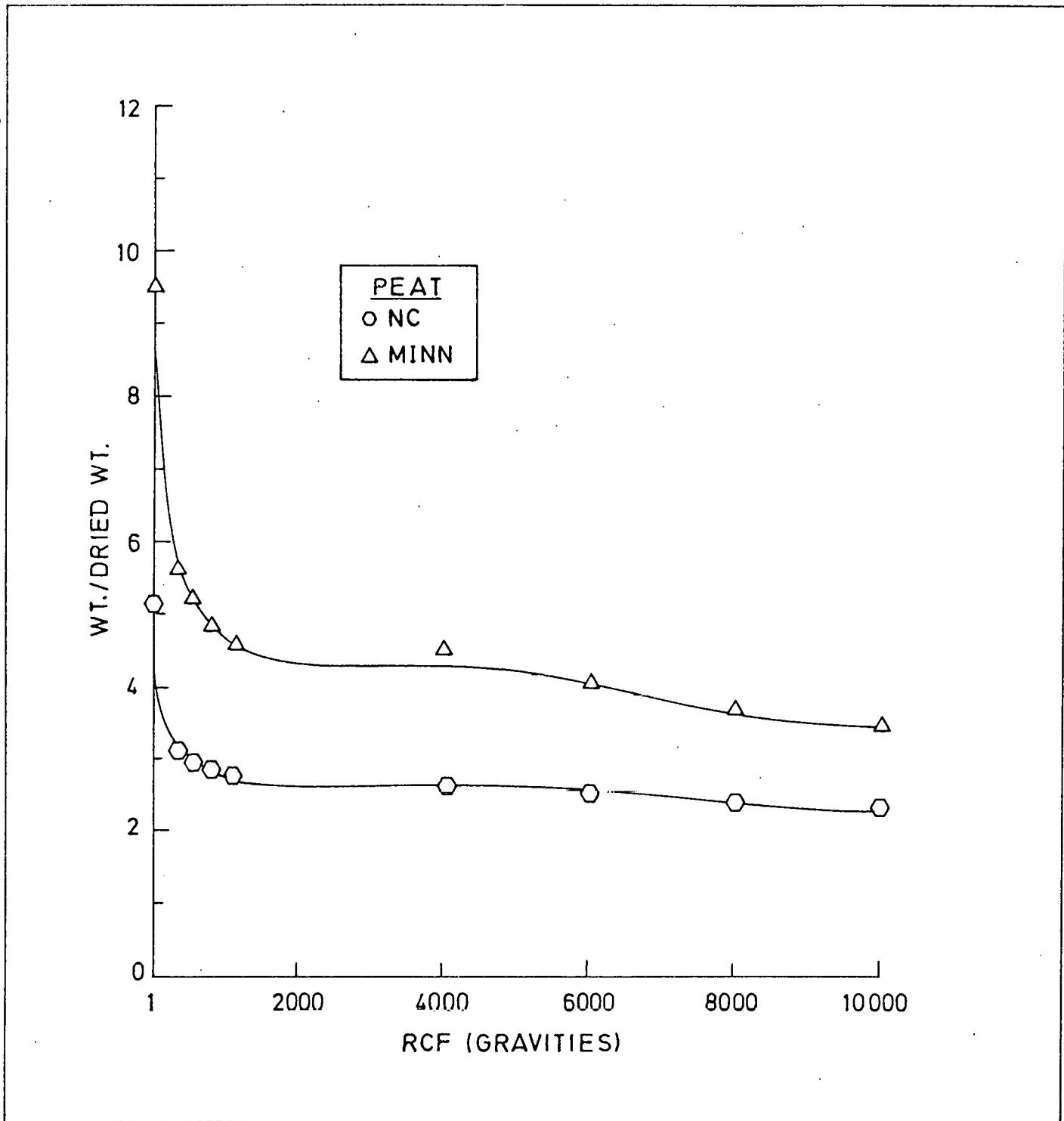


Figure 5 TR. Viride Cellulase-Treated Peat Retains More Water Than Native Peat.

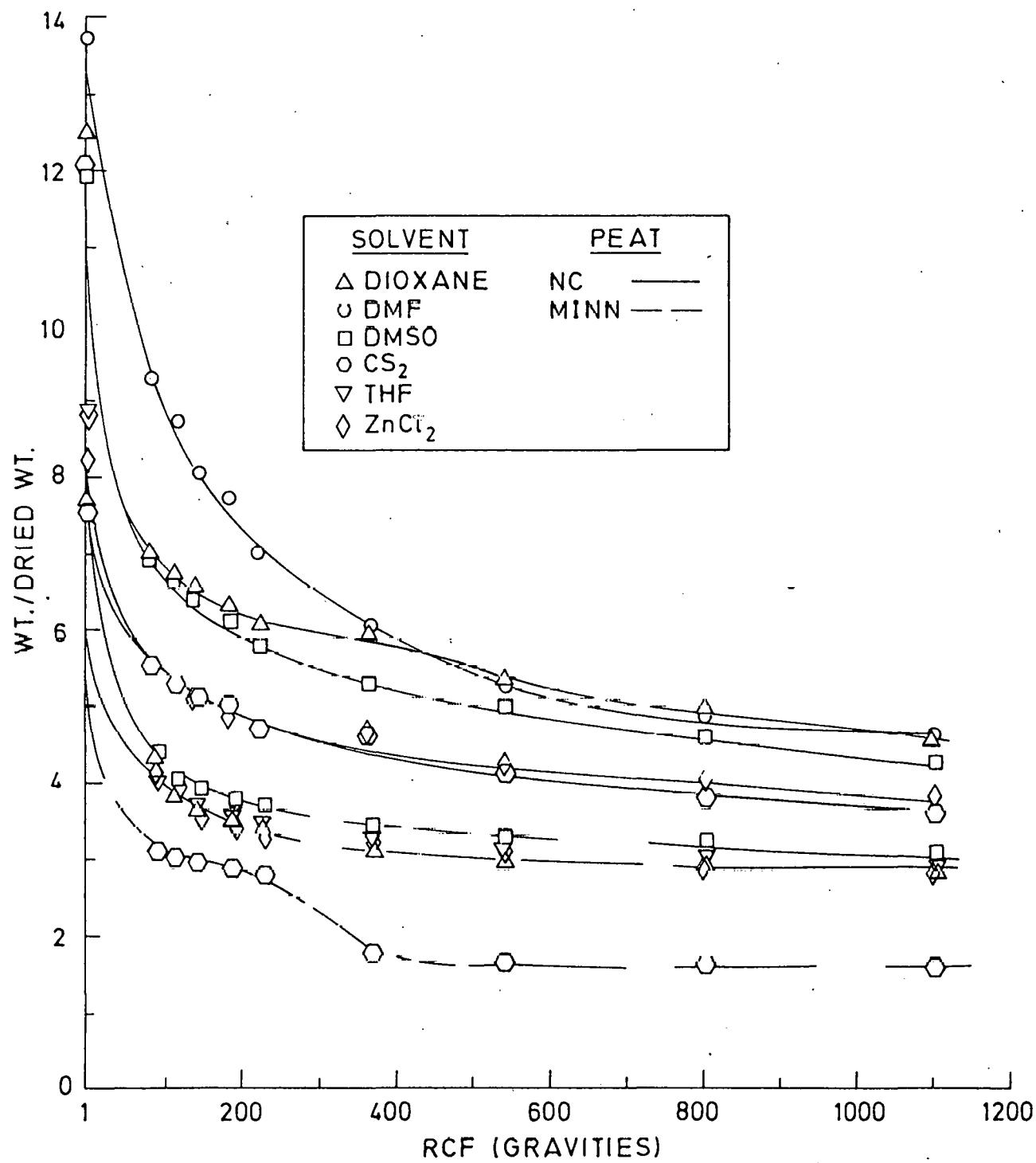


Figure 6 Peat Samples Which Have Been Solvent Treated Before Centrifuging Displayed Varying Characteristics.

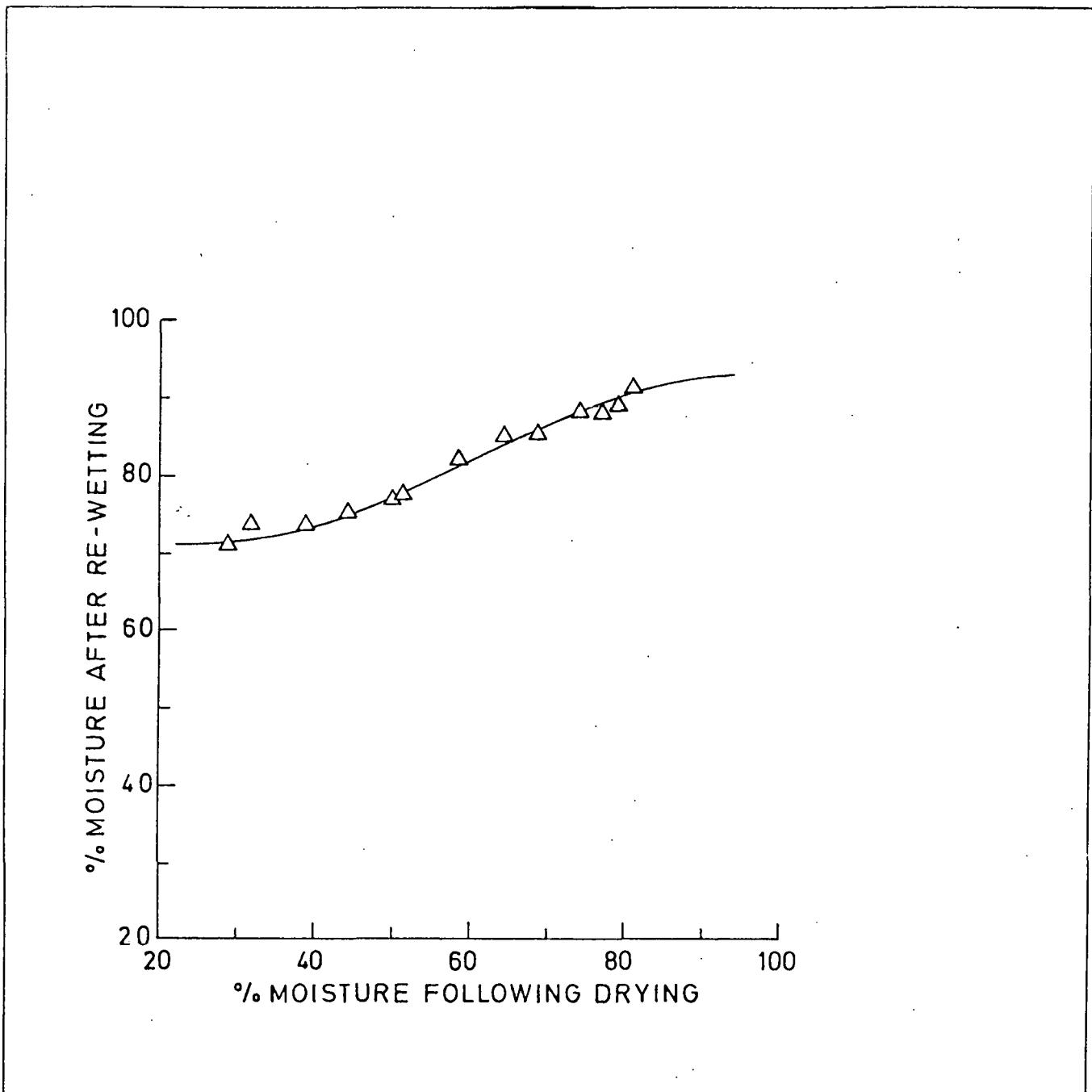


Figure 7 Quantitative Data on Non-Reversible Moisture Loss Was Obtained on North Carolina Peat.

## QUESTIONS AND ANSWERS

Q: The left axis on all those graphs, was that pounds of water per pound of dry solids or was that pounds of total weight per pound of dry solids?

A: The total weight. It's water plus solids relative to the dry weight. So by treating with the carbon disulfide, we were able to centrifuge it down to about 33% moisture content, which I think is rather interesting.

(Slide) You've seen this if you've been to a previous meeting. Basically, it's just a setup for maintaining a constant humidity around a sample of peat, circulating the air around it well, measuring the weight loss as a function of time with an electronic balance that the peat is suspended from here, and we are in the process of coming up with some data on equilibrium moisture contents as a function of the humidity of the chamber.

(Slide) The first set of data and the only one I'm going to show you because I knew I was going to run out of time is this. It's well known that, if you dry peat and then try to rehydrate it, you don't come back to the same material. We've quantitated this in the following way. We took some peat samples, we dried them down to various levels. This is the initial peat. This happens to be North Carolina peat, here. This is the initial peat, which is a little below 90% moisture content here, and we would dry it from, let's say, 85% down to 70% or down to 60% or down to 40% or as far down here, I think, as 25%. We haven't gotten all the data down in this low region yet. But we've dried it down, let's say, to 30% and then we have soaked it in water. We've added it to a great excess of water to see how much water it would soak up again.

Now, presumably they should all go back to the initial value. In other words, we start out at 85%, if you don't dry it, or 90%, whatever this is, it should be at that same value. What happens is initially you sort of stay up here. In other words, if you don't dry it very much, it will come back to the same moisture content that it had initially.

## QUESTIONS AND ANSWERS

However, now, if you begin to dry it under, let's say, 60%, it will not come back up to this initial moisture content of 90% or whatever it was, even though you soak it in a huge excess of water. In other words, you have permanently closed off some of the pores or permanently changed the structure of the peat in such a way that it no longer will pick up as much moisture as it did before and this becomes very dramatic when you get it dried down to 25% or so. Now it can only be rehydrated to a moisture content of about 70% by soaking it in a huge excess of water.

So what we now want to do is take some of this sort of material and carry out some of those centrifuge tests we've seen before to see if we can indeed show that the shape of the curve is changed. In other words, that we have closed off some of those pores that were previously present in the peat by this drying process.

Q: Do you soak the wet peat in the solvent?

A: Yes.

Q: There is no heat, no temperature?

A: No heating, nothing, right.

Q: And you are hoping to replace the water with the solvent?

A: What we were hoping to do was to remove something with the solvent.

Q: The question is how much of the water which was present in the original peat is now in the solvent phase?

A: Presumably we removed --

## QUESTIONS AND ANSWERS

Q: Without even centrifuging it.

A: Yes. Presumably we have removed a good fraction of it. How much, I can't tell you. But then presumably we've replaced it by then exchanging back from the solvent back to water. Now your point is a good one, that we may have irreversibly removed some water with this new solvent that we've equilibrated it with at some point in the process and I can't really argue against that. I mean, that's certainly possible.

What we were really interested in finding out, though, was without drying the peat, presumably without allowing any physical forces which could crush pores out of existence, we wanted to see if we could change the properties of the pore walls by this solvent treatment so that they no longer retain water to the same extent that they did. It seems with the carbon disulfide we certainly did something.

Q: It would have been nice if we could compare the effects of solvents at constant concentration of the solvent in the peat. The way I see it, when you are soaking wet peat in different solvents, the amount of solvent which now gets soaked into peat will be different for all these solvents.

A: Yes.

Q: And my question is how much was the variation of the solvent content of peat when we were looking at the effect of the solvent?

A: Yes. I see what you're saying. We couldn't measure that very well because in some cases, as you know from the studies you've done, these sort of turn into gummy materials. The solvents somehow modify the peat pretty drastically and some of the peats, after we'd solvent-treated them, were sort of gummy and it was very difficult to separate the solvent and the peat and find out how much solvent was in the peat. So it was difficult to do

## QUESTIONS AND ANSWERS

that. But some of the points you are raising are good ones and, if we had the time, we would certainly like to try experiments of this type.

Q: My question is basically how you could say that this is a comparison between a Minnesota peat and a North Carolina peat when you have not got a representative moisture level in Minnesota peat. It had apparently already been dried.

A: Yes, quite right.

Q: It's at about a 10 to one weight ratio.

A: We now have, thanks to Mr. Rader and some other people, some good samples of virgin Minnesota peat and we are going to begin some studies on these and try and determine what the differences are. Perhaps the virgin Minnesota peat will be more like the North Carolina peat. But, at the time we did these, these were the only things available to us.

Q: I understand that but what I am saying is when you compared them you imply that that's a typical Minnesota peat, and it's not--because we've tested it in three major areas in Minnesota and it was all right at 89% moisture, which is a weight ratio of about 10 to one.

A: That's quite right.

Q: And the beaker tests pretty well show that too because you showed virtually no colloidal water in the Minnesota peat.

A: Right.

## QUESTIONS AND ANSWERS

Q: I think maybe it might have been a surface layer, it could have been a surface layer, which might have had some peat value.

A: Right. Okay.

Q: From the data that I saw, it appeared that you were able to get as high as 25% solids, dry solids, with straight centrifuging on the North Carolina peat. I agree with Frank that the Minnesota peats really are kind of a null test --

A: Right.

Q: -- because they had been dehydrated previously. But on the North Carolina peat, which presumably had not been dehydrated, I am surprised to see that you were able to achieve as high as 25% solids on peat which had not been treated with any solvent or any surfactants or enzymes or what-have-you with straight centrifuging.

A: Yes.

Q: As opposed to even pressing them, of course, that's quite good, and I would not have thought that centrifuging was as effective as a high-pressure, long-time mechanical pressing.

Is that in fact true, that you got up to 25% solids?

A: I think it is. That sounds about right. Yes, I think 75% moisture does sound like a reasonable number that we did get. It's fairly reproducible. Don't forget that we're talking about small samples and holding them at this high centrifugal force for long periods of time, like an hour or two hours or something like that. So that obviously something like that would

## QUESTIONS AND ANSWERS

not be economical unless there were some way found of duplicating these conditions in the factory.

Q: I wonder in your rewetting experiments what temperature did you dry the peat at and whether you have any idea of whether different delta T's might have an effect on what you can rewet the peat to?

A: These were -- all our samples were dried in a vacuum oven at 105 centigrade. So that we have not investigated drying under more severe conditions. Presumably under those conditions we haven't removed any of the chemically contained water but, from what we could tell, this was a legitimate way of trying to dry just the absorbed and adsorbed water.

**COMMENT:** The thing I was trying to point out is that probably in most commercial types of drying, other than possibly solar drying, you would end up with high level peat, and, therefore, more change of the peat properties.

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**TESTING OF SOD PEAT EQUIPMENT AND ELUCIDATION  
OF SOD DEWATERING CHARACTERISTICS**

ANDREW B. ALLEN

FIRST COLONY FARMS, INC.  
CRESWELL, NORTH CAROLINA

## **BACKGROUND**

The sod peat harvesting program at First Colony Farms is designed to develop a practical, cost-efficient, environmentally acceptable means of producing a high grade fuel peat at or around 30% moisture from the highly decomposed, colloidal and woody peats found in abundant quantities along the Atlantic and Gulf coastal areas.

## **OBJECTIVES**

1. To determine the production rates of the sod peat harvesting equipment during varying climatic and seasonal conditions and to develop a balanced sod production methodology from bog preparation through stockpiling of harvested sod peat.
2. To determine the drying characteristics of sod peat and the parameters affecting sod peat dewatering, including the following:
  - a. Diameter and geometry of sods
  - b. Weather conditions
  - c. Solar radiation
  - d. Handling and stockpiling
3. To determine the cost in dollars per million Btu's to produce and stockpile sod peat in a balanced peat program.
4. To extrapolate the results of the First Colony sod peat project to sod production in other areas of the United States.

## **TECHNICAL PROGRESS**

Experiments aimed at developing the equipment and technology required to produce a high quality fuel grade sod peat are currently being carried out at First Colony Farms. These experiments consist of actually operating the various

units of equipment through each operation required in a scheduled production operation and collecting the required data necessary to determine the cost to produce and stockpile sod peat in a balanced program. Actual production samples have been taken and analyzed along with collected weather data to develop drying curves during varying weather conditions and seasonal changes. From this, the number of production days, harvesting days, and bog preparation days have been developed for a given year.

The sod peat method can be divided into distinct phases of operations that include:

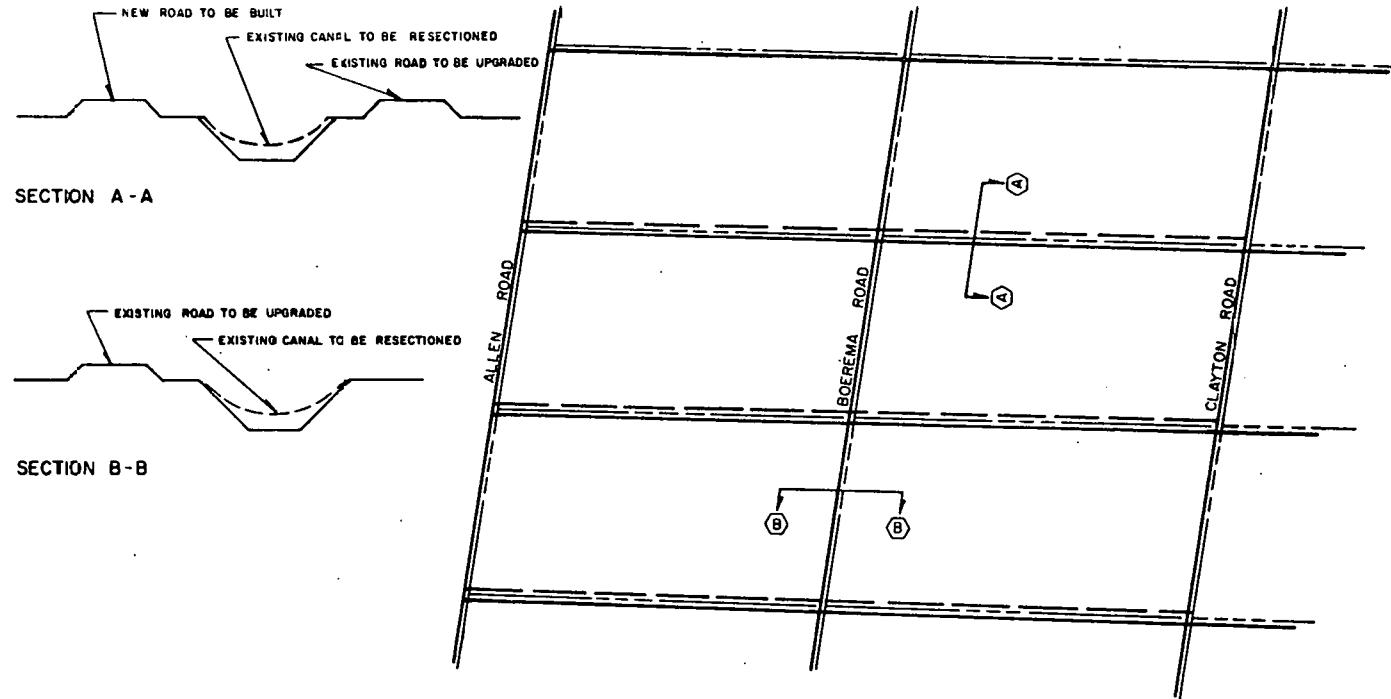
1. Initial bog preparation - This phase includes activities such as major canal and road construction, installation of drainage structures, ditching, grinding of surface vegetation, augering, fine milling, ditch cleanouts, and fine grading. The initial bog preparation phase is actually the preparation of a large solar collection that dries the sod peat after production. Therefore, it is essential that the surface of the bog be well graded and sloped to prevent any ponding of precipitation so that the drying will be enhanced or accelerated.
2. Sod peat production - That is, the mechanical removal of wet peat from the bog and its extrusion onto the bog surface where it is left to air dry. The production of sod peat is accomplished with the quadruple head sod extruder attached to the 450 H.P. Base Unit. This unit cuts four 1-3/4 inch wide slots by approximately 14 inches deep in the bog surface. The wet raw peat taken from these slots is thrown up to the extruder chamber and pushed out through an orifice approximately 4 inches in diameter. The extruded peat, called sod, then falls to the bog surface where it is left to dry to 30% moisture prior to harvesting. The ideal moisture content at the time of production is approximately 65%. This can be accomplished by varying the depth of cut in the bog surface, thus varying the moisture content of raw peat.
3. Loading and transportation - After the sod peat has dried to the desired moisture content (around 30%), it is windrowed into a long ridge. This

allows for additional drying of the sods, especially the portion that has been in contact with the ground. The sods are then conveyed to the carts by the loading unit and transported to the stockpile area. Stacking units are used to stack the sods into a properly shaped stockpile.

4. Annual bog preparation - Following the production season, the fields are excessively out-of-shape because of the depletion of the surface and the ditches are partially filled with eroded peat. The ditch cleaning, regrinding, shaping, and fine grading operations will be required to correct this problem.

#### **FUTURE WORK**

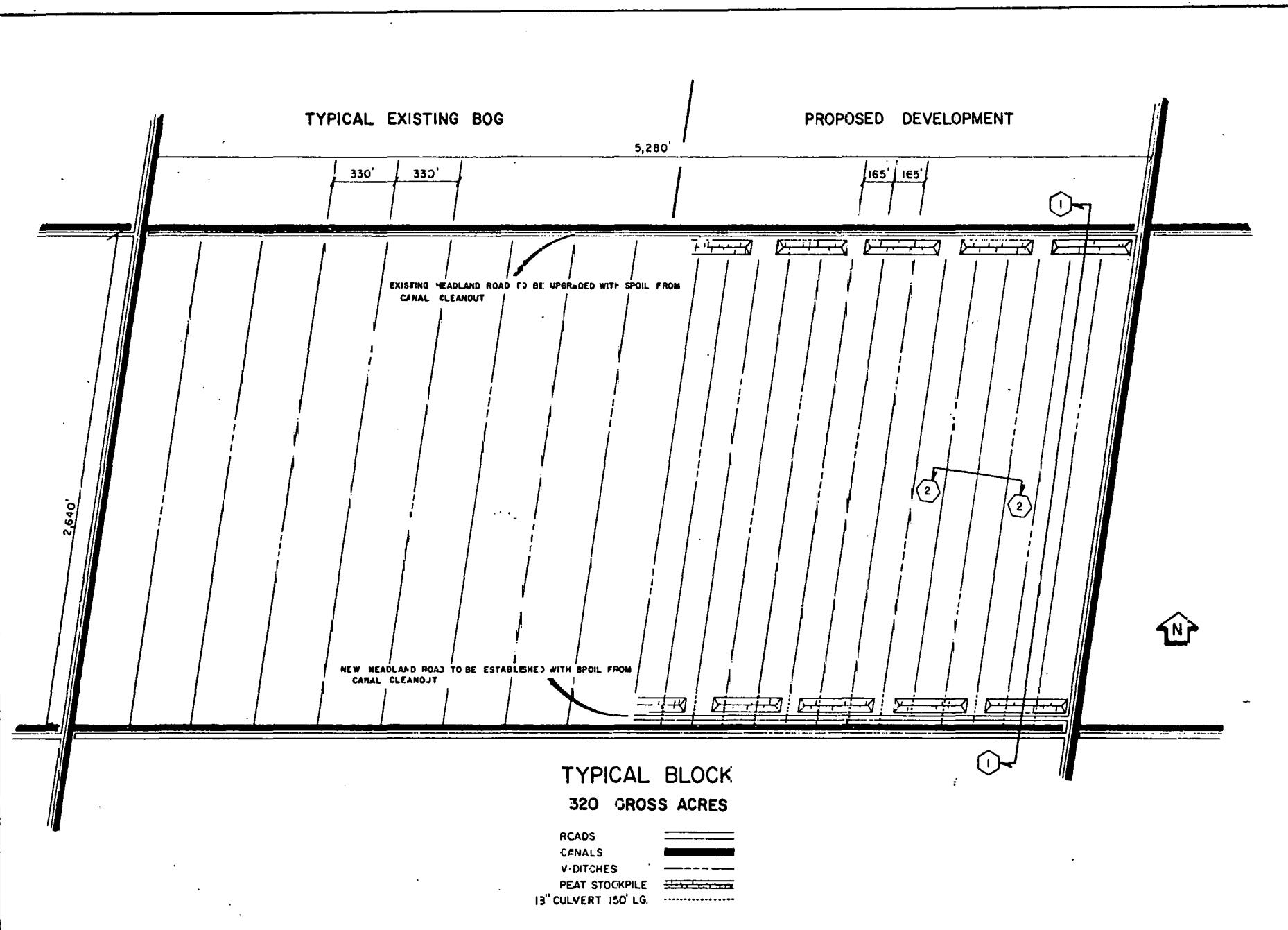
All of the field data now collected will be compiled and analyzed and additional drying curves developed. From the established production rates and equipment operating cost along with manpower requirements, a total cost in dollars per million Btu's will be determined for a balanced sod peat program.

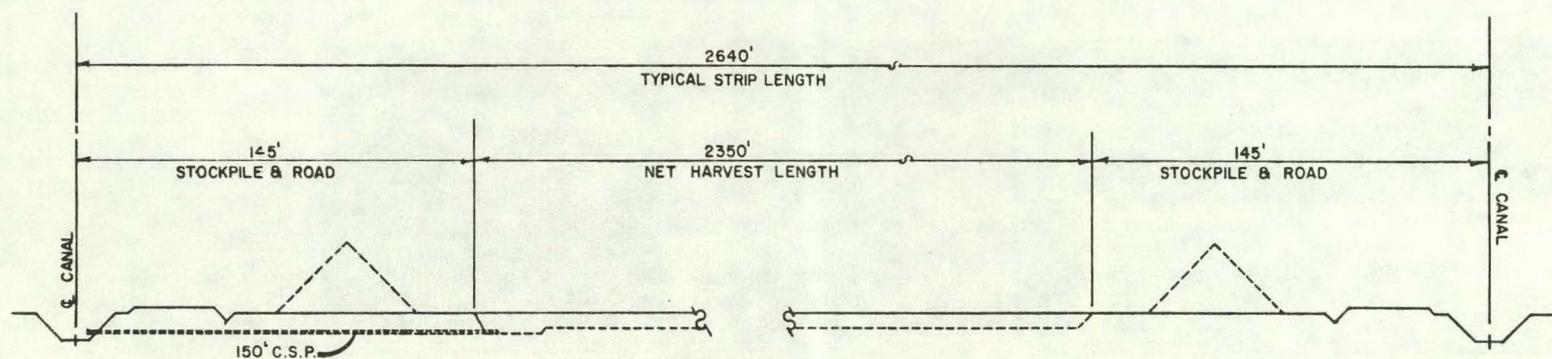
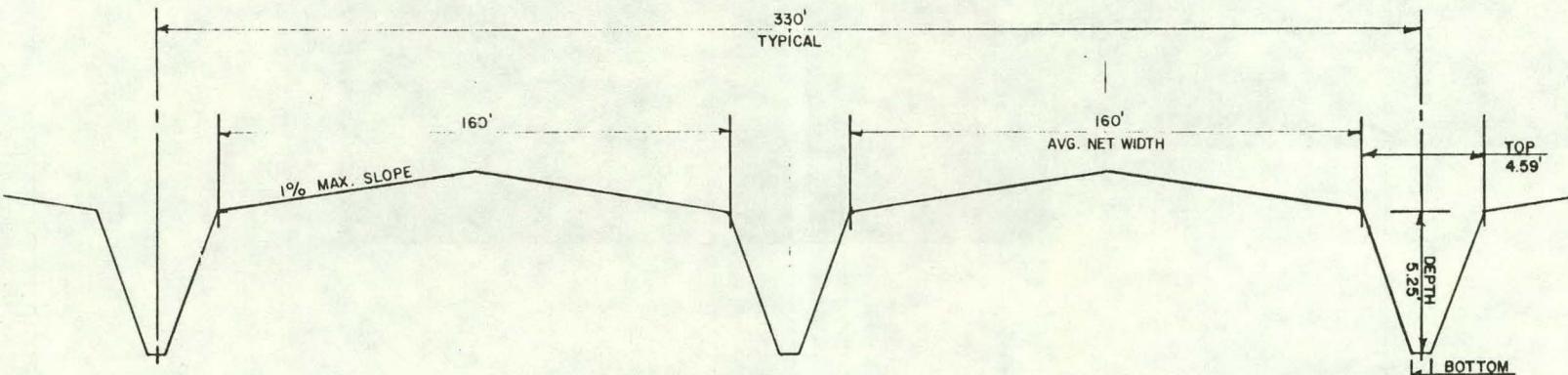


INITIAL 1920 GROSS ACRE PEAT BOG

NEW HEADLAND ROAD  
EXISTING ROAD  
EXISTING CANAL

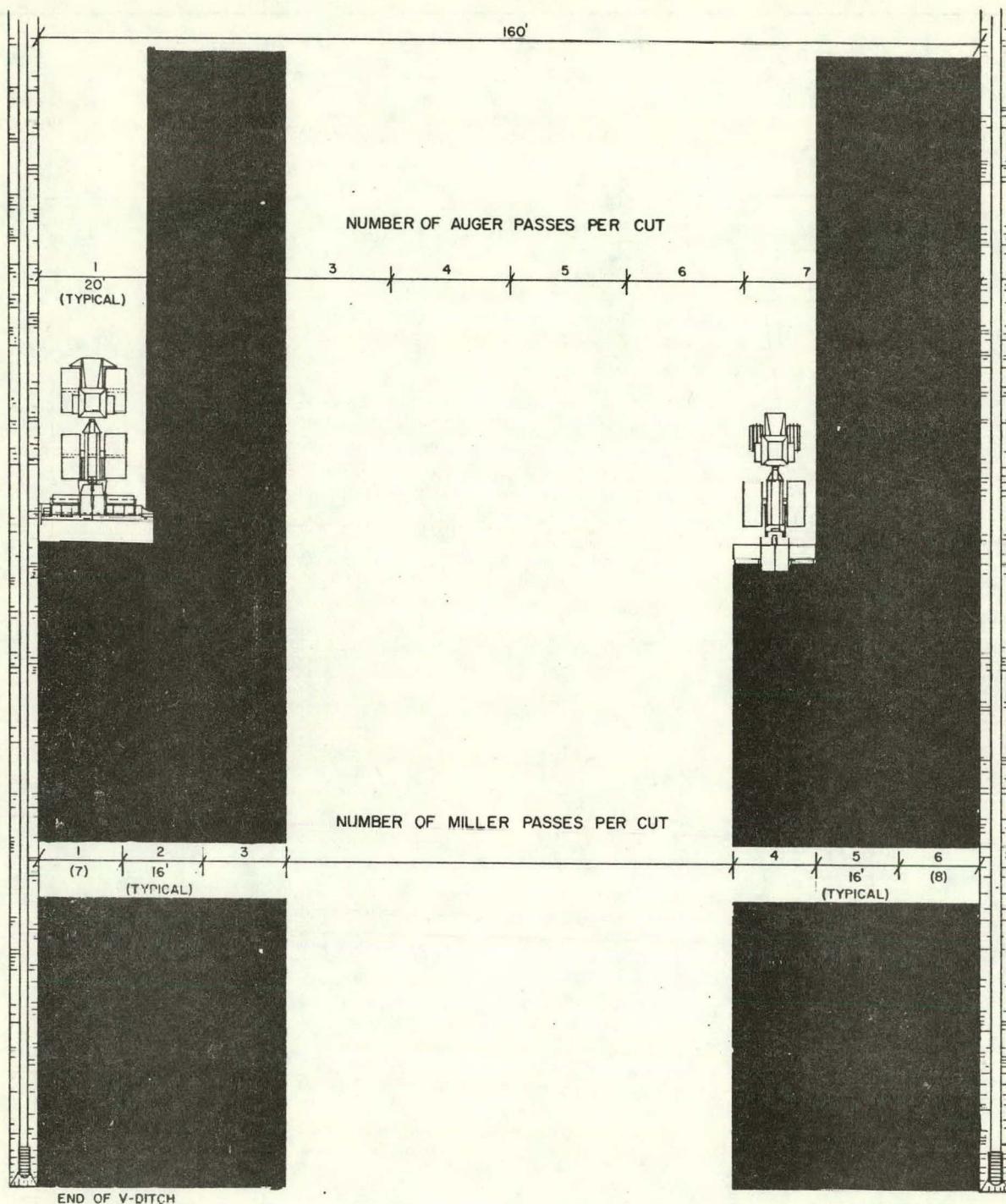
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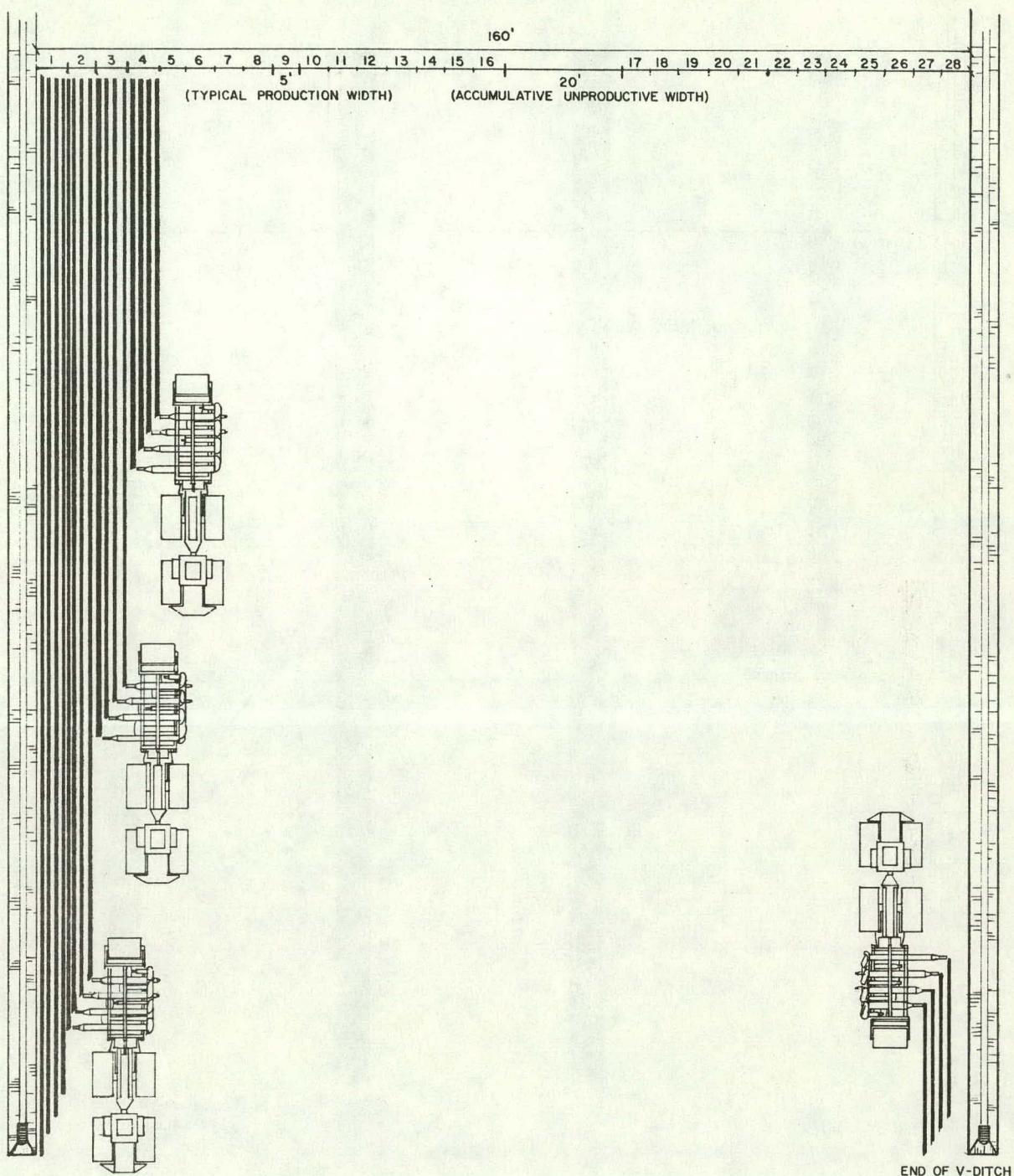




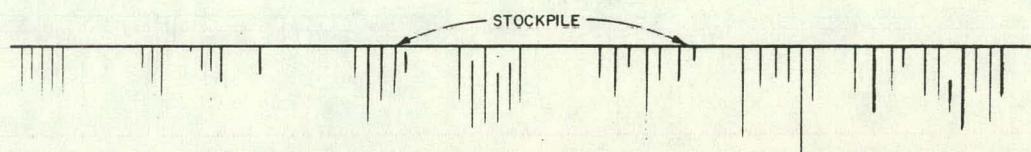
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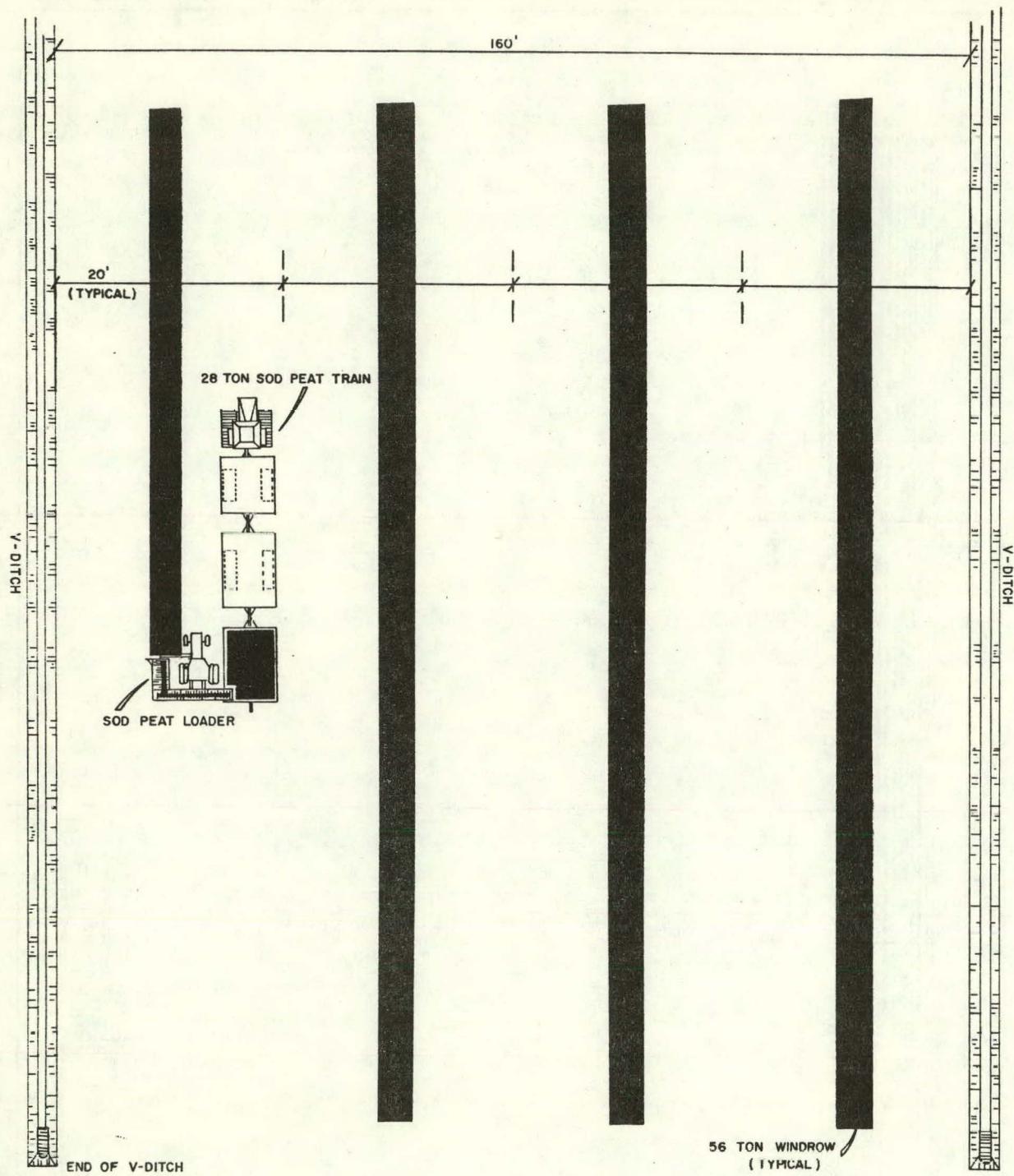
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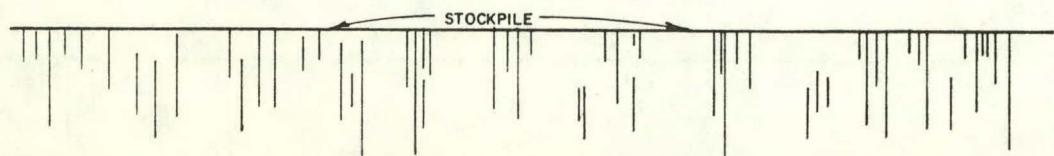


### SOD EXTRUSION





SOD LOADING AND FIELD TRANSPORTING



## INITIAL BOG PREPARATION

FIRST COLONY FARMS, INC.  
SOD PEAT PRODUCTION PROGRAM

<u>Operation</u>	<u>Type Equip.</u>	<u>Ft./Hr.</u>	<u>Fuel Consmp.</u>
A. Initial Bog Preparation:			
1. Initial 4" Vegetation Grind of Entire Field	Bros Rotor Mixer	6000 Ft/Hr	14 GPH
2. 8" - 10" Regrind at Proposed New V-Ditch	Bros Rotor Mixer	5000 Ft/Hr	14 GPH
3. Construct New V-Ditches & Install Necessary Culverts	Screw Ditcher w/450 Base	750 Ft/Hr	15 GPH
4. 8" - 10" Regrind of Remainder of Field	Bros Rotor Mixer	5000 Ft/Hr	14 GPH
5. Rough Auger Entire Field	Auger Planer w/310 Base	4000 Ft/Hr	14 GPH
6. Rough Grade Entire Field	Cat L2-14 Motor Grader	4.68 Acres/Hr	10 GPH
7. Clean Out Existing V-Ditch and/or Cut New V Ditch	Wheel Ditcher w/450 Base	1500 Ft/Hr	15 GPH
8. Level Center Windrows and 8"-10" Regrind of Entire Field	Bros Rotor Mixer	5000 Ft/Hr	14 GPH
9. Fine Grade Entire Field	Motor Grader	6 Acres/Hr	10 GPH
10. Roll and Seal Entire Field	Roller Drum w/1066 Tractor	10 Acres/Hr	7 GPH

## SOD PEAT PRODUCTION

FIRST COLONY FARMS, INC.  
SOD PEAT PRODUCTION PROGRAM

<u>Operation</u>	<u>Type Equip.</u>	<u>Ft./Hr.</u>	<u>Fuel Consmp.</u>
1. Sod Production	Quadrup'e Head Sod Unit; 450 Suokkone Base	3600 Ft/Hr 32 Tons/Hr @ 30% M.C.	15 GPH
2. Sod Peat Windrowing	Sod Peat Windrower Unit; Modified I.H. Farm Tractor	13,000 Ft/Hr	10 GPH
3. Sod Peat Loading	Modified Athey Force Feed Lander; 10 Ton Transport Carts; modified I.H. Farm Tractor	13,000 Ft/Hr	10 GPH 8 GPH

## ANNUAL BOG PREPARATION

FIRST COLONY FARMS, INC.  
SOD PEAT PRODUCTION PROGRAM

<u>Operation</u>	<u>Type Equip.</u>	<u>Ft./Hr.</u>	<u>Fuel Consmp.</u>
B. Annual Bog Preparation:			
1. Clean out Existing V-Ditch and/or Cut New V-Ditch	Wheel Ditcher w/450 Base	1500 Ft/Hr	15 GPH
2. Level Center Windrows and 8"-10" Regrind of Entire Field	Bros Rotor Mixer	5000 Ft/Hr	14 GPH
3. Fine Grade Entire Field	Motor Grader	6 Acres/Hr	10 GPH
4. Roll and Seal Entire Field	Roller Drum w/1066 Tractor	1.0 Acres/Hr	7 GPH

# PRODUCTION VS. HARVEST CYCLES

MONTH	MARCH		APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER	
TYPE OF DAY →	TO WET	PRODUCE ONLY	TO WET	PRODUCE ONLY	TO WET	PRODUCE ONLY	TO WET	PRODUCE ONLY										
DAY OF MONTH ↓	HARVEST	PRODUCE	HARVEST	PRODUCE	HARVEST	PRODUCE	HARVEST	PRODUCE										
1	x				P28	H16		P50	H39	x			P103	H80	P128	H15	x	
2		P1			P29	H19		P51	H40	x			P101	H9,92	P129		x	
3		P2	x					P52		x			P102	H93	P130	H16,117	x	
4		P3	x					P53	H42,43	x			P103				P147	H39
5		P4	x			x				x			P104	H94			P148	H40
6	x				P30		x			x			P105	H95			P149	H41
7	x					P51		P54			P61	H62-58	P80		P106	H86		
8		P5			P32	H20		P55			P62	H59	P81		P107	H97	P131	
9		P6			P33	H21		P56			P65	H60	P82	H71	P108	H98	P132	
10		P7			P34	H22	x				P64		P83	H72	P109	H99	P133	x
11		P8			P35	H23	x			x			P84	H73	P110	H100,101	P134	
12		P9			P36	H24		P57	H44,45	x			P85	H74,75	x		P135	
13		P10	x					P58	H47	x			P86				P136	
14		P11	x			x					P65		P87	H76,77	P111		P137	
15		P12			P37		x				P66		P88	H78	P112		P138	
16		P13			P38		x			x			P89	H79	P113		P139	H118
17		P14	H1		P39	H25	x			x			P90	H80	P114	H102,103	P140	H119,120
18		P15	H2,5		P40	H26	x				P67		P91		P115	H14	P141	H121,131
19		P16	H3,6		P41	H27,30	x				P68		x		P116	H106	P142	H122,123,125,122
20		P17	H4		P42	H28,31	x				P69		x		P117	H106	P143	H124,126,133
21		P18	H7,9		P43	H29,32	x				P70	H61	x		P118	H107	x	
22		P19	H8,10		P44	H33	x			x			x		P119	H108	x	
23		P20	H11		P45	H34	x			x			P82		P120			P164
24	x		x			x		x		x			P83	H81	P121	H109	x	
25		P21			P46	H35-38	x			x			x		P122	H110,111	x	
26		P22	H12	x			P59	H46,48	x			P94	H82,83	P123	H112	P144		
27		P23	H13	x			P60	H49-51		P71	H62,64		P95	H84	P124	H113,114	P145	H127-128,134-136
28		P24	H14		P47		x			P72	H65		P96	H85	x		P146	H130,137,138
29		P25	H15		P48		x			P73	H66		P97	H86	P125			H159
30		P26	H16		P49		x			P74	H67		P98	H87	P126		x	
31		P27	H17			x					P99	H88,89	P127					H16
TOTAL DAYS OF HARVEST & PRODUCE	13		15		7		8		18		20		9		17		107	
TOTAL DAYS OF PRODUCE ONLY	14		7		4		6		7		8		10		5		61	
TOTAL DAYS OF NO WORK	4		8		20		16		6		3		11		6		74	

P1 - "P" INDICATES SOD PRODUCTION, H1 - "H" INDICATES SOD HARVEST, H1 - "H" INDICATES FIRST PRODUCTION RUN  
 H1 - "H" INDICATES SOD HARVEST, H1 - "H" INDICATES HARVEST OF FIRST PRODUCTION RUN

16 days per cycle =

168 potential production-harvest cycles

TOTALS

3 HARVEST ONLY

10

107

7

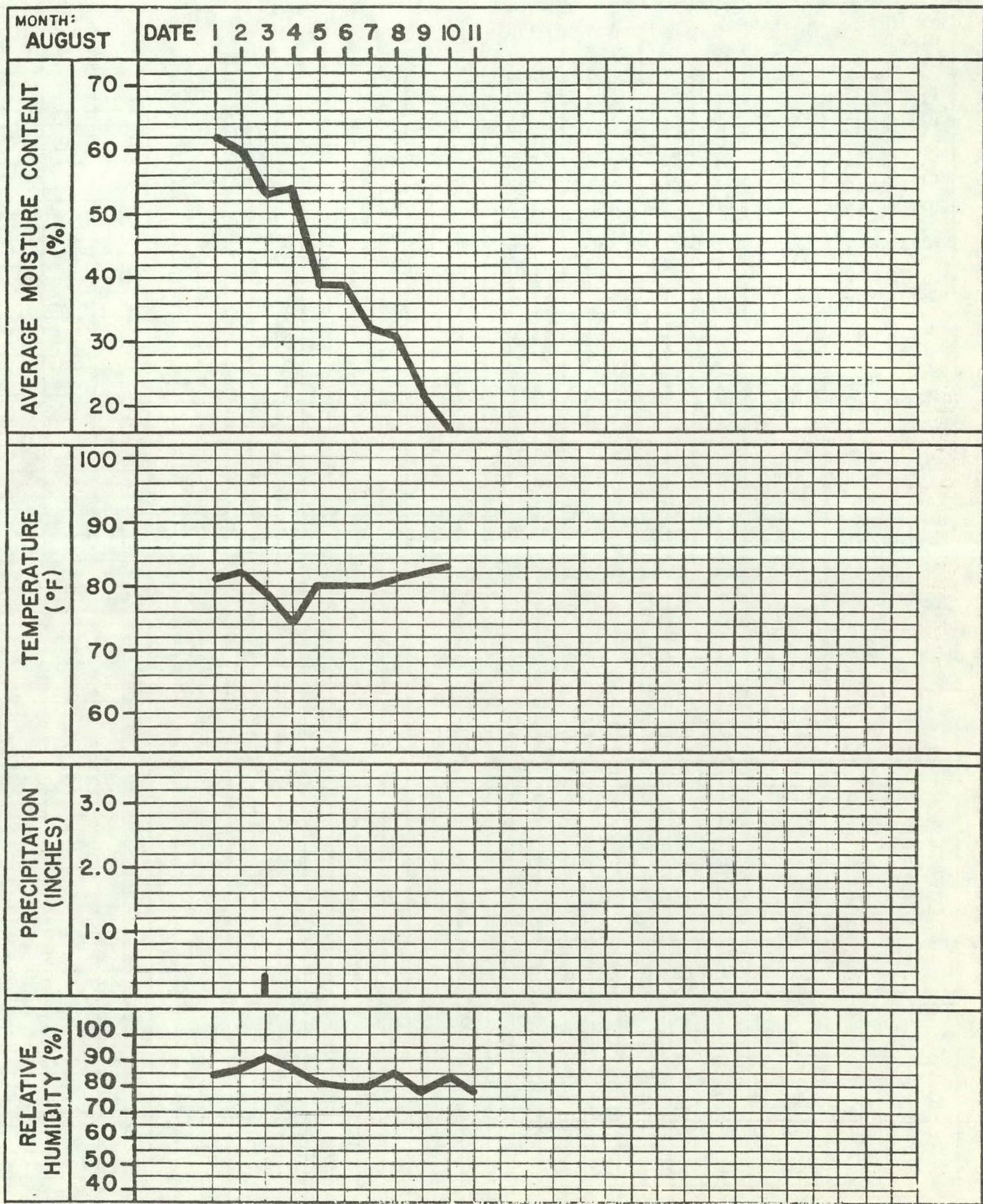
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FIRST COLONY FARMS, INC.

RT. 1, BOX 201 CRESWELL, N.C.

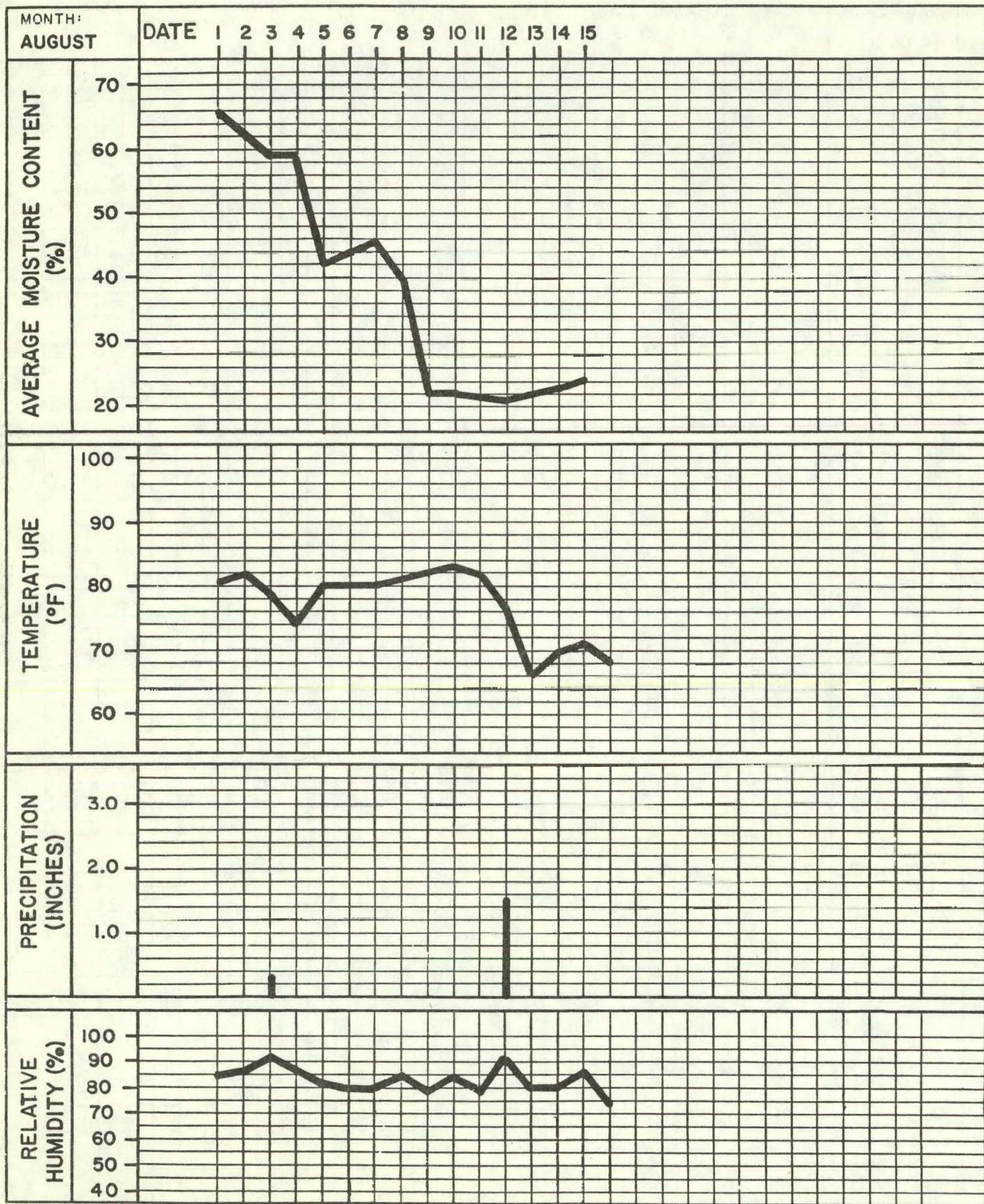
SOD PEAT DRYING TEST NO. 1

SOD PEAT DIAMETER: 90 mm



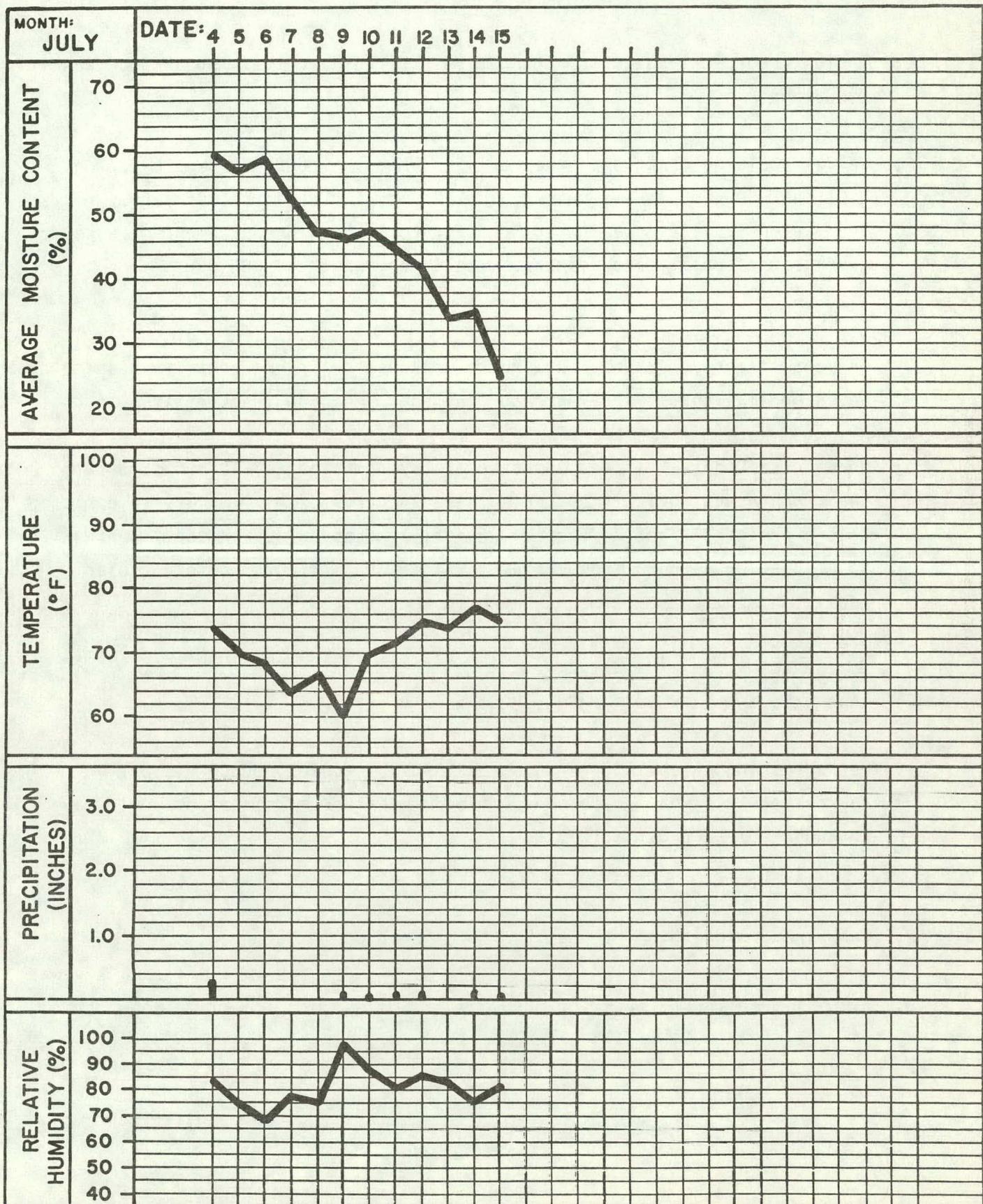
FIRST COLONY FARMS, INC.  
RT. 1, BOX 201 CRESWELL, N.C.

SOD PEAT DRYING TEST NO. 2  
SOD PEAT DIAMETER: 101.6 mm



FIRST COLONY FARMS, INC.  
RT. 1, BOX 201 CRESWELL, N.C.

SOD PEAT DRYING TEST NO. 3  
SOD PEAT DIAMETER: 110 mm



## QUESTIONS AND ANSWERS

Q: I didn't correctly hear the production rate you were talking about. Was it 8,000 tons?

A: We were talking about a program only in theory of 800,000 tons a year. Now, that 800,000 tons a year would be something realistic as far as a gas production facility requirement or peat to methanol requirement or a power generating facility requirement. That's why we chose 800,000.

Q: On your graphs you didn't show hours of sunshine or per cent of sunshine or anything like that. Are you recording that, keeping track of it?

A: We have that data. It was a matter of trying to get all of these data on the graph pretty quickly to get up here and try to tell you a little bit so that everything's not on there. We realize that. I think the important thing that we need to show on there, additional things, would be solar radiation and that will be on there in the future.

Q: What area do you need for 800,000 tons a year?

A: We're talking about 1920 gross acres that you would produce off of for approximately 5 years before depletion of that area. Then you would move to another 1920 gross acre plot.

Q: Can you say something of what the total cost would be?

A: We will have that at a later date.

## QUESTIONS AND ANSWERS

Q: What about environmental monitoring, are you doing any characterization and baselining?

A: The State of North Carolina currently has three projects going on based around First Colony's peat operations. One of those is air quality, another study is fugitive dust, which is similar to the air quality study, the other is a water monitoring, water sampling program. So yes, there are three studies going on. We are not conducting them, the state is doing that.

Q: The state is doing it.

A: Right.

Q: Is that data made available to you?

A: Yes, they sure are.

Q: Do you have to wait until the state has completed its testing before you get the go-ahead from the state to begin an operation of this magnitude?

A: We are currently permitted by the state to mine peat on 15,000 acres. Of course, at the present time it would be ridiculous for us to go ahead with a program because we really don't have a customer that could take 800,000 tons. So, as things materialize from that sense, I think that we'll see some fitting or meshing together of the regulations and what we're doing but as far as I know now there is nothing to prevent us from mining 800,000 tons a year.

## QUESTIONS AND ANSWERS

Q: What was involved in your obtaining this permit?

A: We were the first people in the State of North Carolina to apply for a peat mining permit. So we had to go through a learning process with the state. They actually had no formal procedures for permitting so they were established kind of jointly. You know, we just sat around and talked and they went back and they came up with what they thought would be required.

Now I will admit it's a little harder now to get a permit to mine peat in North Carolina than it was when we did it two years ago. But there have been 5 other permits issued in the last 6 months that I know of.

Q: Your sod extrusion is conducted when the moisture content is about 60% from looking at the graphs you have this morning.

A: 60 to 65.

Q: Have you determined that to be the optimum moisture content for these sods? What happens if the moisture content is 70 or 55 or 50%?

A: What we have found is that the extruder, the particular extruder that we're using works at an optimum of around 65%. We are currently working on a new extruder design that may change that but right now with the present quadruple-head extruder 65% is the optimum and, if it gets too wet, say 70%, production is down, you have longer, ropier sod and it takes longer for it to dry and it just doesn't produce as well. On the other hand, if it's too dry, you have the other problem, the extruder clogs and it doesn't work properly.

So the 65% is a pretty fine line in there of what you want. However, you can vary your moisture content by varying your depth of cut. The extruder cuts, say, normally around 14 inches of depth and we can raise that up or lower it to get a little wetter or a little drier material.

## QUESTIONS AND ANSWERS

Q: That new extruder which you are developing, do you hope that it will be able to work with higher moisture content?

A: Actually, I'd hope it would be able to work with a little lower moisture content. That was the aim.

**COMMENT:** The fiber content would depend on the amount of wood the extruder encountered at any particular place in the field. So, if there's no log or wood or stump that he's cutting through, you will not have the fiber. If he hits a log, he saws through that and that fiber is incorporated in the sod also. So it would depend on the actual characteristics of the field as far as the fiber content.

Q: For direct combustion, from experience or what you've been told by the utilities, is 30% the optimum moisture content for burning the peat?

A: No. Most of them would take the sod and probably pulverize it and then dry it down further. Now, one of the things you can do with sod is burn it in, say, some type of wood-fired boiler as is, at that moisture content, which would be fine. But if you were going to generate power, you would probably pulverize it and dry it further.

Q: You showed the table with the figures for fuel consumption, which is for all the equipment. Could you give us an estimate for the total fuel use, total fuel consumption per ton for peat? I think that that would be very helpful, the investment for this 800,000.

A: Yes. I can give it to you.

## QUESTIONS AND ANSWERS

Q: And what would be the labor input part?

A: The only way I can do it very quickly is to tell you that if you take an 800,000 ton a year operation, take the total tonnage produced and multiply that by the Btus per pound and come up with the total number of Btus you produce. If you take 1.45% of that, you end up with Btus of fuel, which you could then convert to gallons. So 1.45% of total Btus is the Btus of fuel that we would use.

Q: And what would be the total capital investment in this machinery?

A: Oh, we'll know that as we finish our program.

Q: The 800,000 tons per year, at what moisture content is that?

A: 30%.

Q: At one time you are working with a hollow sod and what you have described are apparently the solid cylinders, not the hollow ones. What is the reason for giving up the hollow sod?

A: The hollow sod had approximately a one-inch hole in the center, it was 110 millimeters in diameter and we found roughly that production was down in pounds per lineal foot of travel or tons produced. The drying rate was somewhat quicker, a little bit quicker, not a great deal, but the rewetting characteristics were higher. It tended to trap water in that hole during rains and then the bulk density was down, the overall bulk density. So we have backed off of that.

Duf

## **WET CARBONIZATION PDU STUDIES**

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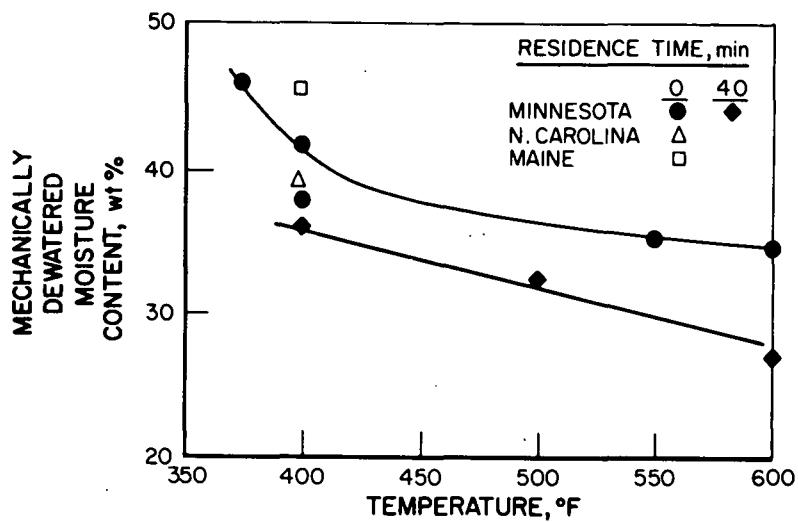
## **BACKGROUND**

Peat has an excellent potential to become a viable fuel source because of its low sulfur content and high reactivity. However, when harvested from the bog it can have moisture content as high as 98%. The dewatering method used after harvesting determines to a large extent the cost of peat, and whether or not peat will become an economically viable chemical feedstock or fuel.

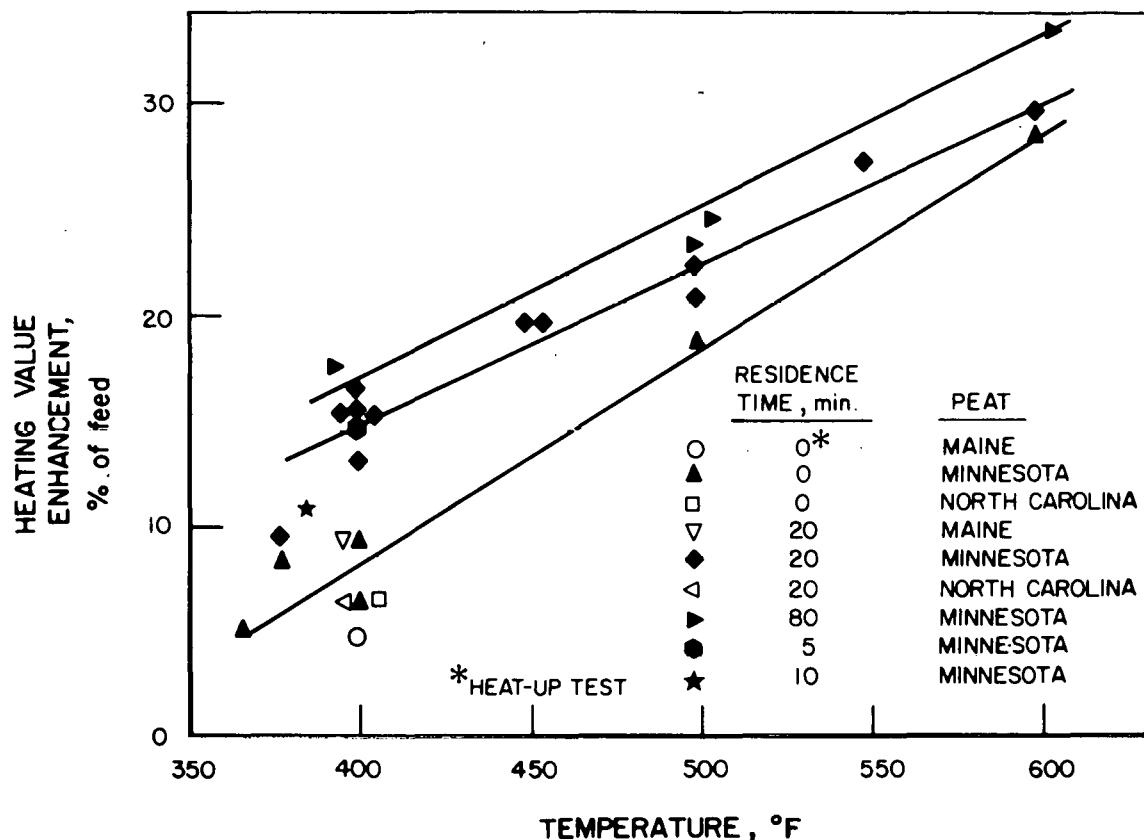
Wet carbonization is a thermochemical beneficiation process wherein the physical and chemical nature of a carbonaceous material is altered. This process can improve the mechanical dewaterability, increase the heating value, and produce a usable chemical feedstock from the wet peat. The process of wet carbonization consists of heating peat-water slurry at elevated pressures to disrupt the colloidal nature of the feed material by breaking carboxyl and hydroxyl groups; this results in removal of oxygen from the carbonaceous material as carbon oxides and water, and also increases the heating value of the final product.

As a feedstock for a gasification plant, wet carbonized peat requires less oxygen for gasification, and also produces less carbon dioxide that must be removed downstream in the acid-gas removal system than raw peat.

Under the sponsorship of the Department of Energy, (DOE), Gas Research Institute (GRI), Minnesota Gas Co., Minnegasco and Northern Natural Gas Co. (NNGC) (now Internorth), the laboratory-scale wet carbonization tests have been conducted with Minnesota, North Carolina, and Maine peats in a batch autoclave. The results of these tests were very encouraging. The data showed that wet-carbonized peat can be mechanically dewatered (in a laboratory press) to moisture contents as low as 27% (Figure 1), and that the heating value can be increased as much as 33% over that of raw peat (Figure 2). Associated with wet carbonization is the loss of oxygen and carbon in peat. Figure 3 shows the percent loss of oxygen and carbon as a function of temperature. Depending on the end use desired, reactor conditions can be controlled to optimize the product yield and characteristics.



**Figure 1**  
**The Effect of Wet-Carbonization Temperature on the Final Moisture Content of Dewatered Peats from Minnesota, North Carolina, and Maine.**



**Figure 2**  
**The Effect of Temperature and Residence Time on the Heating Value Enhancement of Wet-Carbonized Minnesota, Maine, and North Carolina Peats.**

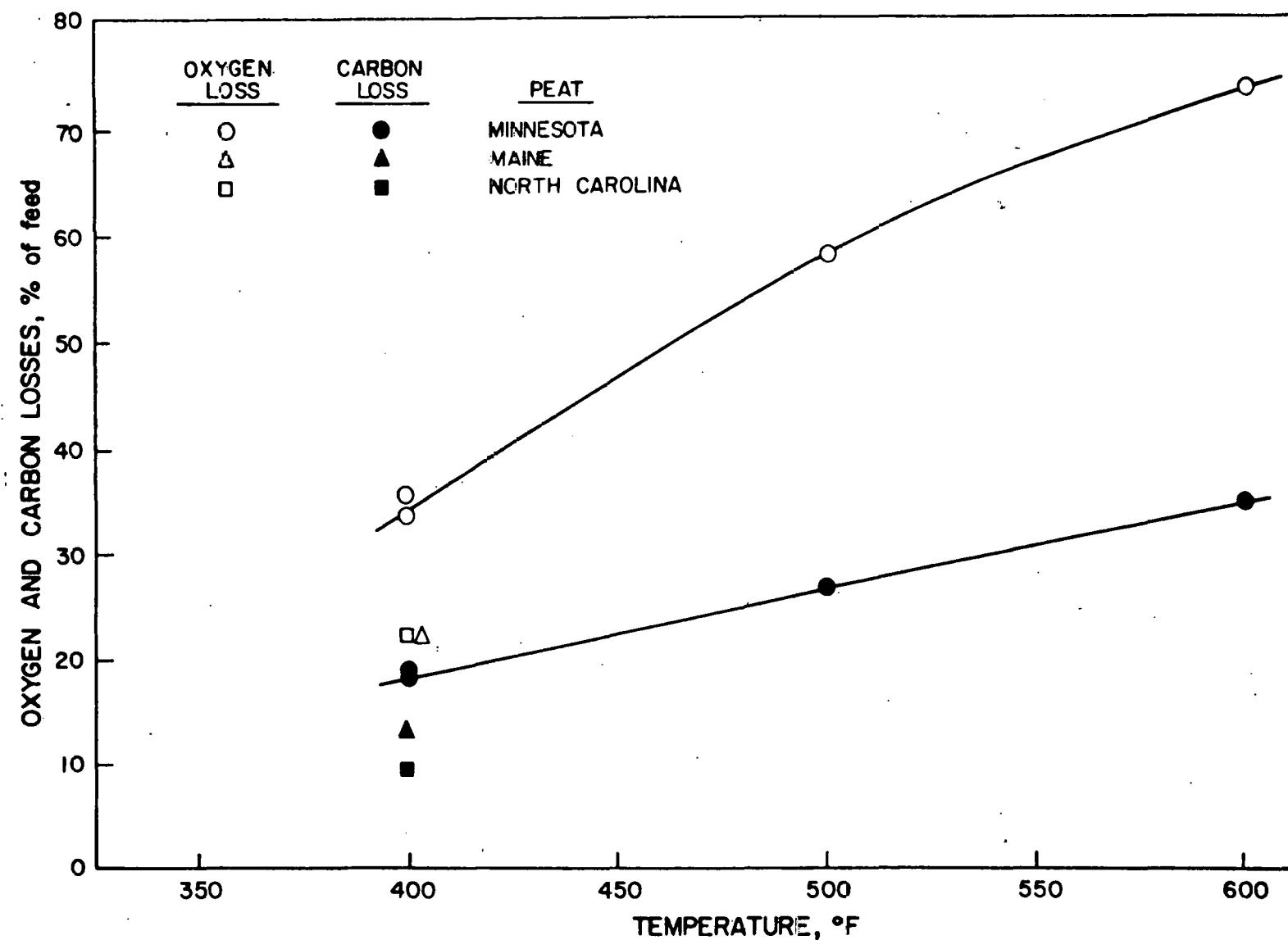


Figure 3  
The Effect of Temperature on Carbon and Oxygen Conversion During Wet-Carbonization Heat-Up  
(Residence Time of 0 Minutes) at Constant Pressure.

## OBJECTIVES

The objectives of this program are to design and construct a continuous wet carbonization process development unit (PDU), and to operate the PDU to determine the effects of temperature and residence time on the dewaterability and heating value of Minnesota, North Carolina, and Maine peats. Additional information will be generated on the effect that the wet carbonization process has on the hydrogasification characteristics of these peats. Further information on the heat transfer and slurry transport characteristics will also be obtained.

## TECHNICAL PROGRESS

The effects of temperature, pressure, and residence time on the dewaterability and wet carbonization characteristics of peat will be studied in this program. The range of proposed operation conditions is presented in Table 1. A peat-water slurry of approximately 5% dry solids by weight will be fed to the system at a rate of 800 lb/hr. A schematic flow diagram of the wet carbonization PDU is presented in Figure 4.

**TABLE 1**  
**RANGE OF PROPOSED OPERATING CONDITIONS FOR PEAT**  
**WET CARBONIZATION PDU.**

<u>Type of Peat</u>	<u>Temperature, °F</u>	<u>Operating Pressure, psia</u>	<u>Mean Residence Time, min</u>
Minnesota			
North Carolina	350 - 550	190 - 1100	10 - 40
Maine			

Design Rate of Peat-Water Slurry @ 5% (wt) Dry Peat to First CSTR at 820 lb/hr.

Feed peat (sized less than 500 microns) will be prepared for the PDU tests and will be placed in one of two 340-gallon slurry preparation tanks. Water will be added to these tanks to adjust the solids concentration to the desired level. Each tank is designed to hold enough slurry for approximately 4 hours of PDU operation.

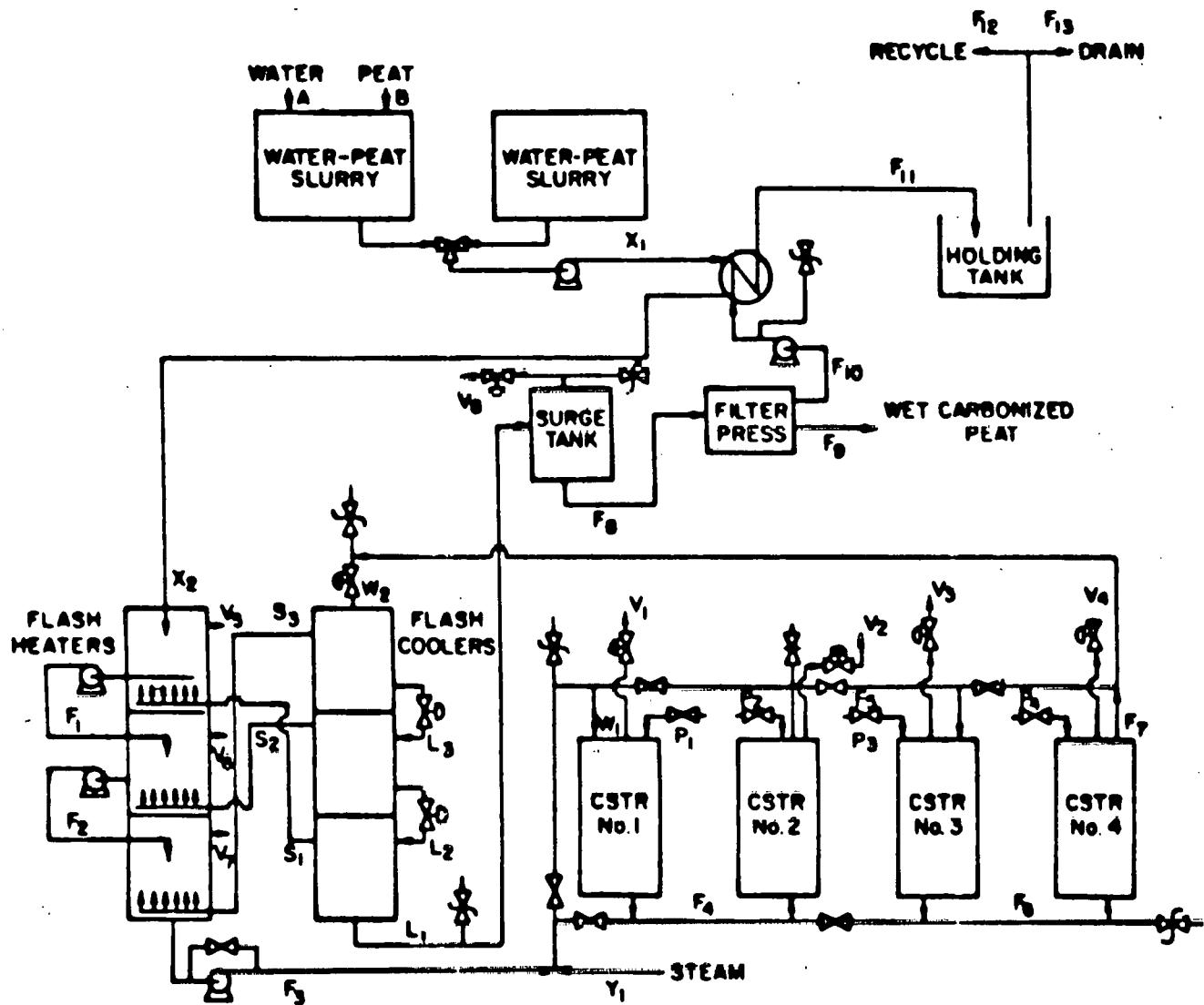


Figure 4  
Wet Carbonization of Peat, Process Development Unit Flow Diagram.

The flash-heat exchange system consists of three stages of flash heating and three stages of flash cooling. In this system, the hot, wet-carbonized peat slurry will be lowered in pressure in three stages, flashing off steam in each stage. The saturated steam will then be condensed in the appropriate stage of the flash heater section, thus heating the feed peat slurry. Each stage of the flash heater is approximately 12 inches in diameter by 3 feet long. A 65 gpm recirculation pump will provide an adequate flow of slurry to generate a curtain of liquid to effect good liquid/steam contact. Each stage of the flash cooler consists of a 6-inch-diameter pipe approximately 3.5 feet long. Figure 5 is a process flow diagram of the flash heat exchange system. From the third stage of the flash heater, the heated peat slurry will be pumped by a reciprocating metering pump to the first continuously-stirred tank reactor (CSTR). Just before the first CSTR, the peat-water slurry will be sparged with super heated steam to raise the slurry temperature to the desired level. The CSTR system (4 CSTRs) can be operated in any combination of series and/or parallel flows. Each CSTR is constructed of 3-1/2 feet of 16-inch, Schedule 100, 316 stainless-steel pipe. The slurry is continuously stirred by an Autoclave Magnedrive II agitator. Three 16-inch-diameter, 8-inch-long heating bands, each having an output of approximately 4000 watts will be used to maintain the desired CSTR temperature. Four inches of fiberguard 1200 insulation will surround the CSTR

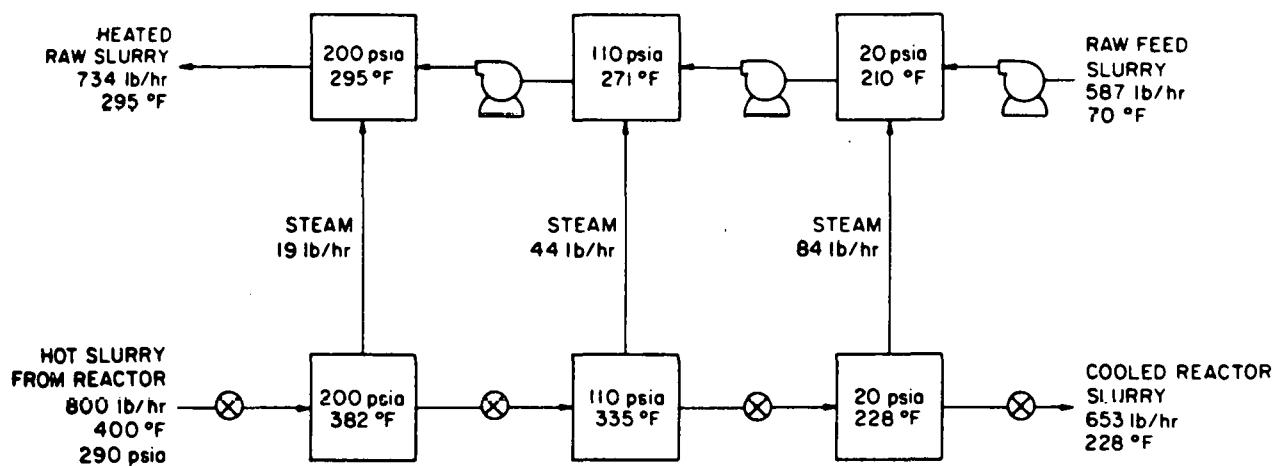


Figure 5  
Process Flow Diagram of the Flash Heater/Cooler System.

to minimize heat loss. A control and instrumentation diagram for the CSTRs is shown in Figure 6. Following the last CSTR, the processed slurry will be transferred to the flash cooler section where it will undergo three pressure letdown stages to atmospheric pressure.

From the last stage of the flash cooler section, the processed slurry will flow into a 340-gallon combination surge and holding tank before being pumped through a filter press. Upon removal of the wet-carbonized solids, the filtrate will then be passed through the shell-and-tube heat exchanger on the shell side. Both the shell side and tube side flows will utilize a 120-gpm recirculation pump to maintain the desired slurry velocity in this heat exchanger. The cooled, spent liquor can either be recycled to a slurry feed tank or directed to liquid storage for eventual disposal.

The design of this continuous wet carbonization PDU was completed and the installation work is essentially complete. All major vessels and pumps are in

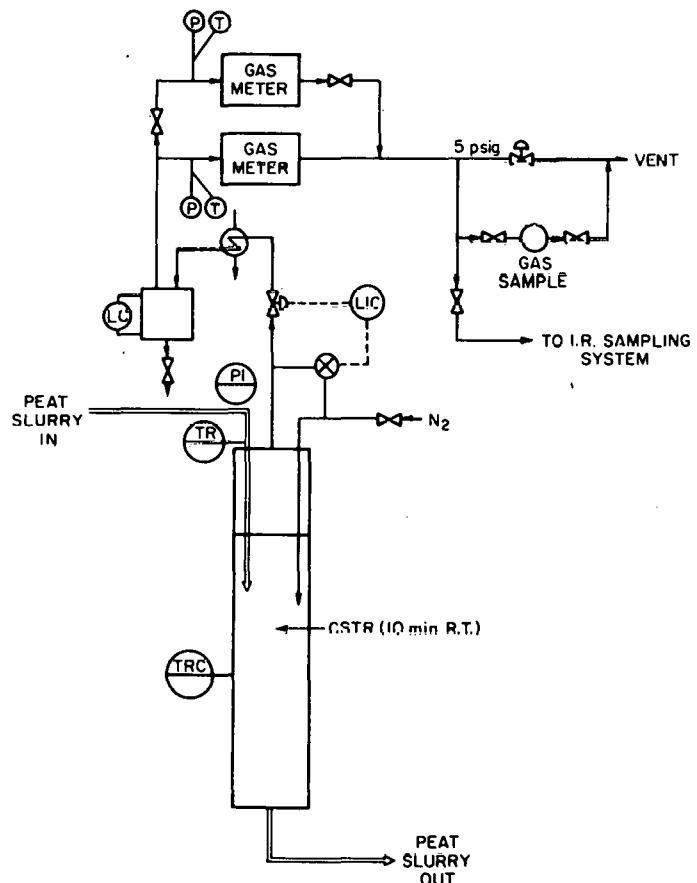


Figure 6  
CSTR Process Control and Instrumentation.

place; final hookup on instrumentation and insulation is underway. Figure 7 shows the general layout of the PDU equipment. Figure 8 is a picture of the top view of the 4 reactors (CSTRs), with the flash heater/cooler system and the shell and tube heat exchanger in the background. Figure 9 shows a sideview of the unit with insulation installed on the reactors. The computer based data acquisition and control systems were received, and work was started to connect the process signals to the computer and application programs are being prepared.

#### FUTURE WORK

Equipment shakedown will begin shortly after the completion of installation. The control system will be tested and continuous wet-carbonization tests will begin. The wet carbonized peat will be mechanically dewatered with pressures on site and hydrogasification characterization of selected wet carbonization peats will be tested.

Finally, a process design and economic study will be conducted using the data obtained from this PDU.

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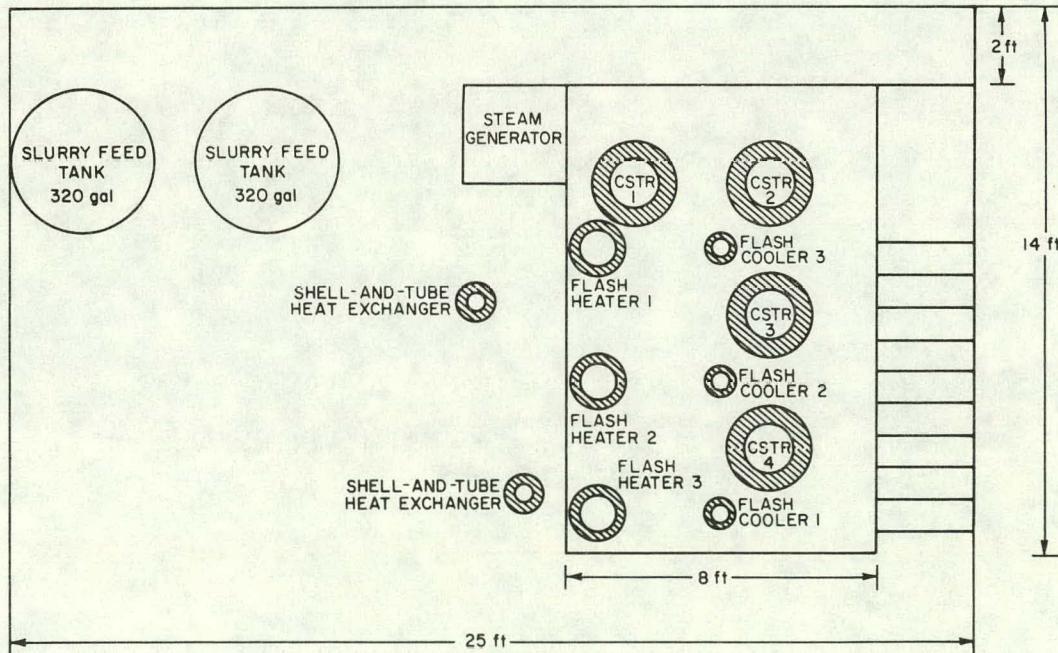
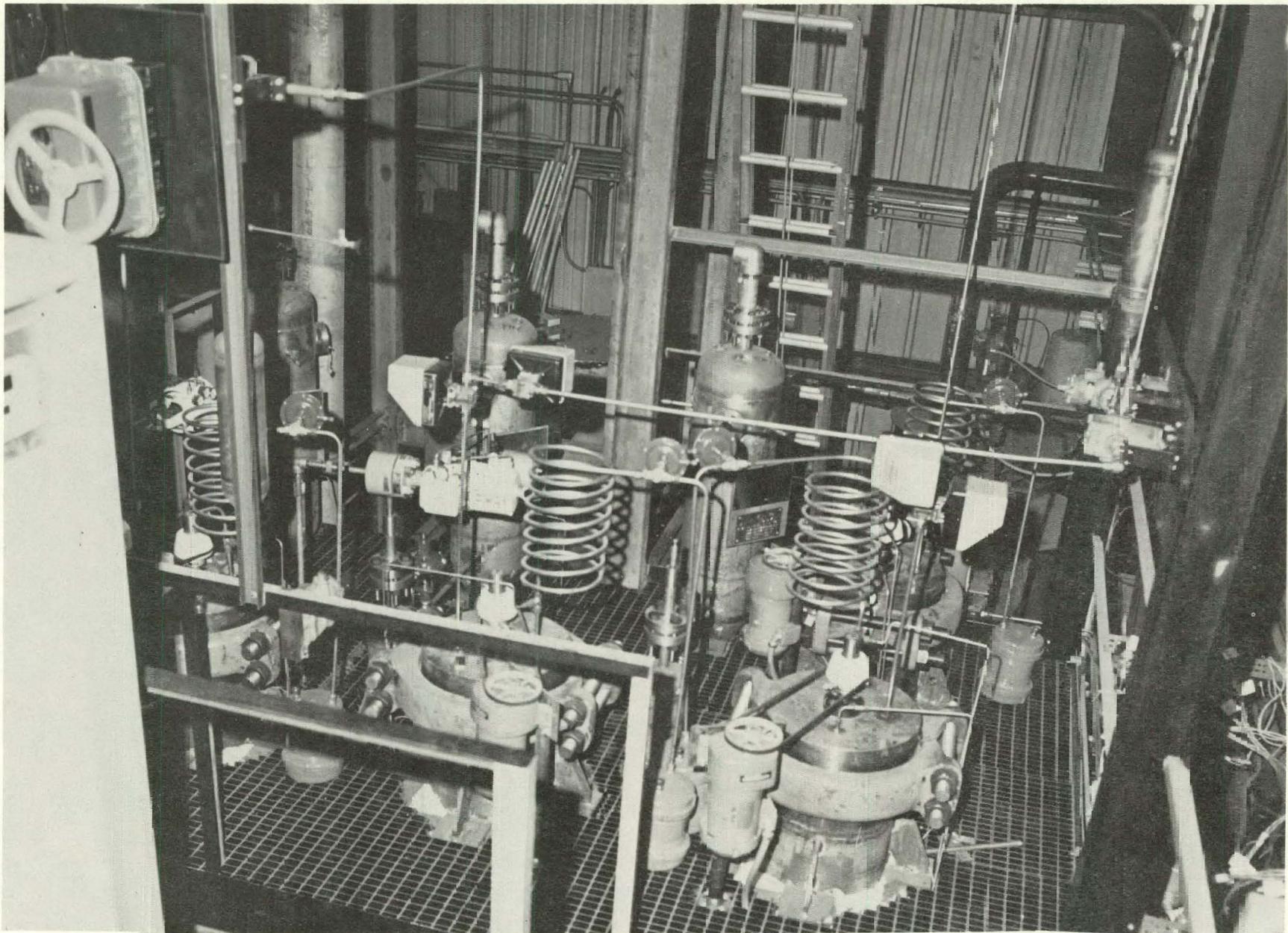


Figure 7  
Peat Wet Carbonization PDU General Floor Layout.



**Figure 8**  
Top View of the Four Reactors (CSTRs) with the Flash  
Heater/Cooler System and the Shell-and-Tube Heat Exchanger in the Background.

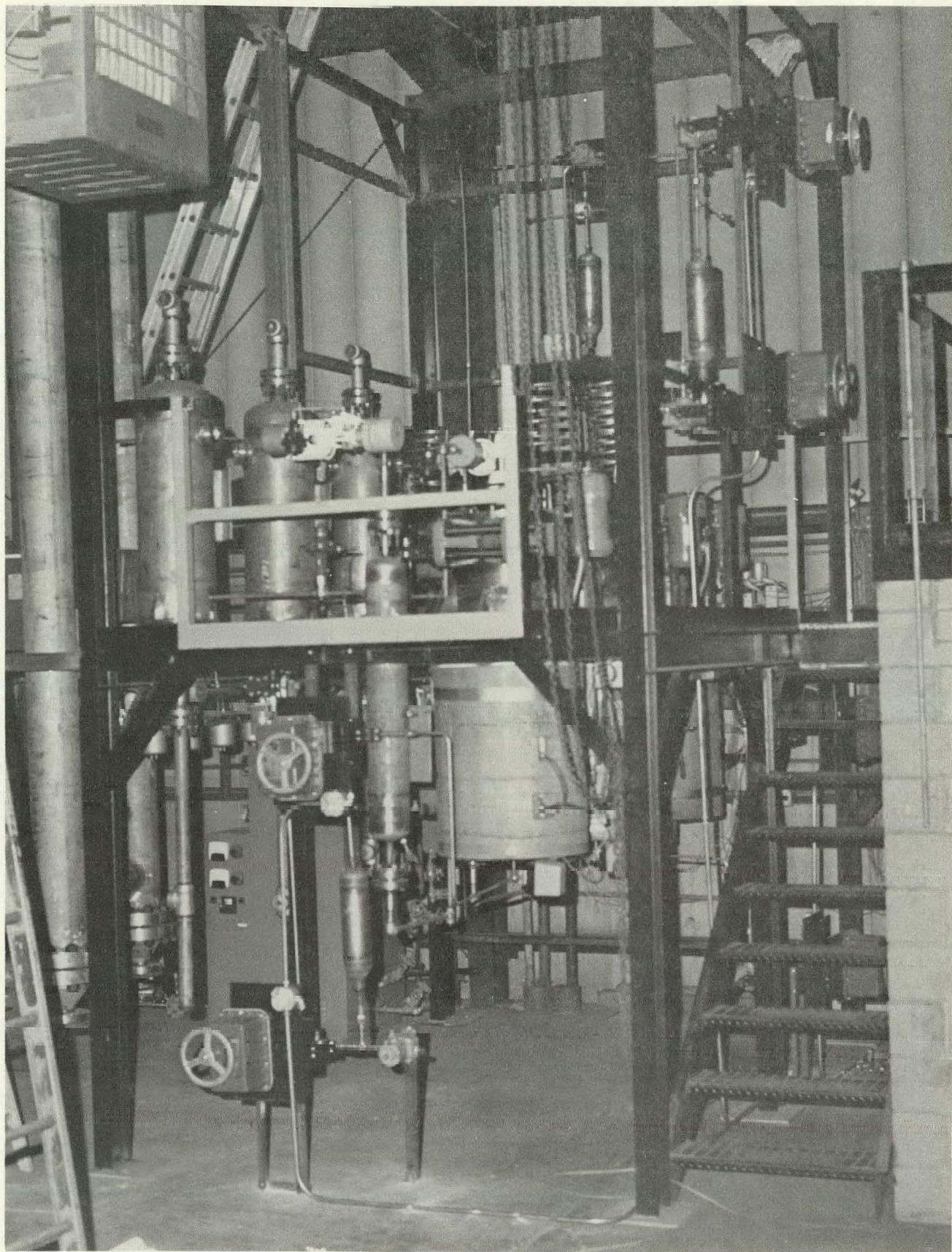


Figure 9  
Side View of the PDU with Insulation Installed on the Reactors.

## QUESTIONS AND ANSWERS

Q: I thought there was some reasonable amount of some useful products like methane and hydrogen and CO in the off-gas as an additional -- in addition to CO<sub>2</sub>. Is that right? Have you measured any compositions of your offgases there?

A: Yes, we have and it's 96% -- more than 90% is CO<sub>2</sub>, very little methane.

Q: Even at the high temperatures?

A: Even at the high temperatures.

Q: On the first slide when you showed several kinds of peat from Minnesota, Maine, and North Carolina, correct me if I am wrong, but do I understand you are going to have only a few data points for North Carolina and Maine but those peats are actually more favorable for the process that you're describing?

A: It depends what you mean by more favorable.

Q: The data points that you have are located more favorably on the graphs that you presented.

A: Okay. The way I looked at them the increase in the heating value of North Carolina peat as a per cent of the original heating value of the raw peat was less than it is for Minnesota peat and the reason for that could be that it is a more decomposed peat than Minnesota peat. So, even though the absolute increase in the heating value might be the same, and I don't remember the numbers, you have a proceedings from the last year's conference and we can calculate numbers from there, the absolute increase in heating

## QUESTIONS AND ANSWERS

value might be the same for the three peats we have tested but when you do it as a per cent of the heating value of the raw peat it is lower for North Carolina than for Minnesota. The improvement in heating value is a lower percentage of the original heating value of raw peat for more decomposed peat.

Probably that is not surprising.

Q: You mentioned that the wet carbonization process would be likely to make noncontiguous deposits commercially exploitable. At what minimum size would you say that this process might be economically feasible in terms of exploitation?

A: It's a very good question but I don't think any work has been done in that area. Maybe John Rohrer in his presentation might be in a better position to answer that question.

Q: Dharam, you showed those four continuous stir tanks and you said they were in series. Is that right?

A: Yes, that is correct.

Q: Do you have any data on the mechanical dewatering, what value comes from wet carbonization?

A: Data for mechanical dewatering?

## QUESTIONS AND ANSWERS

Q: Yes. Do you have any data for this? After wet carbonization you have to do something to the compression and wet carbonization becomes sort of a pre-treatment.

A: Yes.

Q: Can you show me the data from the mechanical dewatering and what role the wet carbonization would play in that change?

A: I had a slide that showed the effect of temperature and residence time in the wet carbonization reactor on the mechanical dewatering characteristics. It showed that wet carbonized peat can be mechanically dewatered to moisture contents as low as 30%.

Q: With the wet carbonization step you have said that it would be more economical or you would be able to economically transport peat that has an increased heating value. What are you trading off that against, the cost of transportation or --

A: The cost of wet carbonization step itself. Yes, it will have less cost for transportation in terms of dollars per million Btu for the transportation segment compared to the raw peat but you have to see whether the wet carbonization -- the capital required in the wet carbonization process, the operating costs of the wet carbonization process -- are going to justify the decrease in the transportation costs that you are accomplishing. It should be less than --

## QUESTIONS AND ANSWERS

Q: Have you done the economics on that or is this just a theory?

A: We have not done the economics of it. As I said to Joel, at the end of the Btu program when we will have the data from the continuous unit we will be doing the process design and the economics but John Rohrer in his presentation might have some economic numbers -- have numbers on economics on the wet carbonization process because they have been looking into commercialization of this technology, not necessarily the one at IGT but the same generic process.

Q: Do you envision, without looking at specific sizes, this type of a technique being put in the bog and then having the ability of transporting the peat out of small areas of the bog into a central locating station or whatever?

A: Yes, that is one potential of it, because some of the harvesting studies that have been done indicate that for a large size synthetic fuels plant, where you need large quantities of peat, it's difficult to find contiguous bogs large enough to support one plant. The cost of transporting peat to the processing plant is a significant portion of the harvesting cost, and if the wet carbonization process is proven economical, it will eventually cost us less to transport that peat to the central processing facility on an overall basis even after accounting for the capital and the operating costs for the wet carbonization plant itself. That is the hope.

Q: You said the pressate water contains about 10% organics, which are subject to biological treatment. Have you done any biological studies?

A: It is not included in the present program but I hope one of these days DOE will fund work somewhere to look into that aspect of it.

Q: So that has not been explored?

A: Not at this time.

**COMMENT:** Mr. Rohrer: That has been explored elsewhere.

**COMMENT:** Dr. Punwani: And it is not really 10% organic. This is 10% of the feed carbon as dissolved organics.

**PEAT WET CARBONIZATION  
COMMERCIALIZATION PROSPECTS**

JOHN ROHRER

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Our company became interested in peat several years ago after doing a rather extensive evaluation of a number of different conventional harvesting and alternative harvesting and dewatering approaches. We would like to pursue a tack whereby we would look to synthetic dewatering of peat. Our investigations indicated to us, and we do have a division that manufactures filtration equipment, presses, and what-have-you, that we could not get to the type of economics that we wanted without going to some sort of pretreatment of that peat. In looking at pretreatment, we came to the conclusion that thermal pretreatment seemed to be the most viable alternative at this particular point in time, although work is being done in solvent extraction and a number of other different areas.

We surveyed what had done in thermal pretreatment, of wet carbonization, partial wet carbonization, to the extent that there was data available in high pressure, high temperature carbonization, and there was not very much, and we looked at the past work that had been done and decided to join forces with J.P. Energy O.I. in Helsinki, Finland, who had done work in wet carbonization dating back to about '74, which picked up on the earlier work that had been done in Sweden in the '50s.

So our firm has been for the last two years working in cooperation with J.P. Energy, Oy towards a commercial project or commercial projects utilizing wet carbonization technology. I might mention that the work in this area has involved several Wheelabrator Divisions, including our M.W. Kellogg Division, more recently our Rust Engineering Division and our Swanson Division, which manufactures heat exchange and flash heaters, flash coolers, crystallizers, evaporators and that sort of equipment, as well as the Energy Division, which has directed the work.

So what I have tried to do is update up on what I think are the commercial prospects and the commercial timing, a commercial status report, if you will, for wet carbonization. One thing I want to point out initially is that, while we feel that wet carbonization is ready for commercialization, we do not feel it has been fully developed. We feel that there are many areas of improvement yet to come.

By way of simplistic example, mechanical dewatering of peat that is wet excavated might be able to commercially achieve perhaps 3 pounds of water remaining per pound dry solids. With wet carbonization we can get down to below one pound of water per pound of dry solids, as Dr. Punwani indicated.

That's very significant because, even on a wet carbonization plant, the cost of the filtration and thermal drying equipment is more than half of the capital cost of the plant, so you can appreciate what the economics of a plant that did not require, did not utilize any thermal pretreatment would be. It just is simply not feasible.

By the same token, however, if we can put twice as much throughput through the thermal pretreatment section of the plant and/or if we can increase the dry solids content going into the filtration and drying part of the plant, perhaps to a half a pound of water per pound of dry solids, if either or both of those could be achieved, we could further improve the economics of the process by as much as another factor of two. So we don't think that work should be stopped here. We think that we're at a point now in the development of wet carbonization where it is commercially very interesting and in some applications economically viable, but we think that there's an awful lot more technical promise down the road, which we hope we, the Department of Energy, Minnegasco, and IGT and others are able to reap.

What is necessary for commercialization of wet carbonization? Obviously, we need a developed technology. It may not be optimized but it must at least be adequately developed. I'm going to address that. We obviously need market commitments. We have to have customers who are ready and willing to buy the output of a carbonization plant. We need acceptable economics for that particular market and we need somebody who is willing to put up the equity and debt capital.

I think we are at the point where we have achieved those four objectives or are rapidly approaching that point and that is the outline of what I will talk about.

I am just going to quickly review our perspective of field dried peat. The deposits were remote. They generally produced low bulk density material, either mill peat or sod. They require expensive specialized combustion equipment, which most people whom we talked to were not willing to invest in.

The moisture content of field dried peat is quite variable. Many of the U.S. peat deposits are in northern climates. Field dried peat might be more applicable to the southern climates like North Carolina and Florida, but in places like Minnesota, Wisconsin, Maine, Alaska, it didn't offer much promise, as is evidenced by the production shortfall in Finland this year where they had only about 40% of the harvest that they had last year because of climatic conditions during the summer.

Seasonal labor force was a problem, more and more of a problem in the U.S., and we saw a number of environmental problems that we felt might not be as easily overcome in the U.S. as they have been in the Soviet Union and Finland, which included dust explosions and bog fires. Many of you, of course, are aware of the bog fires in the Soviet Union this summer, which were a real problem.

The alternative approach is wet carbonization, which allows year-round wet excavation of the peat combined with synthetic dewatering in a process plant, followed by densification where necessary. Obviously, if the process plant is also going to be a gasification or liquefaction plant, the densification step would not be necessary.

One thing that I should mention is that when you do densify wet carbonized peat that has not been fully devolatilized or highly devolatilized, the lignins and tars and waxes in the peat tend to make it very water-resistant and even water-repellent so that you can actually store these pellets or briquettes or what-have-you under water for substantial periods of time without a lot of significant water regain. i.e., we have been able to make materials that might have a regain of from 7 to 12% submerged for about 30 days. It depends upon the density of the briquette that you're making and the carbonization conditions.

We also could reclaim the bogs in a very timely manner. With wet excavation we can go in and remove peat from 100 to 200 acres in this year and reclaim that 200 acres next year, rather than taking, say, 4,000 acres under simultaneous activity and have to wait 20 years before that 4,000 acres can be reclaimed. In fact, 20 years later those first 200 acres probably will have a 20-year stand of trees, mature trees growing on them or some other -- put to some other use, agricultural use or returned to a wilderness condition.

Of course, we have a better handle on air and water pollution control with this process.

Figure 1 is an example of a densified carbonized peat. This particular one was pelletized but briquetting is also suitable.

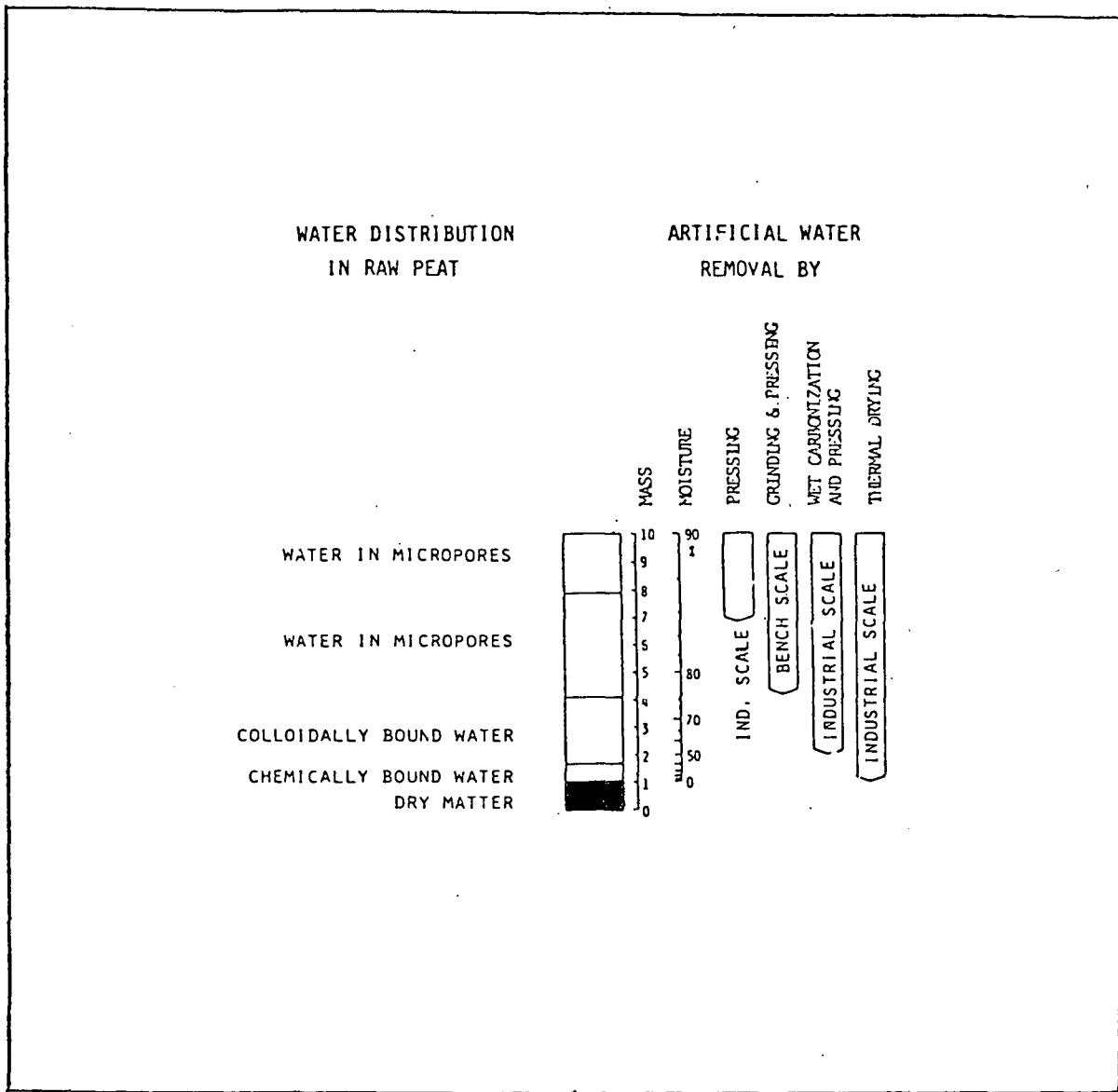
The basic problem is that peat in the bog is 10 parts of water for one part of dry solids. Pressing alone can remove only a small portion of that. You can go to a grinding condition to try to break up some of the peat cellular, fibrous material and do a little better on pressing in terms of ultimate moisture but, of course, you do require more presses because the material is more fine at this point. You still don't get to the condition where thermal drying becomes cost effective.

Then, if you go into thermal pretreatment, you can get down to about one part of water per part of dry solids, at which point thermal drying and filtration become cost effective. The final pound of water, of course, is removed by thermal drying.

Peat dewatering problems are summarized in Figure 2. Just a quick thumbnail of prior work in wet carbonization. There were two commercial plants operating utilizing wet carbonization. Both of them utilized an essentially batch type of process. Both were significant in scale in terms of being over 50,000 dry tons per year of annual production.



**Figure 1**  
**Wet Carbonized Peat Pellets Produced via J. P. Energy Process.**



**Figure 2**  
**The Peat Dewatering Problem:**

- A. Raw Peat after pressing still contains three or more parts of water per part dry solids -- too much for direct use or subsequent thermal drying.
- B. Wet carbonized peat after pressing has less than one part water per part dry solids -- suitable for direct use or efficient final drying. The processed peat also has higher Btu content and high moisture resistance (especially when briquetted or pelletized).

One of those was in Dumfries Scotland. The second plant was in the Soviet Union and, incidentally, the Soviet Union's plant was built for the combined purpose of producing fuel and producing byproducts, both gaseous byproducts and water solubilized byproducts.

The Swedish Peat Company developed a low severity process development unit in the '50s and continued development work and engineering work until the mid-'60s, at which time the continuous declining price of oil discouraged its efforts.

The energy situation in Finland right around the time of our oil embargo in '73-'74 prompted J.P. Energy to initiate efforts over there. They built a new process development unit and, really, I think the focus and thrust of J.P. Energy's efforts have been not so much with process modification but with really applying modern equipment to the generic wet carbonization process, basically looking at each unit operation, whether it be heat exchange or reactor or the filters or the thermal dryers or the densification equipment, looking at each stage and determining what is the best available equipment at this point in time for that particular unit operation.

So it's really been more of an equipment trial, equipment demonstration, equipment development effort than it has been a process development effort.

Of course, Dharam described the work that has been initiated by DOE/IGT under InterNorth and Minnegasco sponsorship and DOE sponsorship. Ontario Research has done some work in the wet carbonization area and I should also mention that partial wet air oxidation and wet carbonization are intrinsically very similar. What you essentially are doing is using either as a way of heating a peat slurry and you'll heat them perhaps to the same relative conditions.

Both plants would need heat exchangers before the cooking vessel. Both plants, of course, would need filtration, thermal drying, densification. The only difference is that in a wet carbonization plant you supply the heat via steam through an indirect heated steam boiler. In a partial oxidation, rather than using the steam boiler to generate the heat for the cooking vessel, you do it

by injecting air or, most probably, oxygen into the cooking vessel and get some of the feed peat to oxidize, generating its own heat. So that's really the only difference.

There are some differences in terms of the solubilized materials. The work that J.P. Energy did in partial wet air oxidation indicated that there were significantly more solubilized materials under the same processing conditions with wet air oxidation than there were under indirect steam heating. So the oxygenating atmosphere did create more solubilized material, a lower carbonized yield.

The J.P. Energy process is basically outlined on the flow diagram shown in Figure 3. At the far left, we see a pulper; both drum types and powered blade types of pulpers have been tested and utilized. This equipment, incidentally, was demonstrated at a process development or demonstration unit that was at the 25,000-ton-per-year scale level, and that unit was operated for two years, just completing its operations last year.

The next two vessels that you see here are heat exchangers. Several different types of exchangers were tested. The particular exchangers that were finally utilized were an exchanger that is similar to a shell and tube exchanger, except that the tube bundle was rotated inside of the shell. It was found that they could agitate the slurry that way, keep it in suspension, utilize a thicker slurry--a higher solids concentration slurry--and enhance the heat transfer coefficients by doing this. That is one particular piece of equipment that they did do some development work on.

The first vertical vessel is the flash heater/cooling. What they did is integrate into one or two pressure vessels 10 stages of flash heating and flash cooling, which was a packaging area, and did some work on the geometry of those particular vessels.

The next vessel is a plug flow reactor. Most of the work here was looking at various types of reactor designs and methods of removing off-gases--vent-gases--during the course of the plug flow reactor.

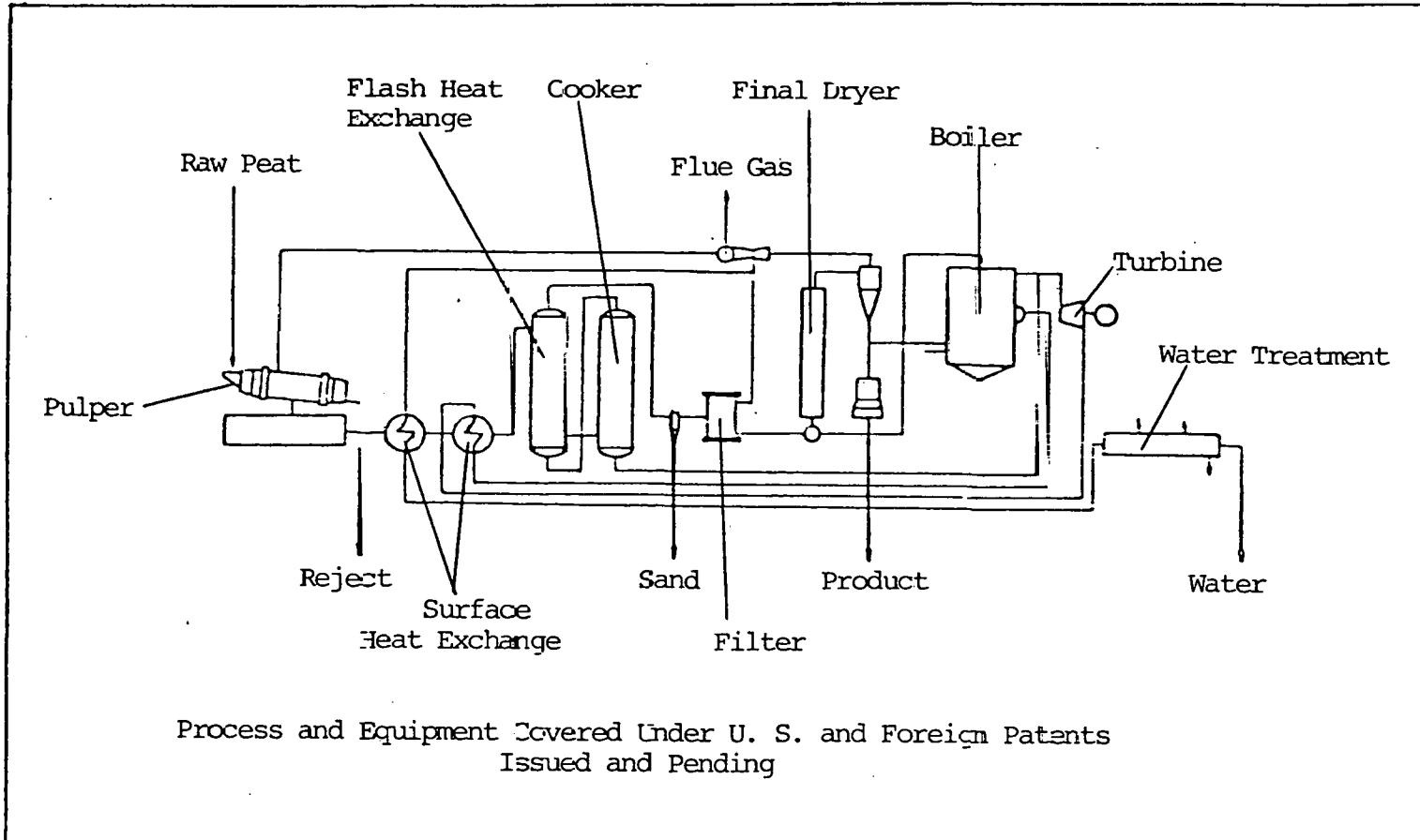


Figure 3  
The J.P. Energy Wet Carbonization Process Builds Upon Earlier Work in Scotland,  
Russia, and Sweden. PDU and Pilot Scale Testing has Been Completed.

After that, the material is subjected to some sort of hydroclone or other device that can remove suspended solid materials of higher density than the organic peat material, i.e., sand or nonorganic ash. A major portion of it can be removed in this fashion, so some peats that might be rather high in ash content, say 20 to 30%, a significant portion, often more than half, of the ash can be removed after carbonization because the slurry no longer has its colloidal nature, and you can drop the ash out.

I might also mention that some ashes are partially solubilized. It depends on the nature of the ash, but some ashes in the cooking process are partially solubilized so some ash reduction results.

After that, the slurry goes into filtration. The filtration can be either of a plate type or a belt type; both types have been used, and there are ongoing efforts utilizing both types to try to optimize them.

Following that, the filter cake goes into thermal drying. In this case, we're showing the flash dryer. Both flash dryers and bed types of dryers have been utilized.

Following that, we go into densification and, again, we have done trials on both pelletization and briquetting. The dryer gases are scrubbed with filtrate from the filter press in a wet scrubber just to be sure that no fines escape and the exhaust gases from the power boiler, which generate the steam and some electricity for the plant, those off-gases are used as your drying medium.

I want to also mention that oversize material from the pulper, which we refer to as pulper reject, goes into the power boiler as a supplemental fuel. Also going into the power boiler is primary and secondary treatment sludges from the wastewater treatment plant, which also go into the power boiler where anaerobic digestion is used. We have done work utilizing a combination anaerobic/aerobic treatment process, and that process is also used in a number of sugar refineries--it's a commercial process--and these filtrates do respond very well to it. The sludges from that process go into the boiler.

The vent gases from the reactor vessel also go into the boiler. The methane from the anaerobic treatment can account to as much as 6% of the plant energy balance, so it's a very significant component, as far as fuel for the power boiler, where it's utilized.

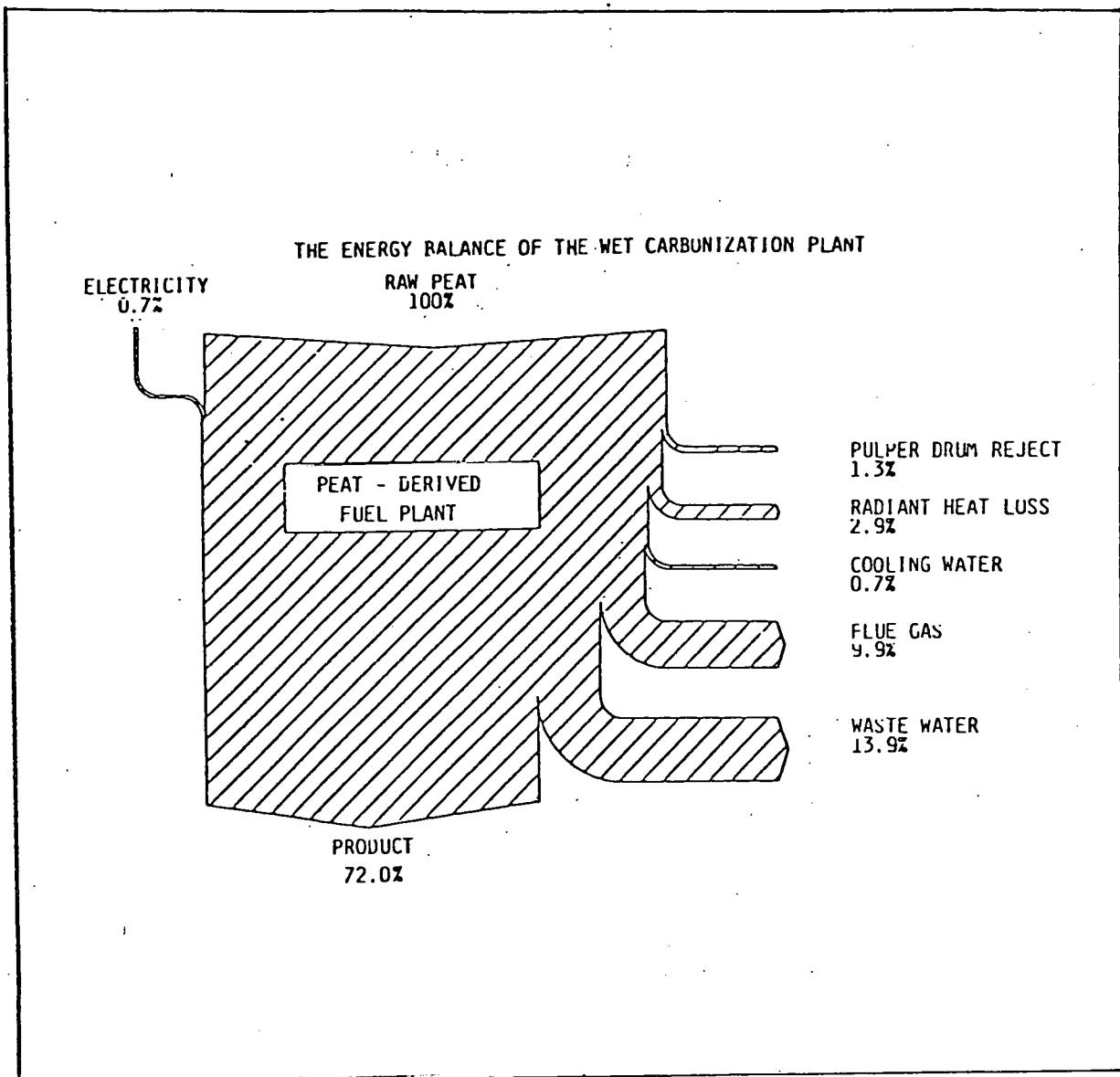
That essentially is the process.

Just to look quickly at where the whole process starts, that's on the bog in the harvesting operation. Significant thought and work has been done on how do we excavate peat in its wet state. No one is doing this on a commercial basis because nobody has a need for underwater peat on a commercial basis. Fortunately, however, several equipment suppliers are equally convinced that wet excavation of peat is on the near-term horizon. This particular machine was developed this last year by a Finnish supplier, and it is quite similar to the bog preparation equipment that Andy Allen showed you, the deep miller that they use for initial bog prep and also for grinding up their wood each year, except that what we have done here is the cutting drum has been put on a 30° angle, which allows you to get a rather deep cut. Material is removed to a depth of about 6 feet or 7 feet. If it's a 12-foot deep bog, for example, our second pass would then come back either that year or a subsequent year and remove the remaining material.

The material is transferred to a long-line conveyer or to narrow gage rail or to surface-supported carts and then taken to the dewatering plant.

The energy balance of the PDF process (see Figure 4), excluding methane recovery from water treatment, is 72%. With methane recovery from water treatment, it is projected to be 78%. That does not include harvesting energy, which is not a significant factor.

The status of the equipment for various unit operations is summarized in Figure 5. In wet harvesting equipment, there are, of course, conventional pieces of equipment available--dragline, excavators, floating barges that can be used for wet harvesting--and, of course, there also is new equipment such as the machine I showed you, which is currently under trials in Finland.



**Figure 4**  
**The Process Efficiently Utilizes Peat Feedstock with a 78% Overall Efficiency When Water Treatment Plant Energy Recovery is Included.**

## J. P. ENERGY PROCESS - EQUIPMENT STATUS

ITEM	COMMERCIALLY AVAILABLE AND DEMONSTRATED W PDF	IMPROVED EQUIPMENT DEVELOPED AND DEMONSTRATED
WET HARVESTING MACHINERY	X	X
PULPER	X	
SURFACE HEAT EXCHANGERS	X	X
FLASH (MULTI-STAGE) EXCHANGERS	X	X
REACTOR	X	X
FILTERS	X	
DRYERS	X	
BRIQUETTER/PELLETIZER	X	

**Figure 5**

**Commercially Available Equipment can be Used in the PDF Process for all Unit Operations.  
Some Improved Equipment Designs Have Also Been Successfully Demonstrated.**

Pulpers - We have used commercially available equipment. We have not attempted any development of new pulpers.

The surface heat exchangers - The rotating tube bundler heat exchanger that I showed you is a development that has been completed.

There has been some improvement in multistage flash coolers and flash heaters.

The reactor - Even though commercial cooking vessels like those used in pulp mills have been used for wet carbonization, there are some improvements that have been made there. For filters, dryers, and briquetters, conventional, off-the-shelf equipment has been utilized.

In terms of where is carbonized peat utilized, I think that coal boilers for initial projects are a very obvious application and, of course, what this says is that one must seek to find areas where coal and carbonized peat or peat-derived fuel are competitive. So it behooves one to look in places where delivered prices of coal are quite high--places like Sweden, Maine, and several other parts of the U.S. where the delivered prices of coal exceed \$60 a ton.

The advantages, of course, of peat-derived fuel over coal are lower sulfur and ash content. It is compatible with both stokers and pulverization equipment, though, if you're not going to high severity carbonization, your Btu content might be lower than, say, bituminous coals, though it would be higher than sub-bituminous coals or lignites.

Of course, PDF is less dusty and more homogeneous in its size, so it handles easier than coal.

Another potential application is in coal boilers that otherwise would require some sort of desulfurization. There the cost of a flue gas scrubber would add perhaps a dollar per million Btus and, if you add the PDF processing cost to the alternative cost of flue gas desulfurization, quite often in some of these oil-burning boilers that are converting back to coal, which otherwise

would require a scrubber because of the ambient air standards in that particular section, it becomes economically viable.

Another area that is quite interesting is the use of peat-derived fuel in residual oil boilers. You may know that there's a lot of effort going on right now, both private and federally sponsored work, towards utilizing the huge utility and industrial U.S. boiler stock that has been built for oil and gas, to try to use alternative fuels in it. Most of that work has been directed toward coal. Coal has some very serious problems when you try to burn it in residual oil boilers.

For one thing, it burns only about half as fast as residual oil, so volumetric heat release is very much restricted.

Another problem with coal is it runs 10 to 15% ash and, of course, these boilers were designed with tight furnaces, tight tube spacing, that were not designed to accommodate that kind of ash.

Peat, being much lower in ash, and especially wet process peat where you can further beneficiate down the ash and where you leave the volatiles in--because we want to use those volatiles to maintain a very rapid burn rate--it turns out that pulverized peat, when it's fully dehydrated, and I want to reemphasize when it's fully dehydrated, burns as quickly as or slightly faster than residual oil. So it can be burned in many resid oil units without significant derating.

Ash can be a problem, even though peat has much less ash, and for many peats, like the North Carolina peats and the Maine peats, ash contents are down to less than 5%. Nevertheless, ash has to be reckoned with, and we have just recently initiated a program, a combustion test program with a major boiler supplier to address some the ash problems.

And, of course, it's certainly cheaper to go to a conversion of a residual oil boiler than to replace it. In fact, if you've got a large, total system, the cost of a peat beneficiation plant and the cost of converting the boiler in many cases is about half the capital cost of building a new, scrubber-equipped, coal-fired boiler plant. I'm talking about 50, 100, 150 megawatt types of sizes.

So those give you some idea as to where some of the initial markets for peat-derived fuel, wet carbonized peat, will probably come.

As I mentioned, we initiated or are initiating a multi-client, privately-funded combustion program at a major boiler manufacturer. That program is just being structured right now. If other companies are interested in participating, we would welcome hearing from them. The objective is to suspension-fire peat-derived fuel in oil and coal units at up to a rate of 50,000 pounds an hour of boiler size and in several smaller units as well. The fuel has been prepared this summer for that test and we expect to initiate it before the first of the year.

We also, of course, will be analyzing and evaluating the compatibility of PDF with existing pulverization equipment, as well as new pulverizers, burners, and particularly controls.

Just to add some hard evidence to the prospect of burning dehydrated peat in tight furnacing, there is a recent installation in Sweden that is currently burning pulverized wood waste that has been dehydrated and pulverized peat that has also been dehydrated. This is a photo of the flashdrying dehydration plant that was built. This plant is about 300,000 pounds an hour of steam production to my knowledge, so it's a significant scale plant.

The furnace in this plant is much smaller than a coal size furnace. The volumetric heat release is in the same range as an oil-fired furnace.

Figure 6 shows another plant that was a converted oil plant in Finland that was converted to dehydrated peat, again showing evidence that it can be burned.

# CONVERSION OF OIL FIRED BOILER TO DEHYDRATED PEAT KEMIRA OY VISCOSE MILL, VALKEAKOSKI, FINLAND

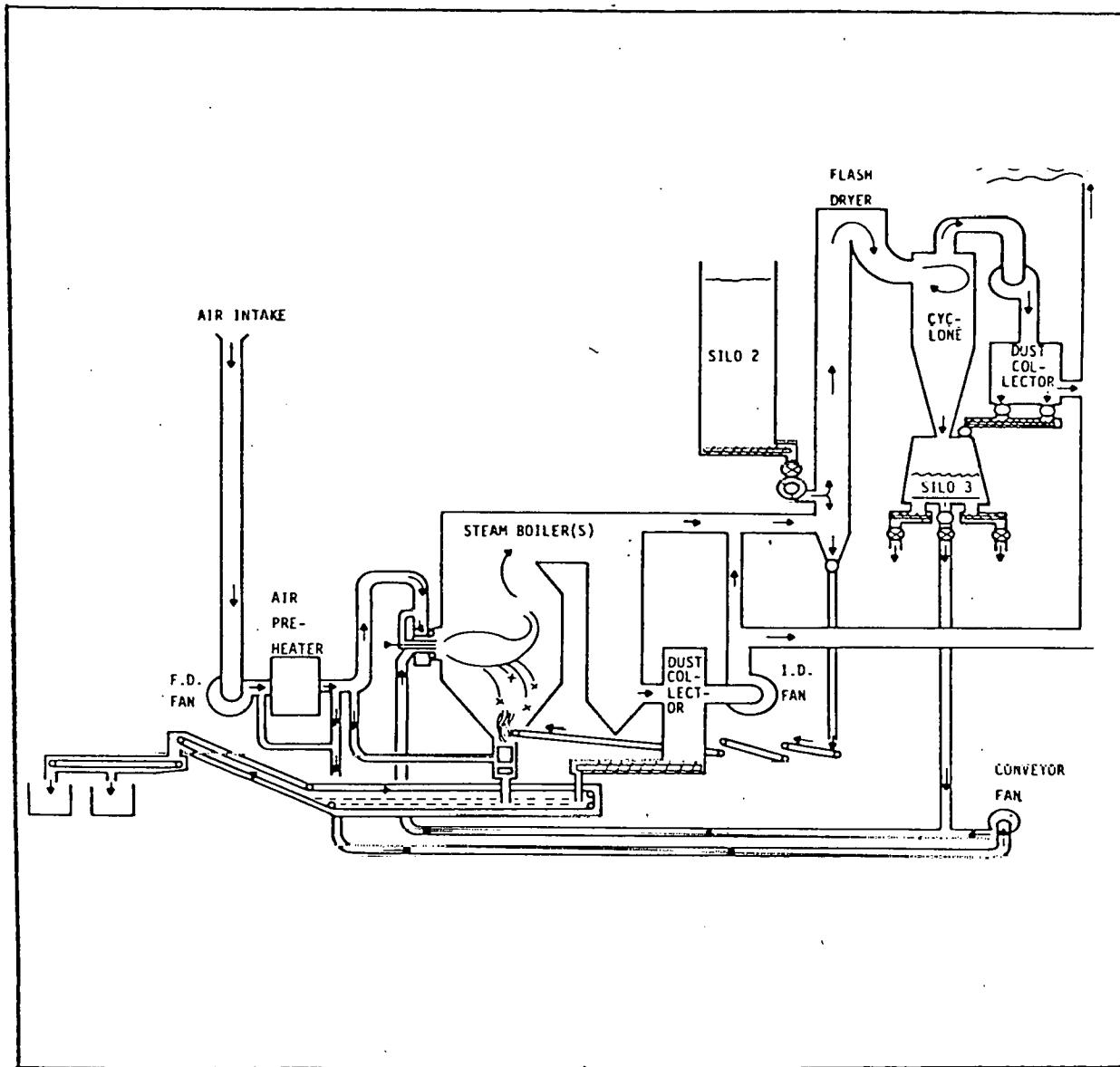


Figure 6

The Ability of Fully Dehydrated Pulverized Peat to Displace Oil Without Degrading has Been Successfully Demonstrated in the Above Conversion, Successfully Operating for Several Years.

Other applications include kiln fuels and furnace fuels, and downstream other applications, of course, include peat stocks for gasification and liquefaction.

A very high grade metallurgical coke has also been produced from PDF. The coking yield is about 50%.

In terms of projects, we are pursuing a project in the State of Maine that we are hopeful of being able to commercialize. Some of the parameters of the project are:

- 330,000 tons/year production
- 150 full time employees
- \$40-60 million capital cost
- Resource 150 to 250 acres/year for 20 years
- 3-4 years for siting, permitting, and construction

The markets are primarily coal boilers and resid oil boilers for that particular project and, of course, the objective is to try to get as much of the fuel as possible into smaller scale use, which does command the higher value but which doesn't have as much established distribution at this point in time.

Alaska is also a very promising area, primarily for export to Pacific rim countries.

We would envision that a project for about a half a million tons a year in Alaska could be competitive on a delivered basis with Alaskan coal. The PDF would have a higher Btu content than Alaskan coal and, of course, it probably could command some increased value because Alaskan coal tends to be high in ash and high in water content, whereas this material could be burned in a lot of existing coal and even some oil-fired boilers in Taiwan, Japan, Korea, that could not burn Alaskan coal.

The following shows the scope of the Alaskan project:

- 1/2 million tons/year production

- \$75 million capital cost
- 250 full time jobs
- 3 years - siting, permitting, and construction
- Resource - 350 to 650 acres/yr. for 20 years
- Siting - Matanuska-Sustina Railbelt, Kenai Peninsula, or Beluga

I think, in summary, PDF initial projects that we'll probably see will include Maine and/or neighboring New Brunswick, and Alaska. A decision is being made in the next couple of months relative to a possible project in Sweden utilizing the J.P. Energy technology, and Onesta, Amatra, and several other Finnish companies are also looking at a possible plant in Finland.

In terms of the economics of wet carbonization, resource procurement is generally a relatively insignificant factor, usually less than 5 cents per million Btus. Wet peat extraction and transport is a highly site specific and highly variable factor, but our cities have indicated that in plant scales in excess of 100,000 tons a year it should generally be delivered to the plant gate for less than \$1 per million Btus.

The process plant capital and operating costs depend on the severity of the condition that you're trying to achieve in on-plant scale, of course, and to a lesser extent on the property of peat itself. They can run from \$1.25 to \$2.25, in current dollars, and densification equipment can run anywhere from zero, if you don't densify, i.e., you feed it directly into a gasifier, up to 35 cents per million Btus, if you go to pellets. Briquettes fall somewhere in between.

## QUESTIONS AND ANSWERS

Q: The last slide shows the cost per million Btu to be anywhere from \$1.55 to 3.60. How does it compare with not just coal but the oil and all the other costs also, per million Btu?

A: Coal, Appalachian coal f.o.b. mine might be \$1.25. So we don't envision sending Florida or Maine PDF down to the Appalachian states as a substitute for coal. I think that when you add the cost of desulfurization to coal burning, which adds at least another dollar per million Btus, that broadens the market for beneficiated peat fuel substantially. When you add the fact that coal requires at least 50% derating when burned in oil-fired equipment or when you add the capital cost of two coal-burning installations versus conversion of existing oil units to a beneficiated peat fuel, then the economic prospects become better yet.

So I think it depends on whether you're competing with oil or whether you're competing with coal and where you're competing with coal.

Q: How does PDF compare with natural gas and the lignite type fuel that is also becoming cost-competitive recently?

A: I think that coal delivered to Florida is about \$1.75 per million Btus to \$2.00 per million Btus, so I think that there a large-scale wet carbonization plant could be probably at an economic parity with coal. If that large-scale coal burning plant required desulfurization equipment, it might be very competitive with coal, but it would have to be large scale and I think you're going to see smaller scale plants before you're going to see plants of that scale.

**COMMENT:** In Florida many of the utilities, particularly the municipalities, the small ones, use natural gas because it is cheaper. And it costs less than a dollar per million Btu.

## **QUESTIONS AND ANSWERS**

**REPLY:** Yes, but that is a very temporary situation. I think that you'll find within the next 12 months, except for old contracts that still have some time to go, you won't see much of that.

**COMMENT:** Again, the incentive for the PDF probably is better with the small units rather than big utility boilers.

**COMMENT:** I don't think they're going to do well competing against dollar natural gas but I don't think you're going to see much of that.

**EXPORT OF BENEFICIATED  
PEAT PELLETS**

DON MARKLE

ALASKA DIVISION OF ENERGY  
AND POWER DEVELOPMENT  
ANCHORAGE, ALASKA

## **EXPORT POTENTIAL OF ALASKAN PEAT**

### **BACKGROUND**

The Legislature of the State of Alaska has appropriated \$500,000 to the Division of Energy and Power Development for an economic feasibility study and preconstruction costs analysis for a plant in southcentral Alaska that uses developed technology to process peat for fuel for export and domestic use.

The State effort is the direct result of the State resource estimation program funded by the Department of Energy. The estimation program has determined there are approximately 107,000,000 acres of highly organic soils or peat in Alaska through investigations that have been conducted for the past two years. Approximately 30,000,000 acres of this total is predicted to be outside environmentally and economically unattractive permafrost lands. Approximately 56,000,000 acres of this 30,000,000 acre total could be expected to be prime physical and economic deposits. The physical characteristics of the prime deposits indicate closely associated groups of bogs with areal extents ranging over 1,000 acres per bog and depths averaging 8-14 feet. The peat itself has high dry weight density and good fixed carbon and volatile quality.

This information and preliminary cost analysis instituted by the Division and private industry indicated good export potential for Alaskan peat.

### **OBJECTIVE**

The objective of the State program is to conduct an economic feasibility study for commercial peat operations in southcentral Alaska for processing of peat for export and domestic use.

### **ECONOMICS**

The Railbelt region of Alaska includes Anchorage, Fairbanks, the Kenai Peninsula, and The Valdez-Glennallen areas, which together account for about two-thirds of

the population of the State. This region is presently served by nine major utility systems. Three are municipally owned and operated, one is a Federal wholesaler, and five are rural electric cooperatives. Another entity, the Alaska Power Authority, is empowered to own and operate power generating facilities and to sell power in the region but does not presently do so.

The State of Alaska, Office of the Governor, has contracted with Battelle-Northwest to perform a Railbelt Electric Power Alternatives Study. The primary objective of this study is to develop and analyze alternative long-range plans for electrical energy development for the Railbelt region. These plans will be used as the basis for recommendations to the Governor and Legislature for Railbelt electric power development, including whether or not the State should concentrate its efforts on development of the hydroelectric potential of the Susitna River or pursue other alternatives.

A major task of the Railbelt Electric Power Alternatives Study is to examine electric energy technologies for their potential viability in the Railbelt region. Technologies found to be technically, economically, and socially viable will be considered in the development of electric energy plans for the Railbelt Region.

The purpose of this report is to provide an overview of a number of candidate electric energy technologies for Railbelt electric power planning. This information will be used to support the selection of "viable" energy technologies for subsequent in-depth consideration in later stages of this study.

- Technical characteristics
- Siting and fuel requirements
- Costs
- Environmental considerations
- Socioeconomic considerations
- Railbelt applications

## **OVERVIEW OF GEOGRAPHIC AND SOCIOECONOMIC CHARACTERISTICS**

Approximately 260,000 people reside in this geographic region, which extends approximately 450 miles from the southern end of the Kenai Peninsula north to Fairbanks.

Geographically, the area is characterized by three major lowland areas separated by three mountain ranges. The lowland areas include the Tanana-Kuskokwim lowland, the Susitna lowland, and the Copper River lowland. The Alaska Range, the Chugach and the Talkeetna Mountains form boundaries to the three major lowland areas. Much of this land area in Alaska has recently been designated national interest land by the Alaska National Interest Lands Conservation Act of 1980.

Major industries in the Railbelt include fisheries, petroleum, timber, agriculture, construction, tourism, and transportation. The Federal government provides employment in both the military and civilian sectors, although these sectors are presently declining. Current and potential economic activity is directly related to development of Alaska's natural resources.

## **ELECTRIC GENERATING CAPACITY**

Eight utilities presently serve the region:

- Chugach Electric Association
- Anchorage Municipal Light and Power
- Homer Electric Association
- Matanuska Electric Association
- Seward Electric System
- Golden Valley Electric Association
- Fairbanks Municipal Utilities System
- Copper Valley Electric Association

The City of Anchorage is served by Chugach Electric Association and Anchorage Municipal Light and Power. Most of the Kenai Peninsula is served by the Homer

Electric Association, while the area in the vicinity of Palmer and Talkeetna is served by Matanuska. Each of the aforementioned systems is interconnected. Seward Electric System serves Seward. Fairbanks is served by Golden Valley and Fairbanks Municipal, which are interconnected. Copper Valley serves Glennallen and Valdez through a transmission line connecting the two towns. Power is also generated by the Alaska Power Administration, military installations, the University of Alaska, and self-supplied industries. The Anchorage-Fairbanks intertie will be built in 1984.

Existing electrical generation capacity by major utility and type is shown in Table 1.2. Non-utility generation capacity is summarized in Table 1.3. In addition to the central generation systems, a number of smaller installations operated by individuals or small communities are found in the Region.

Planned expansions of utility system generating capacity are limited. Anchorage Municipal Light and Power is the only system currently considering expansion, by adding a 74-MW combustion turbine in 1982.

Current estimates indicate that over 20% of the U.S. energy resources are located in Alaska. Coal deposits represent between 39 to 63% of the United States' totals; oil, natural gas, and hydroelectric potentials are greater than in any other single State (Alaska Dept. of Commerce and Economic Development 1978). Proper development of these resources is important to Alaska's future economic condition.

Preliminary results of the Battelle study indicate that Railbelt electrical needs will be met by natural gas, existing coal plants, and existing and proposed hydroelectric activities. The Susitna project, which goes to license in 1982, is a 1600 MW two dam project that will surpass projected demand in the Railbelt well into the next century. Interim energy needs can be met through expansion of existing natural gas and coal developments.

Therefore the market forces behind any peat development will be primarily its export potential.

**TABLE 1.1**  
**Generating Capacity: Railbelt Utilities (1980) (MW)**

	<u>Combined Cycle</u>	<u>Diesel Electric</u>	<u>Hydro Electric</u>	<u>Combustion Turbine (a)</u>	<u>Combustion Turbine (b)</u>	<u>Steam</u>	<u>Total</u>
Alaska Power Administration	0	0	30	0	0	0	30
Anchorage Municipal Light and Power	139	2	0	0	90	0	231
Chugach Electric Association	0	0	17	120	287	19	443
Fairbanks Municipal Utility System	0	8	0	0	28	29	65
Golden Valley Electric Association	0	18	0	0	163	25	206
Homer Electric Association	0	3	0	0	0	0	3
Seward Electric System	0	6	0	0	0	0	6
<b>TOTAL</b>	<b>139</b>	<b>37</b>	<b>47</b>	<b>120</b>	<b>568</b>	<b>73</b>	<b>984</b>

Source: Battelle (1980).

(a) Regenerative Cycle Combustion Turbine

(b) Simple Cycle Combustion Turbine

**TABLE 1.2**  
**Generating Capacity (MW): Non-Utility Railbelt Installations (1980)**

<u>Fort Richardson</u>	<u>Diesel Electric</u>	<u>Steam Electric</u>	<u>Total</u>
Eielson AFB	0	9	9
Elmendorf AFB	2	32	34
Fort Greeley	2	0	2
Fort Richardson	7	18	25
Fort Wainwright	0	5	5
University of Alaska	<u>6</u>	<u>13</u>	<u>19</u>
	17	77	94

Source: Battelle (1980)

Energy resource consumption within the State of Alaska is currently as follows:

<u>Energy Resource</u>	<u>Percent</u>
Petroleum Liquids	69
Natural Gas	23
Coal	6
Hydropower	2

Note that most of the energy consumed in the State of Alaska is petroleum based. Only 2% of the energy currently consumed comes from renewable resources.

## **EXPORT MARKET POTENTIAL**

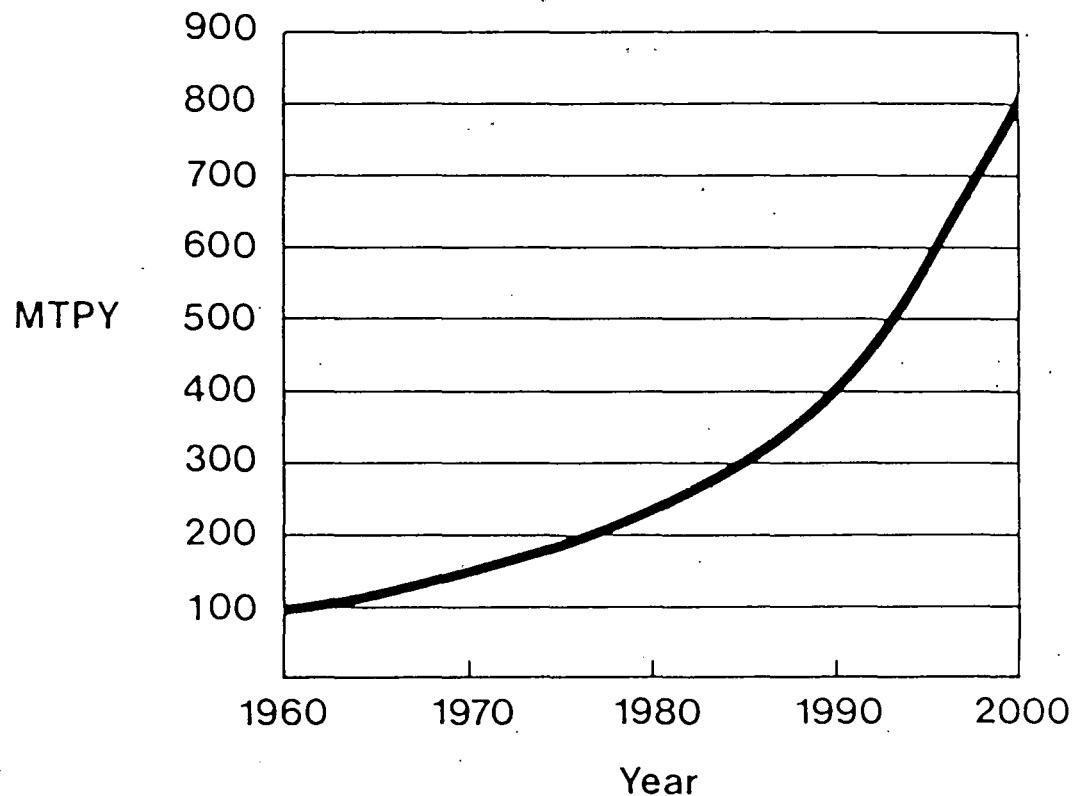
The volume of Alaskan peat is such that large scale export is being considered. The magnitude of development will be of interest on the local, State, National and International levels. No in-depth analysis has been conducted for Alaska's peat export potential. Coal, however, is the subject of considerable analysis and preliminary development at this time. The similar use and economic features of near term development for peat and coal resources in Alaska are such that the positive information derived from coal market analysis can rightfully be used to justify in depth analysis of peat export potential.

Today, oil and gas account for about 60% of the world's primary energy needs, coal about 30%, and the remaining 10% a combination of hydro and nuclear. An interesting and extraordinary fact underlying that division into energy sectors is transportation. Oil and gas have always moved to markets but coal has tended to bring consumption to the locality of its production.

In 1980 some 230 million tons of coal moved by sea, including coking coal, representing about 5% of the total annual world coal production of 2.5 billion tons. However, in that same period the quantity of oil and gas moved by tanker from production areas to countries of utilization was about 60% of total world production of oil and gas.

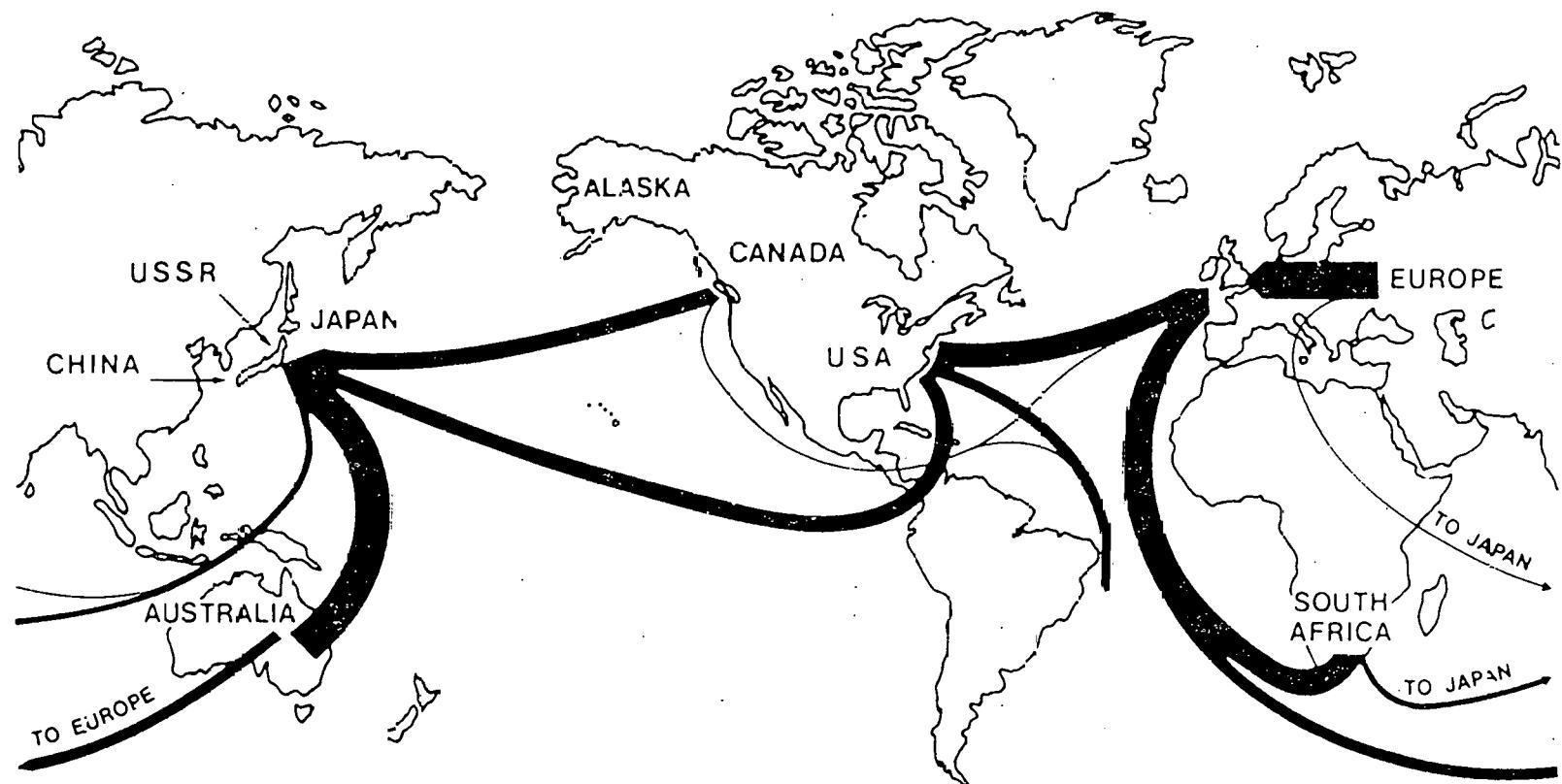
Instability in the Middle East, increased costs of production, and a decrease in new finds indicate the probability of a plateau for oil and gas on a global basis. The overall growth of our energy appetite, even allowing realistically for a successful effort at energy conservation, will still be at around 2.5% per year. This means doubling consumption every 35 years. This indicates a "massive" solid fossil fuel growth in the next decade.

## COAL GROWTH AND FORECAST TO THE YEAR 2000



**NOTE:** THIS FORECAST RELATES ONLY TO COAL TO BE MOVED ON THE OCEANS OF THE WORLD, i.e. OVERSEAS EXPORT COAL AND NOT TO GROWTH FOR DOMESTIC CONSUMPTION WHICH IS, INCIDENTALLY, FAR GREATER THAN THE ABOVE IN TERMS OF TOTAL TONNAGE.

## MAJOR ROUTES OF SEABORNE COAL TRADE



THICKNESS OF LINES INDICATE ANNUAL VOLUMES MOVEMENT OF COAL.

A recent comprehensive study of the world's energy needs, conducted by the Massachusetts Institute of Technology, reached the following conclusion:

It is now widely agreed that the availability of oil in international trade is likely to diminish over the next two decades. Vigorous conservation, the development and rapid implementation of programs for nuclear power, natural gas, unconventional sources of oil and gas, solar energy, other renewable sources, and new technologies will not be sufficient to meet the growing energy needs of the world. A massive effort to expand facilities for the production, transport, and use of coal is urgently required to provide for even moderate economic growth in the world between now and the year 2000. Without such increases in coal the outlook is bleak.

These conclusions were reached after an eighteen-month study of growing worldwide demand for coal. The World Coal Study (WOCOL) data was compiled by sixteen teams, each representing a major energy-using country. Members of each country's team included representatives from industry and government. Volumes I and II of the Study were published in the spring of 1980.

Over the past 20 years the total global growth in annual production of coal was only 600 million tons, including export and domestic coal. Currently, WOCOL is predicting an increase in export coal over the next 20 years of 3 to 4 times present figures, to conservatively 600 to 800 million tons, with some groups estimating that this figure can be as high as 1 billion tons a year by the end of the century.

Whichever we take, it is still a massive rate of growth. One should not be confused with total world production, either - this is the increase in volume to be moved by deep sea vessels to foreign markets.

## COUNTRIES PLANNING SUBSTANTIAL INCREASES IN COAL IMPORTS

-16-



**NOTE:** THERE ARE SMALLER INCREASES OF COAL IMPORTS PLANNED  
SUCH AS SINGAPORE, HONG KONG, PHILIPPINES, ETC. BUT THESE  
ARE RELATIVELY MINOR.

**THE FRAMES FOR POTENTIAL LARGE-SCALE DEVELOPMENT IN ALASKA  
(ANNUAL DEMAND IN MST-A\*)**

		Phase I 1981-Mid/Late 1980's	Phase II Mid/Late 1980's Early 1990's	Phase III Early 1990's & beyond
<u>Markets</u>	Asia	0 - 3.3	3.3 - 13.3	13.3+
	West Coast	0	0	5.0 - 7.0
	Alaska	.7	.7	.7
	TOTAL	.7 - 4.0	4.0 - 14.0	19.0 - 21.0
<u>Supply</u>	Nenana	.7 - 4.0	4.0	4.0
	Beluga	0	0 - 10.0	15.0 - 17.0
	TOTAL	.7 - 4.0	4.0 - 14.0	19.0 - 21.0

\*mst-A = million short tons of 8,000 Btu/lb. Alaskan subbituminous coal

**ASSUMPTIONS**

- Asia: utility demand in Japan, Korea, and Taiwan is filled by expanded production at Usibelli in the short-term and by new mines on the Beluga field in the longer term.
- West Coast: Alaskan coal is converted into methanol and then shipped to the West Coast sometime in the early 1990's.
- Alaska: a 1600 MW hydroelectric facility is built at Susitna substantially eliminating the need for new coal-fired generation in Alaska.

## **APPROXIMATE DELIVERED COST OF COAL**

**\$/tonne (1979)**

	<b>Western Canada to Japan</b>	<b>Australia to Japan</b>	<b>Alaska to Japan</b>
<b>Mine</b>	<b>17.50</b>	<b>20.00</b>	<b>same</b>
<b>Land Transport</b>	<b>15.00</b>	<b>7.50</b>	<b>much less</b>
<b>Export Port</b>	<b>2.00</b>	<b>2.00</b>	<b>same</b>
<b>Marine Transport</b>	<b>8.00</b>	<b>7.00</b>	<b>less</b>
<b>Import Port</b>	<b>2.00</b>	<b>2.00</b>	<b>same</b>
<b>Delivered Cost</b>	<b>44.50</b>	<b>38.50</b>	<b>less</b>

**NOTE: THESE COSTS SHOWN ARE FOR STEAM OR THERMAL COAL.**

- Nenana: only the Usibelli leases are developed. The development plans of Meadowlark Farms (subsidiary of AMAX), which is another leaseholder of the Nenana field, are unknown. Question as to whether the necessary rail and port facilities will be available to export 4 million tons a year.
- Beluga: Phase II data assume two 5-million ton a year export mines; Phase III data assume additional capacity to service a methanol plan.

The figures stated for Alaska coal export, even through Phase II, was a fairly conservative estimate by the State Legislative research group considering world demand. Industry projections are higher, but to a degree they are confidential, so have not been quoted widely. The limiting factor in developing Alaska's share of the coal export trade may well be the amount of capital available, rather than market demand.

#### **ALASKA PEAT AND COAL EXPORT COMPARISON**

Alaska may well have the option to govern more of the world solid fuel market with peat.

The following table is a comparison of Densified Peat and Beluga Coal from the Chuitna River field.

	7.7 MSTPY * Coal	.25 MSTPY Densified Peat
Btu/lb	7800-8200	12-14,000
Ash	7-8%	5-10%
Sulphur	.16-.18%	.1-.2%
Moisture	20-28%	5%
Equilibrium Moisture	25-30%	5%
Shipping Density	48.5 lb/ft <sup>3</sup>	45 lb/ft <sup>3</sup>
Estimate Cost Million Btu Loaded	\$1.00-\$1.70	\$2.7-4.2

- In this comparison costs were extracted from 1979 Bass-Hunt-Wilson coal lease prospective and figures developed by Ekono Inc. for the Susitna Valley.
- Both studies do not include capitalized dock facilities.
- The coal facility is more than an order of magnitude larger than peat facility.
- Coal costs are estimated in 1979 dollars.  
Peat costs are estimated in 1980 dollars.

The comparison shown is crude, but does represent the best estimate of resource comparison. The coal field in the Table is one of the best case Beluga fields. Diamond Shamrock has committed 25 million dollars for development of this lease.

Upon examination of the figures presented, some shift of economics in favor of peat must be made due to the inflation between 1979 and 1980. Despite the inflation factor, in the comparison, it is obvious that the costs for a million Btus is more for densified peat than for Beluga coal at the dock. This cost differential may be reduced if the scale of peat development is closer to that of coal.

It is obvious that peat has nearly twice the energy content per unit volume. The incredible impact of shipping costs (in many instances more than production costs), storage, and plant, boiler and equipment sizing may well compensate for higher cost peat as an export commodity.

Peat also has a number of other characteristics that should be weighed in any comparison with coal.

- Low sulfur content
- Wet extraction possible for slurry transport
- More homogeneous
- Cleaner burning
- Less residue after burning

- Fuel is more versatile
- Reclamation much quicker, less expensive, more applications for land use
- Swamp lands impacted can be converted to productive land, as opposed to productive land impacted for 50 year regeneration cycle.
- Peat can regenerate, though very slowly
- Less susceptible to spontaneous combustion in storage and shipping
- Less moisture per pound
- No dust emissions in processing and shipping
- Less ash per pound
- No moisture gain

In Alaska, two other important factors exist when comparing Beluga coal and densified peat.

- Substantial peat deposits overlay Beluga coal.
- Alaska peat deposits are found along the rail and road system.  
This may eliminate the need for a special use dock.

These comparisons make peat so impressive that the economic viability of this resource should be investigated in depth as an export commodity.

The world demand for coal is such that these two resources do not have to compete. The comparisons are made to point out that densified peat is comparative on the world market because economically it equals developing Beluga coal. The world market demand is such that both can exist and supply separate Far Eastern market segments in the near term and expand to meet demands elsewhere in the long term.

## **FUTURE WORK**

The proposed work schedule for the commercialization effort is not finalized. The Division is presently advertising for Statements of Interest.

## **6-10 MTPY TERMINAL APPROX. CAPITAL COSTS (1981) \$**

Site Services and Rail	\$ 2,000,000
Unit Train Unloading	7,000,000
Conveyors	8,000,000
Stacker / Reclaimers	18,000,000
Shiploaders	12,000,000
Marine Structures	10,000,000
Sampling Plant	1,500,000
Electrical Equipment	5,000,000
Ancillary Buildings	1,500,000
<b>TOTAL (excluding land costs )</b>	<b>\$ 65,000,000</b>

**NOTE:**

THE MARINE STRUCTURES SHOWN HERE AT \$ 10 MILLION WILL VARY FROM SITE TO SITE. DUE TO CONDITIONS OF DEPTH, DISTANCE TO SHORE, ICE, TIDAL RANGE AND SHIP SIZE.

The Statement of Interest is due October 30, 1981. This is a preliminary step required to be invited to the proposers' conference to be held in Anchorage in November. The proposers will be given written and oral instructions at that conference to complete the Request for Proposal.

Criteria for selection will be discussed to eliminate unqualified participants. Due to the negotiation process underway at this time, the final work statement has not been developed nor has the time frame of the feasibility study.

Once the feasibility analysis has been completed and shows market, environmental, and technical probability for success, it is anticipated that a schedule as that depicted will be initiated.

## QUESTIONS AND ANSWERS

Q: My question is when you are comparing coal costs with peat costs, are the coal costs being estimated for opening new mines or existing mines?

A: They're opening new mines and the reason we did that is because industry is already committed to it. Therefore, we felt there was justification in doing that.

Q: So the coal costs are also estimated on new mines being opened?

A: Absolutely. Without the port facility, which I might add, in the case of Alaskan coal, will be required because the coal deposits are on the other side of Cook Inlet from Anchorage.

Q: What is the coal cost for a new mine?

A: They estimated that the dockside cost would be \$1.35 per million Btus.

Q: You mentioned that the peat is overlying the coal reserves in certain parts. What if you were to consider the removal of peat as part of the entire coal operation, would that not then put peat in a much more favorable light?

A: Certainly, and one of the considerations in the analysis that we'll be performing will be how we can combine the facilities.

## QUESTIONS AND ANSWERS

Q: In the characterization of the commercial quality resource that the DOE has used for all of the states with resource estimation, it was considering fuel grade peat to contain less than 25% ash. In Stu's brief presentation, he indicated that the mean value of the ash was averaging around 25%. Do you foresee problems with that in the beneficiation process?

A: We would anticipate that through some type of wet processing you might be able to reduce it and without that, yes, it would. I would assume it would but I would also assume that we could at least approach the possibility of some type of -- you know, reducing the ash content in the wet processing.

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**PEAT RESEARCH IN FINLAND**

**JAAKKO OKKONEN**

**TECHNICAL RESEARCH CENTER OF FINLAND  
JYVÄRTRYE, FINLAND**

## **PEAT RESEARCH IN FINLAND**

The following text only deals with the research on peat as fuel in Finland. The national aims of peat research are:

1. To utilize peat in order to supplement foreign energy sources as economically as possible.
2. To investigate technically and economically new possibilities of utilizing peat.
3. The follow-up study of energy technology and its transfer to Finland (gasification and liquefaction).
4. To increase reliability and security as well as alternative fuels in existing power plants.
5. To develop the handling-, combustion-, and processing technics of peat.
6. The efficient use of energy in connection with the above mentioned aims.

The main branches in peat research are to examine the volume of usable peat resources and to develop production, handling, and combustion technics of peat. An important long-term goal of research is also to create the technology to further process peat.

Peat research is done in many universities and institutes, by engineering companies, by peat producers and equipment manufacturers, by machine shop industry, and in national institutes like the Geological Survey of Finland and the Technical Research Centre of Finland. This text will deal with the research activities carried out by the Technical Research Centre of Finland. With regard to research activities carried out by other institutes, the following research branches of greatest importance can be mentioned.

The Geological Survey of Finland is doing extensive, continuous field research in order to catalogue the usable peat areas. In universities, studies are being carried out to develop methods of inventory, primarily with the use of radiotechnical measuring equipment.

The Association of Finnish Peat Industries is continuing a study on developing a rapid harvesting method of milled peat production. Several companies are co-operating in order to further develop the wet carbonization of raw peat, the so called PDF-process, in connection with the artificial dewatering of peat. They are also developing different alternatives of producing peat for a potential PDF-plant.

Several product development projects are going on for further development of combustion technics. Concerning new applications, one industrial enterprise is developing a new circulated fluidized bed gasifier for production of fuel gas and possibly of synthesis gas. The object is to produce electricity and heat by a diesel motor developed by another industrial enterprise in the smaller communities in Finland. Kemira Oy, the biggest national producer of fertilizing agents, is doing research into making ammonia from peat. The peat consumption of the eventual ammonia factory would be about 5 million m<sup>3</sup>/a.

#### **PEAT FUEL RESEARCH AT THE VTT**

The VTT has traditions in investigating peat. Going back to 1943 the Fuel and Lubricant Research Laboratory has carried out experiments on the processing of peat. Nowadays, the research work is also done in the Domestic Fuel Laboratory, which is primarily responsible for peat research as a fuel, including production and application technology. According to a new work order, the Fuel and Lubricant Research Laboratory concentrates on utilization forms of peat other than energy and on research into processing.

In the Domestic Fuel Laboratory, where about 50 people are working today, peat research is divided into the following branches:

1. Techniques of peat production.

2. Handling technics of peat.
3. Combustion and power plant technics of peat.
4. The environmental effects of peat.
5. Systemtechnics.

The effective utilization of weather factors and development of a control system connected with this is the main task of peat production technology. Another important task is to test new production machines and artificial dewatering methods. The main objects of research in handling technology are at the moment to develop sampling methods and consistent quality, and based to this, to develop an automatic measuring system. Other tasks are to define the feeding and unloading properties of peat as well as its long-term storage characteristics.

The main objects for research in combustion and power plant technology are:

1. To develop the combustion technology of pellets,
2. To carry out basic research on combustion and product development using a 0,5 MW pilot plant (see Figure 1),
3. To maintain and develop the serviceability and reliability system of peat power plants, and
4. To carry out product development together with the machine shop industry.

Regarding environmental impacts, the main tasks are to investigate the environmental disadvantages and to measure the emissions of peat-fired plants.

The main task of the systemtechnical approach is to estimate the value of operations aimed at getting fuels of better quality. Mathematical models for each operation of the handling chain can be made and then the chain can be simulated by computer. By systemtechnical methods it is possible to study very large models in which one can take into account the effects of production, transportation, quality operations, and handling in the light of burning efficiency and economics. Mathematical models are made for the contributing processes and factors, and more extensive simulation models are done by computer.

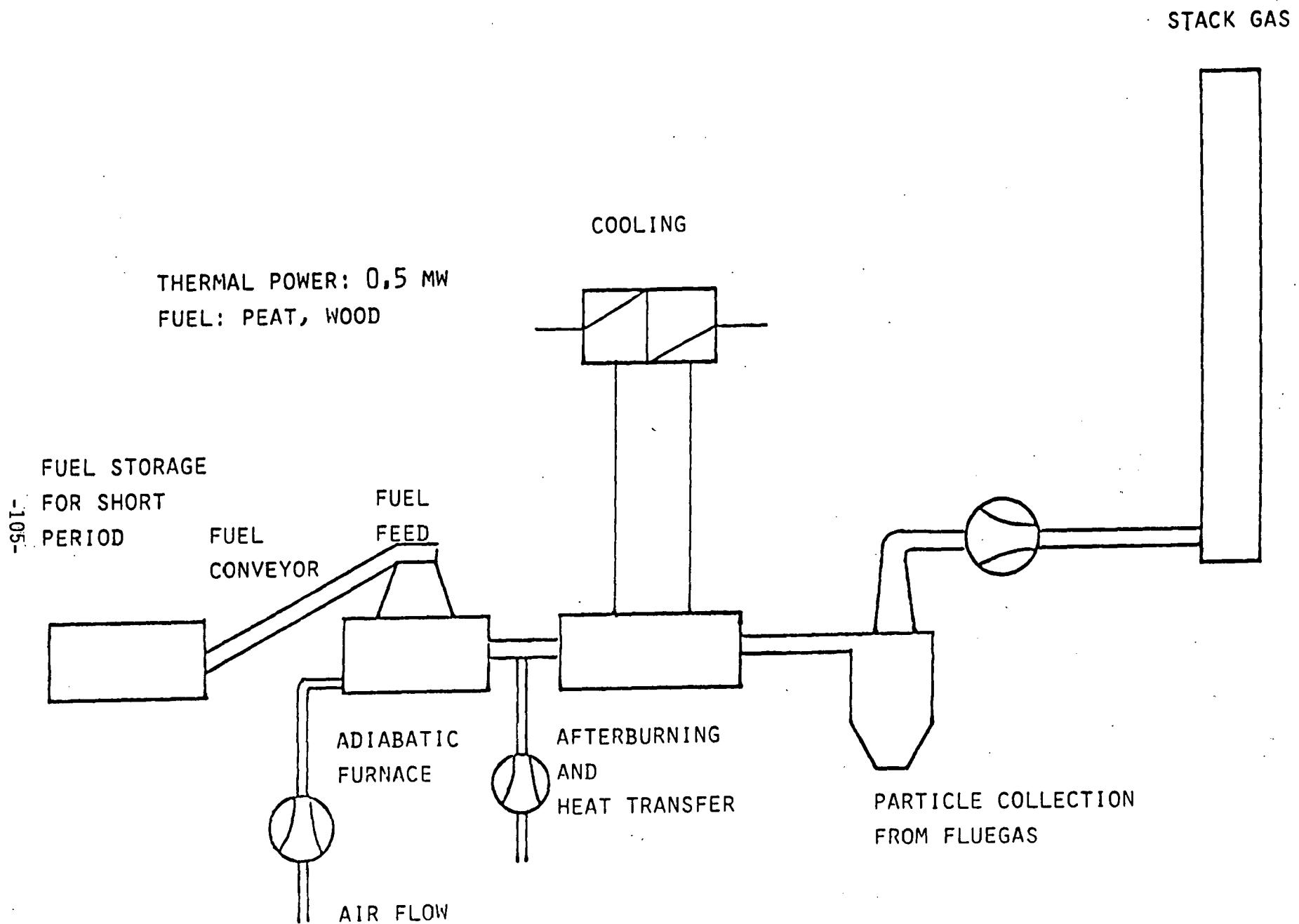


Figure 1 Pilot Plant

The development of peat compressing technology and research into gasification and liquefaction are being carried out in the Fuel and Lubricant Research Laboratory. In gasification the main task is to produce fuel gas by the counter current principle, and according to this technology the practical applications are of current interest. Connected with gasification, basic research is done also in fluidized bed technics, and surveys on the potential use of gas are done. The research also includes gasification experiments on Finnish peat in foreign research institutes in their gasification processes. In the liquefaction project the main task is in different surveys and experiments. The laboratory has done comparative researches on the production process of methanol. Laboratory tests on hydrogenation of Finnish peat have been done in cooperation with the Royal Technical University of Stockholm as well as hydrogenation in the gaseous phase with the IGT in the U.S.A.

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Technical Research Centre of Finland, Domestic Fuel Laboratory  
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THERMAL POWER: 20 kW  
FUEL: WOOD, PELLETS

UNLOADING OF FUEL CAN BE  
CARRIED OUT PNEUMATICALLY

-107-

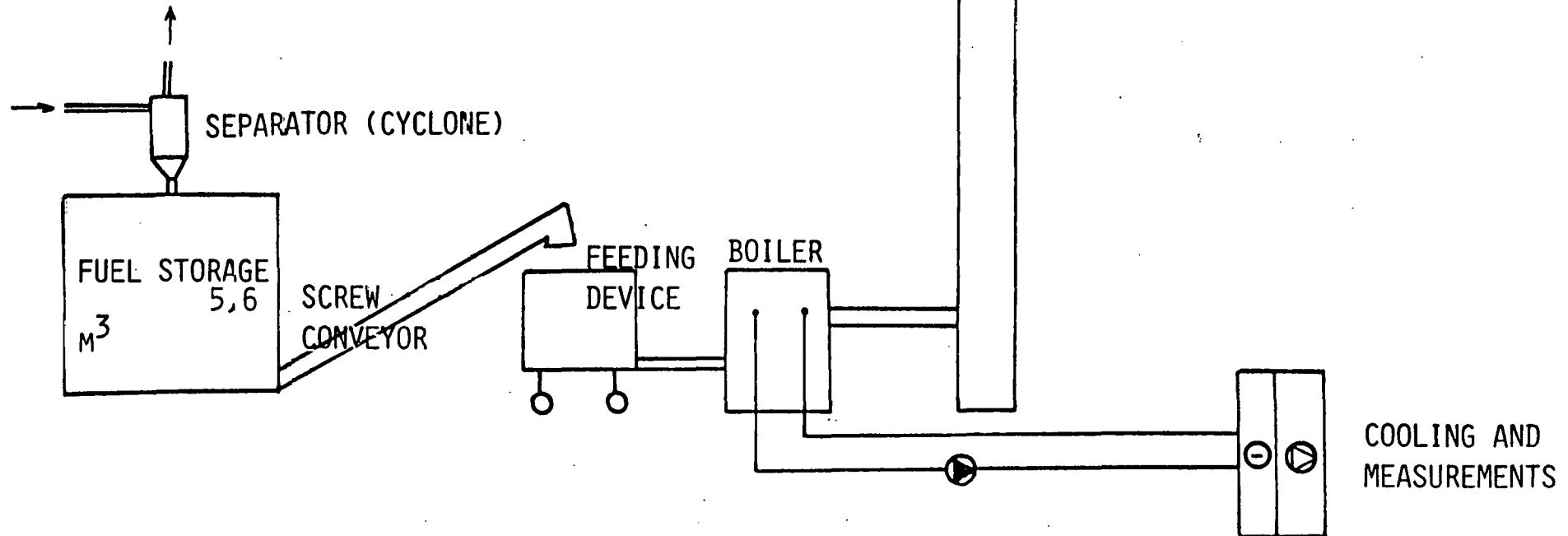


Figure 2

## QUESTIONS AND ANSWERS

Q: You show in one of your pilot plants pneumatic conveyance of peat pellets.  
Do you use air?

A: Yes.

Q: Have you had any problems conveying with air?

A: We have had problems with this in the pellet plant, in pellet boilers.  
This is a very big problem.

Q: How much of Finland's total energy consumption consists of peat?

A: Peat makes up about 2 or 3% of the total primary energy consumption.

Q: It looks like by the year 1995 you want it to go up to about 12 to 15% of  
your energy, is this true?

A: It looks very promising, but these are estimated figures.

Q: Will that be through electricity or some other types of conversion or  
utilization of the peat?

A: Electricity and district heating. No condensing power plants.

## QUESTIONS AND ANSWERS

Q: You had two slides up there of power plants. The second one of them showed combustion apparently in two stages, is this so?

A: (See Figure 2). This means that the fuel is gasified in this furnace and then this gas is afterburner burned in this stage.

Q: So you would get complete combustion in the second stage there?

A: Yes. This is a very common way to use peat and wood chips in Finland in smaller and bigger boilers too, in both cases, up to 10 to 20 megawatts plants. Then we have grate firing plants.

Q: Is that an actual unit somewhere?

A: Yes. We have many units like this. They are existing units.

Q: Is some information available about them?

A: I don't have the data with me but we have done research work on this type of plant and we have researched the efficiency and reliability in an effort to improve these aspects of the plants.

Q: Have you had any experience in reclaiming the mined area, the area that the peat has been removed from, have you had any experience in converting that back into forestry or agricultural production?

A: That is problem in Finland, we don't know exactly what to do. We don't have any common instructions for that.

**COMMENT:** Concerning that question, I had an opportunity to visit a forestry station in Finland two years ago and they have extensive experimentation on reforestation.

**REPLY:** That's right but that is not very common. That is only research work.

**COMMENT:** Right. But I think I can say that in the United States the reclaimed peat areas have been found to be extremely arable farmland. The yields of crops that have been attempted in these reclaimed peatlands have exceeded the yields in traditional soils for those crops, soybean, and sorghum and blueberries, cranberries and that's one of several options.

One that's of interest to the U.S. Fish and Wildlife Service is to upgrade the wetlands status from what it currently is, and I'm not too familiar with that, I believe it's number 7 wetlands, to a higher grade wetland that would be perhaps more suitable for a wildlife that previously inhabited the wetland. So there are a lot of perhaps very favorable scenarios for reclaimed peatland.

Q: The feedstock you had for that plant, these are in pellet form?

A: Yes, pellet form.

Q: In other words, are these extruded pellets or do they just come in as milled peat?

A: The fuel is in pellet form already when it comes.

## **QUESTIONS AND ANSWERS**

Q: Have you tried using any other biomass or any other types of matter to mix with this peat?

A: Yes. We do research work with many kinds of fuels, with poor peat, with peat and bark, and with sub-sub-peat. These are very important fuels in the wood processing industry and are used in their grate-firing boilers.

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**PEAT RESEARCH AND DEVELOPMENT  
IN SWEDEN**

**BIRGITTA PALMBERGER**

**NATIONAL SWEDISH BOARD FOR  
ENERGY SOURCE DEVELOPMENT  
SPANGA, SWEDEN**

I am going to make a presentation on the Swedish Peat R&D Program and first I want to show you some figures just to give you an idea about the size of Sweden so you can compare it with the size of the U.S.

The land area of Sweden is only about 5% of the U.S. land area and we have about 8.5 million inhabitants compared to 222 million for the U.S. So you must remember we are a small country and we have no coal, no oil, and no gas and today our energy consumption is based on imported oil to about 70%.

The total energy supply in Sweden data obtained in 1978 shows the following distribution: oil 70%; domestic hydroelectric power 13%; bark and black lyes in the pulp and paper industry 9%; coal 4%; and nuclear 5%.

The long-term goal of Sweden's energy policy is, therefore, to develop an energy supply system based on lasting, preferably renewable and domestic energy sources with minimal environmental impact, and in the short term, the emphasis will be placed on reducing Sweden's heavy dependence on imported oil as quickly as possible through conservation and various oil substitution measures. Current plans also call for phasing out the nuclear power by the year 2010, in accordance with last year's national referendum. There was also a parliamentary decision to restrict the future expansion of hydroelectric power.

Together these objectives necessitate a radical restructuring of Sweden's current energy system and a gradual transition to a varied base of supply alternatives.

In '75 the Swedish Parliament made a major decision on energy policy that was designed to strengthen national energy planning and preserve as many options for future energy supply as possible. As part of this decision, a new governmental activities concerning new sources of energy was established. That's the National Swedish Board for Energy Source Development. The short name is N.E. and I'm working at that Board. And N.E. was charged with the task of setting up R&D programs, stimulating technical industrial development work through grants and loans, and encouraging widespread applications of research results.

N.E. is a very small department of energy and has about 50 persons working there.

It should be noted that N.E.'s responsibility is only one part of the total renewable energy research activities, which encompass programs between both public and private sectors. For example, extensive R&D programs concerning energy use in buildings, in industrial processes, and with the transport sector are carried out by other independent government authorities as can be seen in Figure 1.

During the next few years Sweden's R&D program for renewable energy sources will focus on accelerated development of domestic fuels. This strategy involves development of techniques for utilizing forest wastes and peat as well as establishing a market for such fuels within the nearest possible future.

In the long-term perspective it is hoped that energy plantations will provide continuous availability of raw energy materials that can be burned directly or converted to more compact, easily-handled fuels.

For this reason, considerable efforts will be devoted to developing methods of fuel conversion as well as new methods of heat and power production. Among the domestic future sources of electricity is wind energy, which can potentially make a significant contribution in the 1990s.

The following table shows N.E.'s major program areas and the planned allocations for each program for the period 1981 to 1984.

# THE ENERGY R & D THE RESPONSIBLE AGENCIES

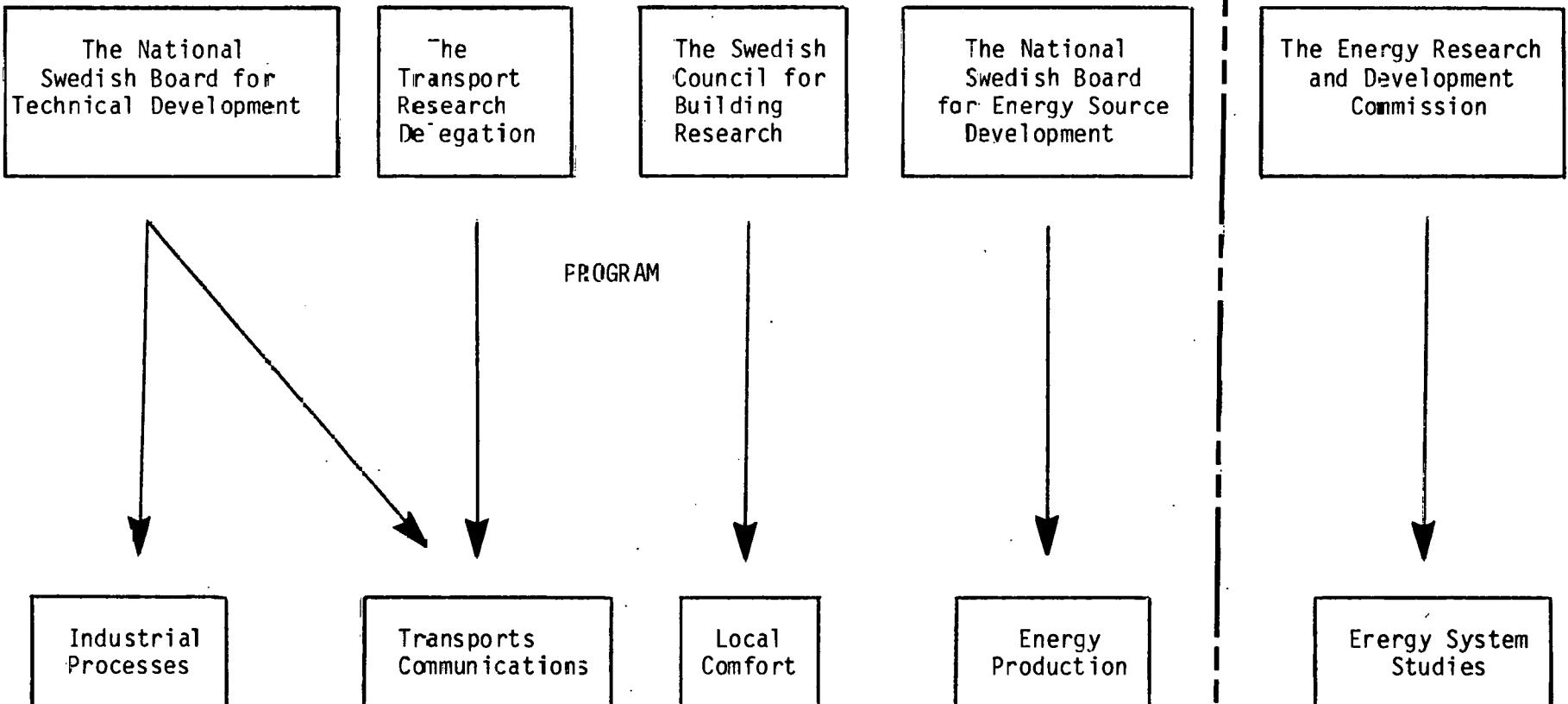


Figure 1

TABLE 1

<u>N.E. Major Program</u>	<u>Allocation (in Millions Swedish Crowns)*</u>
Forest Wastes & Peat	125
Energy Plantations	95
Fuel Conversion	117
Heat and Power Production	60
Wind Energy	150
Fusion Energy	90
Advanced Technologies (solar, aquatic, geothermal, electricity, storage, etc)	50
Energy Supply Studies	13
TOTAL	700

\* one Swedish crown is approximately 3.2 U.S. dollars

Of the 125-million Swedish crowns for forest wastes and peat, about 35 million Swedish crowns are for the peat R&D program.

As I said before, we have no coal and no gas and no oil. We will have to use our domestic fuels, which are wood waste, peat, and, in the future, energy plantations. As far as the peat resources are concerned, about 10% to 15% of the Swedish total land area is covered with peat at a thickness greater than 0.3 meters, which makes a total of about 5.4 million hectares. About 75% of the total amount of peat is located in the north of Sweden. Our major industries and the population are along the coast and in the south of Sweden. So we have to find out methods to get the peat more compact in order to get a more economical way to transport it.

Inventories and estimates of the amounts of peat made by the Geological Survey of Sweden indicate that the energy content corresponds to about 3,000 million

tons of oil. This amount will be sufficient to replace all of our annual oil consumption for about 100 years. This is naturally only a theoretical example to show the quantity of the total amount. Only part of this resource can be recovered and utilized, because of ecological and economical reasons.

During World War II about 1.3 million tons of peat were produced annually, but this figure had gradually been reduced after the war, mainly because of the low price of imported oil. Since the early '60s the production is at a level of 300,000 tons a year and most of this is used for soil enrichment. That's true up to today, however, with increasing oil prices there is a growing interest in domestic fuels and during the 1980s we can expect increases in the commercial use of peat for energy purposes in industry, as well as in the areas of municipal district heating and combined heat and power production.

The first step toward this is made by a pulp and paper company in northern Sweden, Lovholmens Bruk, which has rebuilt its existing oil burners to enable combustion of pulverized peat and wood chips. They are going to replace about 50,000 cubic meters of oil annually.

The commercial harvesting techniques, that's the milled peat technique and the sod peat method, are today capable of competing with oil. Milled peat costs approximately 800 Swedish crowns per ton of oil equivalent and the price of heavy oil in Sweden is about 1,300 crowns. Although the price of milled peat is competitive with the oil, the milled peat method has a lot of disadvantages.

Sweden has a very short harvesting period, only about two to three months, and this is dependent on good weather conditions. I heard from Finland this summer that production has been about one third of the production last summer because of adverse weather conditions.

Also, the area under production should exceed 100 hectares to be economical.

Because of the above disadvantages and the fact that the milled peat method is in commercial use today, the major task in our R&D peat program is to develop new

harvesting methods and in consequence of this to solve the dewatering problem. Thus, the major efforts of the Peat Program are directed toward different methods of digging wet peat and transporting it to a plant for further processing.

The main problem in the use of peat is the high moisture content and the difficulty of dewatering. Major efforts have been devoted in most peat-producing countries to find a method that could be used on a practical and commercial scale. None has yet succeeded in doing so and because of that, we are working along different lines in our program.

One of the main operations in this chain from the peat bog to when you have pellets is the mechanical dewatering. To get this mechanical compression more efficient, you can have various types of pretreatment; another pretreatment step is an addition of polyelectrolytes, and a third method is the wet carbonization process, which was developed by a Swedish company during the 1950s. This third method is being tested in Sweden by the Swedish Forest Owners Association in Delary, where they plan to produce 100 tons of wet carbonized peat.

Peat, together with other domestic raw materials, such as wood waste and biomass from energy plantations, can also be used for producing synthesis gas for methanol production. Work in this field is carried out at the Royal Technical Institute of Stockholm and the results are very promising.

Another method to extract the energy content from peat is being used in the Vyrmethane project, which operates in situ. This process is making use of the natural anaerobic digestion process to break down organic material in the bog. Methane is formed and absorbed by the water in the bog. The methane is then separated by pumping the water to a degassing plant and afterwards the water is recycled underground and more methane is picked up.

The environmental consequence of widespread peat utilization will also be determined in cooperation with the National Swedish Environmental Protection Board, and studies indicate that environmental factors would not significantly restrict the future expansion of peat production.

## QUESTIONS AND ANSWERS

Q: I was wondering, as you have a lot of peat that's above the Arctic Circle, are you in permafrost zones and are you estimating the impact from being in a permafrost zone when you're doing your mining?

A: No, we're not in that zone, our deposit is lower than that zone.

Q: I'm curious as to the economic experiences of the pulp and paper plant in northern Sweden that is importing the peat to burn in their boilers. How has it worked out in comparison with the oil they were previously using?

A: They haven't done it with only their own money. They have had grants from the Swedish Government that cover 50% of their costs. As far as a cost comparison with the oil; peat comes out ahead because as I mentioned before, heavy oil costs about 1,300 Swedish crowns per ton and it is estimated that milled peat will cost about 800 Swedish crowns per ton equivalent. I think they feel sure the rebuilding of the oil burner, so they are capable of using wood chips and peat, will make good economics for the future.

Q: Could you give us a couple of more details about this in situ fermentation process or anaerobic digestion process you mentioned, producing methane in the bog as I understand it.

A: Yes, I have a paper that presents that method and I can give you some copies of that tomorrow.

**PEAT RESEARCH AND DEVELOPMENT  
IN SWEDEN**

**PROFESSOR OLLIE LINDSTROM**

**DEPARTMENT OF CHEMICAL TECHNOLOGY  
INSTITUTE OF TECHNOLOGY  
STOCKHOLM, SWEDEN**

I will discuss projects on alternative energy sources currently under development in Sweden. Particularly the projects being carried on by the Department of Chemical Technology at the Institute for Technology in Stockholm.

Chemical dewatering and conversion is our biggest project and we are now building a continuous liquefaction plant, the Biomass Liquefaction Test Facility, that is sponsored by an international joint venture. We are combining our knowledge in this field with some work that is being done at the University of California.

Mechanical dewatering and conditioning is of great concern to us and 5 or 6 years ago we looked into the various options that are available for dewatering. We came to the conclusion that this biomass liquefaction was one intriguing route and we also found that mechanical dewatering using the countercentrifuge to remove the colloidal material was an economically viable approach. We started actually with the grinding approach, which was also influences the water-retention properties of peat.

We heard earlier about the WC plant or wet carbonization peat plant, which has many features in common with our decanter centrifuge plant (DC plant). We could actually take the flow sheet of a WC plant, remove the high pressure and water treatment systems, and add decanter centrifuges, additional driers, and an effluent treatment system, and you now have a DC plant. The following discussion will cover these modifications.

Instead of the high pressure system used in the WC plant, we have added a decanter centrifuge. These are very big machines and are being used extensively for sewage-sludge dewatering in municipal plants. It's a well proven technology that is reliable and the costs are known.

This decanter plant is using only proven components and proven technology. It's just a transfer of technology from some related areas to the peat slurry area.

The decanter plant also requires additional thermal driers because the mechanical treatment can not remove water economically after about 40% dry matter/60%

moisture content of the peat has been reached. The thermal driers complete the drying process to obtain 90% dry matter content, which is a good level for pelletizing. The wet carbonization can give you something like 45 to 50% economically.

You also have to do something with the effluent containing the fine material that makes up about 10% to 13% of the material in the peat. The effluent is actually an excellent source of fuel, which is obtained by flocculation and another chain on the counter-centrifuge and presses.

These modifications to the WC peat plant will give you a DC peat plant and the cost will be around 3 to 4 dollars per million Btu. This cost was substantiated by a study of a DC peat plant in the west of Sweden. This DC plant produces peat pellets to be used in modified Stockholm gas works. The cost analysis included a 400 kilometer transportation cost from the DC plant to the gas works.

This DC plant is actually showing a cost of about 2 to 3 dollars per ton, which is about 10 cents to 15 cents per million Btu with no transportation. So this part of the scheme has proven to be very inexpensive.

We have determined in a comparison between the WC plant and the DC plant that the DC plant produces material at a lower cost.

We are also quite active in gasification and have developed a process called MINO, which means minimum oxygen demand. It's very similar to the IGT peatgas processes now being scaled up to the power plant size in a joint project with Stuttsveg energy technique and the Department of Chemical Technology at the University of Lund.

We have quite an extensive laboratory development for MINO process and we are now concentrating on tar cracking. Tar cracking for fluegas where you can tolerate the methane and tar cracking where you have to also eliminate the methane for synthesis gas from methanol.

Another project that has been gaining interest for many years is flash pyrolysis of biofuels. Several experiments have been made that show that you could get a fairly large amount of ethylene from peat by flash pyrolysis. I have recently filed a request for MINO for more in depth studies into this area to find the optimum conditions.

We also have a project that is utilizing a process for direct reduction of iron ore using peat. These are two important raw materials in Sweden (iron ore and peat), so we would like to combine them in a process that will derive a sort of methanized iron ore for export. The idea is to inject peat powder into a fluidized bed of iron ore concentrate that has been preheated. This produces a lot of gas immediately, both gas for fluidization and gas for reduction. Money has now been allocated for further laboratory studies of this approach.

Because of much concern over the environmental consequences of small-scale burning of wood and peat, we have found it necessary to include, small scale gasification and combustion processes as projects in our program. The concept is to use peat pellets, wood pellets, and wood chips in a two step process. The first step is to gasify these materials, which is followed by the second step, an adiabatic combustion. It could be done on a very small scale and you try to simulate the conditions of flash pyrolysis and gasification of the residuals in a simple wood furnace or whatever you'd like to call it.

Of course, you could stop after the gasification step and send the fuelgas to a catalytic cracker to remove the tar. This would allow use of the fuelgas for combustion or for the motor generator.

This is just a short overview of some of the work that is being accomplished in peat utilization. We have found peat to have many excellent properties that allow it to replace oil, not only as a fuel but also in the petrochemical industries, at least in the present economic environment of Sweden.

There are many other projects going on in Sweden in other departments and other universities; I have covered only what we are doing in my department.

## QUESTIONS AND ANSWERS

Q: Why is the International Energy Agency proceeding to build a peat liquefaction facility in Sweden, given that a facility very, very similar to the one that is being contemplated, which will cost several million dollars, is already built and existing and has already been operated on woodwaste here in the United States?

A: I simply can say that the idea with this international joint venture is to get to an optimized process and we actually have not decided yet what this process will look like. It will evidently be a two-stage process but exactly how things will be optimized is not known yet.

I visited the plant in San Francisco at the University of California a couple of months ago and they have no experience at all in recovery from trouble. As you know they are working with a very small pipeline, which is plugged up.

The Oregon plant was very much a batch process and we are now dealing with continuous processes.

**COMMENT:** (Mr. Rohrer): No. The Albany plant was continuous. It has been successfully operated producing oil, and the work was considered complete and the plant was mothballed.

Two hypotheses were tried and both successfully proven by producing carbon yields and liquids in the 90% to 95% range in the conversion of cellulose to liquid. The oil was test fired at the Pittsburgh Energy Technology Center in oil-fired boilers and successfully burned at full ratings. It is an oxygenated oil and is not mixable with petroleum-based oils, but as a liquid boiler fuel in its own right, it was quite successful. I suspect, though I do not know, that the same sort of thing could be done with peat.

## QUESTIONS AND ANSWERS

**REPLY:** (Prof. Lindstrom): Our thinking in this area is that it does not make much sense to make fuel oil from peat. You could burn the peat fuel directly at a cheaper cost.

I think the present interest now in Sweden is to in some way run this process so it will yield liquid fuel that could be useful in diesel engines, and there are some features with this oxygenated process that could reduce soot formation, for instance, in diesel engines.

We are now also just scratching the surface trying to find conditions that will give us a peat oil that could be refined for transportation purposes, for engines, not for power plants.

**COMMENT:** (Mr. Rohrer): Our analyses indicate that one would do better to go indirect liquefaction for those types of processes, i.e., go into gas and come back into liquids, because any aliphatic based liquid is going to be highly oxygenated, and the cost of hydrotreating that down to any unoxygenated product is very high. I suspect that it will be cheaper to produce a medium Btu gas and then resynthesize it using methanol synthesis or fission drops or something of that sort.

**REPLY:** (Professor Lindstrom): You may very well be right, but we are curious about the possibility of making a new kind of a fuel for new energy. As you know, methanol is a very good fuel for a diesel engine, if you could ignite it, which requires something of a high cetane number. Methanol is a good fuel from the soot formation point of view because it contains oxygen, and this peat oil also contains oxygen. We would like to modify this process to produce a raw product that could be refined further for future engine use.

Methanol is obviously an alternative but we don't know which approach will be the best as far as cost and resource conservation considerations are concerned.

## QUESTIONS AND ANSWERS

**COMMENT:** (Mr. Rohrer): I'd like to make a comment also on wet carbonization. I visited the Swedish dewatering plant in Markhart two weeks ago to review their progress.

They were achieving only 25% solids and they were using a peat that was highly fibrous. It was about 30% maximum colloidal material, whereas most of the peats that we're considering here are much higher in decomposition and much less fibrous and have more colloidal material. They had also tried one highly colloidal material that was up to 60% colloids. They were able to get to 40% solids only out of the very coarse fraction, which is like a 28th inch plus fraction. The net average solids that they were able to achieve on small-scale equipment (that may not be fully representative of large-scale equipment) was 25% solids, again on this rather fibrous material. You know, 25% solid versus 40% solid might sound like a casual difference but it's a very, very significant one. 25% solids is 3 pounds of water that have to be thermally evaporated for each pound of dry solids; 40% solids is 1.5 pounds of water to be evaporated for each pound of dry solids.

In our wet carbonization work we found that at 50% solids, i.e., one pound of water for one pound of dry solids, the filtration and evaporation plant was more costly than the rest of the plant put together. Don't dismiss the cost of removing that water via filtration and/or thermal treatment. Filtration equipment is very expensive when you need that much of it. The size of the filtration equipment needed is a function of the volume of water passing through it and the dryness of the colloid in that water, which with peat is very, very high.

I just wanted to make the point, that my analysis of that process really reinforced the feeling that some pretreatment of some type was absolutely essential. Now work, obviously, can be done in improving filtration. I know Ingersoll Rand and a number of people are working

## QUESTIONS AND ANSWERS

on that and their objective is to take a medium decomposed peat to 35% solids. Even then, I'm not sure that that would be economic in terms of the subsequent thermal drying that would be required.

**REPLY:** (Professor Lindstrom): I agree with you. Of course, in my country people are not using centrifuges, they are using screens like the technique being used at the plant in Vancouver.

**COMMENT:** (Mr. Rohrer): They use the centrifuge on the colloids.

**REPLY:** (Professor Lindstrom): I was talking about the counter-centrifuge. We have a process development unit in Stockholm where they are feeding peat slurry in this way to remove colloidal matter.

The German company (a combination of a German and a U.S. company which makes the biggest centrifuges in the world) is willing to quote on equipment consisting of the counter-centrifuge and screw presses and a modified roll press. They are willing to guarantee a moisture content around 40% in the feed. I'm not their salesman and I may have some doubt about the 40% level, but I think this pretreatment technology is proven and cheap and reliable.

**COMMENT:** (Dr. Kopstein): I had the opportunity two years ago to visit the laboratory in Stockholm and I saw the cyclocentrifuge apparatus. At that time they were achieving, without any kind of pretreatment of the peat, somewhere around 62% moisture. That would tie in with what you're saying about breaking down the pellets.

Ingersoll Rand has estimated that by extrapolating the available laboratory data with no pretreatment whatsoever you can achieve about 70% moisture content. In fact, at Western Peat Company in Vancouver, without any difficulty at all, using a modified wood press, pulp press, they are able to obtain 72 or 73% moisture content.

## QUESTIONS AND ANSWERS

**REPLY:** (Mr. Rohrer): They're only getting 60% yield. They're passing 40% of the material out as fines, which they're not catching. If you considered the water content of that material, the dewatering would be much, much lower.

**COMMENT:** (Mr. Ismail): I talked with them recently about that and they said that they were very disappointed because this was not enough. They haven't done anything below that.

**REPLY:** (Mr. Rohrer): That's right. They're disappointed in that application. They don't think that has any energy impact.

Q: (Dr. Kopstein): This is at Western Peat?

A: (Mr. Rohrer): That's right.

**COMMENT:** (Dr. Kopstein): Okay. But, if we're talking about the process in Sweden, without too much difficulty, you would see that they're able to get down to 62% or 63% moisture content. The fraction of the feed carbon that comes out in the product wasn't discussed. That's obviously an important factor.

**COMMENT:** (Professor Lindstrom): The only thing I would like to say is that you could actually press a lot of water out of the peat if you could afford the economics. But, there is an economic tradeoff between mechanical dewatering and thermal dewatering. If you have cheap Btus (as with Western Peat Company having cheap natural gas), you could reach 35 or 30% moisture content. If Btus are expensive, then 40% would be the approximate breakeven point in the cost of mechanical dewatering and thermal dewatering. But it seems that beyond the region of 35 to 40% moisture content where mechanical water removal pays, you have to go farther with thermal methods. Of course, thermal

## QUESTIONS AND ANSWERS

dewatering is an area that needs careful attention and work. There is a need for mechanical dewatering development, to develop presses optimized for, for instance, pretreated peat slurries.

Q: When you refer to the term decanter, do you mean the same as centrifuge?

A: Yes, but it's not a normal centrifuge. It's a centrifuge having about 1,000 G's. It has a rotating shell and a screw, so that the material is forced through the centrifuge and is separated into a sludge fraction containing about 17 to 19% dry material and another effluent containing most of the water and the fine material. After you have removed the fine material, you can, of course, press out the water more easily from the filter cake. That's the idea. In Stockholm we have, in all municipal works, a counter-centrifuge. The length of these machines is about 6 to 8 meters (very big machines). The economics have proven them including the cost of maintaining them and everything. We have to carry out experiments to find out the optimum conditions, as has to be done with every centrifuge application, but it's straightforward. In centrifuges you are concentrating on the conversion process but you also need cheap peat. Since nobody is giving us cheap peat, we have to do something about that too.

**DEVELOPMENT OF CONCEPTUAL  
DESIGNS FOR PEAT PRODUCTION SYSTEMS**

JONATHAN LUDLOW  
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The use of peat as anything but a secondary source of energy (whether for direct or indirect combustion) will require a major investment in technology and capital equipment to mine, or (a less emotive word) harvest, the feedstock. For instance, a modest power plant of 500 MW burning approximately 3 million tons of 50 weight percent peat will require the extraction of at least three times the weight of material removed from a large underground coal mine. Depending upon the harvesting method, the volume involved may be up to ten times that of coal of the equivalent heating potential.

This provides the background to the program that Foster-Miller Associates, Inc. (FMA) is currently conducting for the Department of Energy (DOE), Carbondale Research Center. (Contract No. DE AC01-80ET-14104).

The objective is the development of conceptual designs capable of producing 3 million tons of 50 weight percent peat (or its equivalent) per annum. The contract further specifies that in identifying these systems, a range of climatic conditions encompassing those in Florida, Minnesota, and Alaska shall be considered and that a minimum of six systems shall be identified for preliminary analysis. Environmental, ecological, and socioeconomic impacts of harvesting shall be addressed.

The current position of this program is that the six (or possibly eight) systems have been identified and are now undergoing evaluation.

Since the Peat Contractors' Conference in May of 1981, visits have been made to a variety of peat harvesting operations, such as those in Finland, Sweden, West Germany, Ireland, Maine, and North Carolina, and to associated manufacturers of harvesting equipment. These visits, other discussions, and engineering analyses have given rise to various conclusions and to the outline designs of the six principal *novel* harvesting systems.

The majority of the rest of this paper will be concerned with the conclusions arrived at and a description of the six "stereotypical" systems and their points of difference and similarity to existing methods and practice.

The principal conclusions, drawn from studying the strengths and drawbacks of existing harvesting systems, listed in Figure 1 are individually unremarkable but collectively provide a framework for considering each approach to harvesting.

*The first statement "that drying is important" would be trivial if it were not the determinant of much that follows. In the absence of a dewatering method, peat has no value as a fuel for direct combustion, and the range of options revealed if peat can be dewatered away from the field by a means other than leaving it lying around in the sun and wind is as great as solar drying is restrictive.*

*The second statement underlines the first and implies that "in quantities referred to" nonsolar drying could radically extend the geographical area suited to fuel peat production.*

To state that dry peat is not a dense material unless it is compressed is also a mundane statement. It is still worth bearing in mind that at a density of 20 lb/ft<sup>3</sup>, 3 million tons occupies  $3 \times 10^8$  ft<sup>3</sup> or, to put it another way, a silo on a square base measuring 100 ft on a side would have to be 30,000 ft tall to hold a year's uncompacted output.

- **DRYING CONDITIONS CAN DETERMINE HARVESTING METHOD**
- **NON-SOLAR DRYING MAY BE CRITICAL IN NORTH**
- **3M TONS/YEAR REPRESENTS A LARGE VOLUME**
- **CUTTING TIMBER IS BETTER THAN SORTING IT**
- **MIXING HORIZONTAL LAYERS IMPROVES CONSISTENCY**
- **TRANSPORTATION OFF THE FIELD MAY BE A BOTTLENECK**

Figure 1  
Principal Conclusions Regarding Existing Harvesting System.

First Colony Farms have come to two significant conclusions concerning their extreme fossil timber problem:

1. It is much easier to cut it than remove it before harvesting even if equipment must be suitably upgraded
2. The consequence of this to the calorific value of the fuel peat is negligible.

The conclusion is totally in agreement with practice in other industries where "soft" minerals are extracted and equipment is sized to deal with the occasional rock or other inclusion.

In Ireland, where 700,000 tons of milled peat are burned annually, representatives of the "consumer," the Irish Electricity Supply Board, stressed the difficulties caused by variation in quality of what was regarded by them as a somewhat marginal fuel -- milled peat. This variation, a result of the horizontal nature of milled peat production, necessitated the use of extensive blending facilities. This problem does not apply to sod harvesting methods that mix peat from different horizons.

The harvesting of 3 million tons per year represents a scale up of an order of magnitude over all but the largest current operation. On a 4000-hr year, 600 ft<sup>3</sup> (22 yd<sup>3</sup>) of peat must be loaded and transported every minute. This fact suggests that continuous or permanent way haulage may be indicated.

The time taken for peat to air dry on the field determines the area required for a given production volume or inversely the production that can be obtained from a given area. Table 1 illustrates this point for the three states mentioned earlier. The drying time figures mentioned are based upon experience in equivalent climates and are open to argument. The figures for area make no allowance for roadways, turning grounds, ditches, etc.

The above represents some of the constraints under which harvesting systems must be assessed and which were taken into account in defining harvesting systems.

The other principal inputs were the mechanical features of existing and conceptual types of equipment.

It became apparent at an early stage that apart from the wet and dry harvesting modes referred to above the systems did not arrange themselves neatly into a convenient number of sets and therefore in some cases the distribution of features in the six systems derived is arbitrary.

TABLE 1  
PRESUMED HARVESTING CONDITIONS.

	FLORIDA	MINNESOTA	ALASKA
<b>SOD CYCLE (DAYS)</b>	10 TO 14	30 TO 40	60
<b>CYCLES/YEAR</b>	25 TO 30	2 TO 3	1 TO 2
<b>MILLING CYCLE (DAYS)</b>	1 TO 2	3	10
<b>CYCLES/YEAR</b>	100	15 TO 20	3 TO 4
<b>RELATIVE PRODUCTION AREA (ACRES)</b>	2,000	8,000	42,000
<b>FEASIBILITY OF DRY HARVESTING OF 3M TONS/YEAR</b>	GOOD	MARGINAL	POOR
<b>NOTE: ABOVE FIGURES ARE ENGINEERING ESTIMATES TO ILLUSTRATE RELATIVE HARVESTING AREAS REQUIRED.</b>			

Table 2 indicates what these features are and shows how they were distributed among the six systems. The rest of this paper will be devoted to the description and illustration of these methods and systems.

	Methods	System
Dry Harvesting	<ul style="list-style-type: none"> <li>• Improved milling</li> <li>• Deep milling</li> <li>• Improved sod harvesting</li> </ul>	<ul style="list-style-type: none"> <li>• Conventional tractor based harvesting</li> <li>• Bridge harvester</li> <li>• Deep miller</li> <li>• Sod extruder</li> <li>• Improved bagger</li> </ul>
Wet Harvesting	<ul style="list-style-type: none"> <li>• Full face continuous harvesting</li> <li>• Full face cyclic harvesting</li> <li>• Hydraulic harvesting</li> </ul>	<ul style="list-style-type: none"> <li>• Bucket wheel excavator</li> <li>• LGP hydraulic excavator</li> <li>• Slurry barge</li> </ul>

**TABLE 2  
PEAT HARVESTING DESIGN FEATURES.**

DESIGN FEATURE	SYSTEM NUMBER					
VACUUM HARVESTING	1					
BRIDGE STRUCTURES	1	2				
CONVENTIONAL MILLING HEADS	1					
DEEP MILLING		2				
SOD EXTRUDERS			3			
DITCHING ATTACHMENTS	1			4		
HAULAGE/GUIDEWAYS	1					
PNEUMATIC HAULAGE					NOT USED	
SLURRY HAULAGE						6
BUCKET WHEEL EXCAVATORS				4		
HYDRAULIC EXCAVATORS					5	
DREDGING BARGE						6
VERY LPG SUPPORTS					5	
SHIFTABLE CONVEYORS				4	5	
CONTINUOUS HAULAGE		2			5	

The first three systems are for essentially dry harvesting though, in practice, deep milling will require that the product be removed from the field at something over 50 weight percent. These have the following features.

#### Dry Harvesting

Improved Milling	Deep Milling	Improved Sod
• Bridge structure	• LGP miller	• Improved bagger
• Vacuum pickup	• Loading bridge	• Full bog utilization
• Railcar haulage	• Railcar haulage	

The remaining three systems are wet harvesting systems in which material is removed from the field at or above 90 percent water.

#### Wet Harvesting

Full Face Continuous	Full Face Cyclic	Hydraulic Harvesting
• Bucket wheel excavator	• Large hydraulic excavator	• Barge-mounted dredge
• Shiftable conveyor	• Bog foot LGP support	• Surge tank
• Support on mineral layer	• Shiftable conveyor	• Improved slurry injector

The first of the systems was identified as *improved milling* and was conceived to be based upon a bridge structure that carries milling, vacuum harvesting, and ditch maintaining implements, and that loads onto a railcar haulage system (Figure 2).

The bridge itself will be supported at one end on low ground pressure (LGP) tracks on a berm and at the delivery end by rubber tires supported and guided by extensions to the haulage way. The potential advantages of such a system are as follows:

- Great ease of maintenance of field profile
- Noncyclic harvesting

- Low labor costs
- Continuous haulage
- Little compaction of peat harvesting area.

The only part of the milled peat production cycle not accommodated is harrowing, which will take place independently.

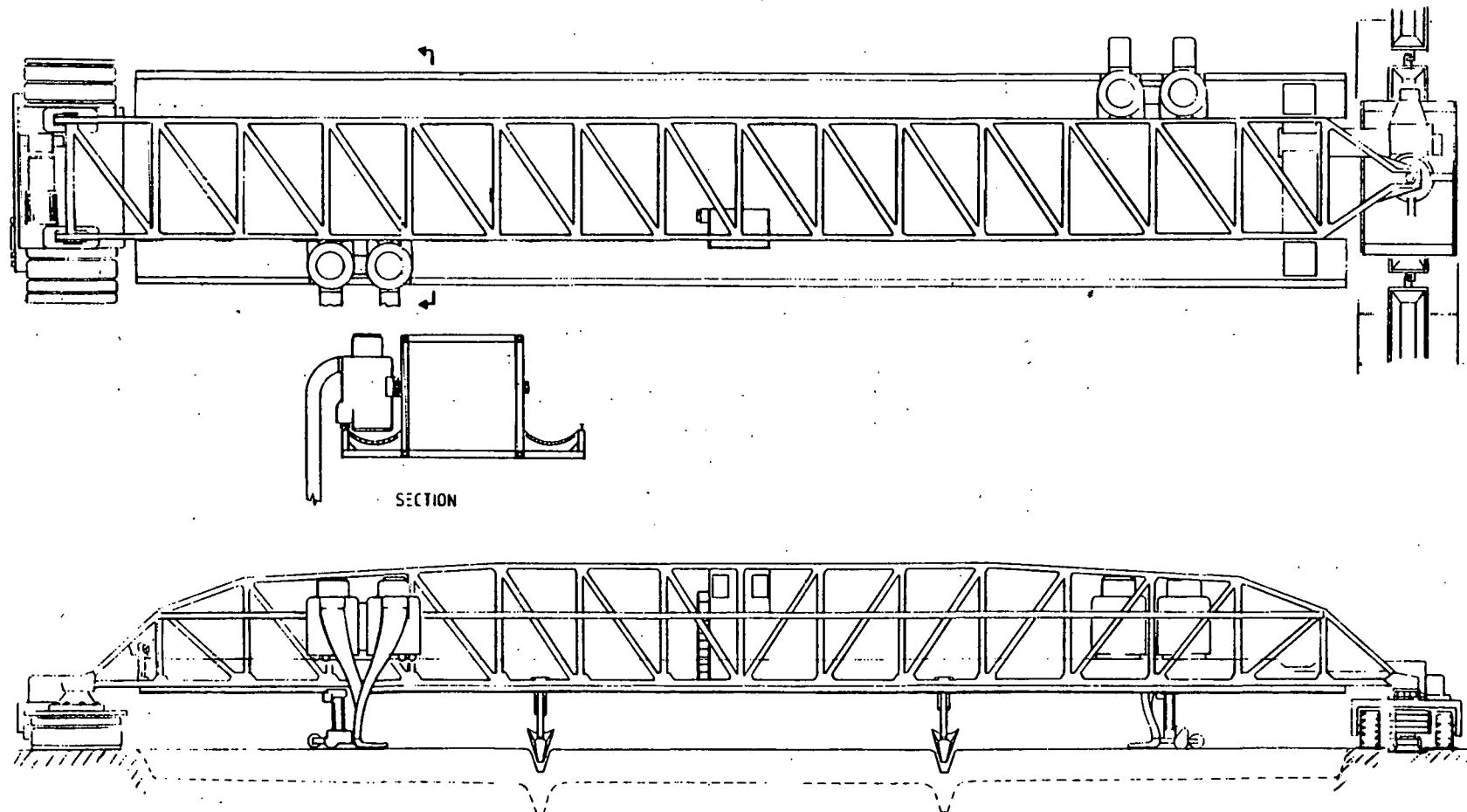
Figure 3 shows an overall view of the proposed system. The use of vacuum pickup is implied by this system and it is worth noting the success of the large harvester built by Down East Peat Co. (Figure 4), which loads 100 tons over a width of 54 ft.

Engineering analysis has been applied to the bridge structure and, given the live and static loads to be applied, a 200 to 300 ft truss could be built of standard materials such as 50,000 lb/in.<sup>2</sup> steel. A 400-ft bridge is possible if aluminum is used and no expense spared.

Table 3 shows some of the numbers that will be assumed in analysis of the feasibility of this system. The conventional tractor/base unit system will be used as a baseline.

Deep milling is a subject that means different things to different people. Figure 5 shows a system based upon a dedicated unit capable of milling to a depth of 1 ft over a width of 60 ft. In this it resembles the equipment employed for subbase preparation on multilane highway construction. The removal of the peat from the field is accomplished by what we have termed a nutcracker bridge conveyor with a lateral displacement of up to 600 ft. This requires that railway track be laid at intervals of 1200 ft.

The product from such a milling operation would not be field dried, though it might be in the range of 65 to 75 weight percent water if conditions such as those at First Colony Farms (FCF) prevailed.



**Figure 2**  
**Bridge Harvester Elevation.**

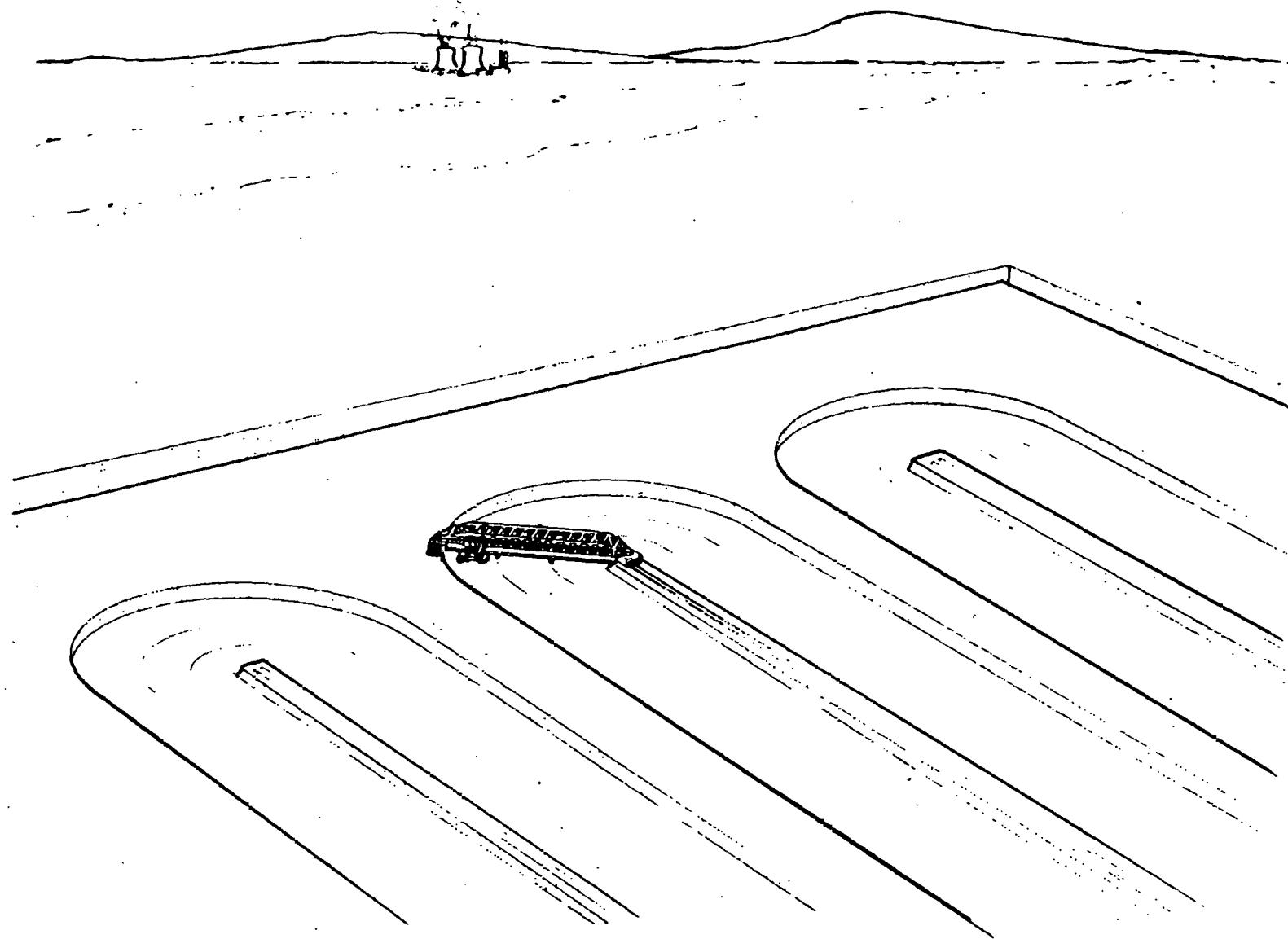


Figure 3  
Bridge Harvesting System.

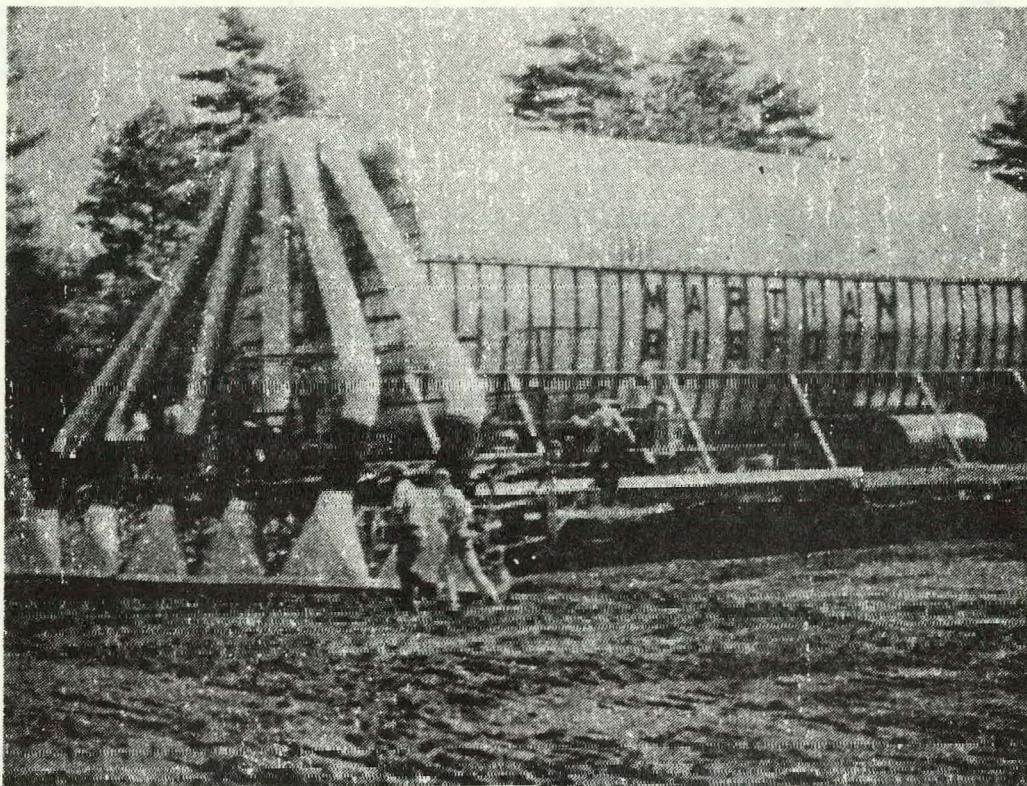
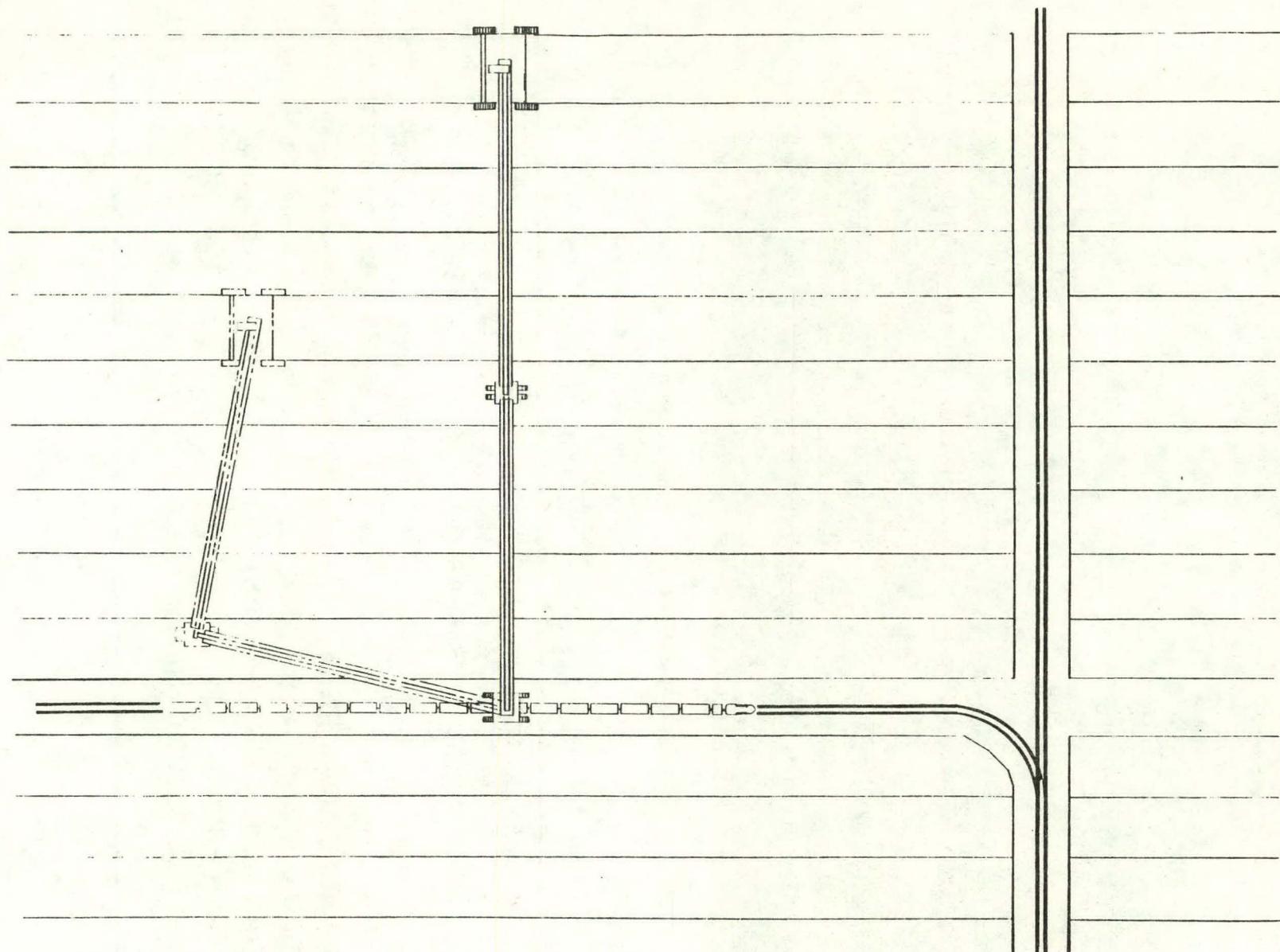


Figure 4  
Down East Peat Co.'s — "Martian Bigfoot."

TABLE 3  
BASELINE PARAMETERS FOR IMPROVED MILLING.

3M TONS/YEAR  $\equiv$   $4 \times 10^8$  FT<sup>3</sup> IN SITU  
200 HARVEST DAYS/YEAR: 20 HR/DAY: 3 DAYS/CYCLE

	BRIDGE SYSTEM	TRACTOR BASE SYSTEM
NUMBER OF MACHINES	6	11
SPEED OF ADVANCE (FT/MIN)	17	137
ADVANCE/MACHINE/HARVEST (FT)	61,000	500,000
AREA IN PRODUCTION	$72\text{M FT}^2 \equiv 1650$ ACRES	
RAIL REQUIREMENTS (MI)	16	2



**Figure 5**  
**Deep Milling System.**

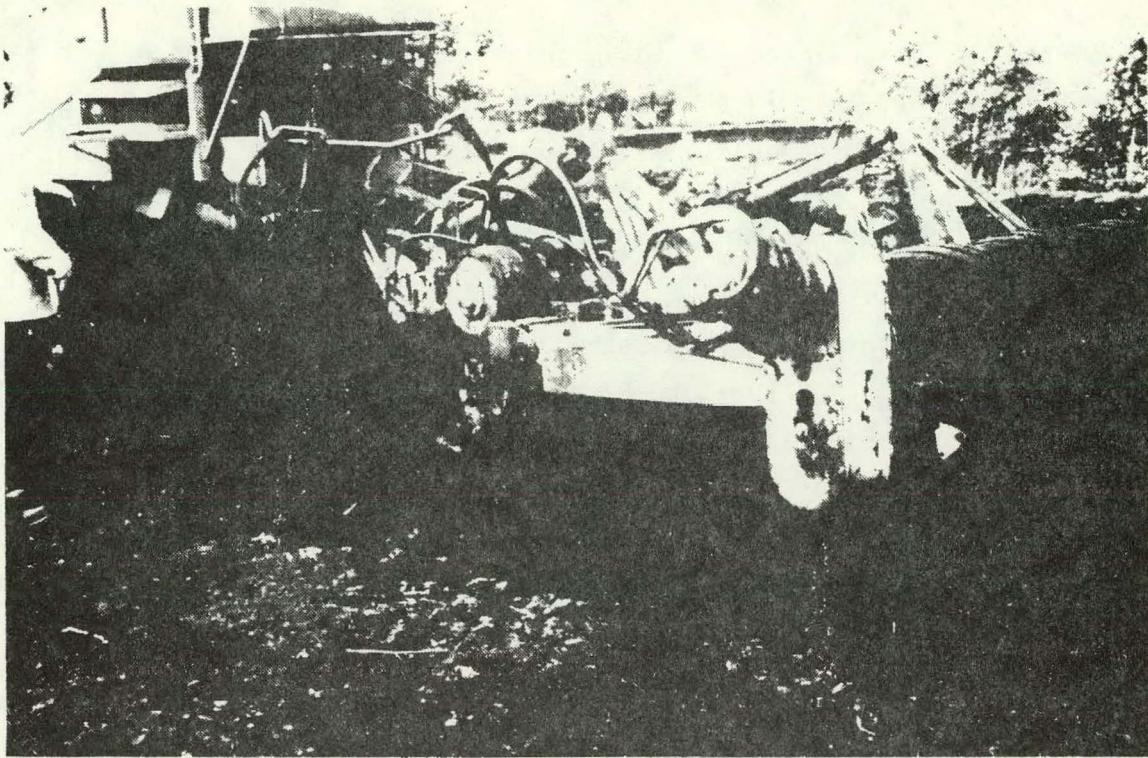


Figure 6  
Svenska Torv AB — Deep Miller.

TABLE 4  
BASELINE PARAMETERS FOR DEEP MILLING.

3M TONS/YEAR =  $3 \times 10^8$  FT<sup>3</sup> IN SITU  
200 HARVEST DAYS/YEAR: 20 HR/DAY: 20 DAYS/CYCLE

NUMBER OF MACHINES	4
ADVANCE/MACHINE/YEAR	125,000 FT
MACHINE SPEED	5.2 FT/MIN
MACHINE OUTPUT	310 FT <sup>3</sup> /MIN
HARVEST AREA	1.1 MILES <sup>2</sup>
RAIL REQUIREMENT	6 MILES
TIME TO FILL 1500 FT <sup>3</sup> RAILCAR	2 MIN

Figure 6 shows a current deep milling machine employed in Sweden and manufactured by Svenska Törv AB. In this case, a width of 8 ft and a depth of 40 cm (16 in.) is milled and recompacted in preparation for production milling.

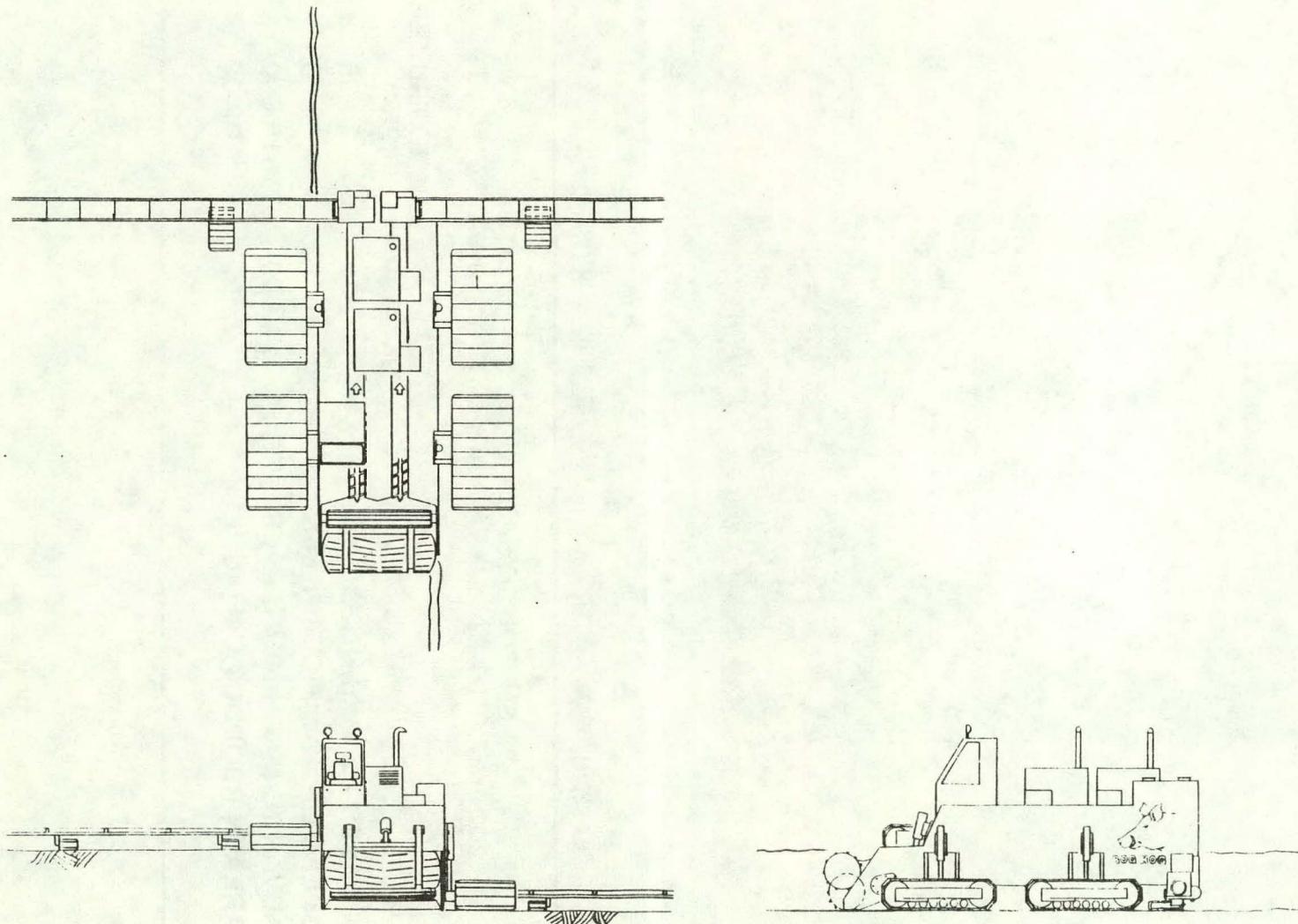
The basic parameters of such an operation are shown in Table 4.

Sod harvesting is also an existing method of production, there being two different approaches, that of the Bord Na Mona that employs machines referred to as "baggars" and the Finnish technology that will referred to as saw extrusion, which has been employed by FCF. These methods are similar in that sods are left to air dry on the field but differ in that the Irish/German systems extracts to nearly full depth in a single pass while the saw extruder is a multipass machine that depletes the field by 1 to 2 in. per pass.

For the purposes of this study an improved bagger will be compared with the state-of-the-art saw extruders. The improvements conceived for the bagger (Figure 7) are principally concerned with output. It is assumed that an extrusion rate equivalent to the saw extruder can be maintained, although current machines achieve only a third of this rate (about 10 ton/hr). The other improvement required will be the utilization of the full field width for sod drying. At present the standard bagger boom (Figure 8) is 54m (177 ft) long with field width of approximately twice this. This arrangement is required since the bagger spreads sods on either the high or low bog and therefore only at the beginning or end of the life of a field is anything like the full bog width available for sod drying. It is not difficult to conceive of a machine in which the spreader conveyor covered both the high and low bog and allowed full use of the most precious resource on a dry harvesting operation -- drying area.

Table 5 contains the baseline parameters that will be used to determine the effectiveness of both the improved bagger and the saw extruder.

The harvesting systems described above are all aimed at removal of the product from the field in dry or semidry condition. The methods that are described below all presuppose that a means exists for dewatering or conversion off the bog.



**Figure 7**  
**Improved Bagger System.**

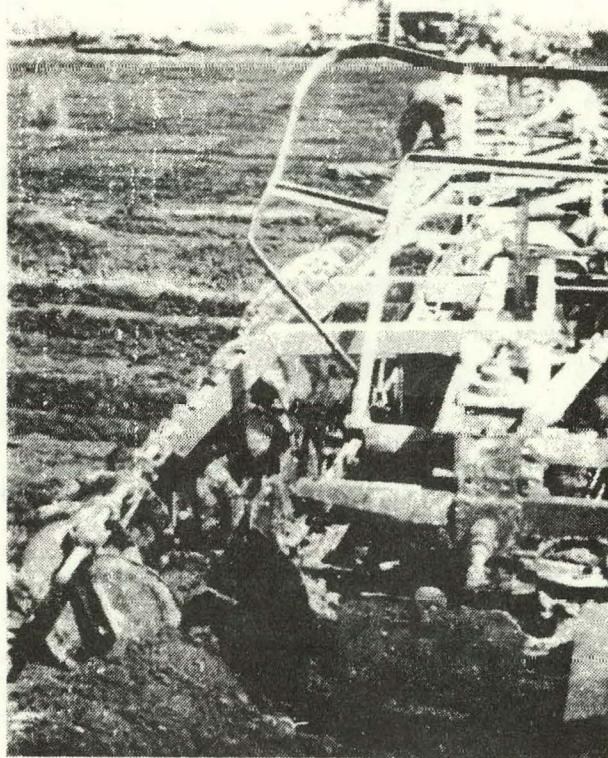


Figure 8  
Bord Na Mona Bagger.

TABLE 5  
BASELINE PARAMETERS FOR IMPROVED SOD HARVESTING.

3M TONS/YEAR = 5 X 3 FT<sup>3</sup> IN SITU  
200 HARVEST DAYS/YEAR: 20 HR/DAY: 10 DAYS/CYCLE

	'BAGGER'	SAW-EXTRUDER (PK4)
NUMBER OF MACHINES	36	36
SPEED OF ADVANCE (FT/MIN)	1.2	68
ADVANCE/MACHINE/HARVEST (FT)	14,000	816,000
AREA IN PRODUCTION (ACRES)	2,300	3,400

The first of these is an application of a piece of equipment that is well-suited for cutting and removing low strength, relatively homogeneous, material at a steady rate and delivering it onto a continuous haulage system already sized. This item is the *bucket wheel excavator* and an analysis has been made of the use of one of the smaller track-mounted units (Figure 9). This unit has a bucket diameter of almost 15 ft and a loading conveyor that can be directed independently of the cutting boom. The projected system would employ a shiftable conveyor on the highwall and place the excavator on the mineral soil (Figure 10). The feasibility of this operation would depend upon the strength and permeability of the mineral soil and the degree to which it could be dewatered.

One feature of this layout is that given the ability of the excavator to cut the organic, transition, and mineral layers selectively and to deliver the cut material to different locations it may be possible to use the excavator to cut and mix the transition and mineral layers and to discharge this improved "soon to be topsoil" away from the highwall. Table 6 shows the operating parameters assumed.

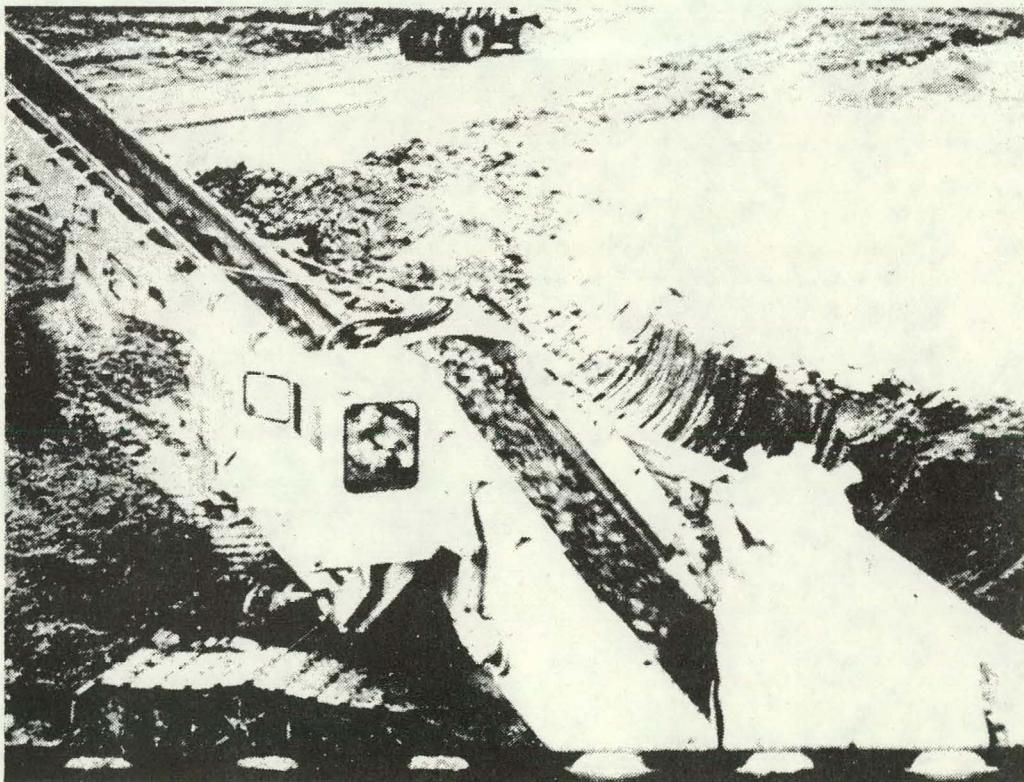
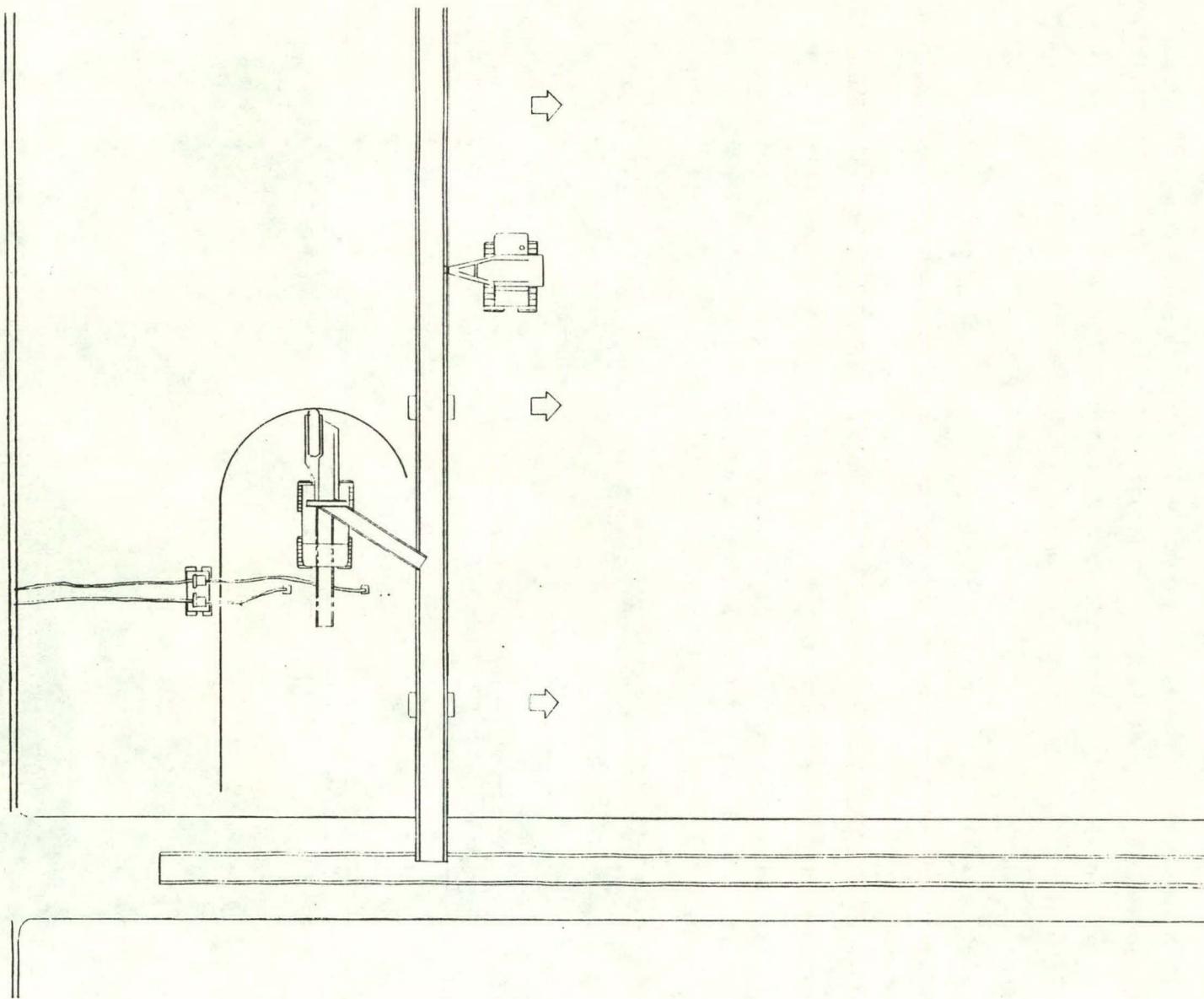


Figure 9  
Bucket Wheel Excavator — M.X. Inc.



**Figure 10**  
**Bucket Wheel Excavator Harvesting System.**

TABLE 6  
BASELINE PARAMETERS FOR FULL FACE CONTINUOUS HARVESTING.

3M TONS/YEAR  $\equiv$   $5 \times 10^8$  FT<sup>3</sup> IN SITU  
200 HARVEST DAYS/YEAR: 20 HR/DAY: 10 FT BOG DEPTH:  
PERMEABLE MINERAL SOIL

TYPICAL SMALL BWE

MX INC TYPE 750

WHEEL DIAMETER 14 FT 8 IN.

EFFECTIVE OUTPUT 27,000 FT<sup>3</sup>/HR

NUMBER REQUIRED 5

ADVANCE RATE 100 FT/HR/MACHINE

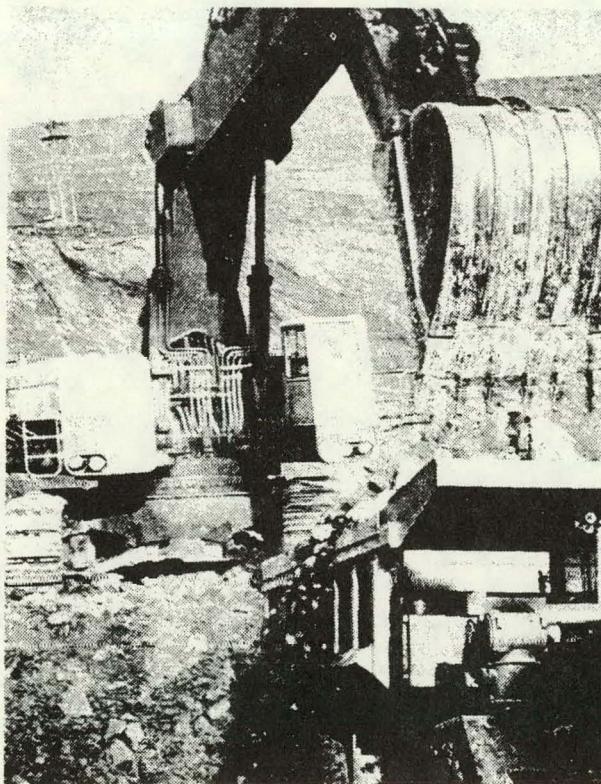
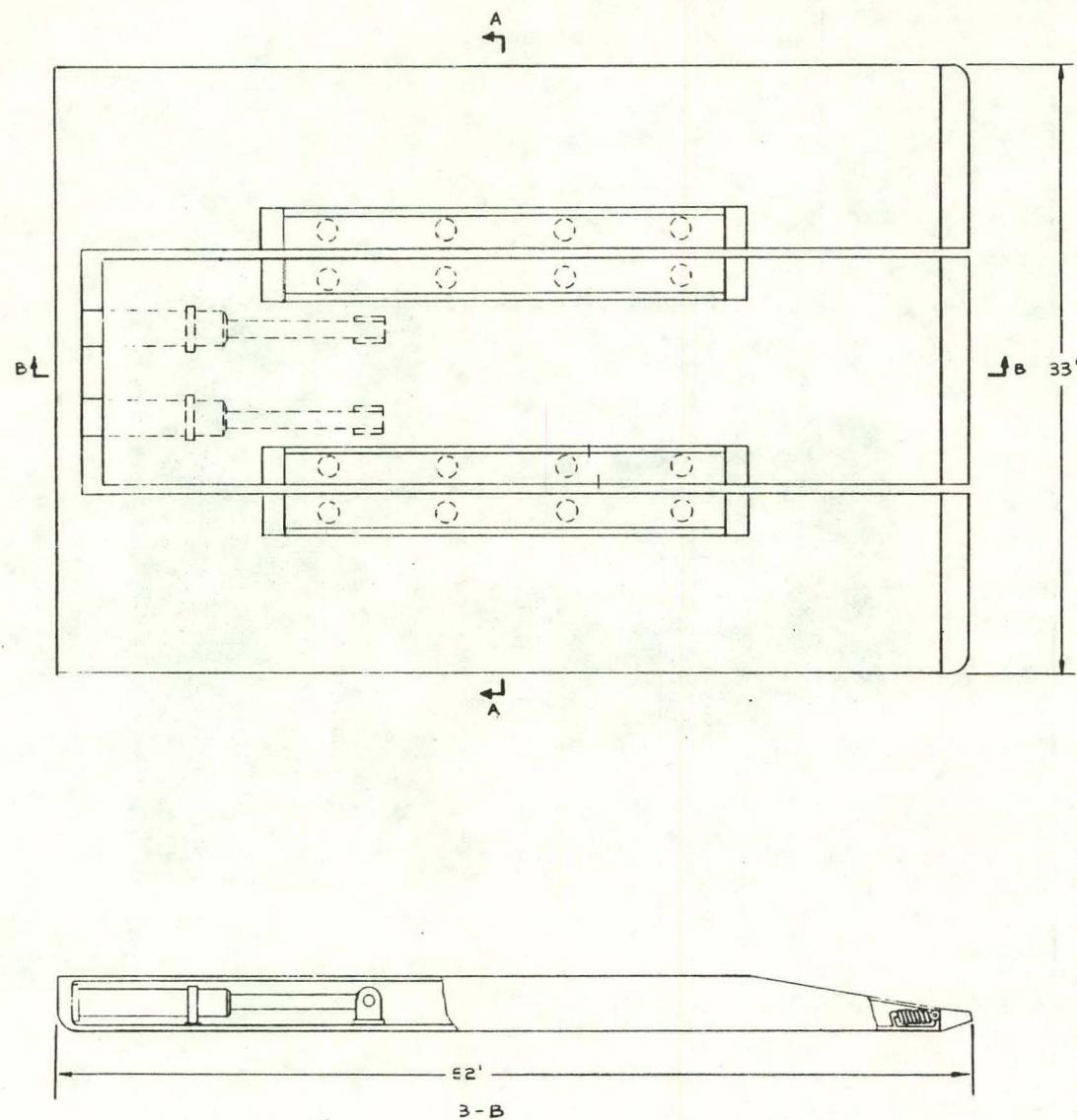


Figure 11  
Poclain Excavator.



**Figure 12**  
"Bog Foot" LGP Support.

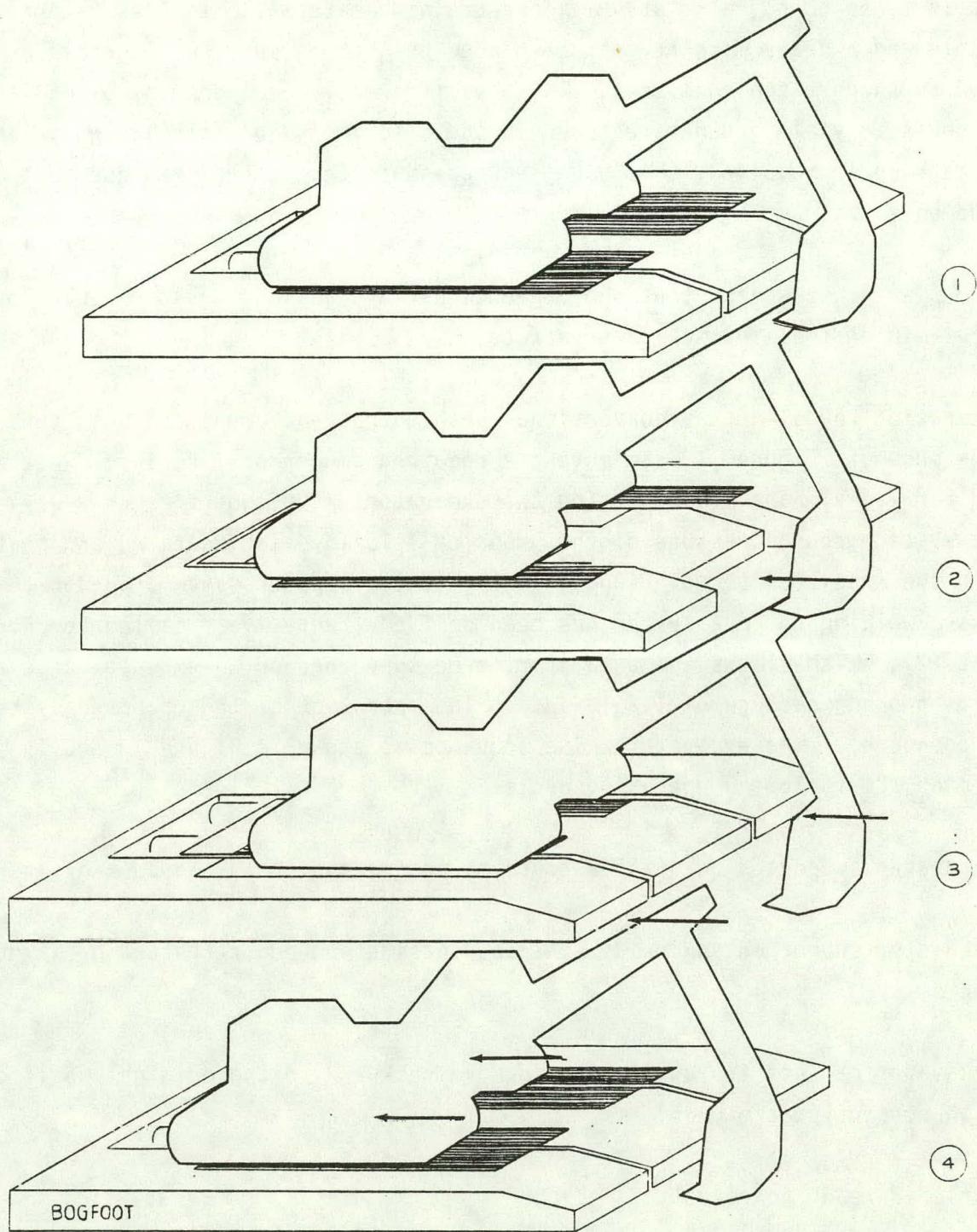


Figure 13  
"Bog Foot" Operating Cycle.

The problem of ground support is addressed above by placing the machine on what is, it is to be hoped, a relatively free-draining material. If this is not available and a heavy machine must be placed on the bog surface, other means must be used to support the equipment. This has frequently been done by extending track shoes to yield ground pressures in the 5 to 10 lb/in.<sup>2</sup> range, though if a heavy machine is involved, this usually represents the lower limit due to spatial requirements.

It was apparent, however, that the conventional hydraulic excavator represented a useful mining tool for wet peat extraction.

Consideration revealed that conventional high-output equipment, such as the machine shown in Figure 11, can move the required amount of material. What was called for was a means of supporting the excavator on the bog in such a way that a static ground pressure of the order of 1 lb/in.<sup>2</sup> is generated and that allowed the excavator to move independently of its support system. Under this impetus a walking support system has been derived (tentatively called Bog Foot) (Figure 12), which allows the excavator to be supported on an extended area at a very low ground pressure of 1.2 lb/in.<sup>2</sup>. The operation of the proposed system is independent of the excavator. The sequence is shown in Figure 13 and is based upon the following operating cycle:

1. Excavator supported on outside pontoon, inside pontoon drawn back by jacks
2. Excavator supported on inside pontoon, outside pontoon retracted by same jacks
3. Excavator can use its own tracks to move backward to the original position with respect to the platform
4. Cycle is ready to repeat.

The relationship between the excavator, support pad and continuous haulage is shown in Figure 14. The tracked vehicle is a hopper/lumpbreaker/feed mechanism

to even out variations in feed rate. Table 7 contains the outline of the operating regime assumed.

The drainage requirements for operation of the preceding types of equipment are not nonexistent since any increase in weight-bearing capability that can be achieved by predrainage will result in improved operating conditions for the heavy equipment.

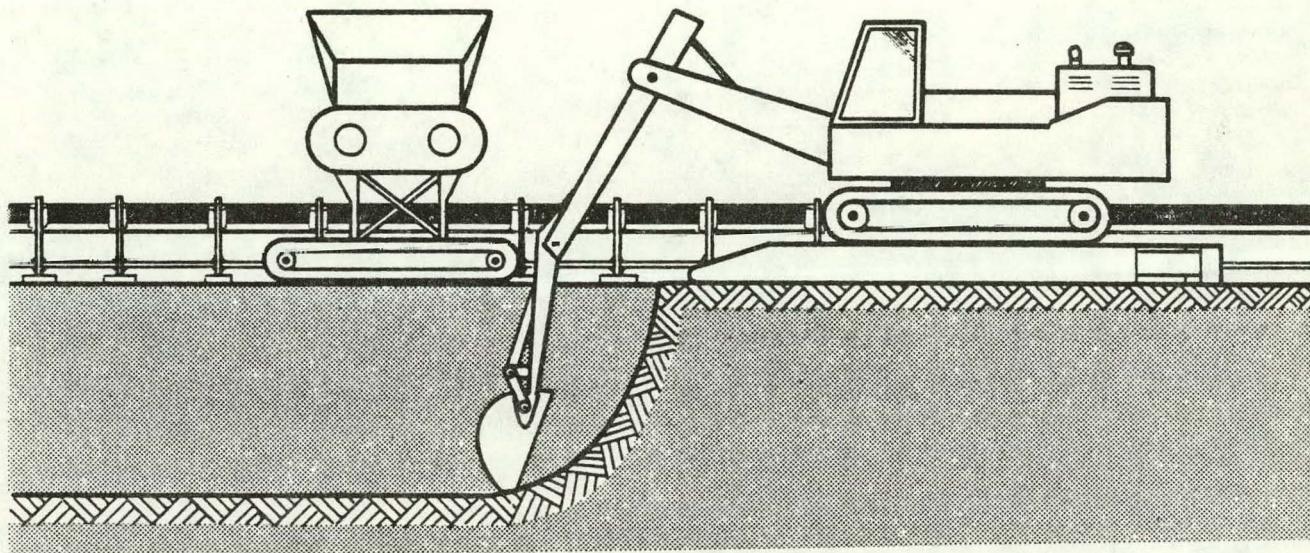


Figure 14  
"Bog Foot" System — Elevation.

The final harvesting scheme may be described as hydraulic rather than merely wet since a barge is employed in flooded portions of an undrained bog. The use of dredging barges on undrained bog and the transport of peat slurry 1 or 2 mi has been achieved by a number of operations, the most notable being Western Peat Moss. The principal unknown, however, is whether the performance of the

overall system can be improved through reducing the quantity of water that makes the round trip and the amount of fine peat returned to the bog. The quantities of material involved also raise questions concerning the pipe diameters required and the horsepower required to propel the peat.

In this application a standard dredging barge, fitted with a large surge tank/peat hopper, is used. As a refinement of normal practice it is suggested that the slurry be formed and pumped by a two-rotor injector such as that which FMA has developed for coal slurry handling. This device, with two moving parts, consists of a helical feed screw and a relatively conventional pump. These two units are driven independently so that, with suitable monitoring of the quantity of solids in the output, a relatively constant percentage peat slurry can be pumped by varying the relative speed of the injector screw with respect to the pump.

**TABLE 7  
BASELINE PARAMETERS FOR FULL FACE CYCLIC HARVESTING.**

**3M TONS =  $5 \times 10^8$  FT<sup>3</sup> IN SITU  
200 HARVEST DAYS/YEAR: 20 HR/DAY: 10 FT BOG DEPTH:**

- HYDRAULIC EXCAVATOR WITH 15 YD<sup>3</sup> BUCKET ON LGP SUPPORTS (BOG FOOT)
- WITH 50 SEC CYCLE, OUTPUT = 30,000 FT/HR
- FOUR UNITS REQUIRED
- ADVANCE RATE (40 FT WIDE CUT) = 73 FT/HR
- UNIT WEIGHT = 290,000 LB STATIC GROUND PRESSURE 1.2 LB/IN<sup>2</sup>  
FOOT PRINT = 50 X 33 FT, NEUTRAL BUOYANCY

In order to economically transport the quantity of peat involved at a 2.75 dry weight percent, four 30-in. diam pipes will be required for a system throughput of 1.8 billion ft<sup>3</sup>. Return pipes will also be required. The overall operating regime is summarized in Table 8.

The above represents a necessarily brief review of FMA's activity in assessing harvesting systems. It is by no means complete, since the practical and economic evaluations of each system have only just begun.

**TABLE 8  
BASELINE PARAMETERS FOR HYDRAULIC HARVESTING.**

**3M TONS  $\equiv 10 \times 10^8 \text{ FT}^3$  IN SITU  
300 HARVEST DAYS/YEAR: 20 HR/DAY: 10 FT BOG DEPTH**

- DREDGING BARGE WITH IMPROVED SLURRY INJECTOR
- SLURRY 2.75 PERCENT DRY WT  $= 18 \times 10^8 \text{ FT}^3/\text{YEAR}$
- PUMPED VOLUME:  $1.8 \times 10^9 \text{ FT}^3$   $= 5,000 \text{ FT}^3/\text{MIN}$   
 $= 38,000 \text{ GAL/MIN}$
- RECOMMENDED SYSTEM:  
30-IN. DIAM PIPE; FOUR PIPELINES REQUIRED; MEAN  
FLOW VEL (FT/SEC) - 4.5; FLOW RATE (GAL/MIN/LINE) -  
10,900; PRESSURE DROP (LB/IN.) - 15; PUMP HP (TOTAL) - 350.

If some of these systems seem unduly complicated, it should be understood that the basic, almost traditional, methods of milled and sod peat harvesting may prevail where solar drying is employed. It is also true that the large amounts of money being spent to develop methods of drying wet peat will radically increase the scope of options for the use of partially dry and wet peat. The competition is oil at \$4 to \$5 per million Btus and coal that may be produced at closer to \$2 per million Btus and that comes from a mine that requires \$30 to \$60 million investment prior to production. In Ireland, the Bord Na Mona sells 50 weight percent to the Electricity Supply Board at \$1.50 per million Btus and retails briquettes in supermarkets for 0.5 Irish pounds for two stones or about \$2.50 per million Btus.

## QUESTIONS AND ANSWERS

Q: When will your study be done?

A: We have until I believe next March to come up with the final report. So, if invited, we'll make the next six months conference.

Q: For hydraulic harvesting you show 300 harvest days per year. For what type of region is this figure applicable?

A: For the hydraulic harvesting, one would have to assume that it is a place where you were not suffering from freezing up off the bog to any significant extent.

Q: You made an assumption but based on what kind of a climate? Finland, Alaska, North Carolina?

A: It would have to be somewhere south of Finland. The numbers used for harvest days per year are very flexible at the moment. They're just constants that are put in. If I used 300 rather than 200, it was a fairly arbitrary choice and the flow rates would be adjusted accordingly.

**COMMENT:** In a recent study that was done by M.W. Kellogg, they used 8 months as the probable harvesting time that one could expect.

**REPLY:** That would be somewhere between 200 and 300 days, so I think that would probably have been a better figure.

## QUESTIONS AND ANSWERS

Q: Will you be doing some kind of sensitivity analysis to the number of harvesting days, if, instead of 300, you can only get 200 and 250? What would be the impact of that on the cost of the peat or on the selection of the system?

A: I think that will fall out of looking at the utility of each of the harvesting systems in each of the three stereotype climates. Now it's probable that some of them won't fly at all in some climates but that will certainly come out of that study.

Q: What depth of peat bog were you assuming that that cutter head dredge would be operating in?

A: I don't believe I made any assumptions about the depth of the peat.

Q: So you're assuming that you have sufficient depth to operate that unit?

A: Indeed, that's correct.

Q: In reference to the deep mill system that you proposed, where you would use a deep miller and pick up the peat at whatever point the content exists, what depth of peat would you be picking up with that system?

A: The figures have been calculated using a 40-centimeter depth, which is about 16 inches.

Q: What moisture content by going that depth would you expect? I know it's the function of the surface.

A: I believe the moisture content is something like 65% by weight.

## QUESTIONS AND ANSWERS

Q: What kind of moisture gradient exists when you get down from the surface?

A: This I could not tell you. I've been looking at the gross results of people who've been extracting columns of peat.

**COMMENT:** You would get an integrated average of the moisture content of the peat from the surface down to the depth where you extract it, this would be very interesting to know.

**REPLY:** You would indeed have some kind of control over your humidity by adjusting the depth over which you integrated. In wet conditions you could reduce it.

**AN UPDATE OF THE SOCIOECONOMIC ISSUES  
ASSOCIATED WITH THE USE OF PEAT  
AS AN ENERGY RESOURCE**

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About two years ago, Radian Corporation started a study entitled The Socioeconomic Issues Associated with the Utilization of Peat as an Energy Resource. We have completed that study and it's been published. I will briefly overview what we did in that study and then cover recent findings and situations that have developed with respect to socioeconomic issues that are pertinent to peat development.

In the study three levels of development of peat were considered:

- Large Scale Gasification
- Medium Level Development - about the magnitude of a 60 megawatt steam electric generating station
- Small Scale Development - approximately the size of a one megawatt facility

We then analyzed the social and economic consequences of these scales of development on the peat regions of 10 states that were in the peat program at the time and identified four general types of issues in the socioeconomic realm that peat developers are going to have to be concerned with:

- Growth-related economic issues
- Land use issues
- Social infrastructure issues
- Quality of life issues

It is readily apparent that the impact on any region is greatest for large-scale development and scales on down to the smaller levels of development.

In the report, a discussion of 30 issues with descriptions of the institutional framework in which they occur were covered. Based on these issues, mitigation strategies were developed to be used as guidelines by the people who will have to deal with these issues. It was found that the issues stay the same from state to state. All the new states are going to have the same, exact issues that the previous 10 states had. The level of development issues is going to be the same. Also in our mitigation strategies, we identified some programs and/or agencies that developers are going to be relying upon to mitigate these

problems. In the update, these programs and agencies were contacted to obtain their current status. This is where some interesting changes were discovered; changes that will have a significant impact on developers. The findings are listed below.

<u>PROGRAM/AGENCY</u>	<u>STATUS</u>
HUD New Communities Development Corporation	Virtually shut down
Community Development Block Grant Assistance	Funding significantly decreased/ States will be asked to administer this program in the future.
Comprehension Planning Assistance	No longer available
Urban Development Action Grants	Still active - future funding is questionable
CETA Program	No funding available for Public service employment/ Some funding available for employment training.
Section 208 (areawide planning)	FY82 funding is 18% below FY81/ Further reductions by FY83/ President may veto entire funding
Section 201 (Water Quality)	In process of eliminating funding
EDA	Not confirmed, but probably has been eliminated
Coastal Zone Management Program	FY82 funding available \$33 MIL/ These funds came out of coastal energy impact programs/ Plans to be phased out in near future
National Action Planning Commission	Program Eliminated
Energy Assistance Program	FY82 funding approx. \$9 MIL/ Plans are to phase out in near future

The implications of these findings are that all energy developers, not just peat developers, are going to have to fund the local assistance programs on their own. From past experience with other synthetic fuel developments, this is a very significant problem, not one to be taken lightly. Future energy developers are going to have to carefully weigh the consequences of these socio-economic costs when considering development of new projects.

## QUESTIONS AND ANSWERS

Q: How are you setting your priorities for funding community impact projects? How will that differ from the old assistance, federal assistance programs?

A: It's going to go to the state and local governments, which are already fiscally strapped. That's what the theory is at least.

Q: Could you give an example of what you're saying is a local assistance program and perhaps an example of a partnership between a private developer and a municipality in funding this local assistance program?

A: Housing programs, for instance, housing assistance programs, 701 planning grants for setting up comprehensive plans. These things are going to be gone in the future so energy developers are going to have to supply, in some of these rural areas, some of the technical assistance to come up with these housing plans in the boomtown syndrome.

It's really the small towns that are affected the most because they have no planning capabilities at all. Larger cities have planning staffs but the small towns have nothing and when they did away with the funding for the Economic Development Districts, the 701 program, that did away with the Council of Governments' main source of funding, which took away regional planning expertise.

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## **SINGLE-STAGE FLUIDIZED-BED GASIFICATION**

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## **BACKGROUND**

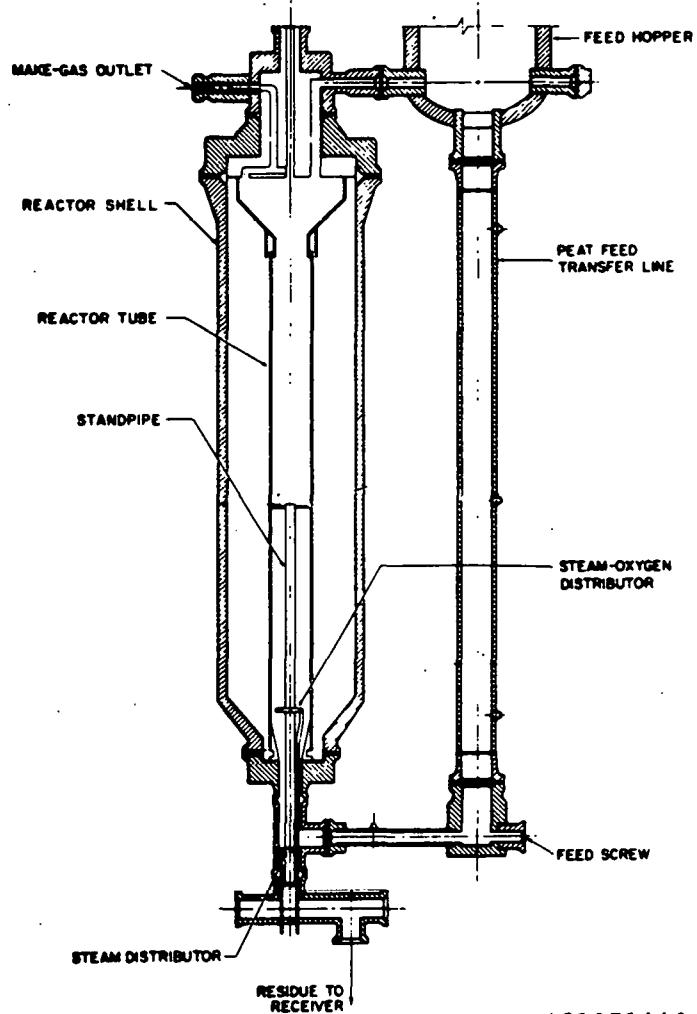
Among other products, peat can be converted to medium-Btu synthesis gas. This gas can be used directly as an industrial fuel or with further processing can be converted to substitute natural gas (SNG), liquid fuels, or chemical feedstocks. The Department of Energy (DOE), Gas Research Institute (GRI), Minnesota Gas Company (Minnegasco), and Northern Natural Gas Company (NNGC) now Internorth, Inc., jointly sponsored the work at the Institute of Gas Technology (IGT) to develop a process for the production of medium-Btu gas from peat. IGT has substantial expertise in the fossil fuel development field and since 1974 has become actively involved with all phases of peat development. The single-stage fluidized-bed gasification process, in addition to being a simple system, maximizes gas production and allows an economic exploitation of small peat deposits.

## **OBJECTIVE**

The objective of this gasification project is to conduct experiments to obtain data for the design of a single-stage fluidized-bed gasifier, and to evaluate the economics of converting peat to synthesis gas and to SNG by this process.

## **TECHNICAL PROGRESS**

An existing high-temperature and high-pressure Process Development Unit (PDU) was modified (Figure 1) to permit the direct feeding of peat to the fluidized bed. Peat flows by gravity from the feed hopper through a 6-inch line to the screw-feeder conveyor. From there, it is fed to the bottom tee section of the reactor and fluidized with nitrogen. Oxygen and steam are fed through a distributing ring into the reactor. Gasification reactions occur in the annulus formed by the reactor tube and a central standpipe. Upon completion of the gasification reactions, peat ash is discharged from the reactor by overflowing into the standpipe and into a solids receiver. All process streams are measured and sampled for data analysis. A detailed description of the equipment has been presented in a previous report.<sup>1</sup>



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**Figure 1**  
**Schematic Diagram of Single-Stage Fluidized-Bed**  
**Peat Gasifier.**

A total of twenty-two tests have been conducted in this unit and detailed results of the first twenty tests have been published.<sup>2</sup> Three peats were tested; Minnesota, Maine and North Carolina. Tables 1 and 2 summarize the operating ranges tested with these three peats and the product yields, respectively. A wide range of operating conditions was tested. Several conclusions can be drawn from the data:

1. No external steam feed is necessary to achieve high carbon conversion. Apparently, sufficient steam was produced for reaction during devolatilization and gasification of peat, and no external steam was fed in subsequent tests.
2. High-moisture content peat (greater than 20%) achieved higher conversion than low-moisture content peat (less than 10%) at moderate reaction temperatures (1550°F to 1650°F), see Figure 2. This difference cannot be explained by the apparent difference in moisture content in the peat feed. The dashed lines account for the amount of carbon that is required to combust with oxygen to produce heat to vaporize all the moisture in the feed peat to the reaction temperatures. It is postulated that in-situ drying of peat improves peat reactivity over that of externally-dried peat, which may undergo cooling and collapsing of pores prior to gasification.
3. Low oil yields, less than 1% of feed carbon, were achieved as expected with the bottom feed operation (see Table 3).
4. High conversion (>90%) of peat can be obtained with relatively mild conditions.
5. No obvious effects of operating pressure on conversion.

The data obtained from these tests are being compared with the existing reaction rate data. Figures 3 through 5 compare experimental versus calculated data on oxygen consumption, carbon oxides yield, and light hydrocarbon gas yield. In this first attempt, the existing model predicted the hydrocarbon gas yields very poorly but oxygen consumption reasonably well.

## **FUTURE**

PDU tests will be completed, and work will continue on developing process concepts. An economic evaluation of the process selected will be conducted.

## **REFERENCES CITED**

1. Pyrcioch, E.J. and Punwani, D.V., "Single-Stage Fluidized-Bed Gasification," presented at the Second Contractors' Conference on Peat, October 16 and 17, 1980, Bethesda, Maryland.
2. DOE Report No. FE 2496-64 through 75, "Experimental Program for the Development of Peat Gasification."

**TABLE 1**  
**REACTOR OPERATING RANGES**

<u>Peat</u>	<u>Minnesota</u>	<u>Maine</u>	<u>North Carolina</u>
Avg. Bed Temp., °F	1514-1768	1612-1690	1667-1682
Pressure, psig	125-529	497-500	124-494
Peat Feed Rate, lb/hr (dry)	18-66	49-65	22-32
Moisture Content, wt %	4.7-24.5	3.4-4.2	25.3-28.3
Steam/Carbon Ratio, mol/mol	0-3.6	0-1.1	0
Superficial Velocity, ft/s	0.6-1.2	0.7	0.7-1.2

**TABLE 2**  
**OPERATING RESULTS**

<u>Peat</u>	<u>Minnesota</u>	<u>Maine</u>	<u>North Carolina</u>
Total Carbon Conv. % feed C	71-91	91-94	73-83
Product Yield, % feed C			
C <sub>1</sub> + C <sub>2</sub>	0.4-10.2	2.2-7.5	2.5-3.6
CO	7.5-42.9	23.7-24.9	23.3-32.9
CO <sub>2</sub>	26.5-86.0	62.3-63.6	54.3-55.1
Benzene	0-4.1	0.6-3.1	0.3-0.9
Oil	0.04-0.76	0.14-0.18	0.12-0.21
H <sub>2</sub> , mol/mol feed C	4.7-37.6	14.5-35.5	24.4-28.3

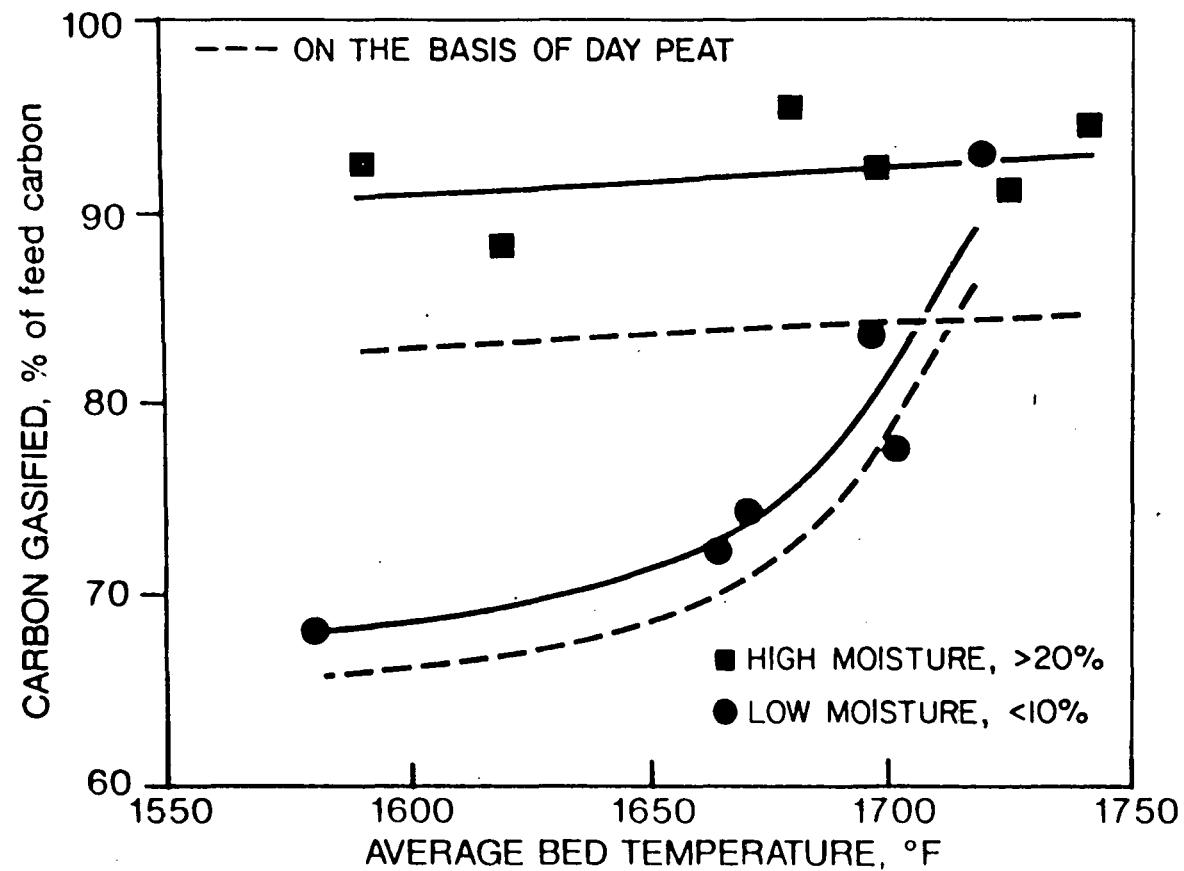
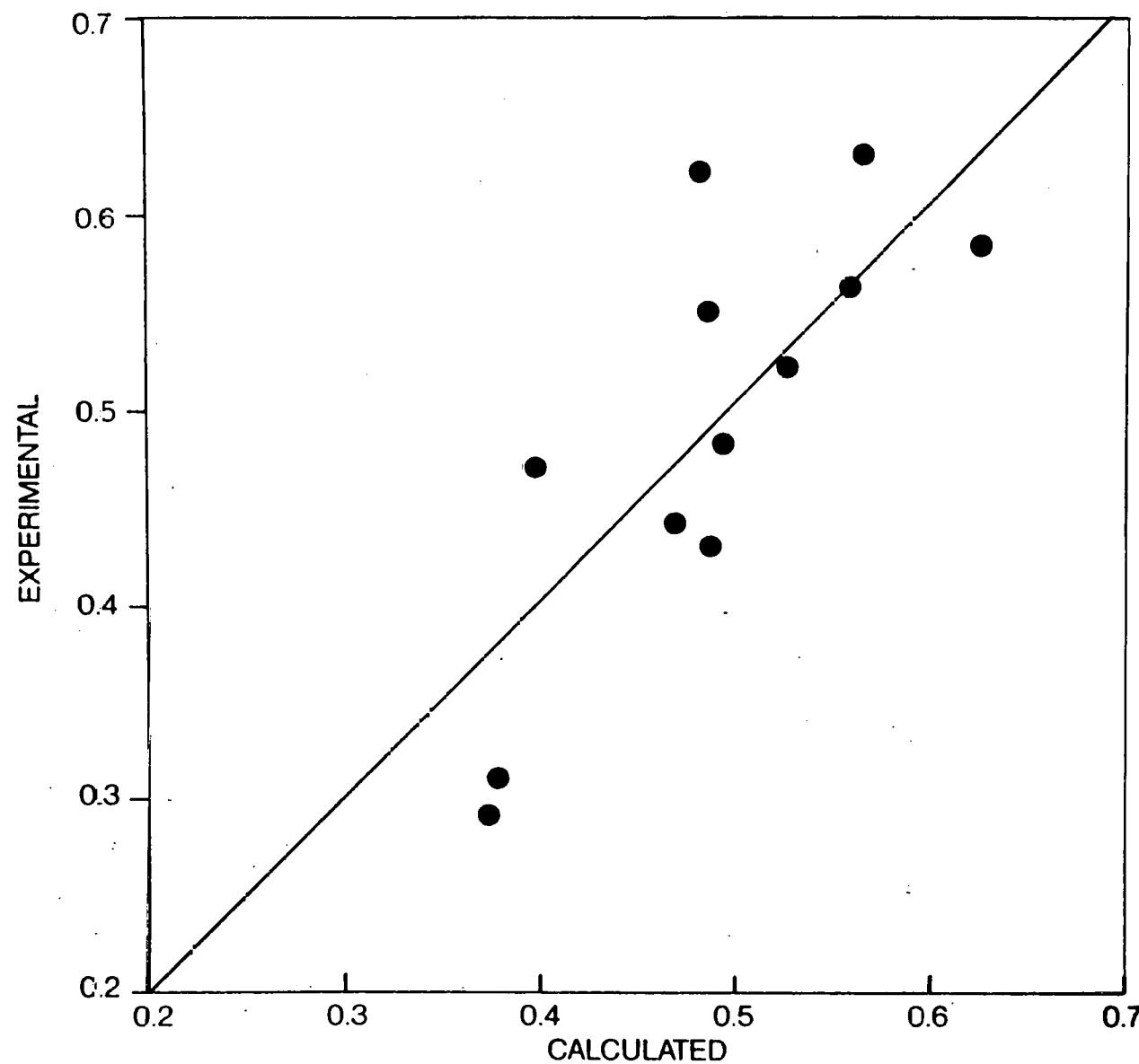


Figure 2  
Carbon Gasified vs. Bed Temperature.



**Figure 3**  
Experimental vs. Calculated Data on Oxygen Consumption.

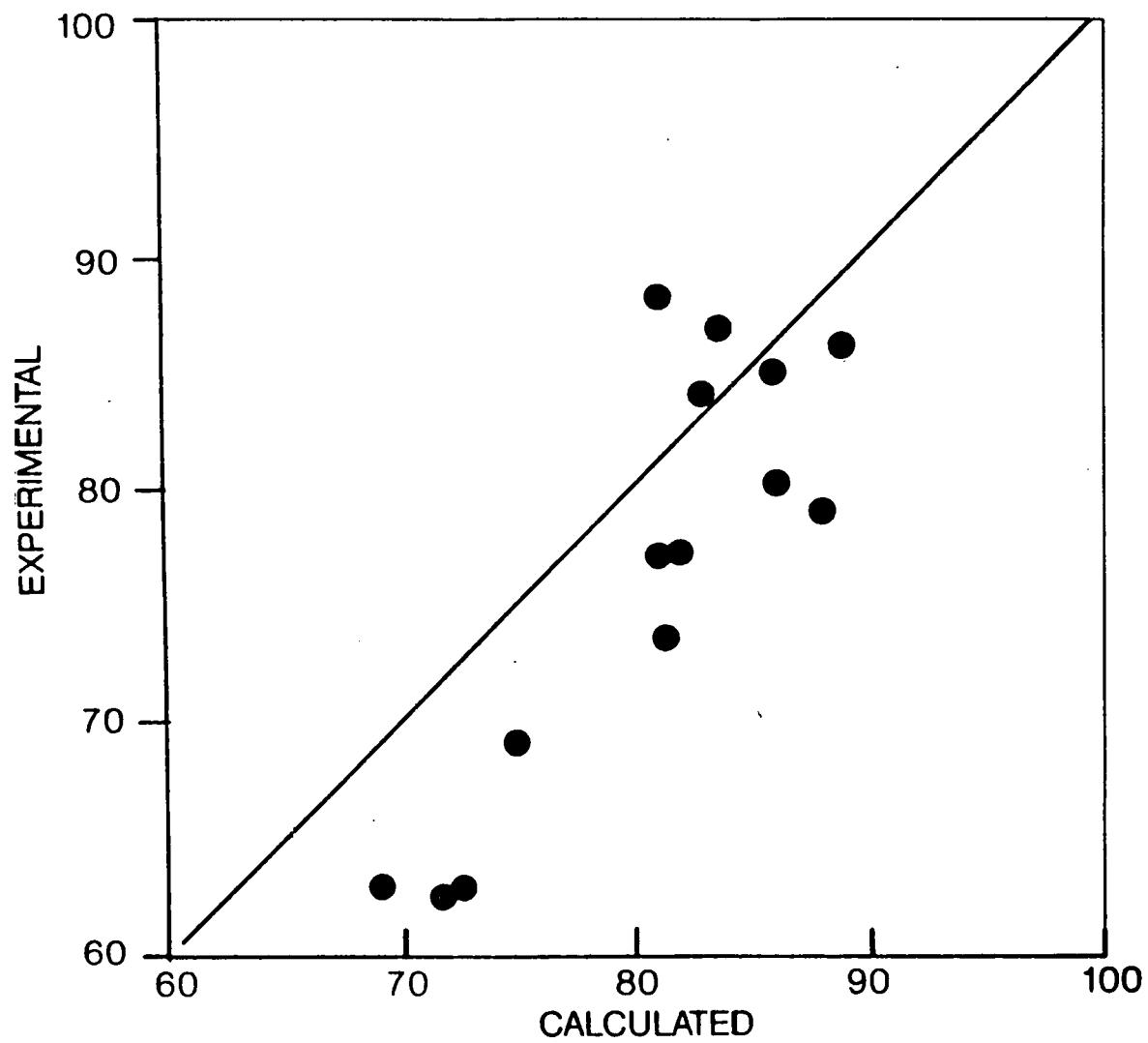


Figure 4  
Experimental vs. Calculated Data on Carbon Oxides Yield.

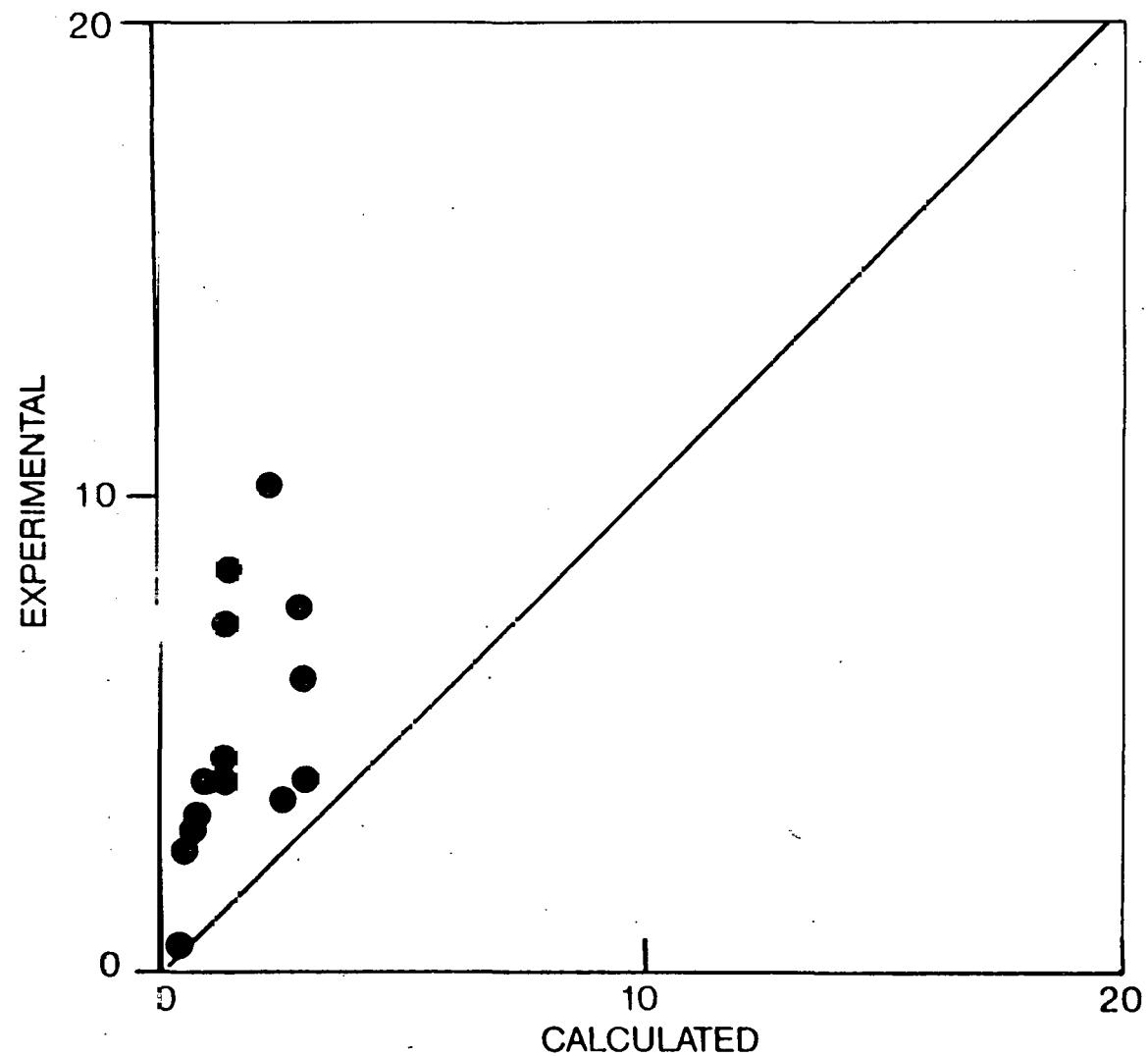


Figure 5  
Experimental vs. Calculated Data on Light Hydrocarbon Gas Yields.

## QUESTIONS AND ANSWERS

Q: Could you elaborate on the difference in looking at the single-stage gasification rather than pilot plant hydrogasification?

A: The single-stage gasification program was initiated to produce low- to medium-Btu gas with a minimum of production of oil; whereas, the two-stage gasification that is presently being developed at IGT in pilot plant scale is to produce an end product of synthesis natural gas with a byproduct of oil.

So we are actually addressing two different markets. We are looking at medium-Btu gas, possibly for chemical feedstock purposes and/or medium-Btu gas applications.

**COMMENT:** (Dr. Punwani): I just want to elaborate a little more. The primary objective of looking at a single-stage gasification system is to develop a simple process that will be more economical at smaller scales of operations. A single-stage process maximizes gas production by minimizing the byproduct, oil.

This is not to say that the byproducts, oils, are not valuable, but in order to make good-quality byproduct oils the two-stage system is relatively more complex and the minimum plant size for which a two-stage system is economical is larger than a single-stage system.

So the objective here was to try to develop a process for making medium-Btu gas which can be upgraded to SNG and it will be economical at smaller scales of production to serve the markets where the economics does not favor installing a 250-million-cubic-foot-per-day SNG plant.

In addition, the site advantages are that the medium-Btu gas can also be used to serve the liquids market via the methanol route, the gasoline,

## QUESTIONS AND ANSWERS

gasoline, the Fischer-Tropsch, or the methanol. And it can also serve the needs of the chemical industry to produce ammonia as a fertilizer.

Q: What was the duration of your test generally?

A: The runs were around 120 minutes. The whole test takes about five hours, including heatup, starting the peat feed, reaching the conditions, and then shutting down.

Q: What about the handling of any ash? How do you deal with that?

A: When the peat is done with the gasification reactions, it overflows into a center drawoff standpipe and is removed through the bottom into a receiver; these are sampled and measured.

**SELECTION OF A CONCEPTUAL  
HARVESTING-DEWATERING SYSTEM  
FOR MINNESOTA PEAT**

AL RADAR  
PAUL TOMICZEK

MINNESOTA GAS COMPANY  
MINNEAPOLIS, MINNESOTA

DRAVO CORPORATION  
PITTSBURGH, PENNSYLVANIA

## **INTRODUCTION**

Dravo Engineers and Constructors, a unit of Dravo Corporation, is presently subcontracted to the Minnesota Gas Company to perform a feasibility study to assess the overall viability of a project to design, construct, and operate a commercial facility for the production of high Btu synthetic natural gas (SNG) from peat. Specific tasks included are peat-harvesting, peat-dewatering, gasification process, long lead items, and economic analysis. The study is part of the Department of Energy grant awarded to the Minnesota Gas Company to research "High-Btu Gas from Peat." The proposed commercial peat gasification facility has been sized to produce about 80 million standard cubic feet of SNG daily. This planned commercial peat gasification facility would consume about 9600 tons of peat (0% moisture equivalent) per day at 30% moisture for 330 operating days per year.

Since the moisture content of the peat at harvesting has a direct impact on the dewatering effort required to produce gasification plant feedstock, the harvesting and dewatering tasks were combined for economic analysis of the various potential systems that might be used to provide this peat feedstock.

This paper summarizes various peat harvesting - peat dewatering alternatives that were identified as having potential for providing peat in the required quantities. It further identifies various factors used to compare the alternatives considered and tabulates the ratios of costs for each of the alternatives which were analyzed.

This paper is presented with the Minnesota Gas Company's permission.

## **GENERAL**

Peat is harvested on various scales throughout the world. Many methods have been tried and used successfully to produce peat. The methods can be subdivided into dry harvesting methods and wet harvesting methods. The method of dewatering peat is dependent on the harvesting method employed and the end use of the peat.

For the purposes of the "selection" process, a number of systems were identified and analyzed for their potential application to harvesting at the scale of production required to support the 80 million cubic feet per day gasification plant. From these analyses, a wet harvesting/dewatering system and a dry harvesting system were identified as being technically feasible for utilizing Minnesota peat. A third system was identified for evaluation that combines features of both wet and dry harvesting/dewatering systems. This system uses existing equipment differently from the manner in which it is commonly used in the peat industry today. Some commercially proven mechanical dewatering processes were identified. Considerable research remains to be done on the process of drying different grades of peat.

#### **DRY HARVESTING METHODS**

Dry harvesting methods are the most common used in harvesting peat and are used almost exclusively to produce peat for both fuel and horticultural purposes. The techniques and technology are developed, and these methods have changed very little in the last several decades. A considerable amount of preproduction bog preparation work is required so that low ground pressure mechanical equipment can operate directly on the bog surface. First, a ditch network is established to delineate and drain production areas. Surface growth, stumps, and roots are removed when the production fields are sufficiently drained, and the cleared production fields are then regraded so that surface runoff will drain into the ditch network. Roads and surface facilities are then constructed, and the bog is ready for harvesting. The preproduction bog preparation may take three to five years to complete. Major dry harvesting methods include the Milled Peat and Sod Peat Methods. Dry harvesting methods normally utilize in-place solar drying to produce 40 to 55% moisture peat. Peat may be stored in the field or conveyed to the gasification plant area and stored prior to use.

#### **MILLED PEAT HARVESTING METHODS**

The milled peat harvesting method is the most popular production method and is utilized in Europe, Canada, and the United States. A layer of peat approximately

1/4 to 2 inches thick is milled or shredded from the top of the prepared production field and left to air dry. The shredded peat is then harrowed to expedite drying. The drying time is dependent on the peat characteristics and meteorological factors, but usually about two days are required. After harrowing several times to expose the undried surfaces, the peat will dry to about 50 to 55% solids. At this time, the dried peat is pushed into ridges at the center of each production field by a ridger or a windrow machine. The dried peat is then collected by a harvester and loaded into the transport system, which utilizes trucks, light rail cars, or wagons pulled by a tractor.

An alternative milled peat production method utilizes a vacuum collecting machine. When integrated with a milling machine that is either towed behind or is attached to the collector, it can collect the previously milled layer of peat and mill the next layer in one pass, and, when full, transport the harvested peat to a stockpile area. The collector, which resembles a large vacuum cleaner, picks up about a 1/4 inch layer of previously milled peat, separates it from air in a cyclone, and settles it in a storage tank.

#### Advantages:

- Milled peat is the most widely used method of peat harvesting.
- The technology is proven, and the method has been used for several decades.
- The harvesting equipment is easily accessible for maintenance and repair (weather permitting).

#### Disadvantages:

- Milled peat is greatly affected by meteorological factors because harvesting equipment must travel on the bog surface and the milled peat is air dried. Annual production can vary significantly depending on the amount of rainfall during the harvesting season.
- Large areas must be developed to utilize the multiple pass equipment efficiently.

- Production fields cannot be reclaimed until the total thickness of peat reserves are harvested.
- Wind losses/dusting and bog fires are problems. EPA air quality standards may be difficult to meet.
- Extensive preproduction site preparation is required (ditching, clearing, production field profiling, etc.). Site preparation may take several years.
- The harvesting operation would have to produce peat during a relatively short harvesting season, which might be exceptionally wet and cold. Therefore, a considerable amount of extra harvesting capacity would be required and equipment utilization would be low.
- Dry harvesting machinery is, in general, small and of low capacity.
- Due to the intermittent harvesting, stockpile requirements are large.
- Labor requirements become very large because of the intermittent work schedule dictated by weather conditions and the short harvesting season.

#### **SOD PEAT HARVESTING METHOD**

The sod peat harvesting method consists of sod cutting, turning of the sod to expedite air drying and sod collection. Trenches are cut into previously prepared production fields by specifically designed excavator/macerators that cut, macerate, and extrude the sods on the field for air drying. Another type is an excavator/macerator or "bucket ladder bagger" as it is sometimes called. It is a tracked machine, operating directly on the bog, that excavates peat using a continuous chain of buckets rotating around a ladder (similar to a bucket ladder dredge) and deposits the peat into a macerator extruder, which then deposits the sods directly onto the field for drying.

After drying to a moisture content of about 75%, the sods are lifted, turned, and piled into windrows using a windrower. To expedite drying, the windrows are periodically turned to expose the sods in the lower portions of the pile. After about one to two weeks of drying, (55% moisture or less), the sods are then gathered with a sod collector machine and transported to a stockpile area by conveyor, truck, or rail.

Advantages:

- Sod peat is a method of peat harvesting used in Europe; the technology is proven and the methods have been used for several decades.
- The harvesting equipment is easily accessible for maintenance and repair.
- The full thickness of peat can be excavated in one pass with a bucket ladder bagger if the bog is sufficiently drained.
- Harvesting machinery is available from several European manufacturers.
- The peat sods do not rewet as easily as milled peat.
- Dusting and wind losses are less of a problem with sod peat than for milled peat.
- Various transportation modes can be utilized: trucks, tractor pulled wagons, rail cars, or conveyors.

Disadvantages:

- Historically, sod peat has been more expensive to produce than milled peat.
- As with the milled peat system previously described, sod peat is affected by meteorological factors because harvesting equipment must travel on

the bog surface and the cut peat is air dried. Therefore, harvesting is possible only during warm, dry, sunny weather.

- Annual production can vary significantly depending on the amount and frequency of rain during the harvesting season.
- Large areas must be developed to provide sufficient area for sod drying. Multiple pass sod cutting machines require large areas if the machinery is to be utilized efficiently.
- Production fields cannot be reclaimed until the total thickness of peat reserves is harvested.
- Extensive preproduction site preparation is required (ditching, clearing, etc.). Site preparation may take several years.
- Equipment utilization is poor because of air drying. A considerable amount of extra capacity is required because an entire year's supply of peat must be harvested during warm days.
- Sod peat harvesting machinery has been historically small and low capacity because the machinery must travel on the bog (low-ground pressure requirements). Therefore, a large number of harvesting machines would be required. Operations management and work scheduling would be difficult.
- Labor requirements are large because of the intermittent work schedule dictated by weather conditions.
- Because of the intermittent harvesting, stockpile requirements are large.

## ALTERNATIVE DRY HARVESTING METHODS

In addition to the above dry harvesting methods, various other dry harvesting systems are examined. Although not commercially proven, these systems were investigated, but were not developed further for the reasons stated.

### a. Mechanical Excavators Operating On Drained Bog

This method would use conventional mechanical equipment operating directly on the bog excavating the full thickness of peat before advancing. The peat could be transported to the dewatering plant using belt conveyors or other systems such as trucks, trains, or tractor-pulled wagons. Although the system would have the advantage of excavating the peat in a single pass, conventional large capacity excavation equipment generates high ground pressure and probably could not be supported on top of the peat without mats. Additionally, thicker peat deposits would be less capable of supporting the equipment, which would induce vibration and impact loading, as well as static loading to the peat surface. Further, the digging action of the excavation equipment would tend to promote failure of the bank if it disturbed material supporting it in any way. Recovery of the equipment would be extremely difficult in the event of bank failure.

### b. Mechanical Excavator Operating on Substrate

In this method, a hydraulic front shovel or bucket wheel excavator would cut into a bank of peat while operating on top of the substrate. The machine would be mounted on a hover barge or on self advancing pads. Peat would be transported to the dewatering plant by conveyor. This system would also have the advantage of excavating the full thickness of peat in a single pass. However, based on the reported poor trafficability of the clay substrata, the system has been eliminated. The problems associated with high water retention material lying on a clay layer compound the questionable bearing capacity of the substrata. The

harvesting season would be shortened considerably by the mechanical problems encountered with equipment operating in freezing mud. Considerable additional production design capacity would be required to meet production requirements. This combined with the transportation problems envisioned have caused us to eliminate this method.

### **WET HARVESTING METHODS**

Wet harvesting methods utilize hydraulic or mechanical excavators for one pass removal of peat and require little site preparation. Trees and brush would have to be removed from the bog surface; however, extensive draining and grading of the production areas are not required because harvesting machinery does not travel on the top of the peat. Instead, high-pressure water monitors or floating dredges are used to excavate the peat, which is then pumped as a slurry to a dewatering area. Processes to dewater wet peat slurries have been identified. Peat slurries can be dewatered by means of mechanical, chemical, thermal, or other methods.

Wet peat harvesting methods can be subdivided into:

Slurry Ditch/Hydro Peat Methods, and Slurry Pond Method

Historically, small scale hydraulic operations were sometimes successful in regions where dry harvesting methods were not technically possible because of adverse climatic conditions or poor terrain for drainage.

### **SLURRY DITCH/HYDRO PEAT METHODS**

These systems were used on a small scale in Europe. The systems utilized high-pressure water monitors to cut the peat from the facewall of a ditch. The peat drained away from the face of the ditch while roots and debris remained. The peat slurry was recovered by a pump and transported to a dewatering or drying area through pipelines. Here the slurry was left to air dry and then was either windrowed or cut into sods.

Advantages:

- Extensive preproduction site preparation is not required.
- The entire thickness of peat can be removed in one pass. Less area is disturbed at one time.
- Peat can be harvested during wet weather.
- Fewer skilled workmen are required.
- The method can be used on bogs that are difficult to drain and will not support heavy equipment.
- All of the apparatus is simple in design and construction. Cost of repair and maintenance is small relative to production.

Disadvantages:

- The system is not commonly used because it is reportedly inefficient for achieving high production rates.
- Roots and debris remain in the ditch while the peat drains away. Reclamation would be difficult because of the scattered debris.
- The depth of peat excavated would probably be difficult to control. A consistent layer of peat could not be left for reclamation.
- Very large quantities of makeup water are required. (Evaporation during air drying allows the moisture to escape.)
- Air drying of peat slurry would require warm, sunny weather.
- Large numbers of employees would probably be required; however, it is reported that fewer workers are required than for milled peat and sod peat.

- Peat resource recovery is reported to be low.
- Large volumes of water may have to be discharged during or following major rainstorms.
- Harvesting season would be limited to warm months because the bog surface and the facewall of the ditch would freeze when temperatures drop below 32°F for extended periods.

#### **SLURRY POND METHOD**

In this method, mechanical excavators or dredges are floated on a pond within the bog, and are used to cut the peat, which is then transported as a slurry to a dewatering site. Some of the equipment that has been utilized includes:

- The grapple dredge, which is usually a clamshell equipped excavator mounted on a suitable hull. Peat is excavated with the clamshell, dumped into a hopper where the peat material is broken up and separated from roots and stumps by high-pressure water monitors and then pumped as a slurry to the dewatering areas.
- The cutter head hydraulic dredge, which consists of a multibladed cutter-head rotating at the end of a heavy structural steel frame, called the ladder, hinged horizontally to the bow of a suitable hull. The outer end of the ladder, near the cutterhead, is supported by wire rope from a derrick at the front of the hull. The ladder also contains a suction pipe and the necessary shafting, gearing, etc. for driving the cutter-head. In-place peat is cut up by the cutterhead, sucked into the suction pipe, and pumped to a dewatered area.
- The bucket ladder dredge, which has a single continuous chain of buckets that rotate over tumblers located at each end of the ladder. Bog material is scooped up by the buckets at the lower end of the ladder and then dumped into chutes or onto conveyors when the loaded buckets

rotate over the top tumbler. The excavated peat is then be conveyed by belt or slurry pumped to the dewatering plant.

### **CUTTERHEAD HYDRAULIC DREDGE—SLURRY PIPELINE**

This system is similar to an existing slurry pond system--a cutterhead hydraulic dredge-slurry pipeline-solar drying system that has been successfully producing horticultural peat in Louisiana, U.S.A.

#### **Advantages:**

- Cutterhead dredges are commonly used excavators, although not for peat production.
- Little preproduction site preparation is required. Bog dewatering is not required.
- The full thickness of peat is removed in a single pass.
- The cutterhead dredge is a self-advancing continuous excavator.
- Large cutterhead dredges (24" or larger) would probably be able to cut through, or dredge around, stumps, logs, and roots.
- Peat resource recovery is maximized (at the bog) because the fine as well as fibrous peat are recovered by the suction intake that draws the peat into the slurry transport system.
- Meteorological impacts on harvesting are minimized. Harvesting season is maximized and stockpiling minimized. Harvesting is less weather dependent.
- Reclamation costs should be considerably less than for other methods since most wood and roots are removed from the site in the harvesting process.

- Reclamation could be kept somewhat concurrent because of single pass removal of the peat.
- Fugitive dust problems are reduced by the wet harvesting.
- A shorter start-up period is required.

**Disadvantages:**

- Peat slurry pumping is energy intensive since most of the energy expended is used to move water.
- A dredge pond of adequate depth must be maintained. Large standard dredges require a minimum draft of 5 to 8 feet.
- Peat deposits less than 6 to 8 feet thick could not be harvested by large dredges without constructing a series of dikes.
- Water from the dewatering plant must be returned to the bog unless alternative sources of make-up water are available.
- The dewatering plant must handle large quantities of dilute peat slurry.
- The method may not be suitable for bogs with large quantities of heavy stumps, logs, roots, etc.
- The method is unproven on a large scale.

**BUCKET LADDER DREDGE—CONVEYOR OR SLURRY**

This concept is also a slurry pond method. Peat is excavated by a floating bucket ladder dredge as previously described. The method is reportedly used in the Soviet Union and in Cuba on bogs that are difficult to drain.

Advantages:

- Bucket ladder dredges could remove the peat at a significantly higher percentage of solids.
- Little preproduction site preparation is required. Bog dewatering is not required.
- The full thickness of peat can be removed in a single pass.
- A smooth cutaway (bottom of excavation) could be more easily maintained than with some other methods.
- Larger and heavier machinery can be used than on even a prepared bog surface, since the fact that the equipment is floating in a dredge pond.

Disadvantages:

- A specially designed bucket dredge is required. Conventional bucket ladder dredges excavate a relatively narrow trench beneath and in front of the dredge and are best suited for excavating free flowing materials. The dredge would probably have to be redesigned with wider buckets to excavate peat.
- Bucket ladder dredges are more expensive to purchase than cutterhead dredges of similar capacity.
- Bucket ladder dredges require well planned preventive maintenance. Breakdowns are generally more prevalent.
- A continuous, extensible, partially floating conveyor system would be required. Conveying wet, soupy peat is questionable, especially during cold (below 32°F) weather because the peat may freeze to conveyors, hoppers, chutes, etc. A conveying system would have to be developed and the harvesting season shortened.

- Peat slurry pumping is expensive because most of the energy expended is used to move water.
- A dredge pond of adequate depth must be maintained. Bucket ladder dredges historically require a deeper draft than cutterhead hydraulic dredges of similar capacity.
- Water from the dewatering plant would have to be returned to the dredge pond unless large quantities of makeup water were available.
- Roots and stumps may cause operating problems.

#### **SHOVEL DREDGE—CONVEYOR**

This concept is also a slurry pond method. A hydraulic front shovel on a barge mounted turntable would dig, turn, and dump a bucket of peat into an on-board hopper. The peat would then be conveyed to the dewatering plant. Roots and debris could be either separated from the peat and dumped back into the bog or could be macerated and transported to the plant.

#### Advantages:

- Little preproducton site preparation is required.
- The full thickness of peat can be removed in a single pass.
- A front shovel could excavate stumps, logs, and roots more easily than other previously mentioned excavators.
- Roots, logs, and debris could be separated from the peat on the floating barge.
- A front shovel could harvest shallower peat deposits than a similar capacity cutterhead dredge.

Disadvantages:

- A dredge pond would have to be maintained. Too shallow a pond would cause the dredge to become grounded, while too deep a pond would put deeper peat out of machine reach.
- Peat excavation is cyclic rather than continuous: dig-turn-dump-turn-dig..., advance barge, dig-turn-dump-turn, etc.
- Conveyor haulage of wet, soupy peat is questionable, especially during cold (below 32°F) weather when peat would possibly freeze to conveyor belts, chutes, hoppers; thus the harvesting season may be shortened.
- An extensible, continuous, partially floating conveyor system would be required.
- Water from the dewatering plant would have to be returned to the pond unless large quantities of makeup water were available.

**SHOVEL DREDGE—SLURRY PIPELINE**

This concept is identical to the previously discussed concept except that a slurry pipeline would replace the conveyor in transporting the peat from the dredge to the dewatering plant. (This method is very similar to that used by Western Peat Moss in Vancouver, Canada.) Advantages and disadvantages are similar to the shovel dredge with the exceptions pertaining to the transportation mode.

The main advantages of slurry line transport are:

- The system is historically proven, though not for large scale peat transport.
- The transport system follows the excavator. Through a system of ball joints, the pipeline follows the dredge wherever it moves.

The main disadvantages with the slurry line system are:

- Dewatering of dilute slurries.
- A possible wide fluctuation of slurry concentrations caused by the cyclic motion of the shovel.

### **MODIFIED HARVESTING METHODS**

#### **MODIFIED MILLED PEAT (TRADITIONAL AND DEEP MILLED)**

This method is similar to traditional milled peat except that the undried milled or deep-milled peat would be transported to a dewatering plant. Requirement of total solar drying would be eliminated by using a dewatering plant.

Advantages:

- Suitable harvesting machinery could be modified from European milled peat equipment.
- The method would be suitable for harvesting thick or thin peat deposits.
- The method is relatively flexible. The layout of harvesting equipment can be modified.
- Various types of transport systems could be utilized: truck, tractor-pulled wagons, train, conveyor.
- Harvesting areas would require less acreage because of the increased yearly extraction depth per field.

Disadvantages:

- Extensive preproduction bog preparation would probably be required. This would include ditching, clearing, and leveling the bog surface.

- Low-ground pressure equipment would be required because machinery must operate on the bog surface.
- Harvesting machinery could probably not travel on previously harvested areas until a peat crust of sufficient thickness dried.
- Large capacity machinery probably could not be utilized because of ground pressure limitations.
- Harvesting would probably be limited to warmer months because of operational problems in harvesting and transporting peat during cold (below 32°F) weather.

#### **PEAT LONGWALL MINING**

This method is a hybrid dry-wet method. An excavator mounted on a movable carriage would travel back and forth along a single truss spanning between two self-advancing support units. The excavator would travel the length of a peat face while excavating peat. A continuous mobile conveyor system would transport the peat to the dewatering plant. After completing a pass, the two support units would advance and the cycle would repeat.

The method is a hybrid between wet and dry methods in that one self-advancing support would be mounted to a spud barge floating in a previously longwall harvested panel, while the second support would be mounted on crawlers which travel over the peat surface. Therefore, the unharvested bog surface must be drained, cleared, and leveled to provide adequate ground supporting capacity for the crawler mounted support, while the previously worked out panels must remain flooded for the floating support.

#### **Advantages:**

- The method has the potential for high capacity continuous peat production.

- Thick peat deposits could be excavated in one pass.
- The method has the potential for computer controlled operation, which might reduce manpower requirements.
- Large volumes of peat could be excavated without requiring a rapid forward advance rate for the entire longwall.
- A continuous mobile conveyor could be utilized for transport. The conveyor would not have to be repositioned as frequently as with some other previously mentioned methods.
- Peat recovery is high.

Disadvantages:

- Suitable machinery is not presently available.
- The method is unproven. Equipment performance, reliability, cost, and production rates are difficult to estimate.
- Portions of the bog surface must be drained, cleared, and leveled in order to develop a crust that would support the crawler-mounted land-based truss support unit.
- A dredge pond of suitable depth must be maintained for the floating support unit.
- Bogs containing considerable logs, roots, stumps could probably not be harvested with this method.
- Excavating depth will be controlled by the design of the excavator.

- Peat harvesting would probably be restricted to warm months because the peat excavation and transport would become difficult during extended cold (below 32°F) weather.
- Conveyor transport of peat would probably be required. Wet soupy peat would probably be difficult to convey, especially during cold weather when the peat would freeze to the belt, or chutes and hoppers.
- Special conveyor equipment would have to be developed.

#### **SYSTEMS SELECTED FOR EVALUATION**

Based on the factors listed above for the various systems, the following systems were identified for consideration in the selection process:

Milled Peat System

Shovel Dredge-Slurry Pipeline System

Deep Milled Peat System

The harvesting and dewatering efforts associated with each of these systems follows:

#### **SHOVEL DREDGE/SLURRY TRANSPORT (ALTERNATIVE 1)**

This system would use a front shovel mounted on a barge and would pump a 2-1/2% slurry to the dewatering plant. The system is designed to produce approximately 18,600 tons per day of 0% moisture equivalent peat. The system is designed to produce the annual requirement during 7 months of operation out of an anticipated 8 month harvesting season for a safety factor of 1.14. Figure 1 is a conceptual drawing of the front shovel dredge. The peat is excavated using the turntable mounted 20 cubic yard front shovel and is placed in the 32 cubic yard hopper. Here water monitors wash the peat from the roots, which are then scalped off and conveyed into a barge for disposal. The peat then enters an 87,000 gallon capacity

slurry tank from which it is then pumped to the dewatering plant. The sizes of the hopper and the slurry tank were selected to produce a constant slurry volume from the cyclic operation of the shovel.

In order to produce the peat in the required quantities, 7 barges would be required working in 5 bogs initially, as shown in Figure 2. The slurry would be pumped in slurry lines sized as shown. The water removed from the peat at the dewatering plant would be returned to the bogs through a system of pumped return lines and/or open channel ditches.

The dewatering plant associated with this concept would process the peat as shown in Figure 3.

The harvesting operation will deliver a slurry of peat solids at a 2-1/2 percent consistency (oven-dry weight basis) to the dewatering operation. The dewatering operation will be designed to process a total of 18,910 oven dry tons per day (ODTPD) (normal rate 16,134 ODTPD) of peat material for a period of 8 months.

The 2-1/2 percent slurry will be delivered by pipeline to fine screens, which will remove small roots and wood. These roots and wood will be conveyed to storage for fuel usage.

De-rooted slurry at 2-1/2 percent consistency will flow by pipeline to a system of parallel sieve bend screens. Here, the raw peat stock will be dewatered to 5 percent consistency. This operation, in addition to removing approximately 97,000 gallon per minute of water, will also remove about 44 percent of the minus 100 mesh peat.

The thickened slurry from the sieve bends will be piped to a surge basin with an 8 hour holding capacity.

From the surge basin the peat will be pumped at 5 percent consistency to the headboxes of the presses. The peat slurry will be deposited uniformly on the free-draining section of the press, and then be subjected to increasing pressure as the peat travels thru the press.

After leaving the last roll, the peat will have been dewatered to about 35 percent consistency (solids).

The sheet of peat leaving the press is then shredded and dropped onto a belt conveyor for transport to the storage area.

The mechanically dewatered peat leaves the presses at 35 percent solids (65 percent moisture) for the 243 day harvesting season in the following manner. During 220 days out of this period (total 330 days per year gasification plant operation), 10,000 ODTPD are shunted to the drying plant (8,000 t/d for gasifier feed and 2000 t/d for other uses); the balance of the design capacity - 6,813 ODTPD is sent to the stockpile area to replenish the depleted piles. During the assumed 23 days in the 243 day (8 month) period that the gas plant will not operate, the full 16,183 ODTPD dewatered peat production is stockpiled. This rate of stacking permits the 6 month supply stockpile (1,650,000 tons, 0% moisture equivalent) to be built in the 243 day harvesting period while simultaneously supplying 10,000 ODTPD of peat to the drying plant as previously mentioned.

The required storage of 1,650,000 tons of peat (bone dry basis) at 35 percent solids will occupy 9.2 million cubic yards when tampered. Four parallel piles of stockpiled peat will be built. The piles will be serviced by two rail-mounted stacker-reclaimers (each with a 200 foot boom and a 27.5 ft. diameter reclaiming wheel) running between the piles. Peat will be fed to and reclaimed from each unit by a reversible 72" wide conveyor belt. Each pile will be 6,700 feet in length with pile-cross section arranged for 85 percent retrieval by the reclaiming wheel with the balance pushed by bulldozer into the area of the wheel pick-up.

Piles will be built to a height of 50 ft. in order to limit the effect of pressure on spontaneous combustion of the peat at the bottom of the pile. The material will be placed in layers and consolidated to remove as much air as possible to lower the probability of spontaneous combustion. The piles will be built with 37 degree side slopes and a 120 ft. wide top slightly crowned to permit water run-off.

Peat will be reclaimed from the pile when adverse weather conditions shut down the harvesting operation. The peat will freeze to an approximate depth of 18", and this cap will have to be broken up and removed if the bucket wheel is incapable of cutting thru the frozen mass. One reclaimer will have sufficient capacity to feed the drying plant. Cold weather will require one face of the pile to be removed continuously in order to minimize freezing of the working face.

#### **CONVENTIONAL MILLING METHOD (ALTERNATIVE 2)**

This system uses conventional milling equipment that is commonly used throughout the European peat industry, as previously discussed. The basic steps in this method are shown on Figure 4, proceeding from bog development through harvesting to peat loading. In this system the peat is harvested at approximately 50% moisture and stockpiled on the bogs for subsequent transport to the dewatering plant. Peat is reclaimed from the on bog stockpiles and transported to the drying plant by a narrow gage railroad transport system on the bogs, which feeds a standard gage rail system connecting the bog to the plant. Using this method, the daily production design requirement is 151,000 tons per day of 0% moisture equivalent peat. This requirement stems from a shortened harvesting season of 100 days during which an equivalent 35 ten hour harvesting days was assumed to be obtained. Because of the increased weather dependency of this system, a substantial safety factor or over production capacity must be designed into the system. The capability of harvesting 1.5 times the gasification plant annual requirement was included. This permits the operation to withstand back to back bad years, a bad year being defined as a year in which only half of the design requirement is harvested.

To produce peat using this system, approximately 300 millers with tractors, 300 peat pilers with tractors, 150 turners with tractors, 150 ridgers with tractors, and approximately 300 other (ditchers, profilers, deep millers, stockpilers) items of equipment would be required. Approximately 60,000 acres of peat bogs would have to be worked to obtain the production. The peat would be removed from the bog at about 15 mm per pass. About 12 harvests per field per year would be required to achieve the production goal.

Initially, work would commence in 5 bogs as shown on Figure 5. Harvesting would begin in June and run through mid-September. The peat would be harvested and stored in the field. Harvested peat would be transferred from field to field, the production from 16 fields being stored on 1 field. Low ground pressure front end loaders would load the peat from these storage piles into 20 cubic meter narrow gage railroad cars. At the edge of the bog, the peat would be transferred to standard gage railroad cars (210 cubic meter capacity) that cycle between the dewatering plant and the bog transfer area.

Figure 6 depicts how this peat would be processed at the dewatering plant. The operating plan for this alternate delivers the peat from the harvesting fields containing approximately 50 percent moisture. Bulk density for this material is calculated at 20#/cu. ft. loose with a tamped density of 27#/cu. ft. A tamped storage volume of 13.5 million cu. yards will be required at the plant to provide a 3 to 4 months of reserve as a back-up for shortened or wet harvesting seasons.

The same method of stockpiling and reclaiming previously described for Alternate 1 will apply except that 6 piles will be required instead of 4, and 3 stacker-reclaimers will be provided.

During the harvesting season it is planned that no peat will be delivered from the bog fields to either the gas plant or its adjacent stockpiles to prevent traffic congestion in the fields during this busy period. (Some may be brought in on days or nights when harvesting is shut down.)

Peat will be delivered to the gas plant and plant stockpiles during the balance of the year on a 24 hour, 7 day basis. During the 4-month low temperature period, peat will be delivered from the field only to the gas plant with none being stockpiled. If weather interferes with delivery from field to the plant, stockpiles at the plant will be reclaimed to feed the gas plant.

### **CONVENTIONAL DEEP MILLING EQUIPMENT, MODIFIED (ALTERNATIVE 3)**

This system uses typical European harvesting machinery modified to deep mill, pick up, and transfer peat from bogs at approximately 80% moisture. Bog development requirements would be identical, except for acreage, to those for conventional milled peat shown in Figure 4. Figure 7 shows the harvesting sequence envisioned for this system. After the bog had been drained and prepared, a deep miller would deep mill the peat. A peat loader would then be used to load the peat on a shiftable conveyor that transfers the peat to a collecting conveyor that delivers the peat to the dewatering plant. Because the peat is being excavated in a wetter state at a deeper depth than in the conventional milled peat method, less area is required to achieve the required production rate of approximately 30,400 tons per day of 0% moisture equivalent peat. This rate was based on an assumed 6.5 month harvesting season working 2 shifts per day, 5 days per week. The deep miller and peat loader are common items of equipment used in the peat production today; however, they will both have to be modified to perform the functions we propose. These modifications are unproven and have not been tested anywhere to the best of our knowledge but do appear to be feasible. Sketches of the modified equipment are shown in Figure 8 and 9.

To meet the production required using this system, approximately 30 deep millers and 30 peat piles would be required. Additionally, 30 shiftable conveyors and 30 conveyor shifter tractors would be needed. About 31 miles of conveyor would be required for this system. Approximately 13,200 acres would be worked initially in 2 bogs. New areas would be cleared and prepared so that about 25,000 acres might be open at one time.

For this system, dewatering operations would occur as depicted in Figure 10.

The harvested peat will be delivered to the mechanical dewatering area by belt conveyor at a consistency of 20 percent. Peat will be delivered 140 days per year at a design rate of 30,400 ODTPD (normal rate 26,057 ODTPD) to the screening operation.

The screening operation will use rotary disc screens to remove roots, limbs, and rock. Screened peat, at 20% solids, will be transferred to presses and/or to raw peat storage.

Stored raw peat will be held in two piles adjacent to the pressed peat (35% solids). These two storage piles will be serviced by a stacker-reclaimer. Use of this storage system will permit the dewatering plant to operate steadily throughout a 243 day (8 month) campaign each year. Peat at 20 percent solids will be fed to the presses. These presses will squeeze peat between two endless plastic belts supported on rolls. The mat of peat will be discharged from the press at a consistency of 35 percent solids and will then be conveyed to storage. The system will employ 99 presses to process peat at the design rate of 16,183 ODTPD (normal rate 13,807 ODTPD).

The water pressed from the peat, containing fines down to colloidal size, will be returned to the bog area.

The operating plan calls for stockpiling and reclaiming the 35 percent solid pressed peat from the mechanical dewatering presses in the same manner as described for Alternate 1.

#### **SELECTION OF A SYSTEM**

Table 1 summarizes the factors considered in the selection of the harvesting-dewatering concept to be developed further in Phase II work.

Table 2 presents a factored cost comparison of capital, ownership, and operating costs associated with each alternate. These factored costs are reported as a ratio of each to the lowest cost alternate for each item of harvesting, dewatering, and then harvesting-dewatering combined. The lowest harvesting and highest dewatering costs were obtained for Alternate 1. The highest harvesting and lowest dewatering costs were obtained for Alternate 2. Alternate 3, however, provides the lowest combined ownership and operating cost. Alternate 3 was the system selected for further development in Phase 2 of the study. Work is currently underway on this effort.

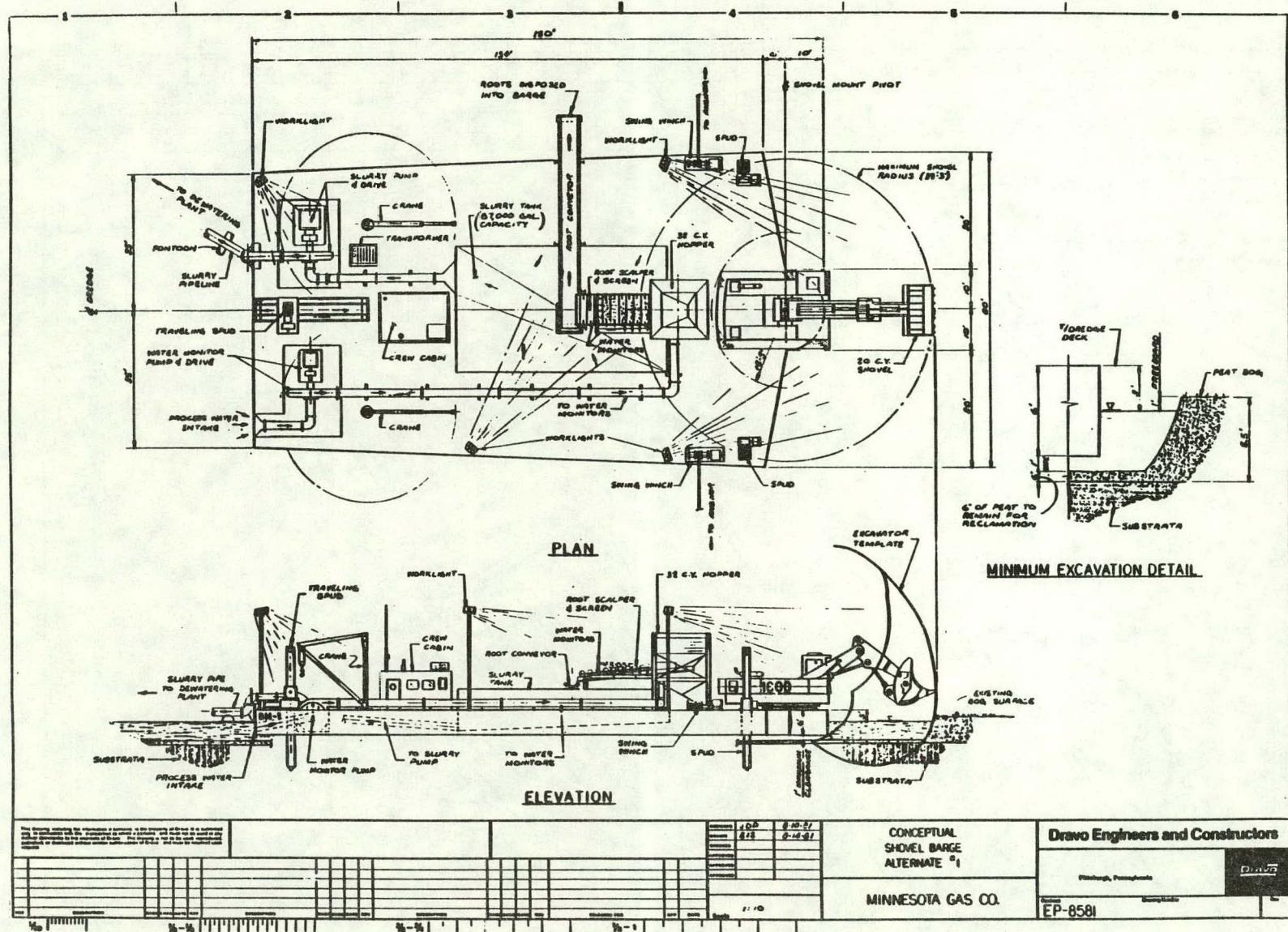
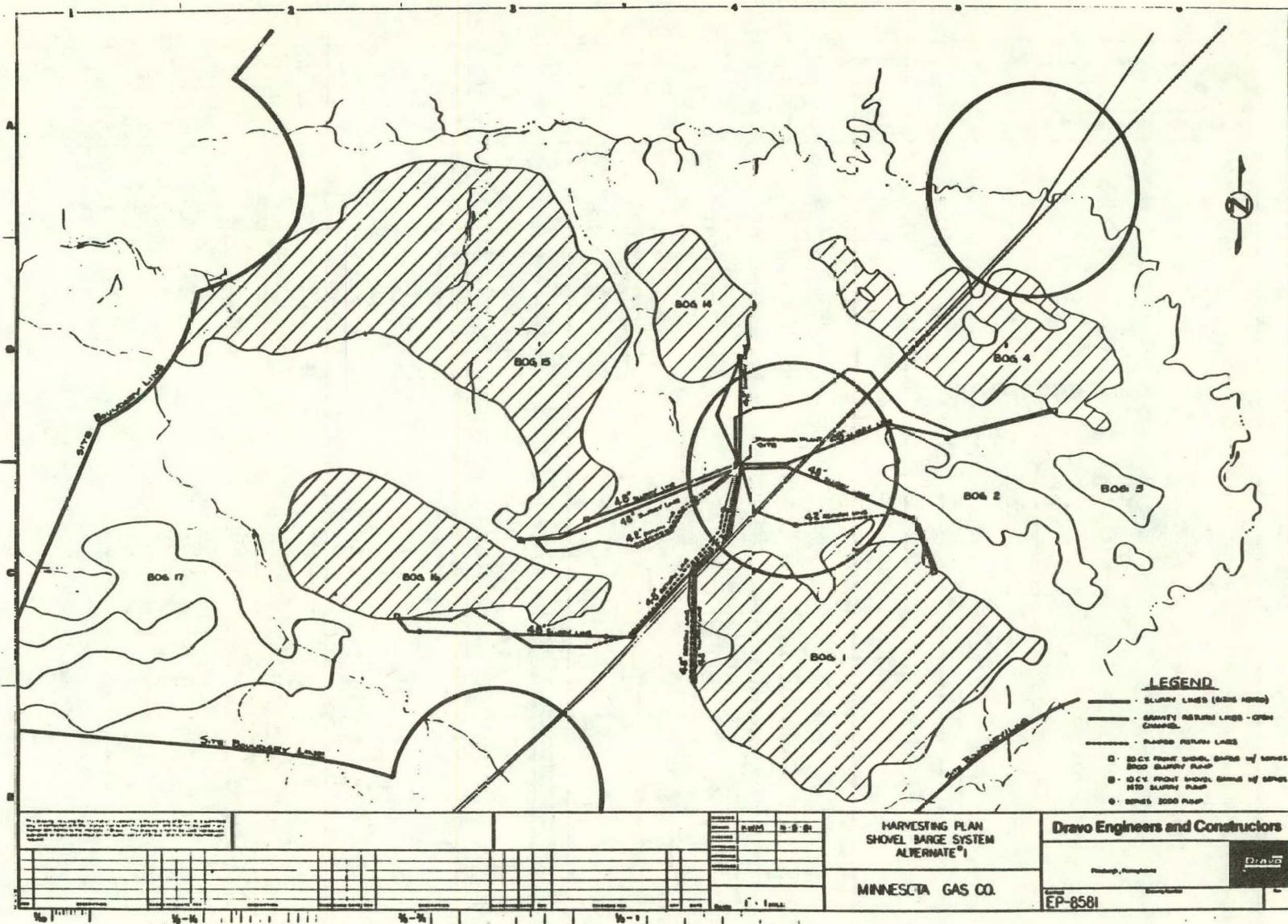


Figure 1  
Shovel Barge.



**Figure 2**  
**Shovel Barge-Harvesting Plan**

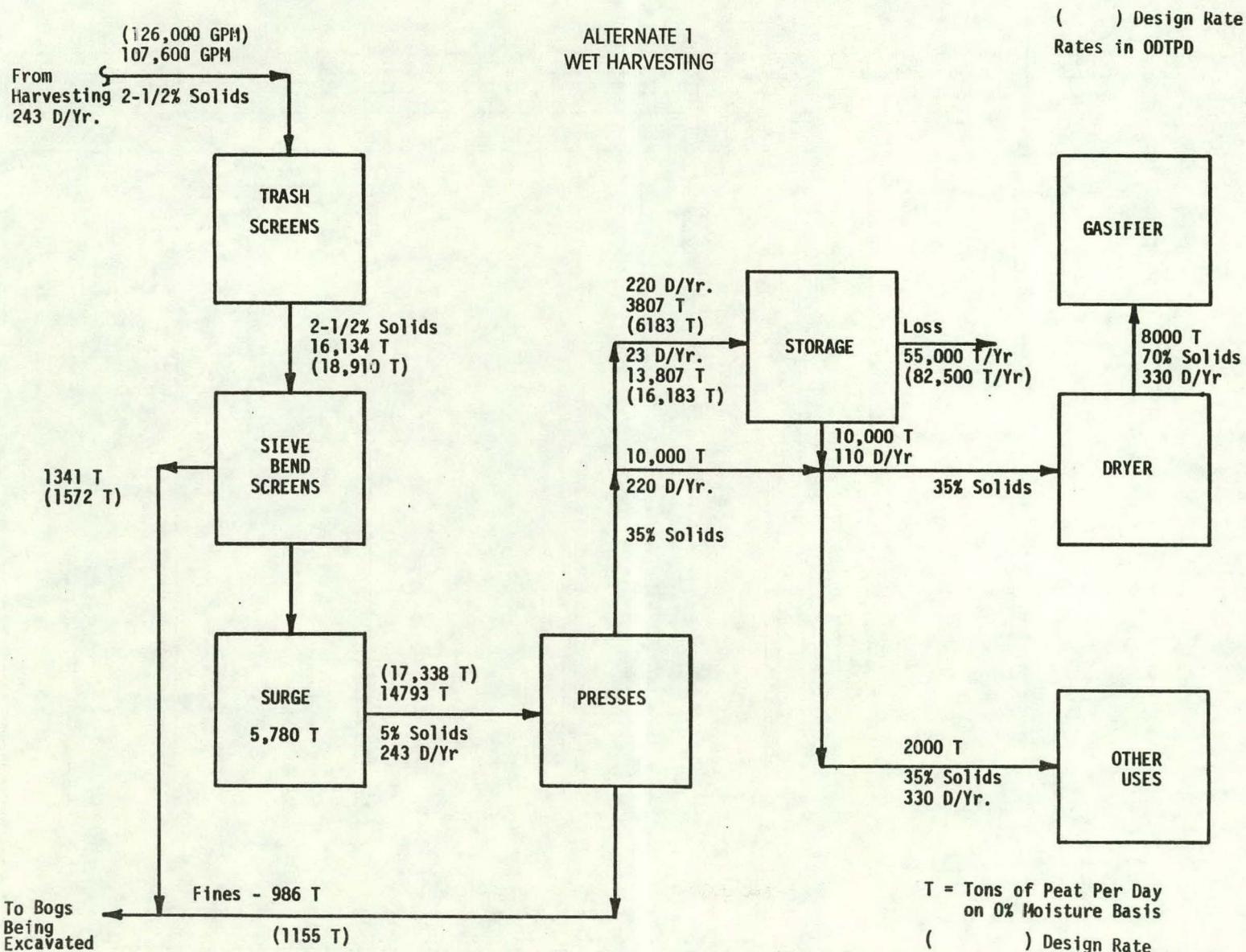
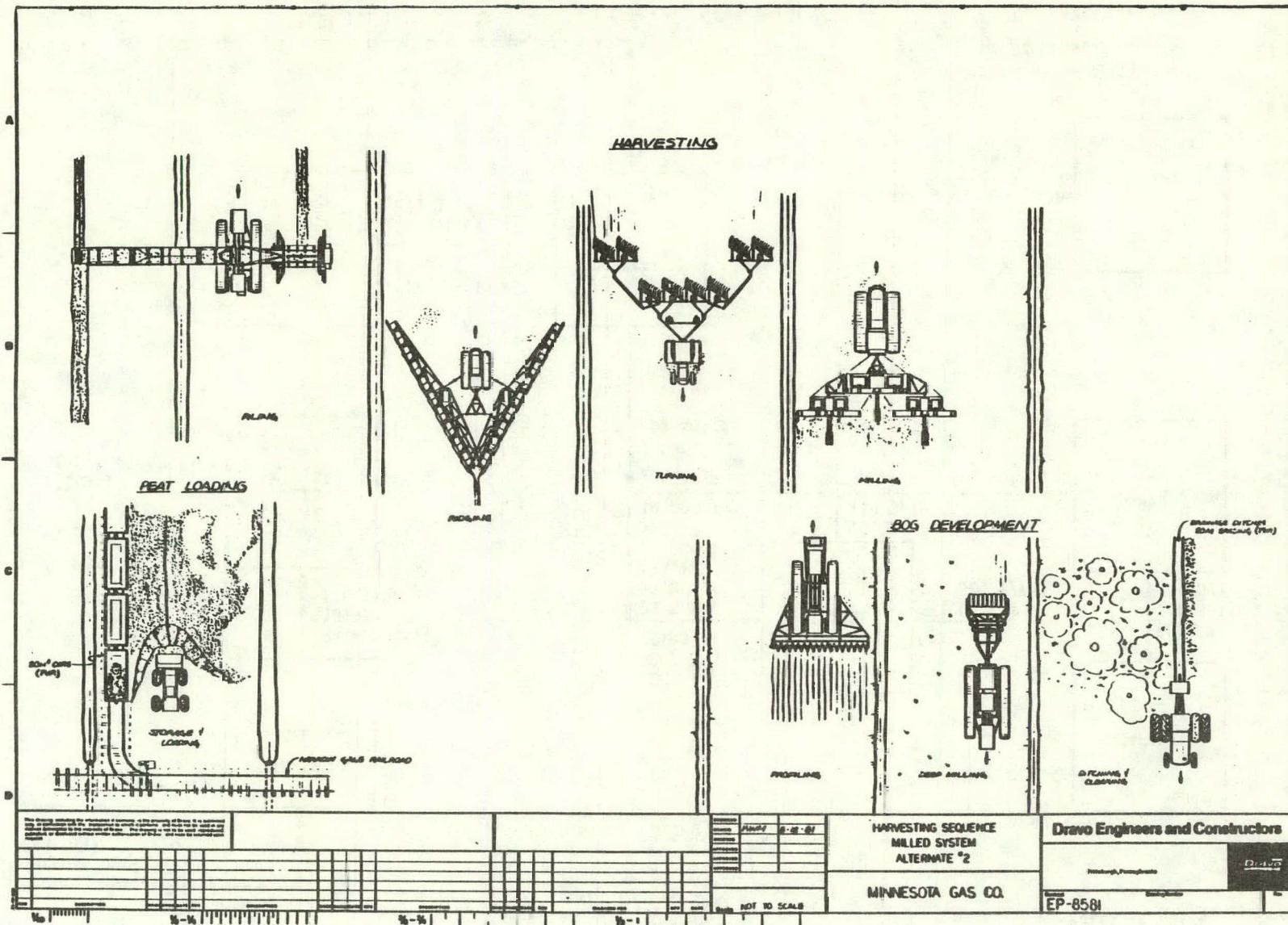


Figure 3  
Alternate 1 Dewatering.



**Figure 4**  
**Milled Peat-Harvesting Sequence.**

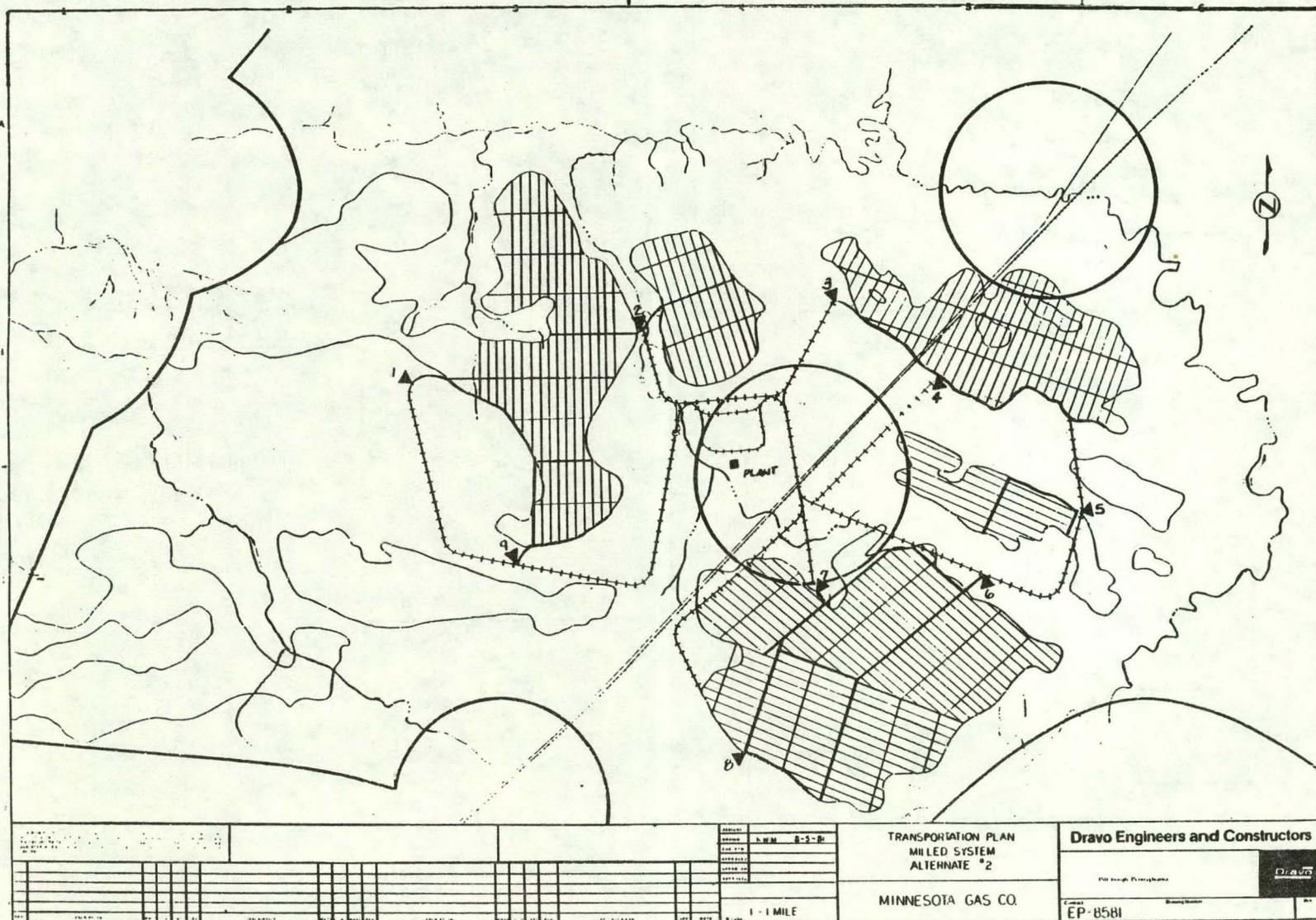
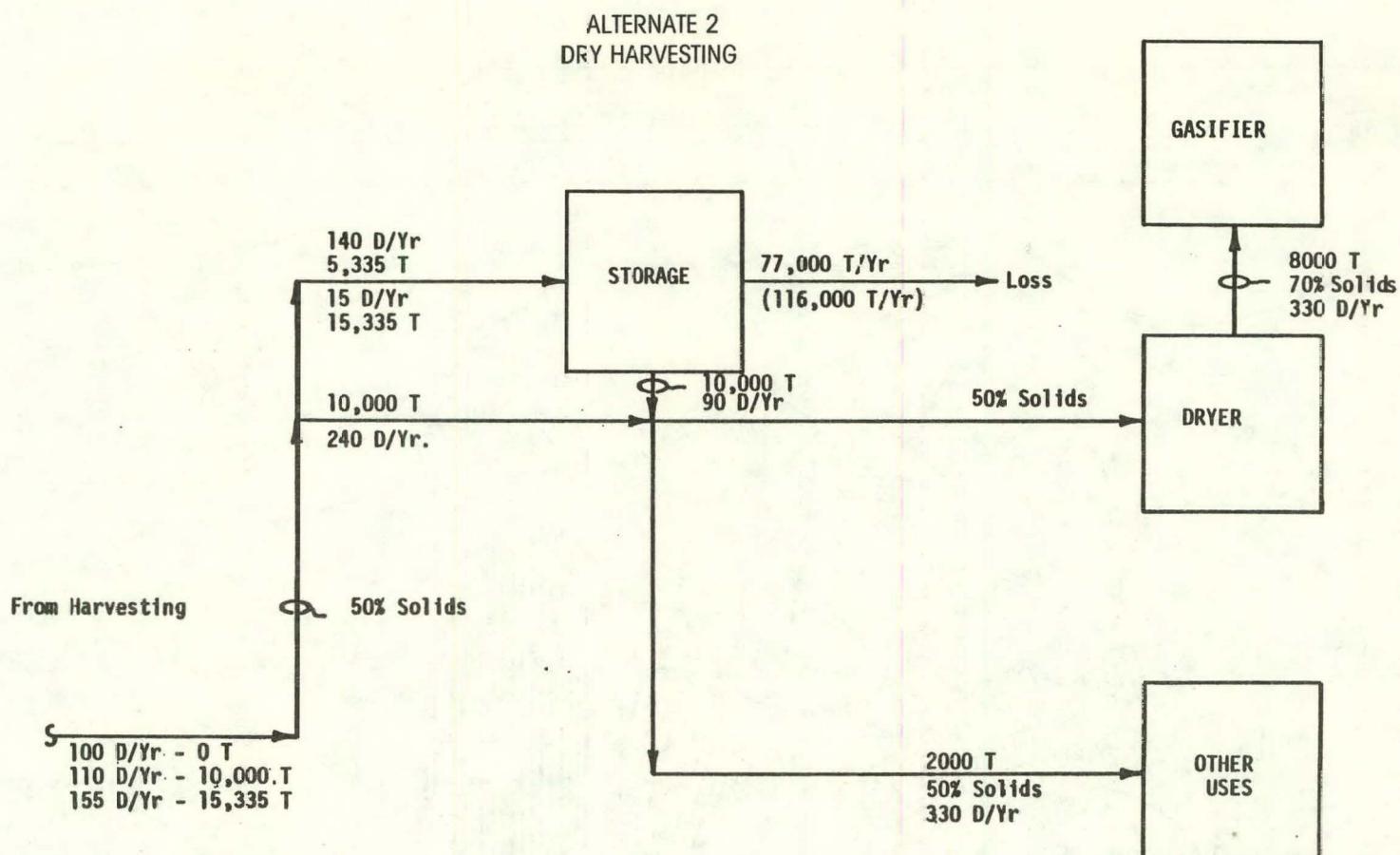


Figure 5  
Milled Peat-Transportation Plan.



T = Tons of Peat Per Day on  
0% Moisture Basis  
( ) Design Rate

Figure 5  
Alternate 2 Dewatering.

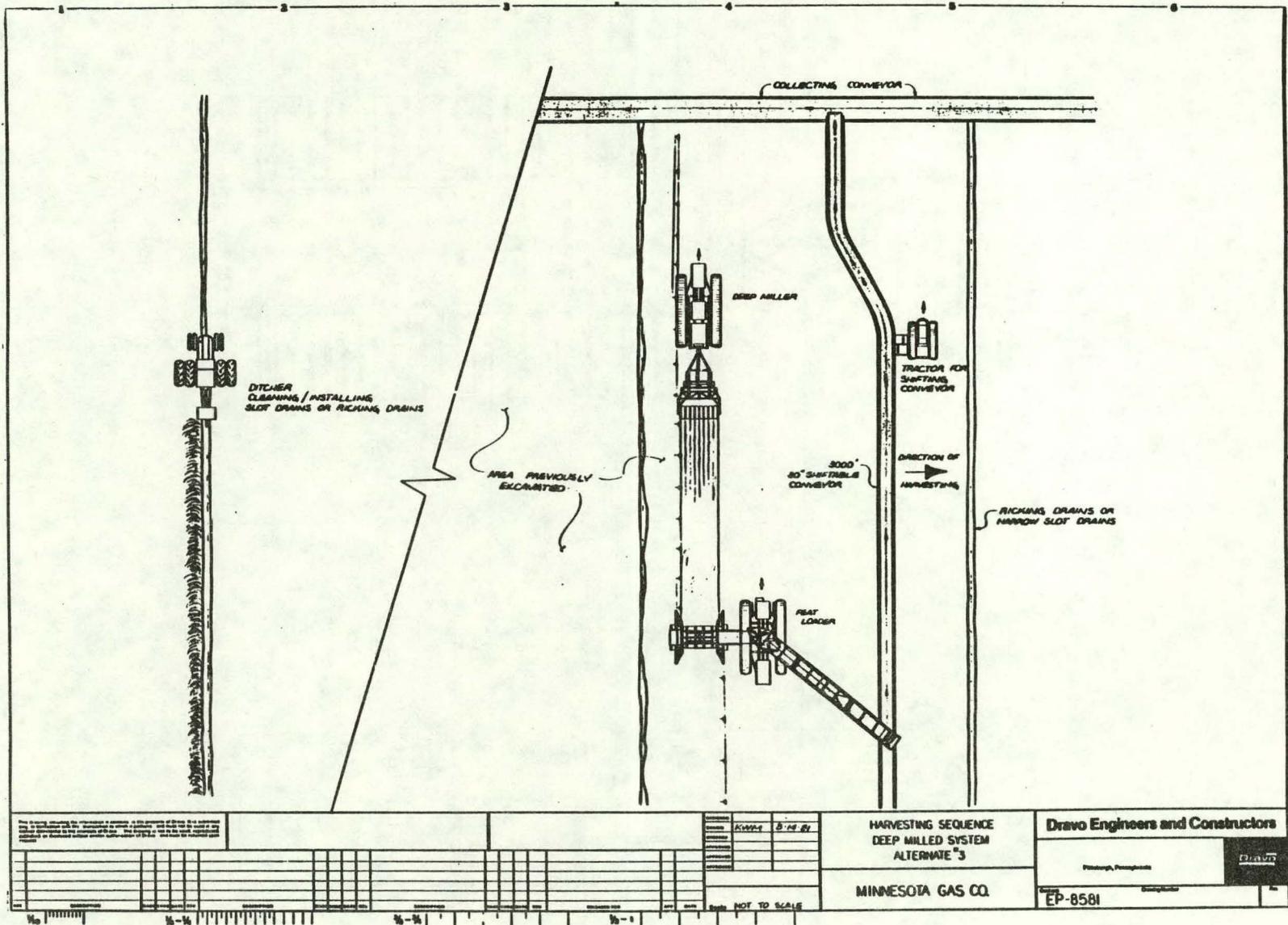
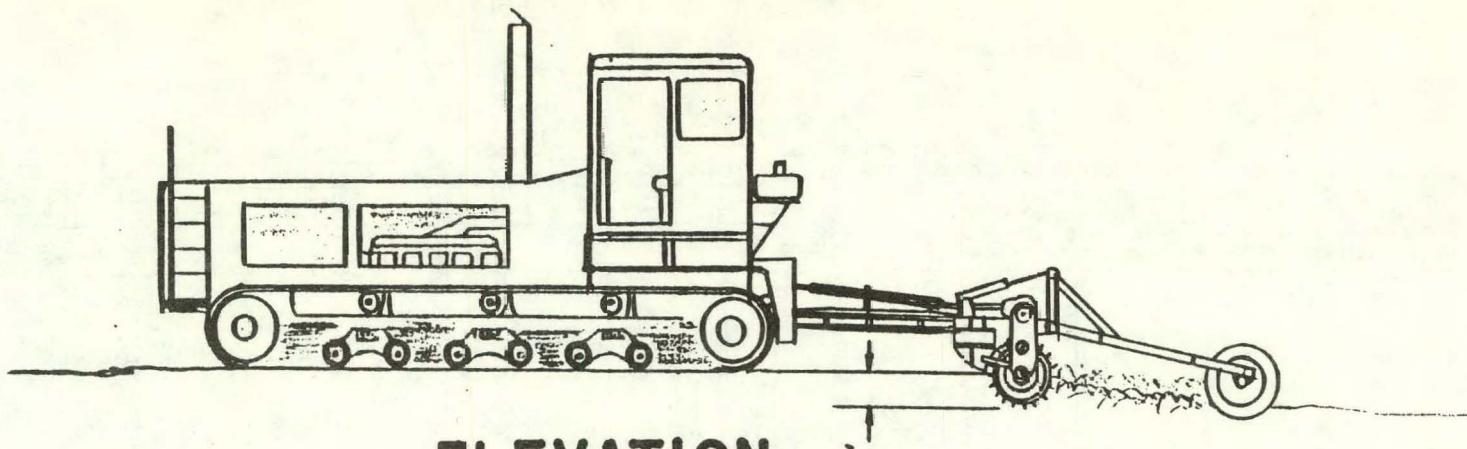
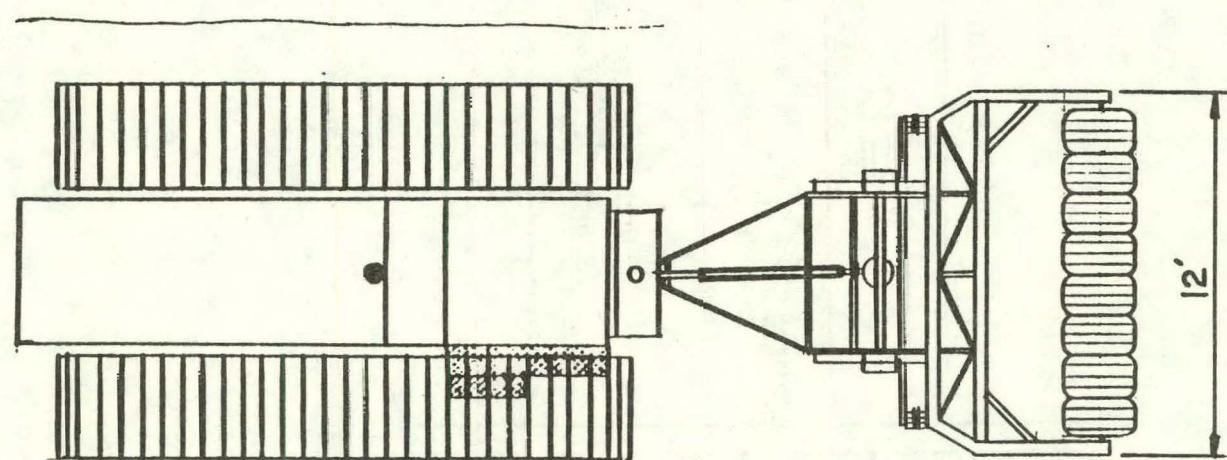


Figure 7  
Deep Milled Peat Harvesting Sequence.



**ELEVATION**



**PLAN**

Figure 8  
Tractor and Peat Miller.



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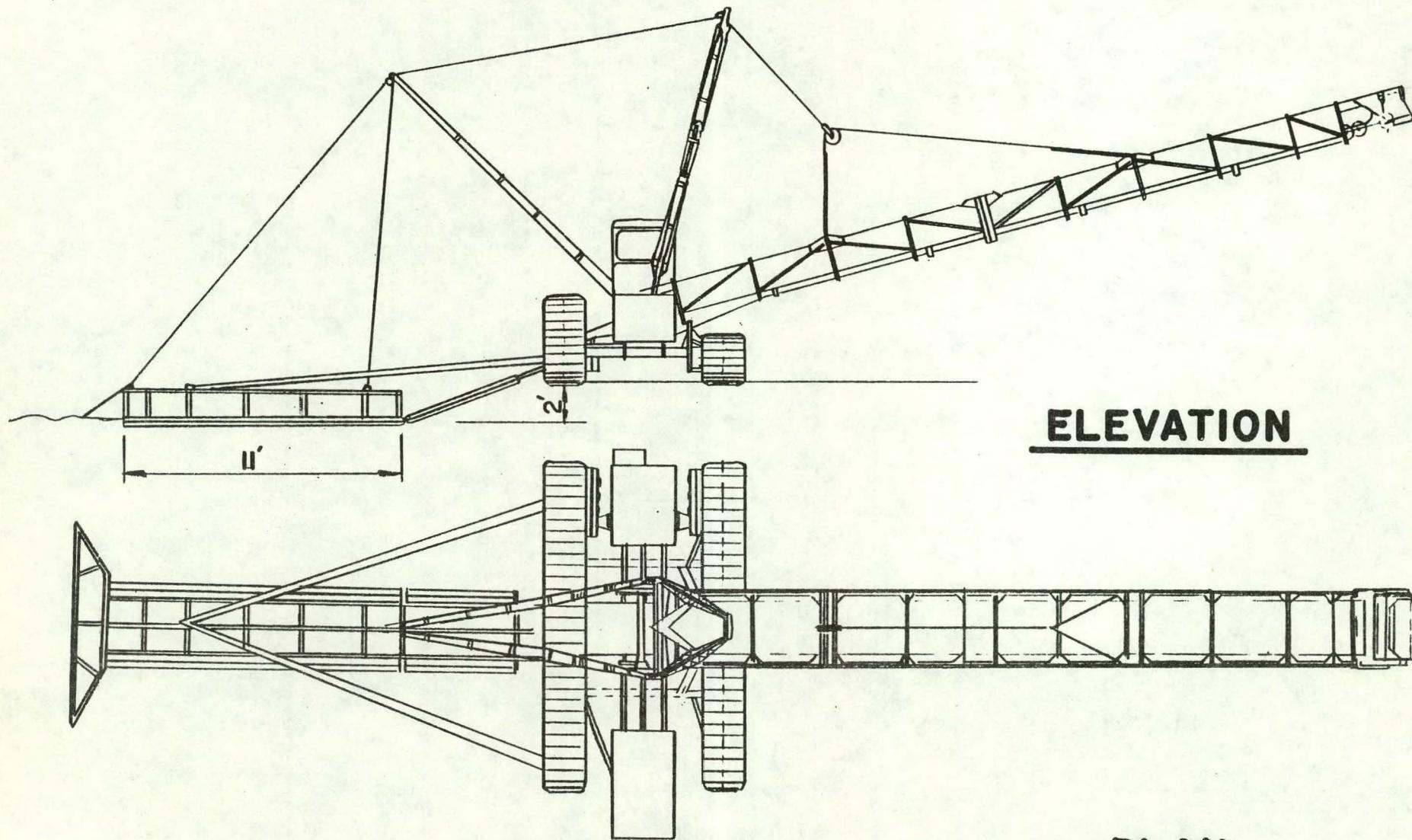


Figure 9  
Peat Ladder.

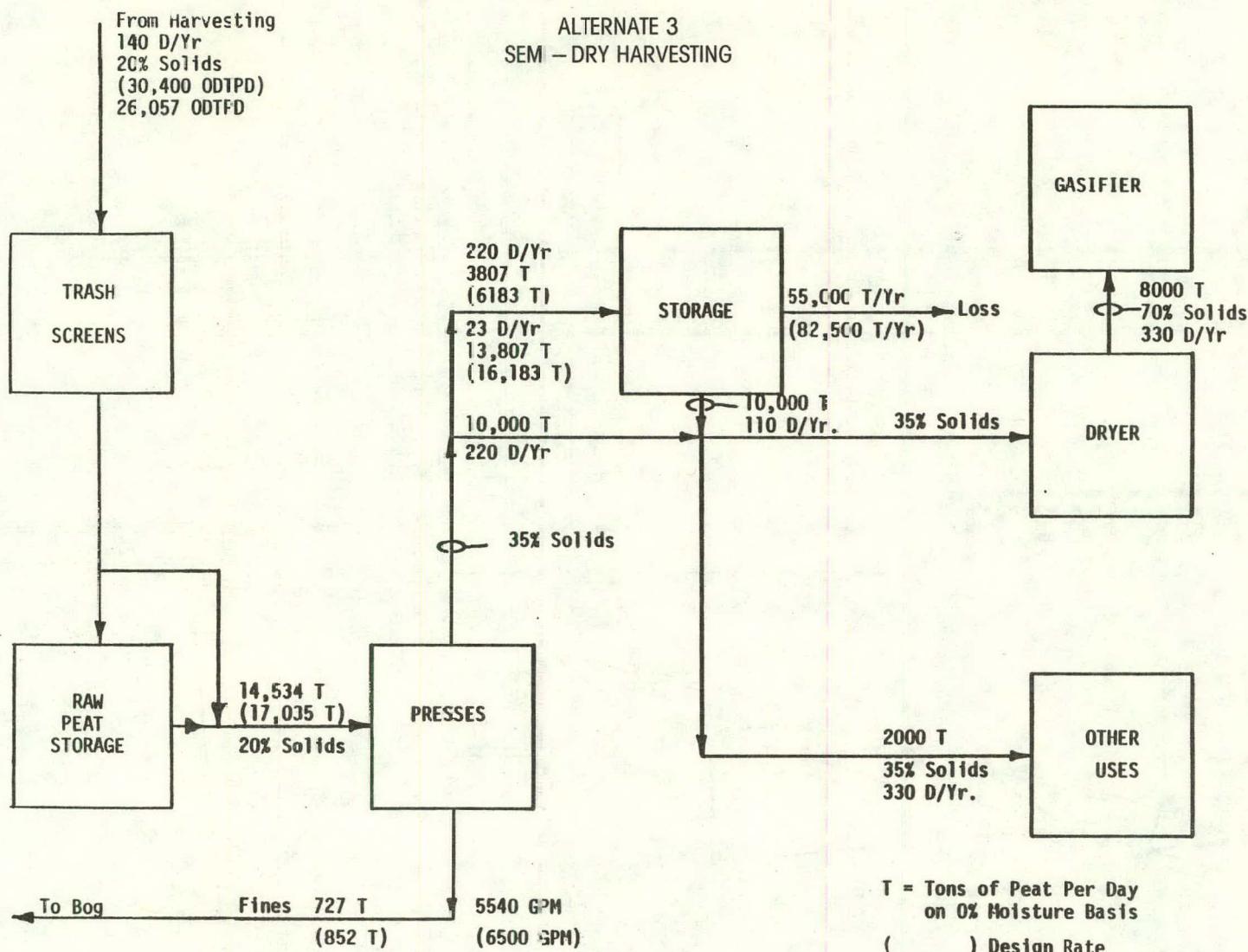


Figure 10  
Alternate 3 Dewaterring.

**TABLE 1**  
**SELECTION FACTORS**  
**HARVESTING—DEWATERING CONCEPTS**

<u>Method</u>	<u>Alternate 1</u>	<u>Alternate 2</u>	<u>Alternate 3</u>
	Wet Front Shovel on Barge	Dry Conventional Milling Equipment	Dry (Modified) Conventional Deep Milling Equipment (Modified)
	Slurry Pipeline to Dewatering Plant	N.G.R.R. - Rail Transport to Storage	Conveyor to Dewatering Plant
	2-1/2% Slurry Peat	45-50% Moisture Peat	80% Moisture Peat
	Mechanical Dewatering	No Mechanical Dewatering	Mechanical Dewatering
	Pump and Gravity Return Water to Bog	No Return Water	Water to Pond or Bog
	Thermal Drying	Thermal Drying	Thermal Drying
Preproduction Time	3 - 4 Years	5 Years	3 - 4 Years
Harvesting Season	8 Months	100 Days	6-1/2 Months
Mechanical Dewatering Period	8 Months	N/A	8 Months
Harvesting Design Production Requirement 0% Equivalent Peat	18,600 Tons/Day	151,000 Tons/Day (35 Days)	30,400 Tons/Day
Safety Factor	1.14 (8/7)	1.5	1.18 ( $\frac{6.5}{5.5}$ )

**TABLE 1**  
**SELECTION FACTORS**  
**HARVESTING—DEWATERING CONCEPTS**

<u>Method</u>	<u>Alternate 1</u>	<u>Alternate 2</u>	<u>Alternate 3</u>
Bogs Initially Worked	5 Bogs	5 Bogs	2 Bogs
Average Acres/Year	3,400 Acres	60,000 Acres	13,200 Acres
Bogs Worked at 20 Years	5 Bogs (3 Depleted)	10 Bogs (1 Depleted) (4 Partially Depleted) (5 New Bogs)	6 Bogs (3 Depleted) (3 Partially Depleted) (4 New Bogs)
Number Persons Harvesting	(Contract Clearing) 450	(Contract Bog Preparation) 1550 Maximum (1000 - Seasonal) (550 - Full Time)	(Contract Bog Preparation) 470 Maximum (340 - Seasonal) (130 - Full Time)
Harvesting Equipment	7 Dredges 10 Booster Pumps 100 Support Equipment	1200 Major Items 925 Harvesting 275 Support 10 S.G. Locos/230 Cars 20 N.G. Locos/390 Cars	220 Major Items 115 Harvesting 105 Support 30 Shiftable Conveyors 10 Transport Conveyors
Dewatering Design			
Production Requirement			
% Equivalent Peat	13,800 Tons/Day	N/A	13,800 Tons/Day
Storage Requirements	1.65 Million Tons 200 Acres	2.48 Million Tons 300 Acres	1.65 Million Tons 200 Acres
Number Persons Dewatering/Drying	130	25	130

**TABLE 1**  
**SELECTION FACTORS**  
**HARVESTING—DEWATERING CONCEPTS**

<u>Method</u>	<u>Alternate 1</u>	<u>Alternate 2</u>	<u>Alternate 3</u>
Dewatering/Drying Equipment	170 Presses 26 Dewatering Screens 2 Stackers/Reclaimers 11 Dryers	3 Stackers/Reclaimers 5 Dryers	100 Presses 2 Stackers/Reclaimers 11 Dryers 6500 gpm Water Treatment System
Reclamation Consideration	6" Peat Tilled into Subsoil Lakes Farming-Forestry	1' Peat Tilled into Subsoil Farming-Forestry	1' Peat Tilled into Subsoil Farming-Forestry
Risks-Unknown	Pumping Characteristics Fines/Colloids Roots	Weather Labor Dust Fires Water Discharges	Unproved Modifications Weather Dust Fires

**TABLE 2**  
**FACTORED COST COMPARISON**  
**HARVESTING—DEWATERING CONCEPTS**

<u>Harvesting</u>	<u>Alternate 1</u>	<u>Alternate 2</u>	<u>Alternate 3</u>
a. Capital	1.00	4.17	1.58
b. Ownership	1.00	3.74	1.41
c. Operating	1.16	1.39	1.00
d. Ownership & Operating	1.00	2.72	1.19
<hr/>			
<u>Dewatering</u>			
a. Capital	6.65	1.00	4.57
b. Ownership	6.75	1.00	4.63
c. Operating	4.83	1.00	4.00
d. Ownership & Operating	6.23	1.00	4.45
<hr/>			
<u>Harvesting-Dewatering</u>			
a. Capital	1.03	1.47	1.00
b. Ownership	1.08	1.45	1.00
c. Operating	1.33	1.00	1.12
d. Ownership & Operating	1.11	1.30	1.00

## QUESTIONS AND ANSWERS

Q: What bog surface preparation is necessary for the dredge system? Do you have to flood it or just start with an initial pool for the dredge to work from?

A: What we envisioned is a dredge system that would work downhill.

There would be some initial preparation required, to remove most of the major growth off of the bog and create an initial pond for the dredge to begin operating in. As the dredge progressed downhill, taking the peat out, the pond would follow it down the grade. When you get to the bottom of the grade, the upper portion would already have been exposed to the air. There might be some areas where it is still somewhat wet, but basically you could start your reclamation efforts much earlier.

Q: What do you think the third system you spoke of will cost? Also, do you think it will ever reach a stage where it is going to be applied?

A: To answer your first question, we are in the process of developing final costs and optimizing. I don't have a figure that I can give you.

To answer your second question, by all means I think it has practicality. I think that it depends on the extent of operation and the precise location of harvesting and dewatering plants that will govern largely the final cost that you might expect, associated with any harvesting scheme.

Q: Is it going to be used in a gasification process?

A: In this case, yes, with the Minnesota Gas Company. It is for an 80-million-cubic-feet-per-day gasification plant.

## QUESTIONS AND ANSWERS

Q: The question I have is about the relative wetness of the three alternatives. I wondered if you would comment on the factor that you have thermal drying there and the alternate you chose is much wetter than the second alternative.

A: Yes. We did in each case consider a drying effort in our analysis and we have included dollars in that analysis. We were comparing peat being delivered to the gasifier at the same degree of dryness, so there is the same degree of exactness in all three alternatives that we did examine.

Q: Did you use a base cost on some form of energy that will be used for drying?

A: The work was done by considering the number of dryers and the types of dryers that would be required in a gasification effort to bring the peat from whatever degree of moisture it was at to the 31% at which it would be fed into the gasifier.

COMMENT: I think that the cost of the energy would be important in that case.

REPLY: Yes, I agree.

Q: Due to the cold climate of this proposed operation, what consideration was given to operating during the months when you have ice in the soil?

A: During the coldest part of the winter we would not harvest at all. The peat would be provided to the gasifier from the storage area where it was previously dried.

## QUESTIONS AND ANSWERS

Q: Did you anticipate any frost or was there a cutoff point?

A: The length of the harvesting season was considered in each case. And as you may recall, when we were talking about the dry harvesting, we were talking only of having 35 effective 10-hour days over a 100-day period. So we did try to consider the weather and the weather dependency in our evaluation.

Q: What is the minimum thickness of the peat for alternative three?

A: We are considering a four foot minimum thickness. We figure that we would try to obtain two two-foot passes. That is our current thinking. Again, this will be largely dependent on the subsoil, how well you can drain it, how much of a variance there is in the bottom of the clay below the peat. There are a number of factors that will enter into the final evaluation.

But our thinking right now is to be able to obtain two passes per field per year.

Q: Which of the three alternatives use the most amount of diesel fuel, both for reclamation as well as for the dewatering, if you use it?

A: I would have to guess, and I emphasize guess, that alternative two with the large number of pieces of equipment that we would have operating would have the greatest requirement for diesel fuel.

We haven't sat down and calculated how many gallons per se of diesel under any one alternative would be required.

Also, when we were talking about the dredges, for example, we were talking about electric dredges.

## **QUESTIONS AND ANSWERS**

Q: Did you work out the cost of mechanical drying versus thermal drying in terms of reduction in percentage of moisture content?

A: That exercise was done, yes. I don't have the figures on it.

Q: You have one alternative that has a storage step. Did your study go into detail on that?

A: Yes, our study did go into quite a bit of detail. All three alternatives have storage. All three have varying amounts of storage. I do have a break-out on it. If you would like to see it, I can show you the differences in the amounts of storage that are required under each of the alternatives.

**GRI JOINT PROGRAM**

**JOHN HOPPE**

**GAS RESEARCH INSTITUTE  
CHICAGO, ILLINOIS**

The Gas Research Institute is a nonprofit organization funding R&D in the gas industry. We are sponsored by the ratepayer and our funding is distributed to us through the gas industry and regulated by the Federal Energy Regulatory Commission.

There are five advisory boards that we are responsible to for our funding efforts. They include the Research Coordination Panel, the Industry Technical Advisory Council, a Municipal Gas Science Advisory Council, and on a program level we have fossil fuel advisors, and of course, we have FERC in the background.

So we try to make sure that we have a coordinated program plan and our program plan is coordinated within GRI as well as without.

In the peat area we have a joint obligation with the DOE on a one-third basis that covers most of the programs that are being funded in peat. These include the resource assessments for the 12 states and; the harvesting studies, including First Colony Farms and Dravo. Dravo is an independent study that we are having made. It is similar to some of the things that have been done in the feasibility study.

On dewatering studies, we are funding the wet carbonization by IGT and aqueous dewatering at the University of Pennsylvania. We have a share in the environmental program, which will begin at the end of this year.

GRI is co-financing the RFP for the socio-economic study that will be coming out next year. We have also been involved with single-stage PDU studies as well as the PEATGAS Pilot Plant.

We have four divisions in the Gas Research Institute: The Supply Division, the Environmental Division, the Fish and Utilization Division, and the Basic Research Division. Our peat research is funded out of the SNG from coal program, which comes under the Supply Division. Of course all the other areas are just as important.

We also have a technical evaluator that is part of this program, and that is M.W. Kellogg. They assist us in doing the evaluation of the program.

## QUESTIONS AND ANSWERS

Q: What is the projected date for completion of the gasification plant?

A: We will have the feasibility study result hopefully in the summer of 1982. If the feasibility results are economically viable so that Minnegasco continues on with the project, it could take a minimum of about four years.

Q: Would decontrol of natural gas prices help or hinder this?

A: Well, decontrol, of course, implies an increase in gas prices, of natural gas, to most people. That, of course, would be beneficial towards any programs that could come and show that synthetic natural gas can be made at a reasonable or at a lower rate than the natural gas. So that would be a benefit to us to a certain extent.

Q: The gas industry lately has announced that there is enough natural gas now to lead us through the next 50 years, I think. How does that kind of information affect your program?

A: It doesn't help. It is something that I am battling, not only in this program, but in other programs. And what it is saying is that we have unlimited resources. My own opinion, of course, is that I don't think that we should deplete these resources on the path that we have outlined at this point. But, of course, we are taking direction in going into unconventional sources and saying, All right, we can get the gas out of the ground. This does make it difficult to argue for a program or for a plant that will cost a couple of billion dollars today.

It means that we have to forestall some of these things that we are doing until either it is resolved that we take the steps right now or put them off until some future date.

**PEAT HYDROGASIFICATION**

**MARTIN GAREY**

**ROCKWELL INTERNATIONAL  
CANOGA PARK, CALIFORNIA**

## **BACKGROUND**

The United States possesses substantial peat reserves, and peat can become a significant source of energy for the country. Thus, the Department of Energy (DOE) has been sponsoring the development of peat gasification technology for the economical conversion of peat to gaseous (and liquid) products. As part of this ongoing program, peat has been successfully processed through the Rockwell Flash Hydropyrolysis (FHP) reactor developed for coal conversion. The Rockwell tests have demonstrated high carbon conversions, consistent data, the coproduction of benzene as a high value byproduct, and a 1000 to 1 scaleup from bench-scale testing. Preliminary process economics studies indicate the potential of the Rockwell reactor for producing high-Btu gas from peat at a cost competitive with or superior to SNG from advanced coal conversion processes.

Rockwell became involved in peat hydrogasification process development as a result of its existing program in coal hydrogasification. Perhaps a brief review of the Rockwell Coal Hydrogasification Reactor would be in order. Figure 1 is a schematic presentation of the reactor, which is derived from aerospace rocket reactor technology. A rocket-type injector sprays impinging jets of pulverized coal and hot hydrogen, at about 2000°F, into the reactor. Rapid mixing followed by rapid reaction occurs, and within a few seconds, SNG and other products are formed. It is desirable to inject the pulverized coal or peat with a minimum of carrier gas in order to minimize the amount of heat the hot hydrogen has to carry into the reactor. This is accomplished by dense-phase feeding, a technique developed at Rockwell that allows the transport of pulverized coal or peat with just enough carrier gas to fill the interstices between the coal particles.

## **OBJECTIVES**

The major objectives of Rockwell's current peat hydrogasification program are shown in Figure 2. These objectives are to:

- 1) Develop a conceptual process design and economic evaluation of an optimized commercial-scale SNG from peat plant using the Cities Service/Rockwell (CS/R) Hydropyrolysis Process.
- 2) Determine the most suitable commercially available peat drying and grinding processes as candidate suppliers of peat feedstock to the Rockwell FHP reactor.
- 3) Conduct replicate testing at selected reactor parameters to provide consistent reactor performance data, good material balances, and characterization of significant minor constituents in the product slate.

#### **TECHNICAL PROGRESS**

Technical progress to date on Rockwell's peat hydrogasification program was reported at the last Contractors' Conference on peat and will be reviewed here only briefly.

Rockwell peat hydrogasification testing has explored a large temperature-pressure envelope of the test conditions, extending previous IGT data to higher temperatures, pressures, and throughputs. The Rockwell carbon conversion data correlate well over a wide range of reactor conditions, and the derived reactor modeling equation also correlates the data from IGT testing in the lower temperature and pressure regions. The high carbon conversions, characteristic of the Rockwell hydrogasification reactor, allow the consideration of process flow-sheet options unavailable for lower carbon conversion reactors.

Figure 3 shows the envelope of reactor temperatures and pressures encompassed in Rockwell testing and compares it with previous testing at IGT. It is also noteworthy that the Rockwell reactor throughputs were 100 to 1000 times higher.

## **DENSE PHASE FEEDING**

Figure 4 shows the experimental system used for performing the peat dense-phase feeding studies. Peat is first loaded into the loading feeder and then transported into the feeder tank. Once the feeder tank has been filled with a sufficient charge of peat, the feeder tank is pressurized and its ball valve opened. The peat then flows through a 2-in. line reducer, the test line itself, and then into a receiver tank. This system is rated for solid feed rates up to 1 T/hr at pressures to 150 psi. The peat flow rates are determined from the load cell and pressure measurements taken on the receiver tank, while carrier gas flow rates are found from the feeder tank pressure and nitrogen pressurant flow measurements.

Typical dense-phase flow engineering data are shown in Figure 5. It is noted that the data exhibit the classical exponential relationship between mass flux and pressure drop, i.e., a straight-line relationship when plotted on log-log paper. The data shown here are for two moisture contents and shows the expected relationship of higher pressure gradient at higher peat moisture content.

## **HYDROGASIFICATION TESTS**

A flow diagram of the Rockwell engineering-scale hydrogasification test facility is shown in Figure 6. The reactor is a thin-walled metal cylinder housed within a pressure shell. The space between the reactor wall and pressure shell is insulated to minimize reactor heat loss. This design results in near-adiabatic operation of the reactor with balanced pressures across the reactor wall. Figure 7 shows the insulated reactor being lowered into the pressure shell in preparation for a test. Figure 8 shows an injector used in the testing. Four streams of heated hydrogen impinge on a central stream of dense-phase-fed pulverized peat with the option of injecting additional oxygen through four orifices.

An average proximate and ultimate analysis of the peat feedstock used for this reactor testing effort on a dry basis is shown in Table 1. The actual peat used had moisture contents between 9.21 and 17.60 wt%.

Figure 9 shows a plot of total carbon conversion vs reactor temperature for a number of hydrogen partial pressures used in the Rockwell experiments. Plotted on the same figure are some IGT data points showing the close agreement in results. Figure 10 shows a similar plot of carbon conversion to liquids.

## DATA CORRELATION

In correlating the experimental results from the hydrogasification test program, a simple peat hydrogasification reactor kinetic model was developed based on earlier analytical efforts of other researchers. A schematic representation of this kinetic model is shown in Figure 11. This analysis uses the devolatilization concept developed by Anthony et al. (Reference 1), which states that pyrolysis proceeds through a large number of multiple parallel reactions that produce volatiles and rapid-rate carbon. The rapid-rate carbon in turn follows the analysis of Zahradnik and Glenn (Reference 2), which allows the rapid-rate carbon to either react with hydrogen, producing hydrocarbon gases plus char, or to simply cross-link and form char. The result of this derivation shows that carbon conversion,  $\eta$ , is given by the equation shown in Figure 12,

where

$\eta$  = carbon or MAF peat conversion  
T = peat particle temperature, (K)  
t = time, (S)  
R = universal gas constant, (J/mol-K)

In this equation, conversion,  $\eta$ , is determined from the particle temperature-time history and hydrogen partial pressure. There are six model parameters whose values are calculated from actual experimental data; these parameters are defined in Table 2.

The integral carbon conversion data from four separate hydrogasification test reactors were used in determining the model parameters of the equation. These four test reactors and facilities were the Rockwell International 0.25-T/hr entrained-flow reactor, the Institute of Gas Technology (IGT) coiled tube reactor, the Cities Service coal tube reactor, and the Rockwell International

0.75-T/hr entrained-flow reactor of this current study. A total of 48 reactor data points were fitted to the equation using a least-squares, nonlinear, computer curve-fitting routine.

A comparison between the model predictions of overall carbon conversion for the experimental conditions of each test point and the experimental results is shown in Figure 12 for carbon conversion. As seen from this figure and Table 2, the model predictions are in excellent agreement with the experimental data: the standard deviations between predicted and experimental values are only 4.3%. Rockwell's, IGT's, and Cities Service's data mesh very nicely over carbon conversions ranging from 40% to 85%. This modeling equation provides a consistent correlation for the experimental data within ranges of operating conditions as follows: reaction temperatures from 850 to 1850°F, hydrogen partial pressure from 0 to 1500 psig, and reaction residence times from 0.50 to 7.7 sec.

### **PROCESS DESIGN AND ECONOMICS**

Process design studies and economic evaluations were made for several different flash hydrolysis (FHP) plants producing approximately 250 billion Btu's of SNG per day from a Minnesota peat by the Cities Service/Rockwell (CS/R) hydrogasification process. The plants are self-sufficient, generating all steam and power from the peat. The peat is supplied to the site with a 50% moisture content. It was shown in these studies that very attractive economics are obtainable and that benzene coproduction significantly reduces gas cost. A summary of the key study results is shown in Figure 13.

The plant configurations analyzed were based upon hydrogasifier performance obtained in test runs conducted at the Rockwell 0.25-T/hr and 0.75-T/hr facilities. Two different process schemes were considered, differing primarily in the method of generating makeup hydrogen (i.e., partial oxidation gasification or steam reforming of product methane).

The design demonstrating the greatest potential for further study was based on Rockwell Test 318-069, which was chosen for evaluation because of the high

overall carbon conversion and BTX formation observed at a relatively low H<sub>2</sub>-to-peat ratio. This test was run at a hydrogasifier pressure of 485 psig, a reaction temperature of 1703°F, and a H<sub>2</sub>-to-peat weight ratio of 0.210. Table 3 summarizes the reactor operating conditions and performance for this run.

The plant configuration uses the steam-CH<sub>4</sub> reforming process to supply makeup hydrogen to replace that consumed or lost in the process. The hydrogen supply to the hydrogasifier is primarily obtained by cryogenically separating hydrogen from the main process stream. In the steam-CH<sub>4</sub> reforming process, a portion of the plant product SNG (pipeline gas) is reacted with steam at 1500°F to produce a hydrogen-rich gas. This gas is further enriched by reacting the CO present in a shift reactor. Carbon dioxide is removed from the gas in an MEA scrubbing system. The makeup hydrogen stream (~ 96% H<sub>2</sub>) is combined with the recycle hydrogen stream (~ 99.7% H<sub>2</sub>), compressed to 530 psig, and preheated to 1500°F prior to injection into the hydrogasifier. A block flow diagram is shown in Figure 14.

Major process plant sections shown include systems for (1) peat storage, handling, drying, and feeding; (2) oxygen production; (3) hydrogasification with preheat and heat recovery; (4) product gas processing including CO shift, acid gas removal, light aromatics separation, hydrogen separation, and gas compression; (5) makeup H<sub>2</sub> generation; and (6) steam and power generation, ash disposal, and feedwater and wastewater treatment.

A factored capital cost estimate was prepared for this plant configuration by factoring process equipment blocks from prior commercial plant studies and escalating to first-quarter 1980 dollars. Total capital requirement is estimated at \$1,612 million. Annual operating costs were based on an annual on-stream time of 90% (7,884 operating hours) and a peat value of \$0.75/MMBtu. Peat is assumed to be delivered to the site with a 50% moisture content and dried to 12.5% moisture to match the experimental conditions of Rockwell Test 318-069. Catalyst and chemical costs were factored from other similar studies. Net annual operating cost is estimated at -\$22.5 million, meaning that the value of the byproducts produced (predominantly benzene) exceeds the gross operating costs. Approximately 8600 BPD of benzene are produced under these conditions.

Table 4 shows the estimated gas cost for this case. The value of \$2.02/MMBtu shown is the average gas cost over a 20-year project life based on the utility financing method with a debt-equity ratio of 75/25 and a return on equity of 15%.

### **TECHNICAL PROGRESS SUMMARY**

Figure 15 summarizes the technical progress made to date. Reactor performance has been extended to the high carbon conversion region with a 1000-to-1 scaleup from bench-scale testing. An analytical reactor kinetic model was developed and shown to accurately predict reactor carbon conversion data: this analysis shows the consistency in the data among four separate gasification reactors.

The general equations describing dense-phase solids transport have been developed. Finally, preliminary process economics have been studied showing the significant reduction in the cost of high-Btu gas when benzene is coproduced and a cost of gas with high potential for further study.

### **FUTURE WORK**

A three-part program, as shown in Figure 16, is planned to continue Rockwell's work in peat hydrogasification. First, there will be a more detailed process study performed by an independent A-E that would develop a preliminary optimized conceptual process design and an economic evaluation of an optimized commercial-scale SNG-from-peat plant using the CS/R hydropyrolysis process.

Second, commercially available drying and grinding peat processes will be evaluated as candidate suppliers of peat feedstock to the Rockwell flash hydropyrolysis (FHP) reactor. Commercially prepared peat from each supplier would be tested in a high-pressure dense-phase feed system to enable selection of suitably processed feedstocks for the CS/R process.

Third, additional 3/4-TPH reactor testing will be performed at reactor parameters that will optimize the overall hydrogasification process. Replicate testing will be conducted with special attention to obtaining good material balances and identifying any minor constituents in the product state.

## **TASK I COMMERCIAL PLANT PROCESS STUDY**

Figure 17 shows the detailed structuring of Task I, the commercial plant process study. The overall objective of this task is to develop a preliminary conceptual process design and an economic evaluation of an optimized commercial-scale SNG from peat plant using the Cities Service/Rockwell (CS/R) Hydropyrolysis Process. The key feature of this process is the Rockwell Flash Hydropyrolysis (FHP) reactor system, in which peat and hot hydrogen are reacted in a single-stage, short-residence-time, entrained flow reactor to produce SNG and high-value byproduct liquids.

The plant will be designed to produce 250 billion Btu/day of pipeline quality substitute natural gas (approximately 960 Btu/scf and 1000 psig) as the major product. (The SNG will comply with gas specifications given in AGA Research Bulletin No. 36.) The hydrogasifier may be operated at conditions such that high-value liquid products, such as benzene, are also formed. In addition, the plant may produce high-purity sulfur and liquid anhydrous ammonia as byproducts. It will be designed as a grass-roots plant, including onsite power and steam generation such that only peat, raw water, air, and consumptive catalyst and chemicals need be supplied during normal operation. Thus, the process will be completely self-sufficient in terms of the generation and utilization of process heat. The design will incorporate the best combination of unit operations and plant subsystems to yield the most effective technical and economic plant. The design study will entail performing basic process studies, preparing conceptual plant flow schematics, conducting parametric trade-off studies on the effect of hydrogasifier operating conditions on overall plant economics, evaluating and optimizing key plant subsystem unit processes, and establishing preliminary capital and operating costs for the commercial plant concept. A brief definition of the subtasks involved in this study are outlined below.

### **1. Basic Process Studies**

This task is concerned with detailed evaluation of experimental reactor performance data for use in the process evaluation. Statistical correlations will

be used extensively to establish the effects of independent reactor variables on gaseous and liquid product formation. Conceptual process flowsheets will be developed and material balances established to define a base case design point for the overall commercial plant concept. Basic economic criteria to be used in the study will also be defined.

The same statistical correlation procedures as used in our coal studies will be used for these purposes. Figures 18 and 19 show the results of analytical modeling and statistical correlation of coal hydrogasification data. An analytical model of the hydroconversion of Kentucky No. 9 coal successfully correlates total carbon conversion and carbon conversion to total liquids and to BTX with standard mean deviations in the order of  $\pm$  2 to 3%. These correlations have enabled the construction of a reactor performance map for Kentucky No. 9 coal as shown in Figure 20. This kind of a map has been used by our subcontractor, C. E. Lummus, to select optimum reactor parameters for coal hydrogasification process studies. The same procedure will be used by C. E. Lummus and ourselves to select reactor operating conditions for peat hydrogasification process economic studies.

## 2. Parametric Studies

This task involves performing detailed parametric studies on the effect of hydrogasifier reactor variables on overall plant economics. Key variables include  $H_2$ /peat ratio; hydrogasifier reactor pressure, temperature, and residence time; and peat properties (such as moisture content). The base case defined in Subtask 1 will be used as a basis from which excursions in the above variables can be assessed. An optimum operating point will be selected for further analysis in Subtask 4.

## 3. Plant Subsystem Studies

This task involves a review and detailed analysis of the various options for selecting key subsystem unit processes. These may include the systems for peat pulverization and drying, peat feeding, hydrogen production and separation, and

peat char utilization. The conceptual plant design and final selection of plant subsystems will be based on utilizing the best anticipated technology, not necessarily proven technology.

#### 4. Process Engineering

This task will consist of preparing the final material and energy balances defined by the result of Subtasks 2 and 3. Specific attention will be given to the integration of plant steam and power requirements in order to maximize overall process thermal efficiency.

#### 5. Process Economics

In this task, the material and energy balances developed in Subtask 4 will be used to determine preliminary capital, operating and product cost estimates for the total complex. A factored estimate approach will be employed to arrive at a total installed equipment cost. Revenue requirements will be calculated using a utility-type financing approach. Cost sensitivity studies will be conducted to assess the impact of variables such as peat cost, benzene byproduct selling price, and various economic investment criteria (such as interest on debt, return on investment, etc.) on the resultant cost of SNG.

### **TASK II PEAT PREPARATION AND FEEDING**

The objective of this task is to evaluate current commercially available drying and grinding processes as candidate suppliers of peat feedstock to the Rockwell Flash Hydropyrolysis (FHP) reactor. This evaluation would include obtaining approximately 1 to 2 thousand pounds of commercially prepared peat from each candidate supplier for performing high-pressure (500-1000 psia), cold-flow, dense-phase feeding tests. One of the commercial drying and grinding processes evaluated will be selected for incorporation into the Process Economic Study of Task I and in supplying the necessary peat for continued reactor testing in Task III.

### **TASK III 3/4 -TPH REACTOR TESTING**

Once the Process Economics Studies of Task I and the Peat Preparation and Feeding Evaluation of Task II have provided an indication of the conditions at which the Rockwell FHP reactor should be operated, further 3/4-ton per hour reactor testing will be performed at the conditions that will optimize the overall hydrogasification process. This series of testing is necessary to build high confidence in the test data at the optimized reactor operating conditions. As we have previously done with the coal, replicate testing will be conducted to establish reactor reproducibility at these conditions. Table 5 shows the results of such testing with Kentucky No. 9 coal indicating a high degree of reproducibility -- both in establishing reactor operating conditions and product mix. The variation in carbon conversion to CH<sub>4</sub>, CO, and benzene are on the order of  $\pm 1\%$ , well within instrumentation accuracy. Much effort will be placed in obtaining material balances approaching 100% and in identifying any minor constituents in the product slate. These extensive reactor data at the optimized operating conditions will be used to affirm the reactor performance data used in the Process Economic Study of Task I.

## REFERENCES

1. Anthony, D. B., J. B. Howard, H. C. Hottel, and H. P. Meissner, "Rapid Devolatilization and Hydrogasification of Bituminous Coal," Fuel, 55, 121 (1976)
2. Zahradnik, R. L., and R. A. Glenn, "The Direct Methanation of Coal," Fuel, 50, 77 (1971)

# ROCKWELL FLASH HYDROPYROLYSIS REACTOR

## REACTOR CONCEPT

SHORT RESIDENCE TIME SYSTEM WITH  
RAPID MIXING AND REACTION FOLLOWED  
BY RAPID QUENCH

## FEATURES

- RELIABLE – NO MECHANICAL INTERNALS
- MAINTAINABLE – VERY COMPACT, ACCESSIBLE
- OPERABLE – STABLE, QUICK STARTUP
- VERSATILE – ALL FOSSIL FUELS
- FLEXIBLE – LIQUEFACTION OR HIGH-Btu GASIFICATION
- EFFICIENT – HIGH PROCESS THERMAL EFFICIENCY
- ECONOMICAL – NO CATALYST

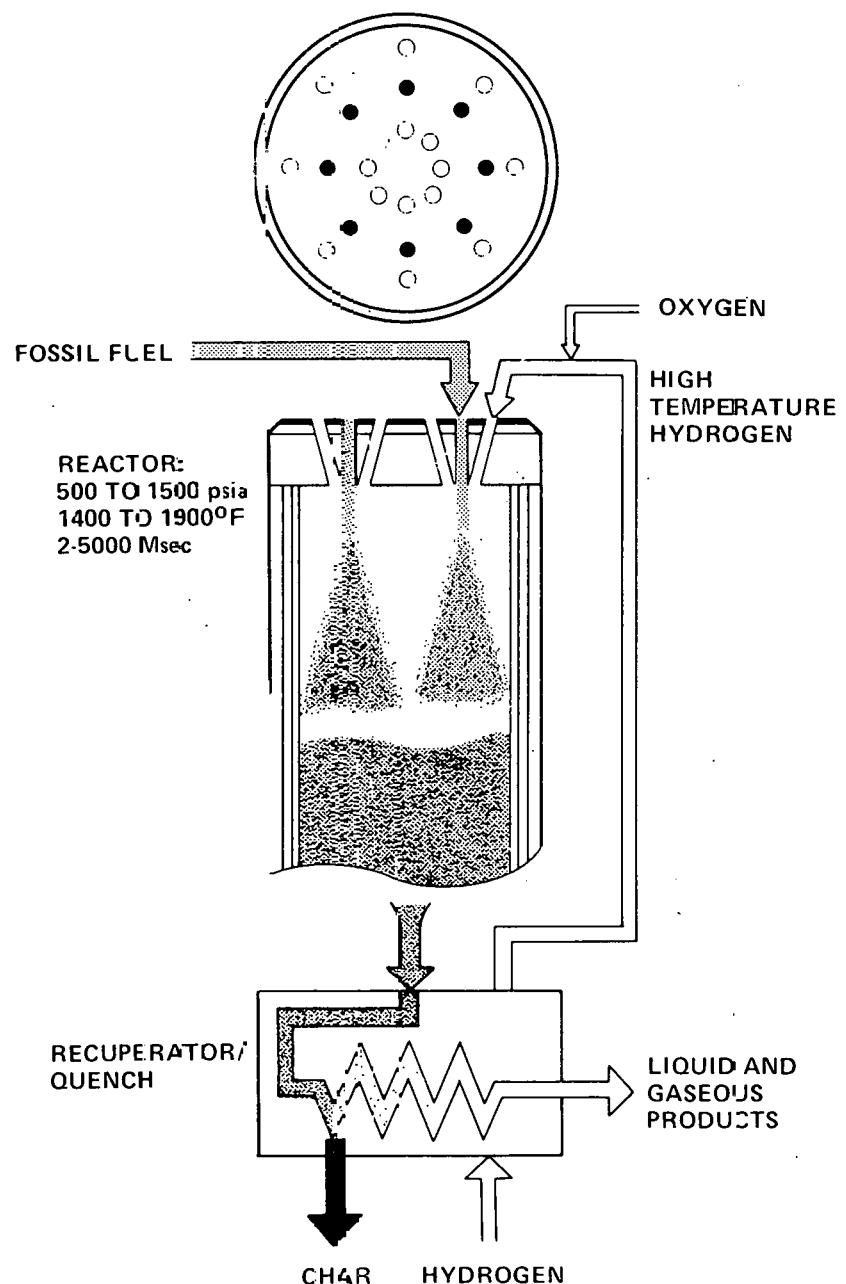


Figure 1

## OBJECTIVES

- DEVELOP CONCEPTUAL PROCESS DESIGN AND ECONOMIC EVALUATION OF OPTIMIZED COMMERCIAL-SCALE PLANT
- SELECT COMMERCIALLY AVAILABLE PEAT DRYING AND GRINDING PROCESS
- CONDUCT REPLICATE TESTING AT SELECTED REACTOR PARAMETERS

# PEAT HYDROGASIFICATION DATA ENVELOPES

-238-

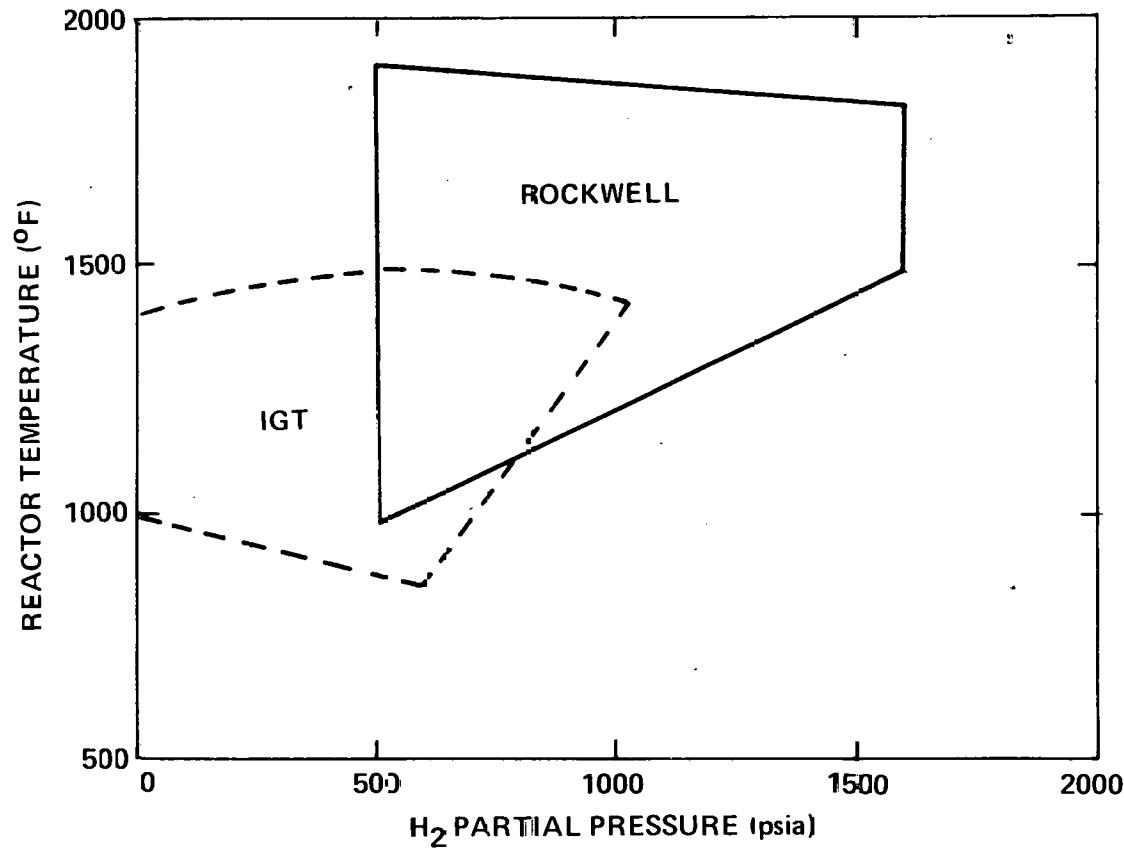


Figure 3

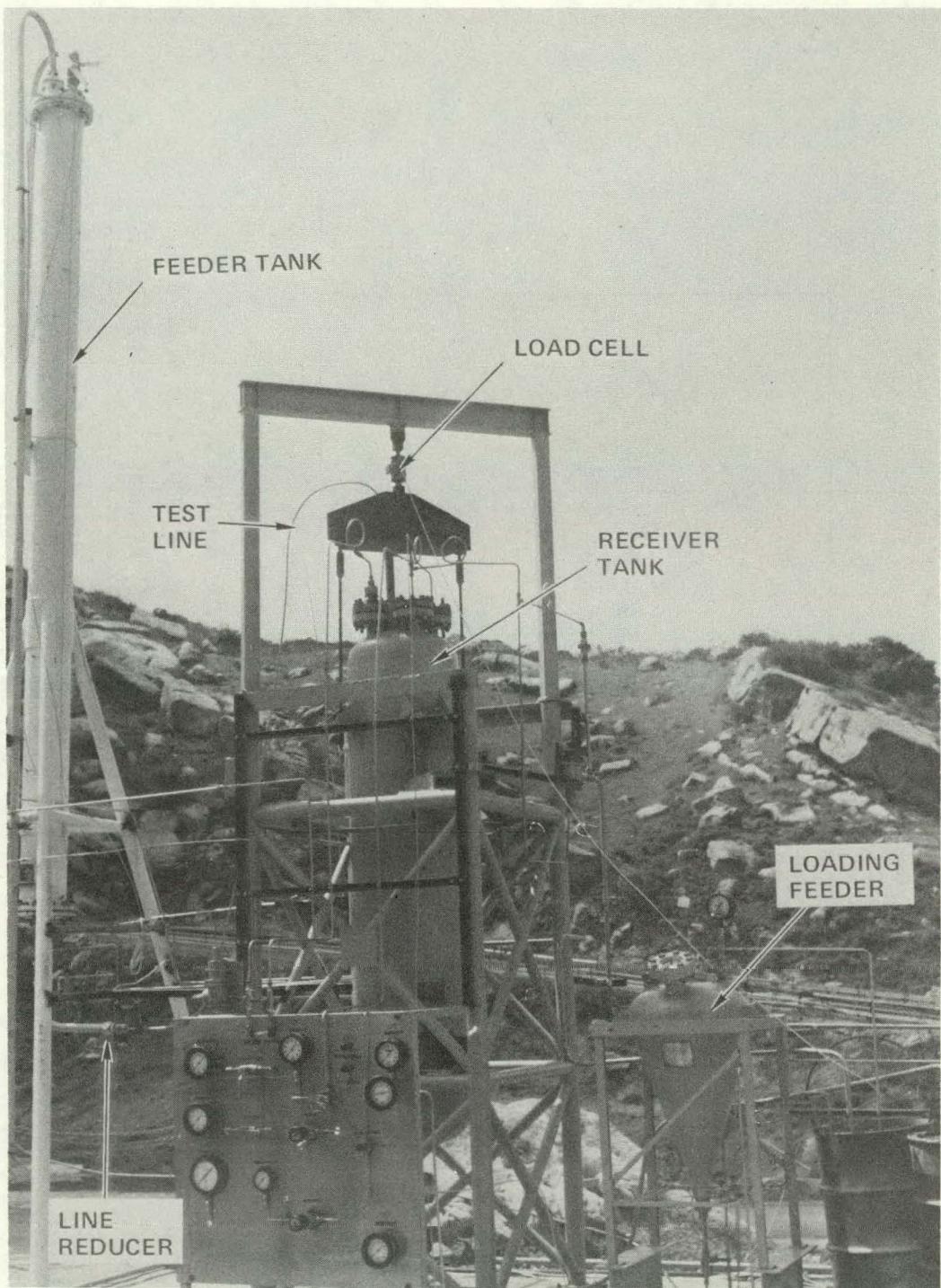


Figure 4

# TEST LINE PRESSURE GRADIENT AS A FUNCTION OF SOLIDS MASS FLUX IN A 1/2-in. OD TUBE

-240-

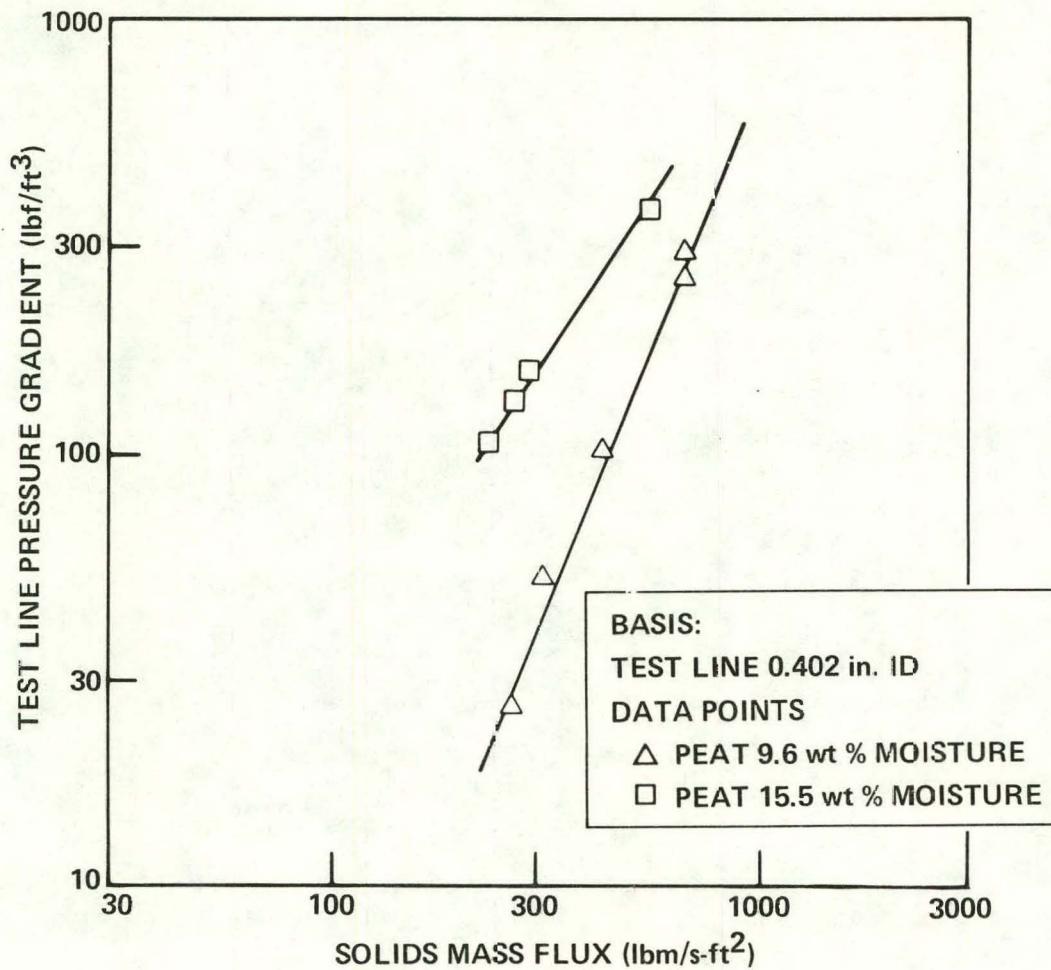


Figure 5

# FLOW DIAGRAM OF THE 3/4-TPH ENGINEERING SCALE TEST FACILITY

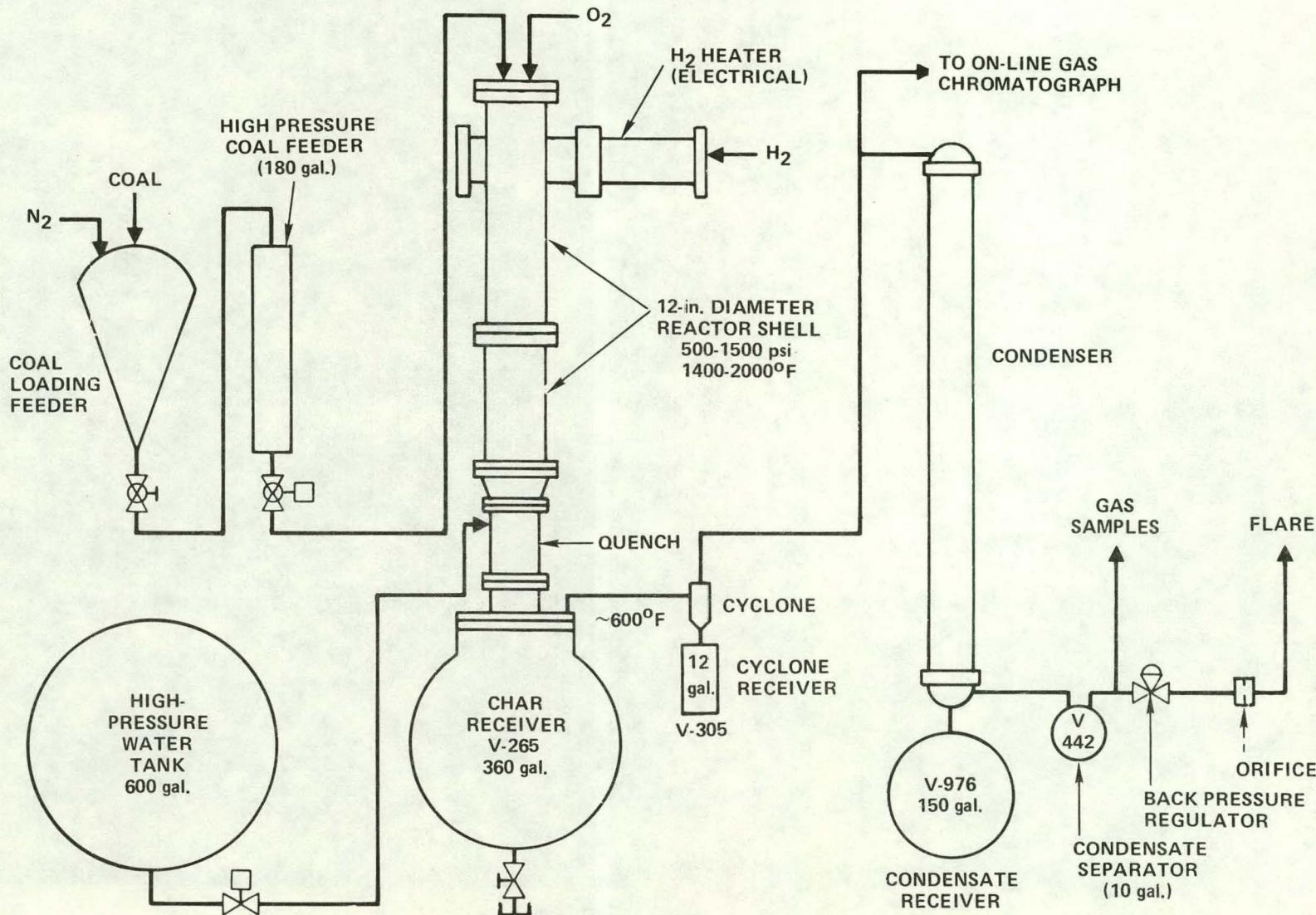
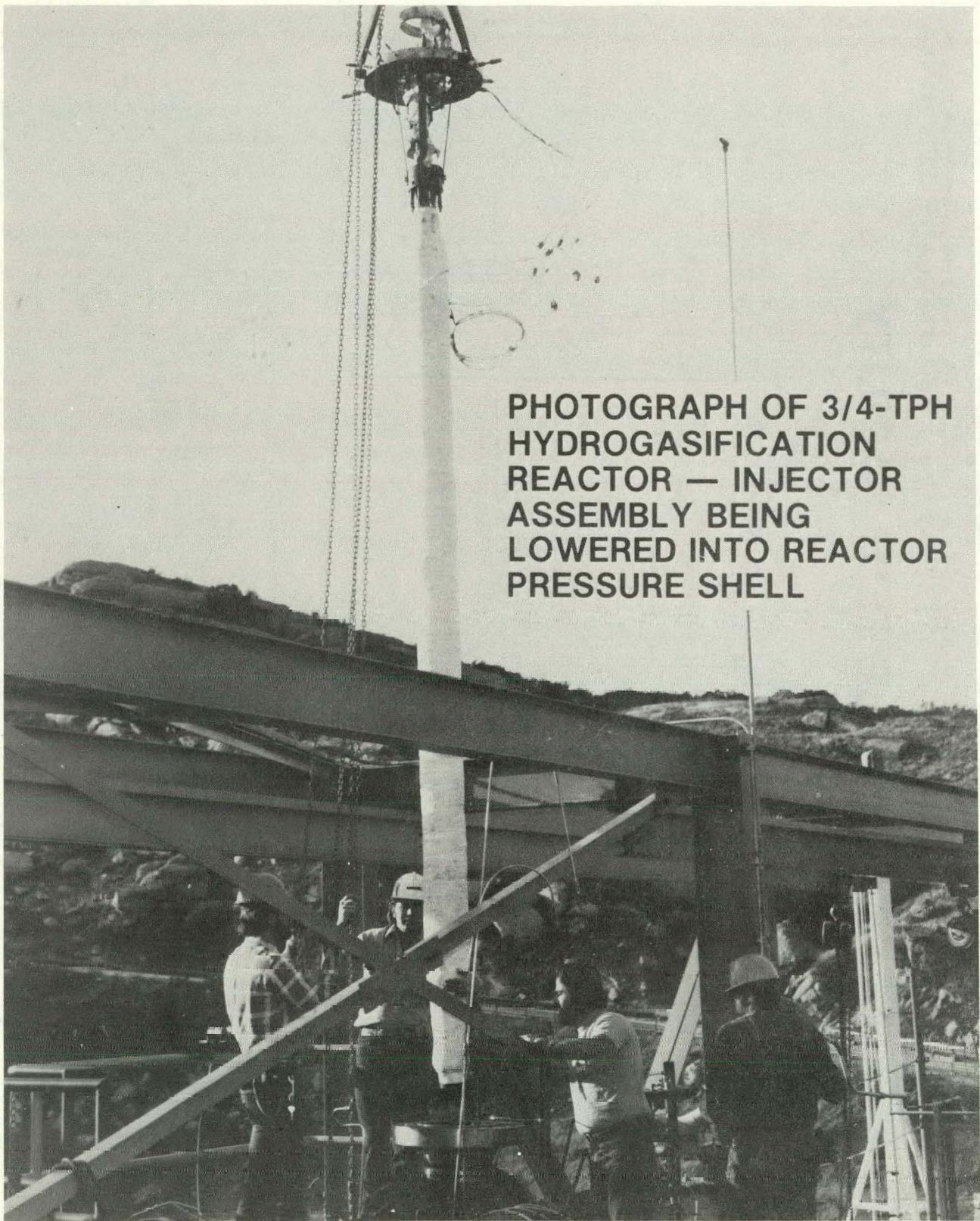


Figure 6



**PHOTOGRAPH OF 3/4-TPH  
HYDROGASIFICATION  
REACTOR — INJECTOR  
ASSEMBLY BEING  
LOWERED INTO REACTOR  
PRESSURE SHELL**

Figure 7

## FACE VIEW OF THE FIRST 3/4-TPH HYDROGASIFIER INJECTOR TESTED

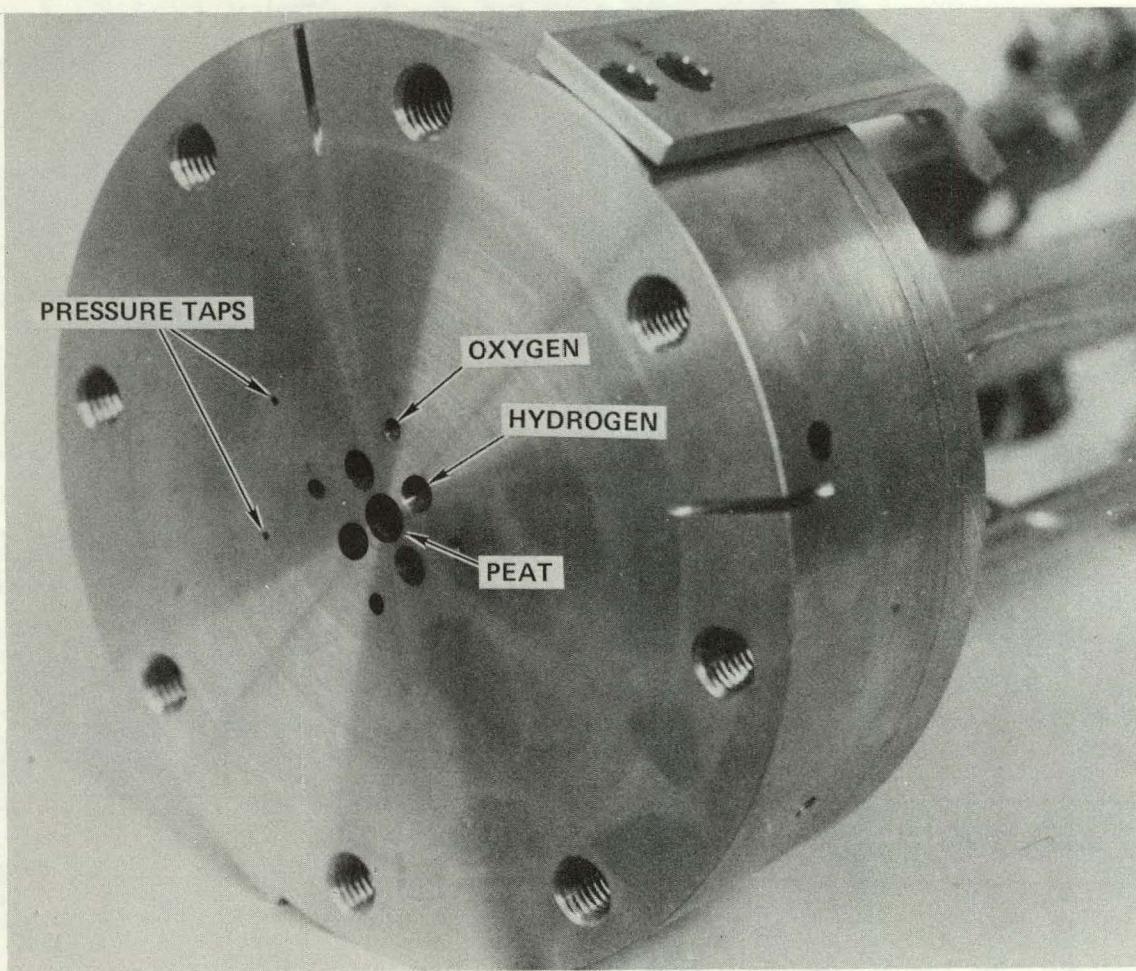


Figure 8

TABLE 1  
PROXIMATE AND ULTIMATE ANALYSIS OF  
THE MINNESOTA PEAT TESTED

ANALYSIS	DRY BASIS
PROXIMATE ANALYSIS	
wt % ASH	14.84
wt % VOLATILE	58.16
wt % FIXED CARBON	27.00
ULTIMATE ANALYSIS	
wt % CARBON	50.15
wt % HYDROGEN	5.14
wt % NITROGEN	2.29
wt % CHLORINE	0.06
wt % SULFUR	0.17
wt % ASH	14.84
wt % OXYGEN	27.35
HIGHER HEATING VALUE (Btu/lbm)	8,469

# TOTAL PEAT CARBON CONVERSION AS A FUNCTION OF REACTOR TEMPERATURE AND HYDROGEN PARTIAL PRESSURE

-245-

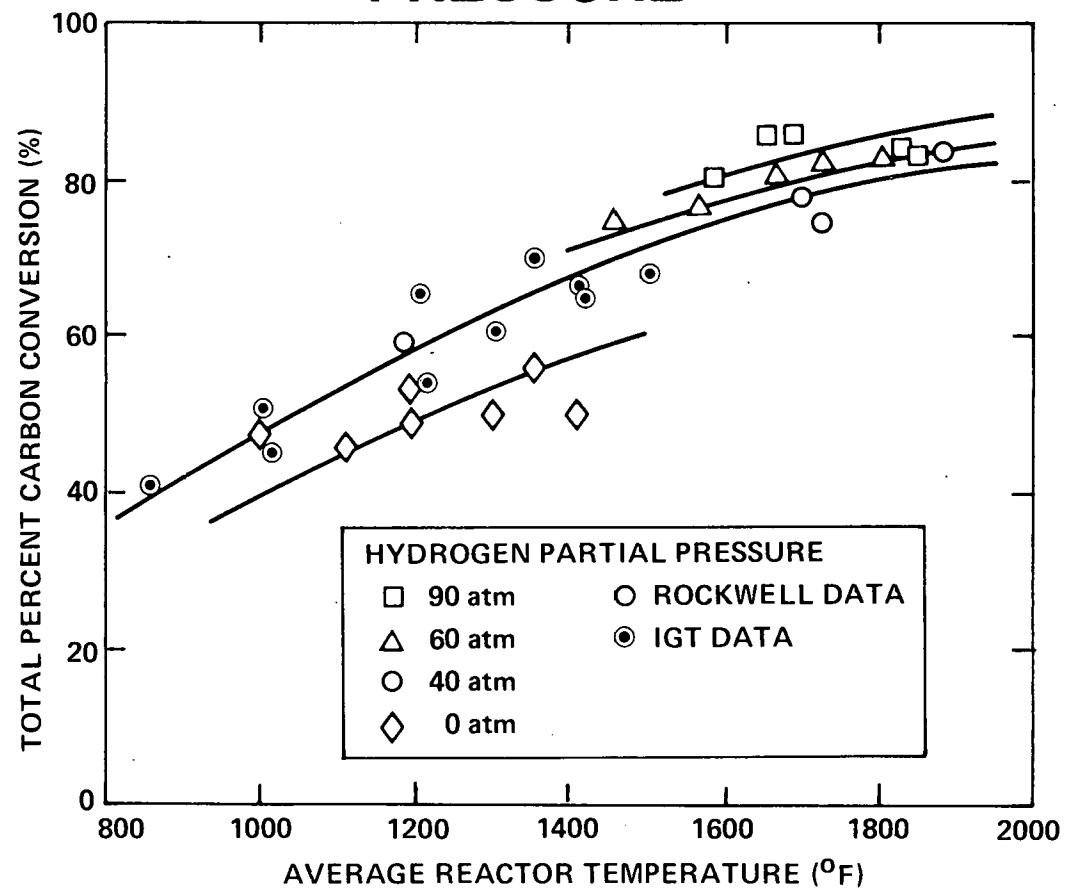


Figure 9

# PEAT CARBON CONVERSION TO LIQUIDS AS A FUNCTION OF REACTOR TEMPERATURE AND HYDROGEN PARTIAL PRESSURE

-246-

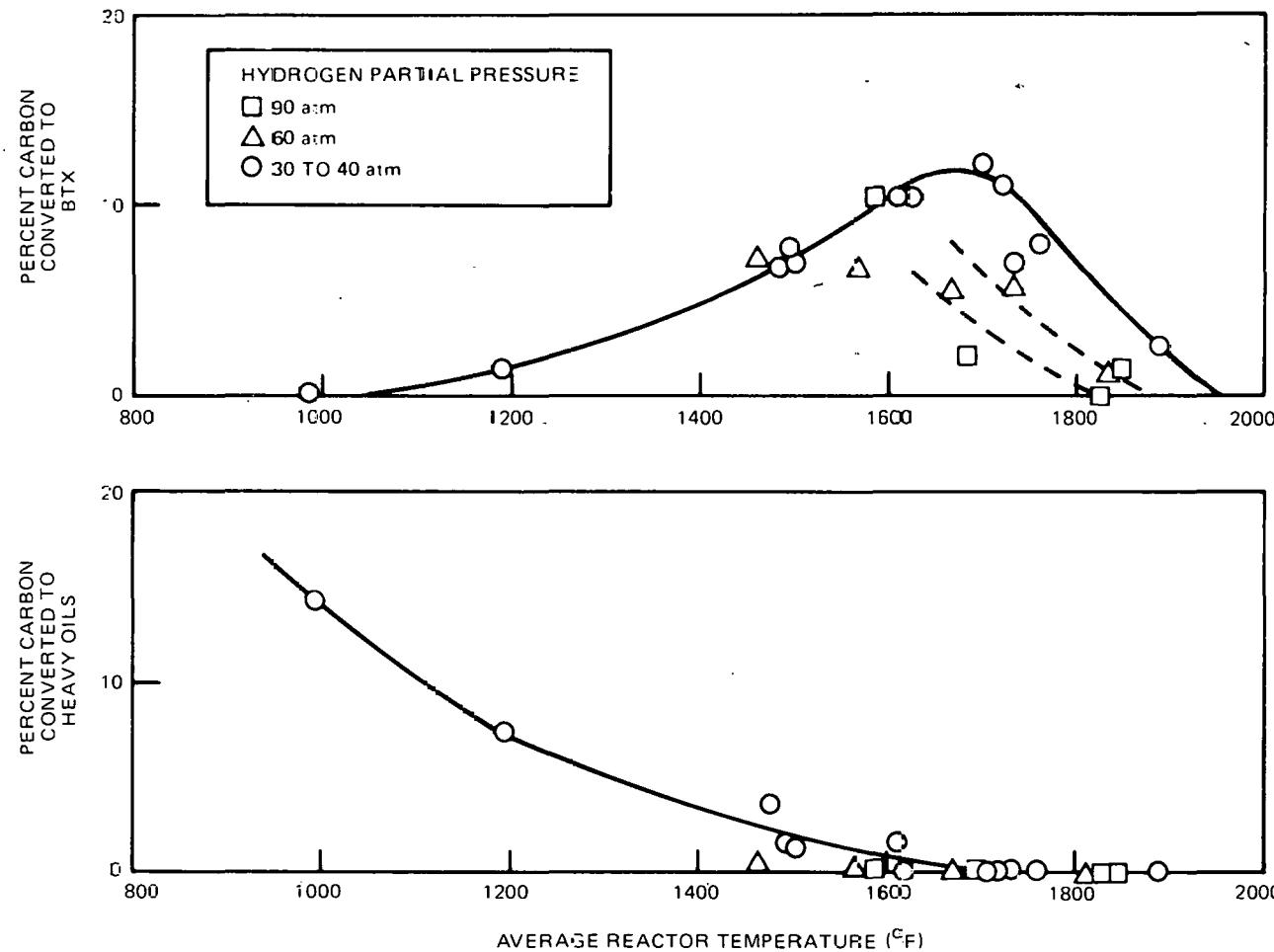


Figure 10

# KINETIC MODEL FOR PEAT HYDROGASIFICATION

-247-

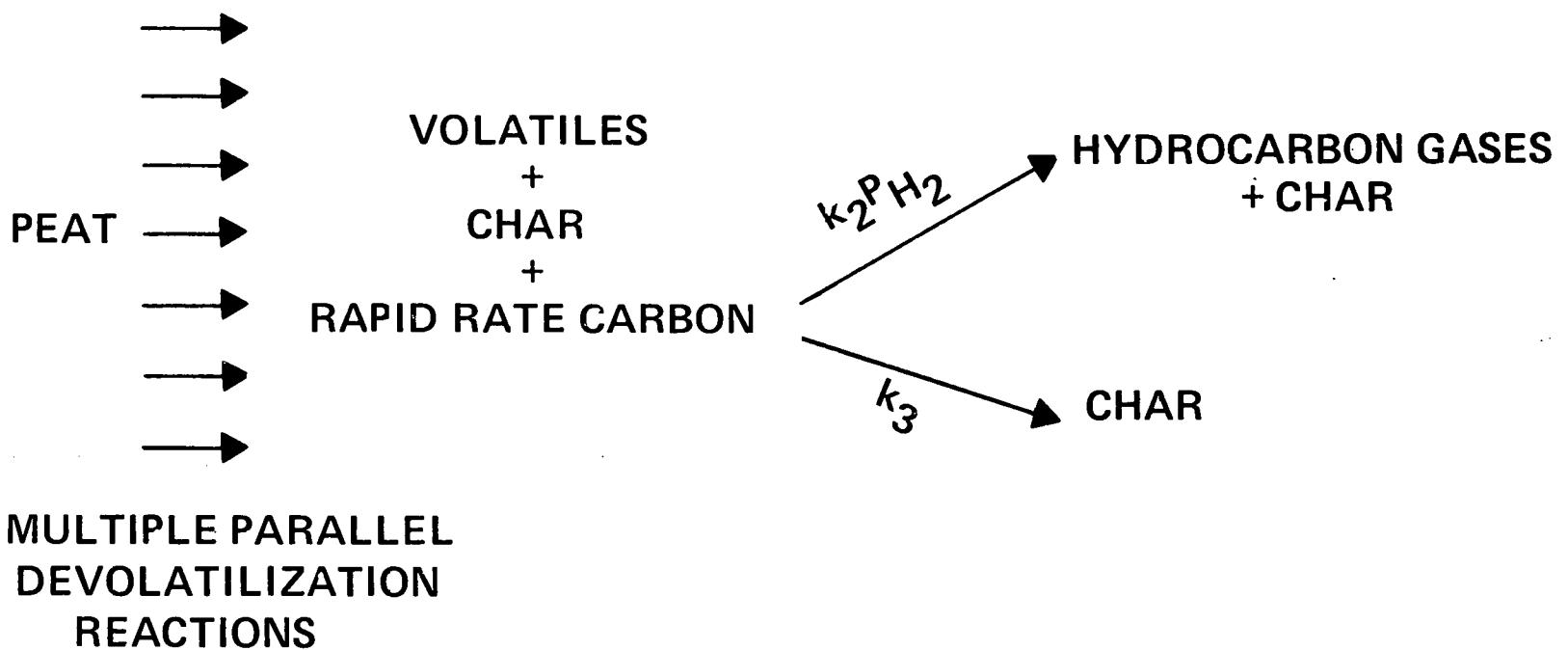
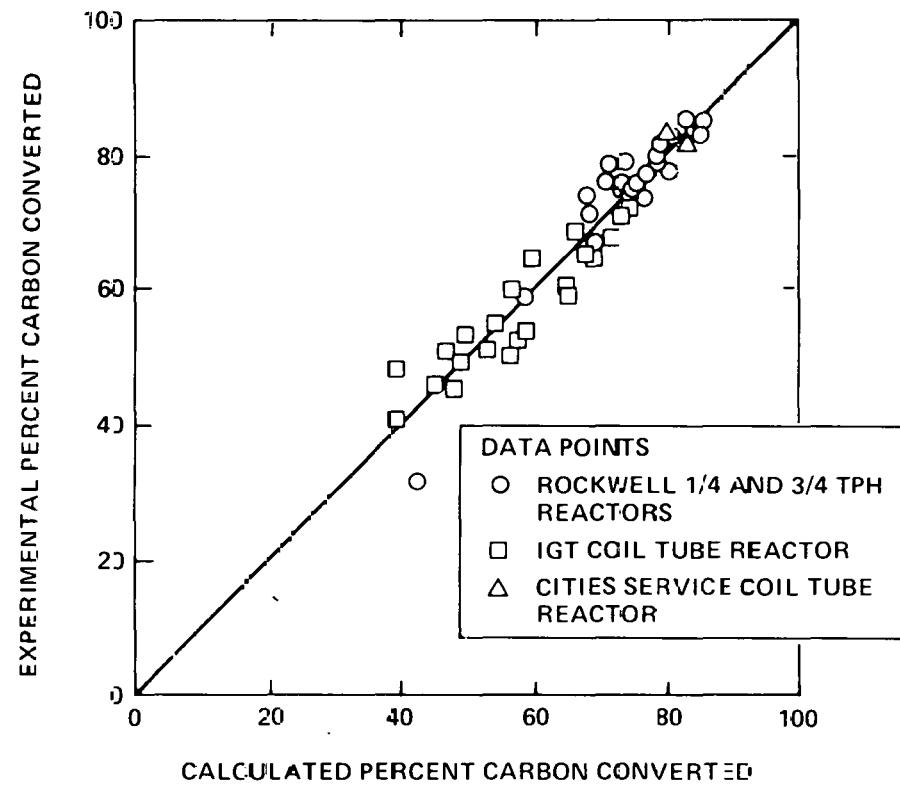


Figure 11

# COMPARISON OF MODEL PREDICTIONS AND TEST RESULTS



$$\eta = \left[ V^* + \left( \frac{C^*}{1 + \frac{1}{bP_{H_2}}} \right) \right] \int_0^{\infty} \frac{1 - \exp \left[ - \int_0^t k_0 \exp \left( \frac{-E}{RT} \right) dt \right]}{\sigma \sqrt{2\pi}} \exp \left[ \frac{-(E - E_0)^2}{2\sigma^2} \right] dE$$

Figure 12

TABLE 2  
MODEL PARAMETERS FOR PEAT HYDROGASIFICATION

MODEL PARAMETERS	A CARBON CONVERSION BASIS
1) $k_o$ , FREQUENCY FACTOR OF ALL PYROLYSIS REACTION (s <sup>-1</sup> )	$1.67 \times 10^{13}$
2) $E_o$ , MEAN ACTIVATION ENERGY OF ALL PYROLYSIS REACTIONS (J/mol)	$2.10 \times 10^5$
3) $\sigma$ , STANDARD DEVIATION OF ACTIVATION ENERGY DISTRIBUTION (J/mol)	$8.43 \times 10^5$
4) $V^*$ , ULTIMATE PYROLYSIS VOLATILE YIELD (wt %)	68.9
5) $C^*$ , ULTIMATE RAPID RATE CARBON YIELD (wt %)	31.1
6) $b$ , RATIO OF HYDROGENATION AND DEPOSITION RATE CONTANTS (Pa <sup>-1</sup> )	$2.39 \times 10^{-7}$
7) STANDARD DEVIATION OF MODEL CORRELATION (wt %)	4.3

# KEY RESULTS OF PROCESS DESIGN AND ECONOMIC STUDIES

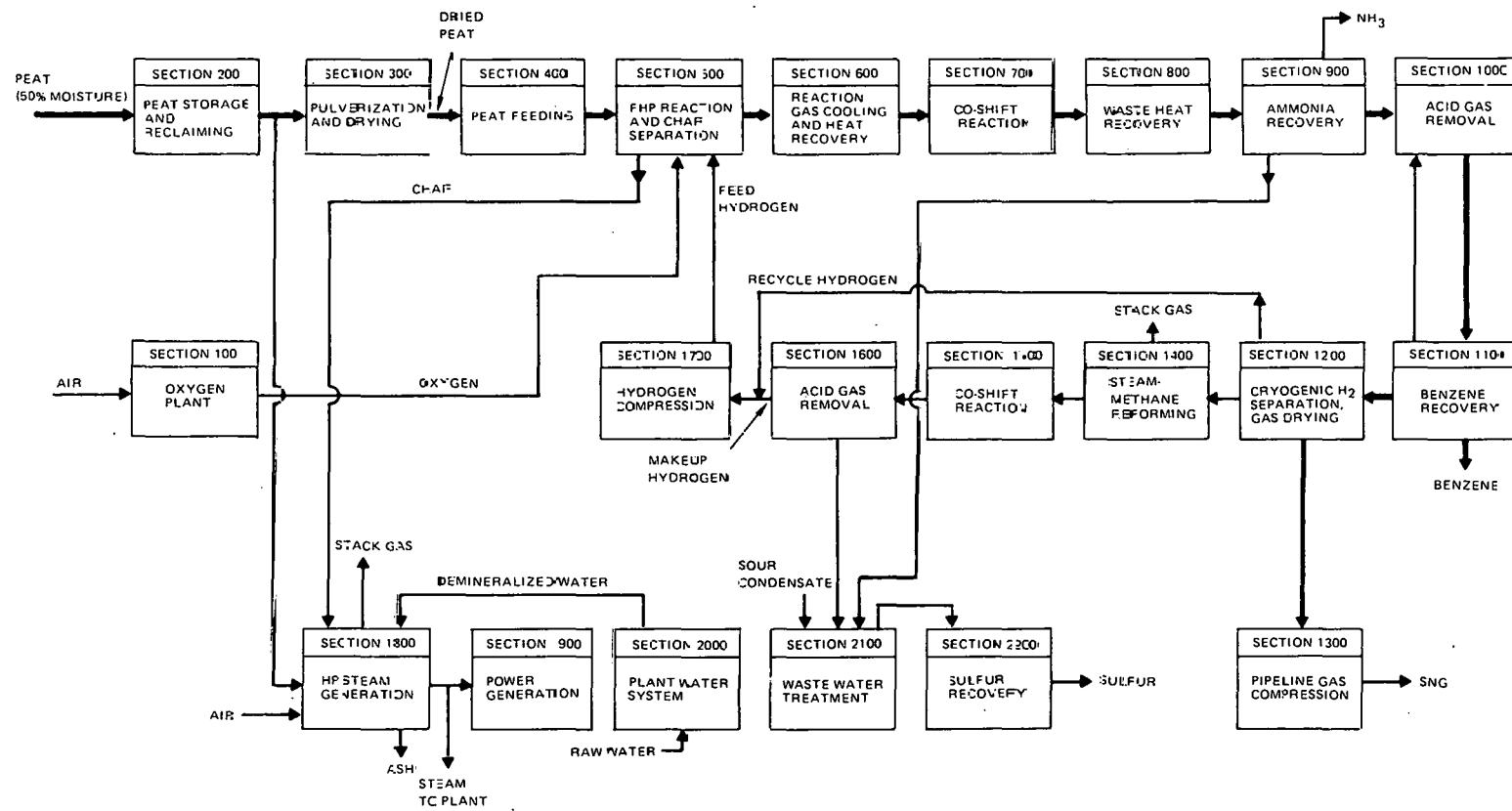
- SEVERAL PROCESS VARIANTS STUDIED
  - MAKEUP HYDROGEN VIA OXYGASIFICATION
  - MAKEUP HYDROGEN VIA METHANE REFORMING
- BENZENE COPRODUCTION REDUCES GAS COST
- POTENTIAL GAS COST OF \$2.02/MM BTU (1st QUARTER 1980 DOLLARS)

Figure 13

TABLE 3  
REACTOR TEST CONDITIONS  
FOR ECONOMIC STUDY

CONDITIONS	RUN 318-069
TEMPERATURE (°F)	1703
PRESSURE (psig)	485
H <sub>2</sub> /PEAT (lbm/lbm)	0.210
RESIDENCE TIME (s)	3.00
PEAT MOISTURE (wt %)	12.54
CARBON CONVERSIONS	
wt % TO C <sub>6</sub> H <sub>6</sub>	10.2
wt % TO C <sub>7</sub> H <sub>8</sub>	0.0
wt % TO C <sub>10</sub> H <sub>8</sub>	1.6
wt % TO CH <sub>4</sub>	29.1
wt % TO CO	26.0
wt % TO CO <sub>2</sub>	2.6
wt % TO C <sub>2</sub> H <sub>4</sub>	0.7
wt % TO C <sub>2</sub> H <sub>6</sub>	5.7
wt % TOTAL	75.9

# PEAT GASIFICATION-MAKEUP HYDROGEN BY STEAM-METHANE REFORMING



**Figure 14**

TABLE 4  
AVERAGE GAS COST

COST BREAKDOWN*	
TOTAL CAPITAL REQUIREMENT (\$ $\bar{M}$ )	1612
ANNUAL GROSS OPERATING COST (\$ $\bar{M}$ )	207.5
ANNUAL BYPRODUCT CREDIT (\$ $\bar{M}$ )	230.0
ANNUAL NET OPERATING COST (\$ $\bar{M}$ )	-22.5
CAPITAL CONTRIBUTION TO COG (\$/ $\bar{M}$ Btu)	2.28
OPERATING COST CONTRIBUTION TO COG (\$/ $\bar{M}$ Btu)	-0.26
COG (\$/ $\bar{M}$ Btu)	2.02

- \*BASED ON (a) 20-year PROJECT LIFE
- (b) 20-year STRAIGHT LINE DEPRECIATION
- (c) DEBT – EQUITY RATIO OF 75/25
- (d) 9% INTEREST ON DEBT
- (e) 15% RETURN ON EQUITY
- (f) 48% FEDERAL INCOME TAX

## IN SUMMARY

- REACTOR PERFORMANCE EXTENDED TO HIGH CARBON CONVERSION REGION
- 1000 TO 1 SCALEUP FROM BENCH SCALE TESTING
- ANALYTICAL MODEL ACCURATELY PREDICTS CARBON CONVERSION
- DATA CONSISTENT WITH BENCH SCALE RESULTS
- HIGH VALUE BENZENE BYPRODUCT PRODUCED
- DENSE PHASE FLOW EQUATIONS DEVELOPED
- PRELIMINARY PROCESS ECONOMICS STUDIED

Figure 15

## PLANNED FUTURE WORK

- COMMERCIAL PLANT PROCESS STUDY
  - OPTIMIZE PROCESS AROUND PEAT'S SPECIAL PROPERTIES
    - ▲ HIGH REACTIVITY
    - ▲ HIGH OXYGEN CONTENT
    - ▲ LOWER SEVERITY REACTOR PARAMETERS
- PEAT PREPARATION AND FEEDING
- 3/4 TPH REACTOR TESTING
  - REPLICATE TESTING AT OPTIMUM REACTOR PARAMETERS
  - MATERIAL BALANCES
  - MINOR PRODUCT CONSTITUENTS

# **TASK I COMMERCIAL PLANT PROCESS STUDY**

- ESTABLISH DESIGN BASIS
  - STATISTICAL CORRELATIONS
  - DATA REVIEW
  - DESIGN AND ECONOMIC CRITERIA
- OVERALL CONCEPT AND PARAMETRIC STUDIES
  - PRESSURE, TEMPERATURE, RESIDENCE TIME, H<sub>2</sub>/PEAT RATIO, MOISTURE CONTENT
  - SELECT OPTIMUM OPERATING CONDITIONS
- PLANT SUBSYSTEM STUDIES
  - PEAT GRINDING AND DRYING
  - HYDROGEN PRODUCTION AND SEPARATION
  - CHAR MANAGEMENT AND OVERALL ENERGY BALANCE
  - HYDROGASIFIER EFFLUENT GAS PURIFICATION
- PROCESS ENGINEERING
  - MATERIAL AND ENERGY BALANCES
  - PLANT BLOCK FLOW DIAGRAM
- PROCESS ECONOMICS
  - DETERMINE CAPITAL, OPERATING AND PRODUCT COST ESTIMATES
  - COST SENSITIVITY STUDIES
    - ▲ PEAT COST
    - ▲ BENZENE BYPRODUCT SELLING PRICE
    - ▲ ECONOMIC CRITERIA

Figure 17

# EXPERIMENTAL VS CALCULATED TOTAL CARBON CONVERSION

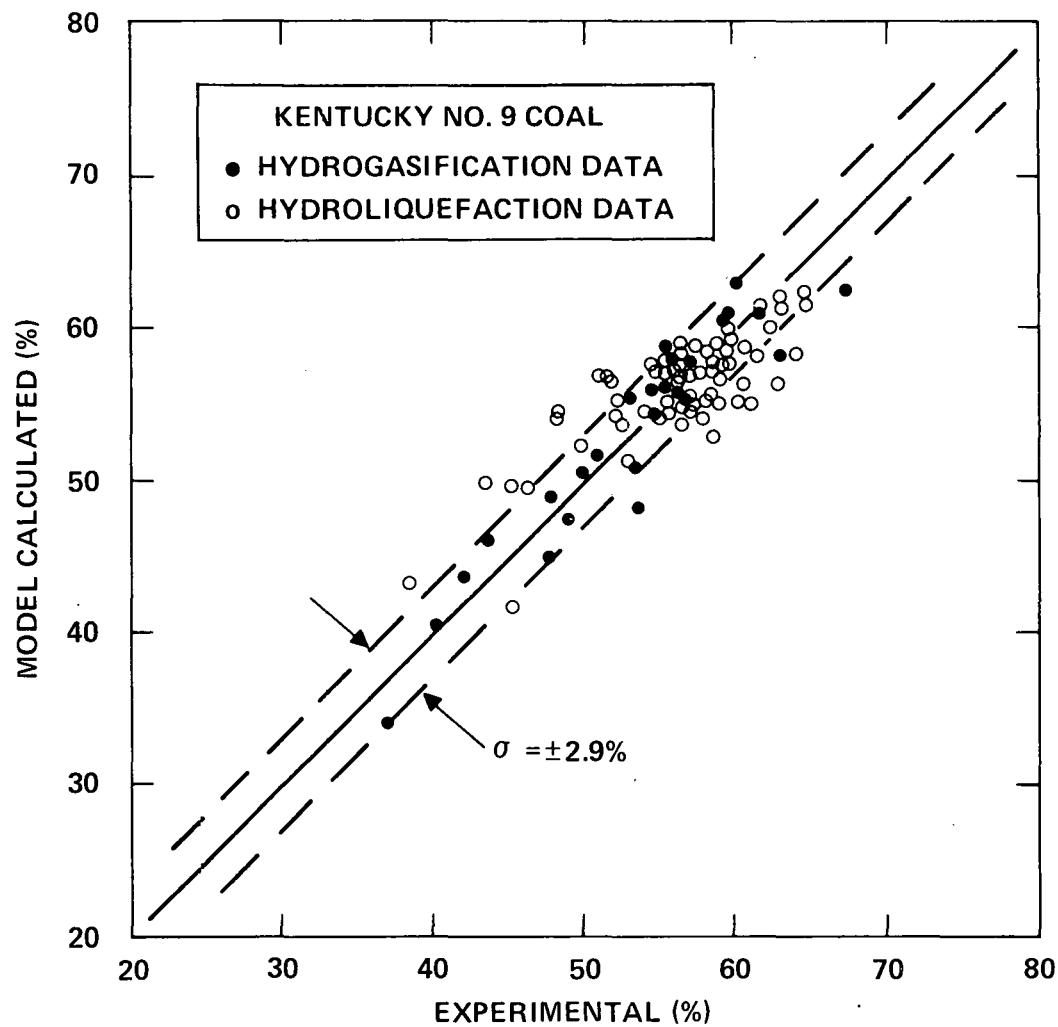
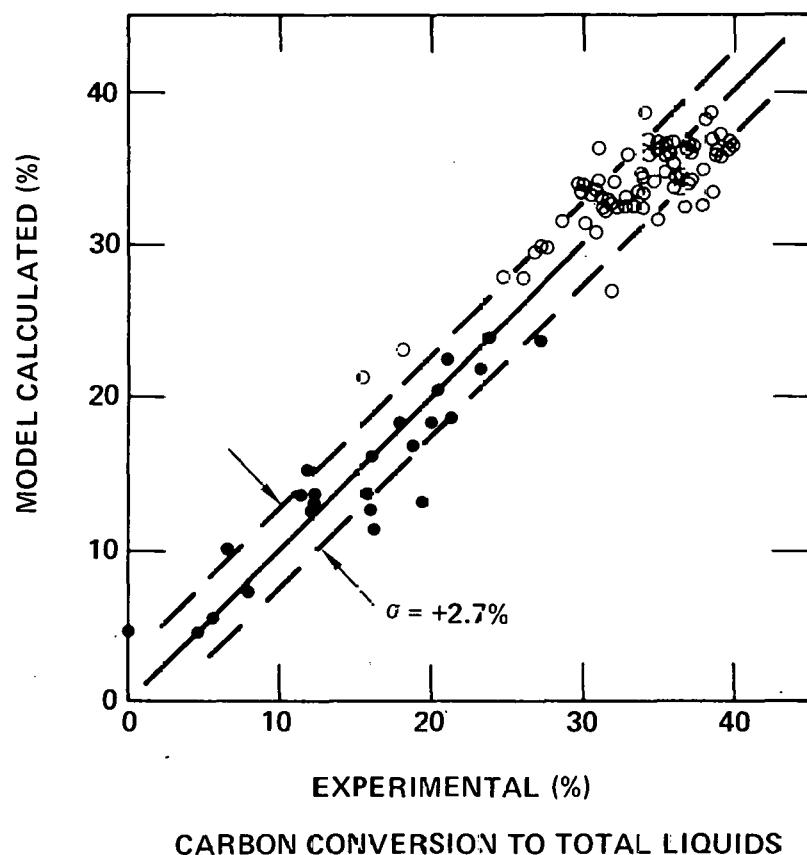


Figure 18

# EXPERIMENTAL VS CALCULATED CONVERSION TO LIQUIDS AND TO BTX

-258-



KENTUCKY NO. 9 COAL

- HYDROGASIFICATION DATA
- HYDROLIQUEFACTION DATA

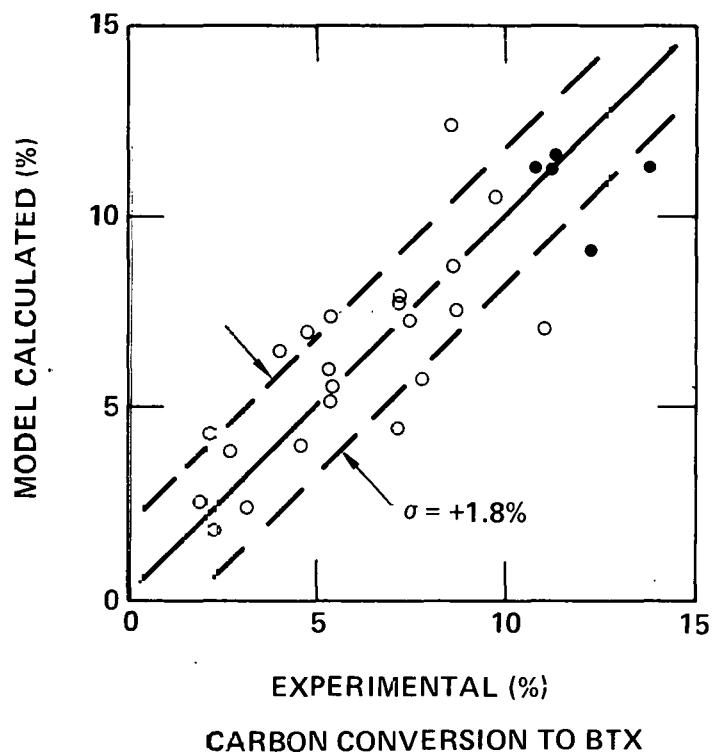


Figure 19

# FHP DATA CORRELATION WITH KENTUCKY NO. 9 HvAb COAL

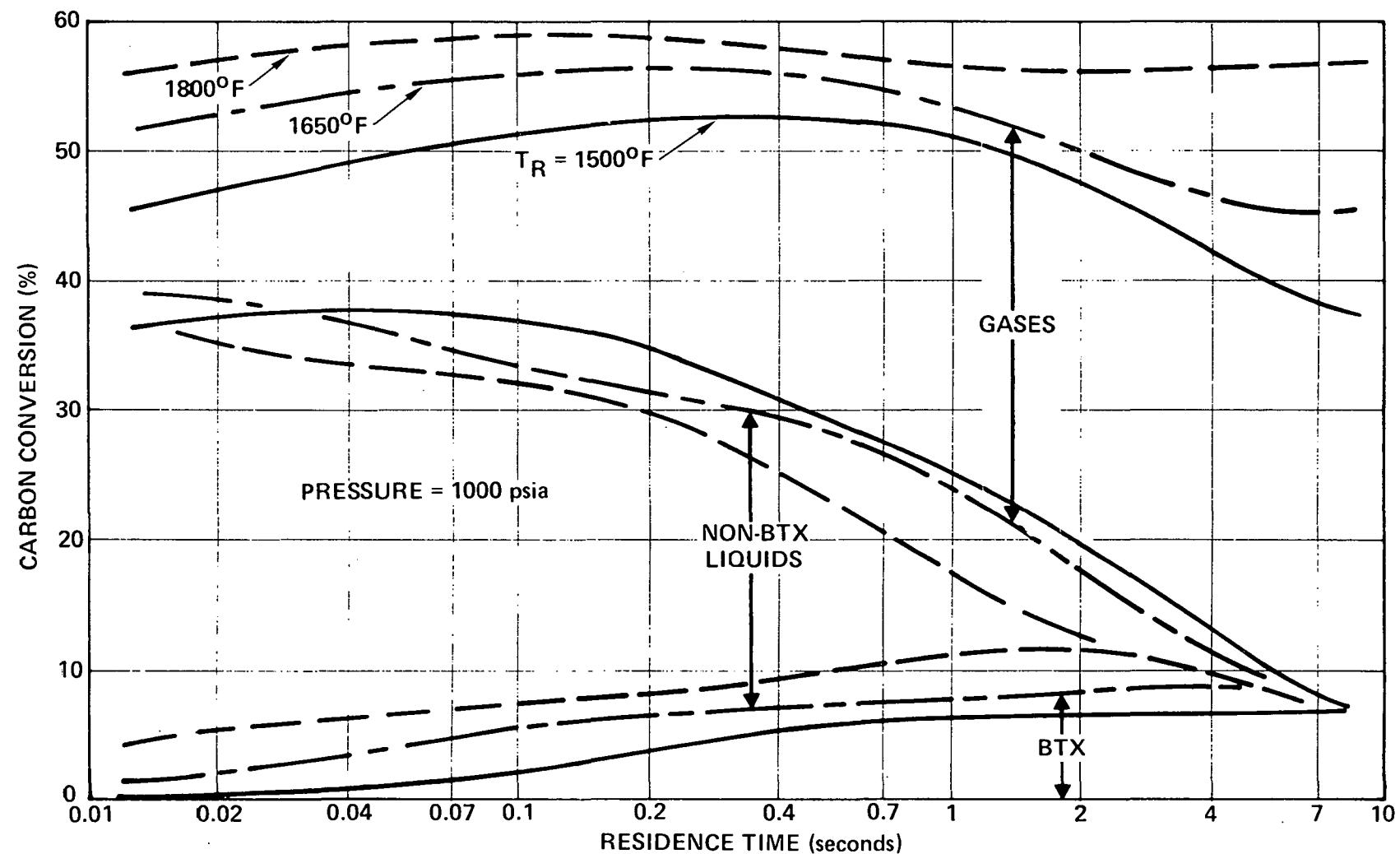


Figure 20

TABLE 5  
DATA SUMMARY: THREE REPLICATE TESTS  
KENTUCKY NO. 9 hvAb COAL:  $O_2$  TO PREBURNER

TEST CONDITIONS AND CARBON CONVERSIONS*	RUN 318-		
	036	037	050
$P_R$ (psia)	1000	1000	1000
$H_2$ /COAL	0.42	0.42	0.44
$O_2$ /COAL	0.22	0.21	0.22
$\tau_{MIX}$ ( $^{\circ}$ F)	1.92	1.91	1.86
$T_{MIX}$ ( $^{\circ}$ F)	1687	1691	1697
$T_R$ , EXIT ( $^{\circ}$ F)	1800	1830	1800
$\eta_C$ , OVERALL (%)	55.7	56.1	54.8
$\eta_C$ , $CH_4$ (%)	39.5	40.0	38.6
$\eta_C$ , CO (%)	4.3	4.2	4.3
$\eta_C$ , $C_6H_6$ (%)	11.2	11.3	10.7

\*NORMALIZED TO ASH TRACER VALUES

## QUESTIONS AND ANSWERS

Q: Your cost analysis with respect to the credit given for benzene indicates that plays a very strong role in getting the \$2.02 per million Btu.

I would like to know what would happen if you nulled out the credit for chemically pure benzene. What would be the dollars per Btu for the gas produced, if there is not that credit taken?

A: I'm not sure exactly, but I would say at least \$1 per million Btu higher.

Q: How much production from the gasifier plant would it take before the amount of benzene produced would have an effect on the present benzene market?

A: We have done some looking at that and it is hard to say exactly. However, it is estimated that a 250 billion Btu per day plant under these conditions would produce about 8,000 barrels per day of benzene. That represents only about one or two percent of the benzene market, and should not have a significant impact.

Q: How long a test run do you generally conduct?

A: All our peat tests were in the 20 to 25-minute range and were completed with normal shutdowns. We were limited by the amount of peat that could be stored in the feed tanks that we had available.

Q: Apparently you have to grind the peat prior to putting it into the unit. Is this something that would be passed on to a commercial sized unit?

A: Yes. The dense-phase feed method that we have been using requires about a utility grind. That is 70% through a 200 mesh. That is what we used for our peat testing.

## QUESTIONS AND ANSWERS

Q: What about the fines and the dust? Do you lose significant amounts or can you pass that through the gasifier?

A: The fines are no problem for the gasifier. On the test that we ran the grinding was done. We received the peat from a subcontractor already dried and ground. But in a commercial plant fines are no problem. The finer, the better.

Q: You showed a cost of the \$2.2 million Btu, does that include the cost of the drying?

A: Yes. That is a grass roots plant that produces all the power necessary. I think the most expensive single block in the process was our steam and power production block where we burned char and additional peat to provide the steam and the heat necessary for drying and all the other energy requirements of the plant. The peat was costed out at 75 cents per million Btu at 50% moisture.

**PEATGAS PILOT PLANT STATUS**

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## INTRODUCTION

### BACKGROUND

The Institute of Gas Technology (IGT), under joint sponsorship of the U.S. Department of Energy, the Gas Research Institute (GRI), the Minnesota Gas Company (Minnegasco), and the Northern Natural Gas Company conducted over 200 peat gasification tests in laboratory- and PDU-scale equipment since 1976. Peat gasification tests were also conducted for Minnegasco in 1974 and 1975. A kinetic model for peat gasification was developed from laboratory and PDU data. The encouraging results of these tests and the model projections show that on the basis of its chemistry and kinetics peat is an excellent raw material for the commercial production of synthetic natural gas (SNG). (A summary of IGT's work on peat gasification since 1976 was presented at the DOE Peat Contractors meeting in March 1980.)

To further advance peat gasification technology, DOE and GRI initiated a pilot-plant-scale program using an existing coal gasification pilot plant. This facility, which has been operating on coal since 1971, was shut down in August 1980 and converted to peat processing. The plant can convert 50 tons of peat to about 0.5 million standard cubic feet of SNG daily.

Only three major pieces of equipment (a peat dryer, a grinder, and a screener) were required to prepare the pilot plant for peat processing. This modification phase was completed in the winter of 1980-81. (Reports covering these modifications and the drying, grinding and screening tests were presented at the Second and Third Technical Contractors Conferences.) Peat was first fed to the gasifier in April 1981, initiating the pilot plant studies for the development of the PEATGAS process. Since that time, the gasification of Minnesota peat by the PEATGAS process has been successfully demonstrated in a series of tests.

In addition to the feed preparation modifications, plans were made to install a lockhopper system for feeding dry peat to the gasifier. The present pilot

plant scheme uses a slurring technique to inject feed material into the gasifier; however, certain economic and operating advantages can be realized if dry peat is fed to the gasifier. Approval to install the lockhopper system was received in August after the test series with slurry feed was completed. This work is now in progress.

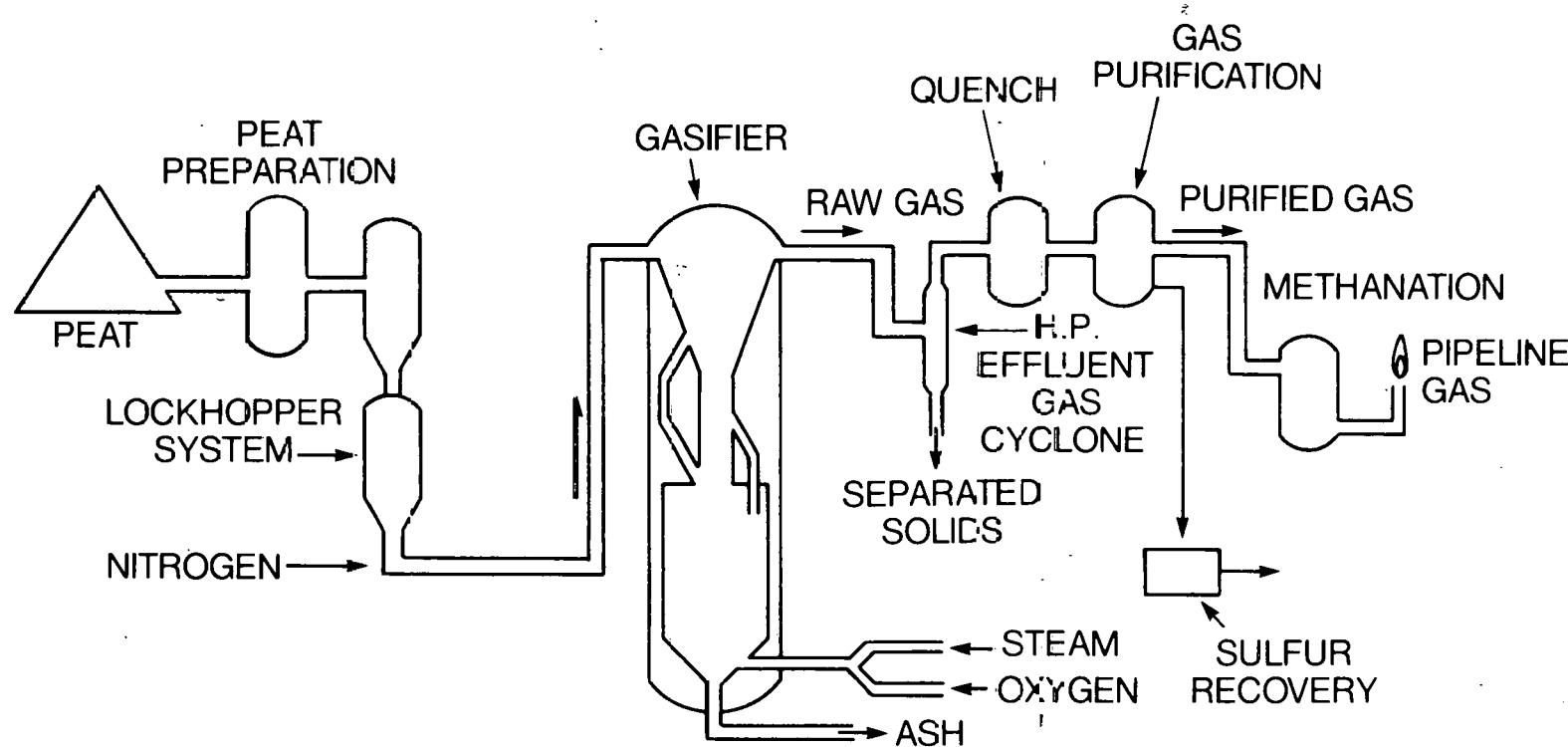
### **OBJECTIVES**

The overall objectives of the program are to modify an existing pilot plant and conduct peat gasification tests. Four specific tasks meet these objectives:

- Task 1 - Design, procure, and install equipment for grinding, drying, and screening.
- Task 2 - Design, procure, and install a lockhopper feed system capable of feeding a nominal 2 tons of peat per hour into the gasifier at pressures up to 500 psig.
- Task 3 - Clean and repair equipment required for operation with peat during the pilot plant transition period. Make arrangements to procure and store air-dried peat.
- Task 4 - Conduct gasification tests in the modified pilot plant.

### **TECHNICAL PROGRESS**

We began the gasification test program with Minnesota peat in the pilot plant facility during this reporting period (March through October 1981). The essential features of the pilot plant are shown in Figure 1. The fully integrated pilot plant facility includes the following processing sections.



**Figure 1**  
**Peatgas Pilot Plant Facility.**

## **PEAT PREPARATION**

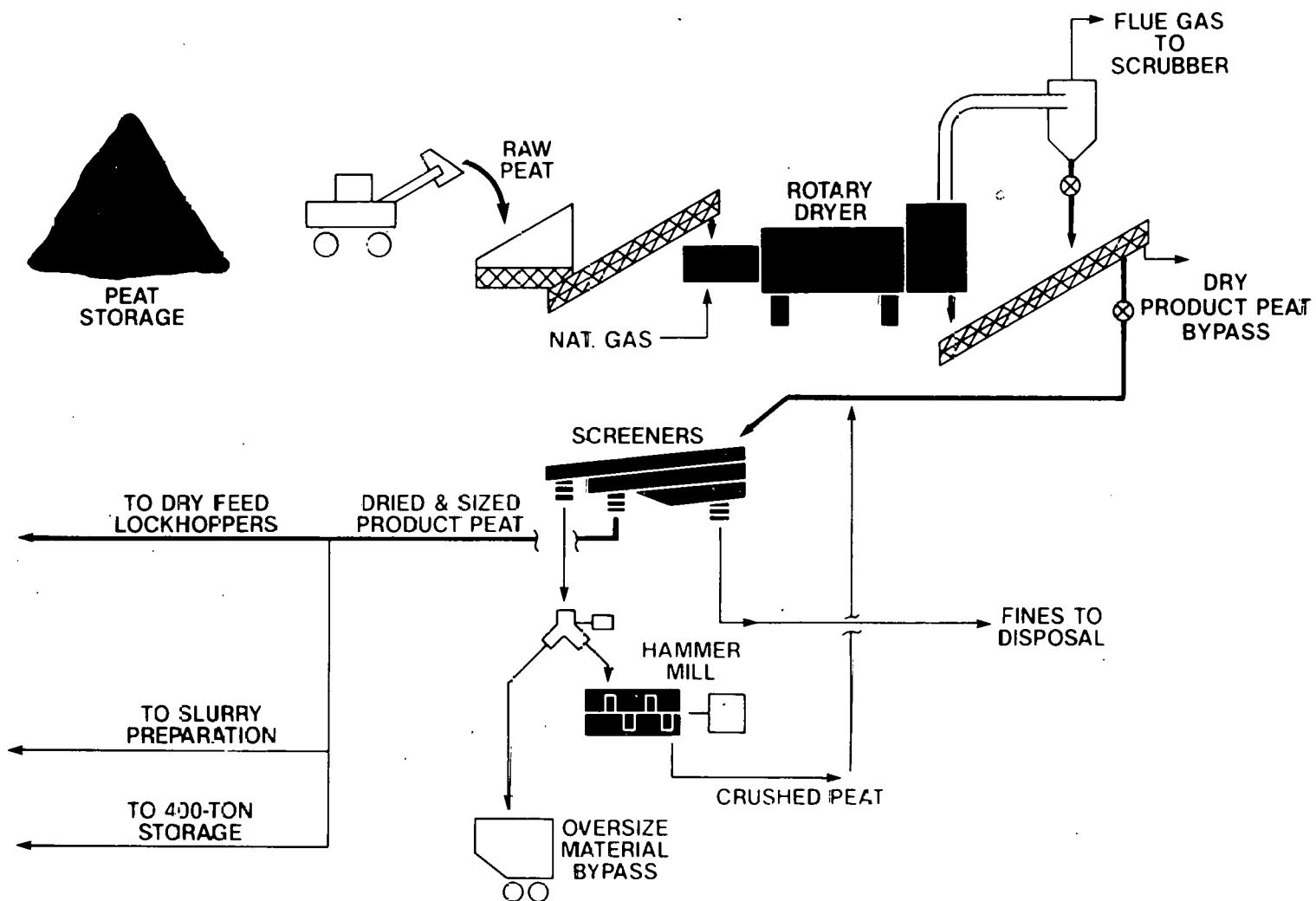
A flow diagram of the peat preparation section is shown in Figure 2. As-received peat containing 60 to 75 weight percent water is dried in a natural-gas-fired, triple-pass rotary drum dryer to moisture levels ranging between 50 and 10 weight percent. As many as 16 tons of wet raw peat per hour can be dried to a moisture level of less than 10 weight percent. The dried peat is screened to a -10+80 USS mesh size product, and the oversize material is crushed in a hammer-mill and returned to the screeners. Product peat is then conveyed to the lock-hopper feed system for injection into the gasifier. Two 200-ton silos are available for intermediate storage of prepared peat.

## **PEAT LOCKHOPPER FEED INJECTION**

The lockhopper feed system (Figure 3) is capable of providing a continuous and measured flow of 1 to 4 tons of dry peat per hour to the gasifier at pressures up to 500 psig. The unit is comprised of two main pressure vessels, called injectors, and a 17-ton surge bin for intermediate storage of the feed peat. A scalping screen upstream of the injectors prevents foreign objects from entering the lockhoppers, which might result in material bridging in the injectors or in objects lodging in the critical lockhopper valves.

In the plant layout, the storage injector is located immediately above the primary injector, and the batch transfer of feed between them occurs substantially by gravity. Transfer is automatic and does not interrupt continuous feeding from the primary injector. Load cell systems are used in both vessels to measure the material flow rate. The load cells in the primary injector continuously monitor weight loss and accurately control the feed rate. High-pressure nitrogen is used as a carrier gas to lift the peat solids to the top of the gasifier.

The system is designed so that only about 15% to 20% of the cycle time is required for peat transfer to the primary injector. This minimizes the time during which the weight rate control system for the primary injector is not functioning. During this period, the feed rate is controlled by differential



**Figure 2**  
**Peat Preparation.**

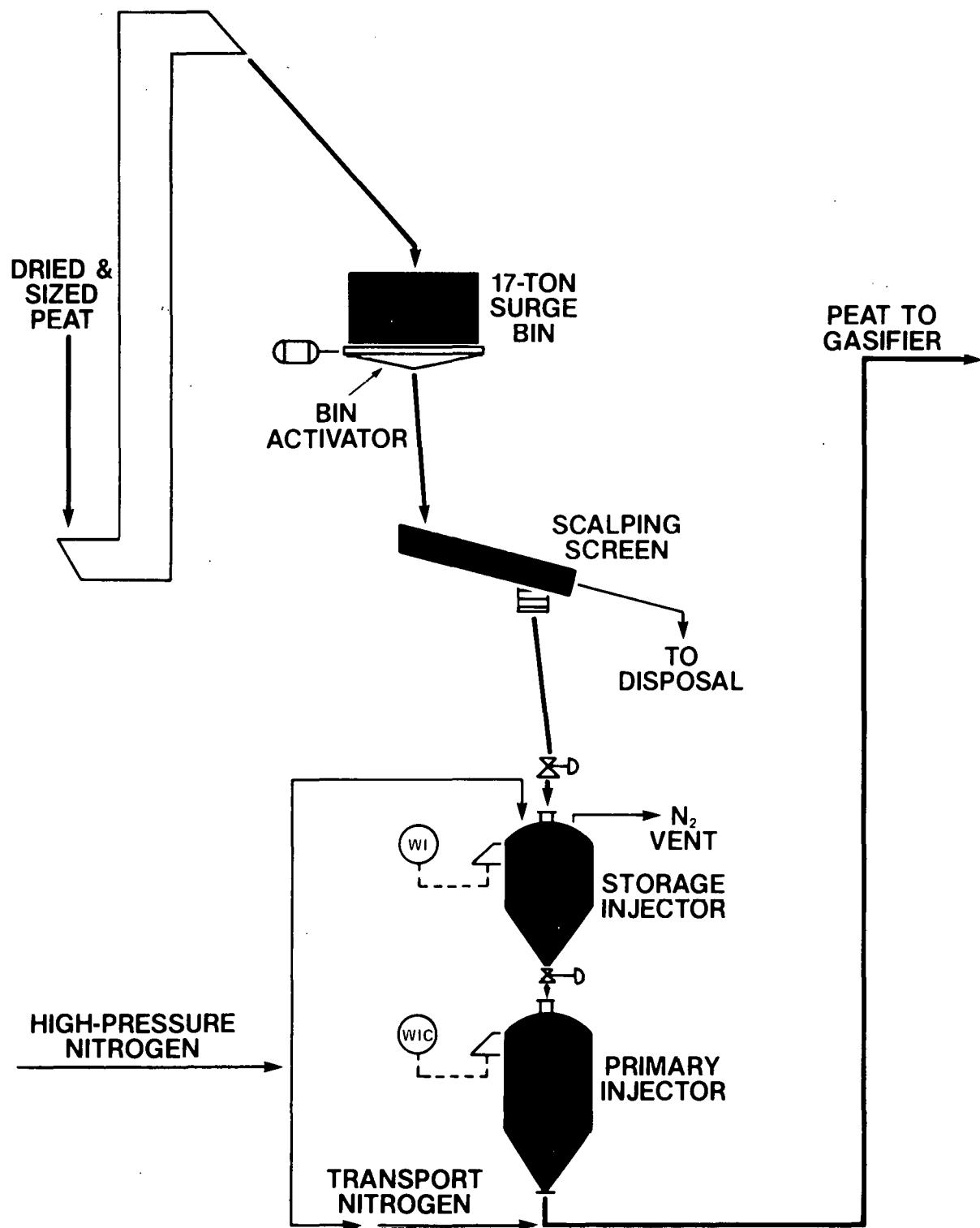


Figure 3  
Peat Lockhopper Feed Injection.

pressure instrumentation to ensure the continuity of a given feed rate. A total weight measurement is also obtained in the feed injector. A balanced pressure expansion joint between the two injectors maintains independent measuring capabilities of both the feed injector and primary injector load cell systems.

This system is currently under construction. Therefore, for the first series of gasification tests, peat was injected into the gasifier using an existing slurry system.

### **PEAT SLURRY PREPARATION**

In this section of the plant (Figure 4), peat is mixed with light oil (principally benzene, toluene and xylene), which is a gasification by-product, to make a slurry. Continuous agitation is provided by a turbine mixer and a low-pressure circulation pump. A high-pressure reciprocating pump then raises the slurry to reactor pressure and transports it to the gasifier. Slurry concentration is normally controlled between 20 and 30 weight percent.

### **GASIFICATION**

The heart of the gasification section (Figure 5) is the PEATGAS reactor in which peat is processed in a series of staged zones. In the lockhopper system, feed solids are first injected into the drying zone at the top of the gasifier where the transport nitrogen is disengaged. Hot gases rising through the fluidized bed from the lower sections of the reactor vaporize the moisture in the peat and preheat the solids to 500°F. When a slurry is used to feed the peat to the gasifier, these gases also vaporize the slurry oil in the freeboard. The dried peat solids then overflow by gravity into the first reaction zone, the hydrogasifier (HG).

In the HG, which operates at 1200 to 1400°F, both the volatile matter and the more reactive part of the peat are converted to methane and other light hydrocarbons in the hydrogen-rich gaseous environment produced in the lower stage of the reactor. The peat particules are lifted cocurrently by gases rising from below in a short-residence-time entrained-flow reactor.

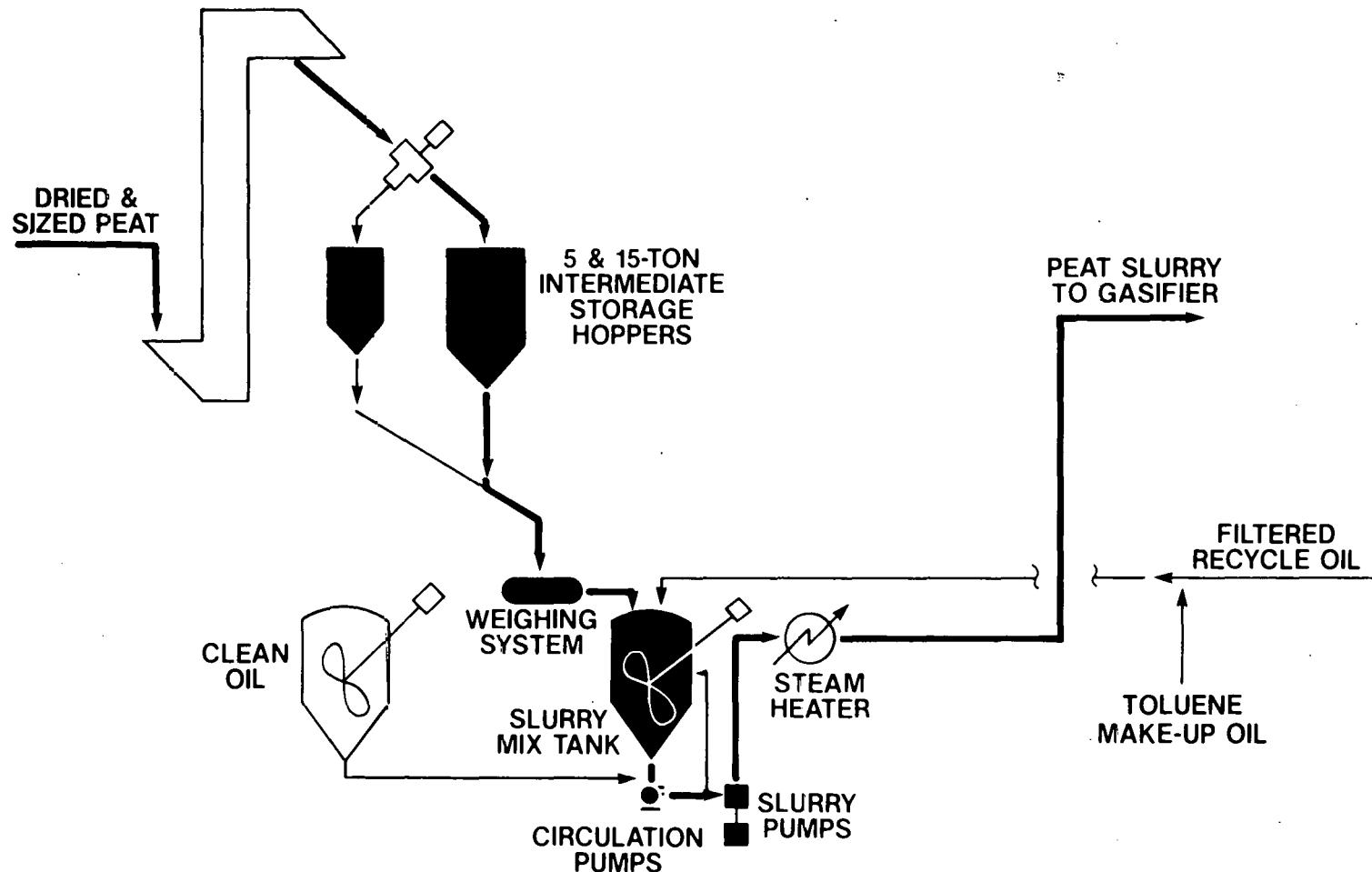


Figure 4  
Peat Slurry Preparation.

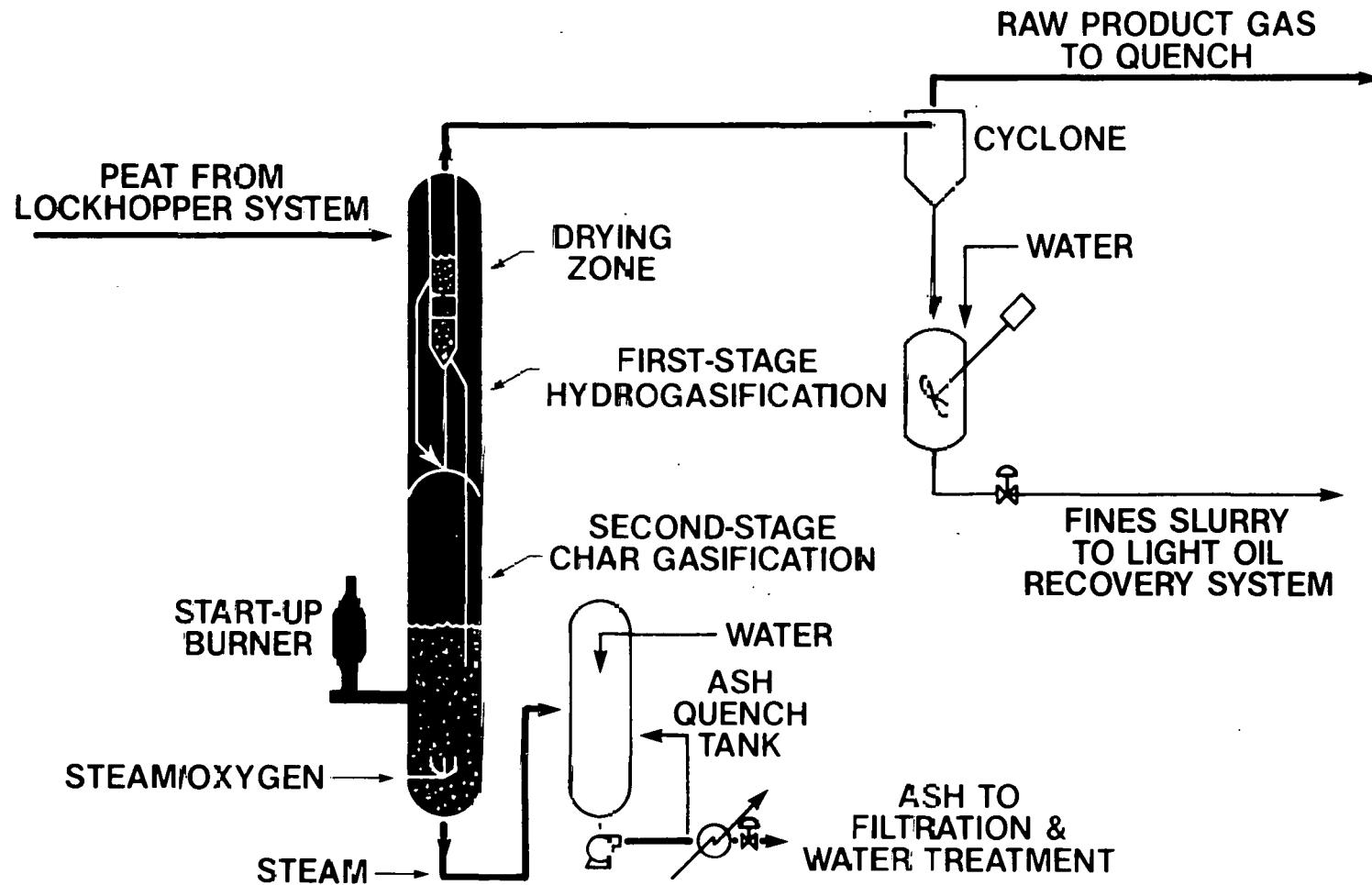


Figure 5  
Gasification.

Oils released in this stage of gasification are directly hydrotreated to form a low-boiling-point liquid by-product, which accounts for 20% to 30% of the carbon gasified. Solids from the HG overflow by gravity to the next stage, the char gasifier (CG).

In the CG, the unreacted char is exposed to a temperature of about 1700°F in a dense-phase fluidized bed. Steam and oxygen are injected into the bottom of this zone through a three-nozzle distributor. These gases serve as the fluidizing medium for the char and provide reactants for the combustion and steam/carbon reactions. The char residue, now over 90% gasified, is discharged from the reactor, quenched, slurried with water, and depressurized. The char residue is recovered in downstream filtration and separation equipment.

#### **PRODUCT GAS QUENCH AND OIL-RECOVERY**

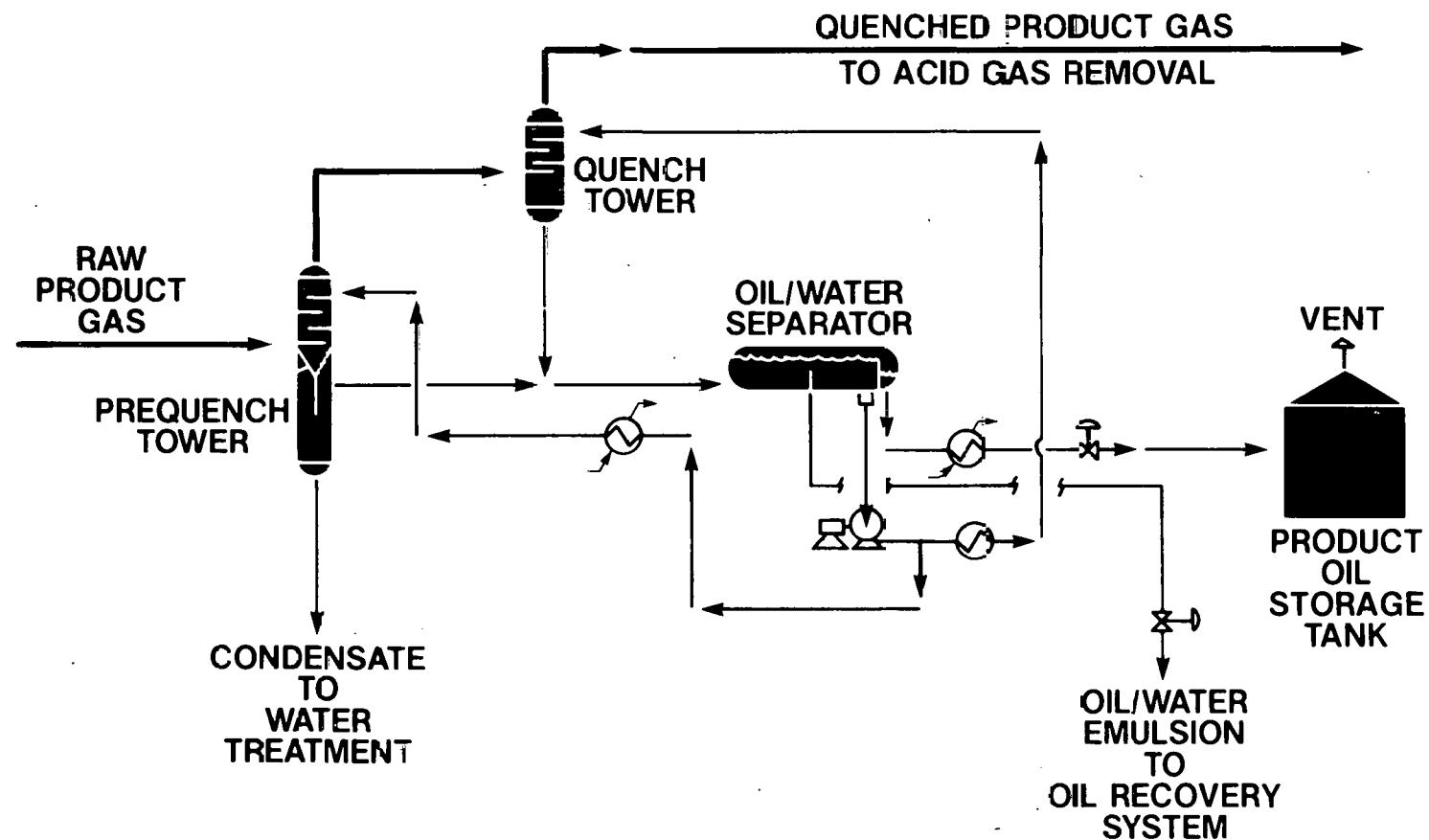
In this section of the plant (Figure 6), the product gas leaving the gasifier at 500°F is cooled to 100°F by direct water quench, which condenses the steam and light oil. After an oil-water separation, the light oil is withdrawn, depressurized, and stored. The water is reused in the quench system.

#### **ACID GAS REMOVAL**

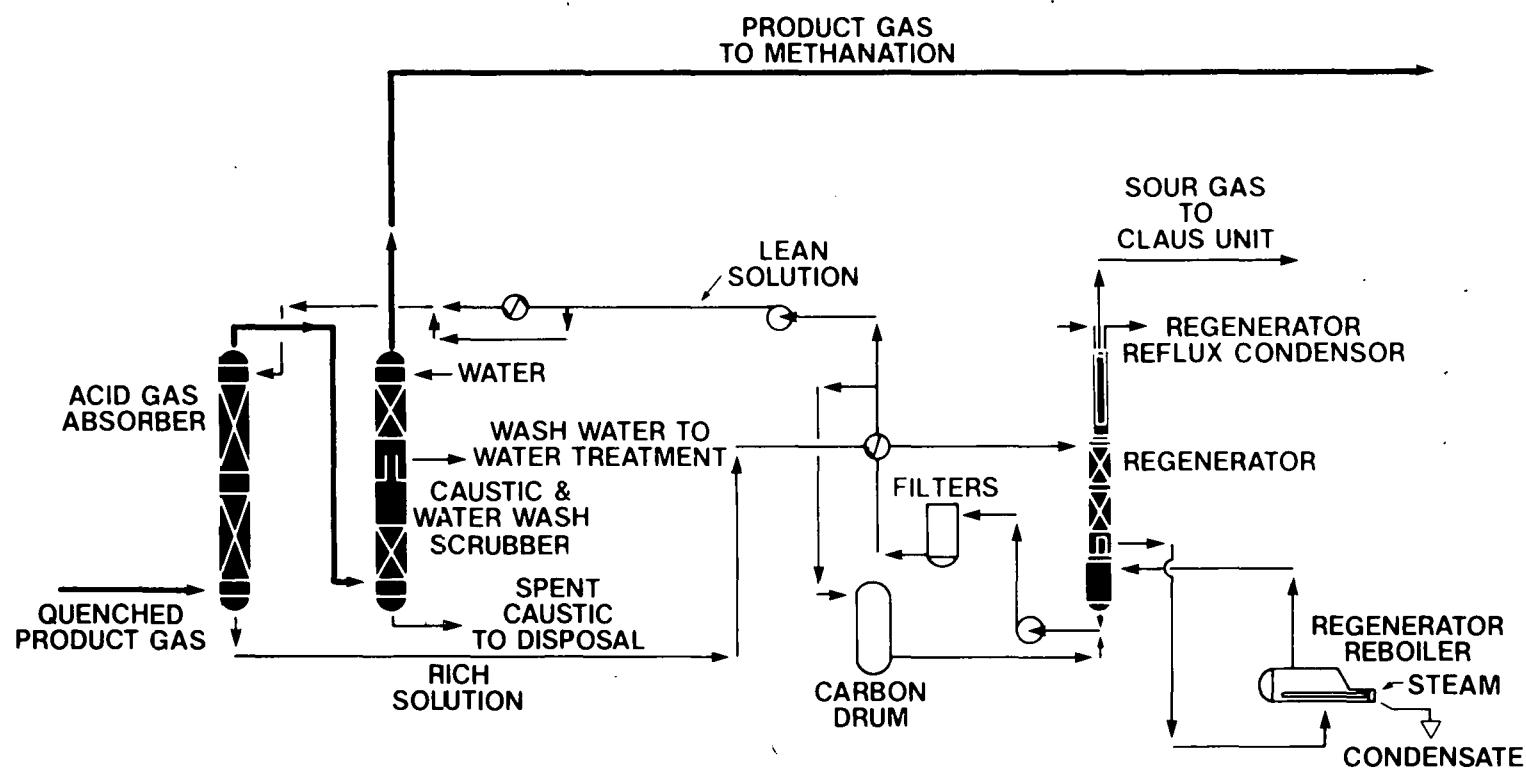
In the acid gas removal section of the plant (Figure 7), carbon dioxide and hydrogen sulfide are removed from the quenched raw gas. A diglycolamine solution is used to absorb carbon dioxide, hydrogen sulfide, and other organic sulfur compounds. The amine solution is regenerated in a low-pressure steam stripper and reused. This facility includes a small Claus unit for the recovery of elemental sulfur from hydrogen sulfide.

#### **METHANATION**

The purified gas is then fed to a catalytic methanator (Figure 8), in which the remaining carbon monoxide and hydrogen are reacted at 500 to 850°F to form additional methane. The gas is cooled and the by-product water removed. The



**Figure 6**  
**Product Gas Quench and Oil Recovery.**



**Figure 7**  
**Acid Gas Removal.**

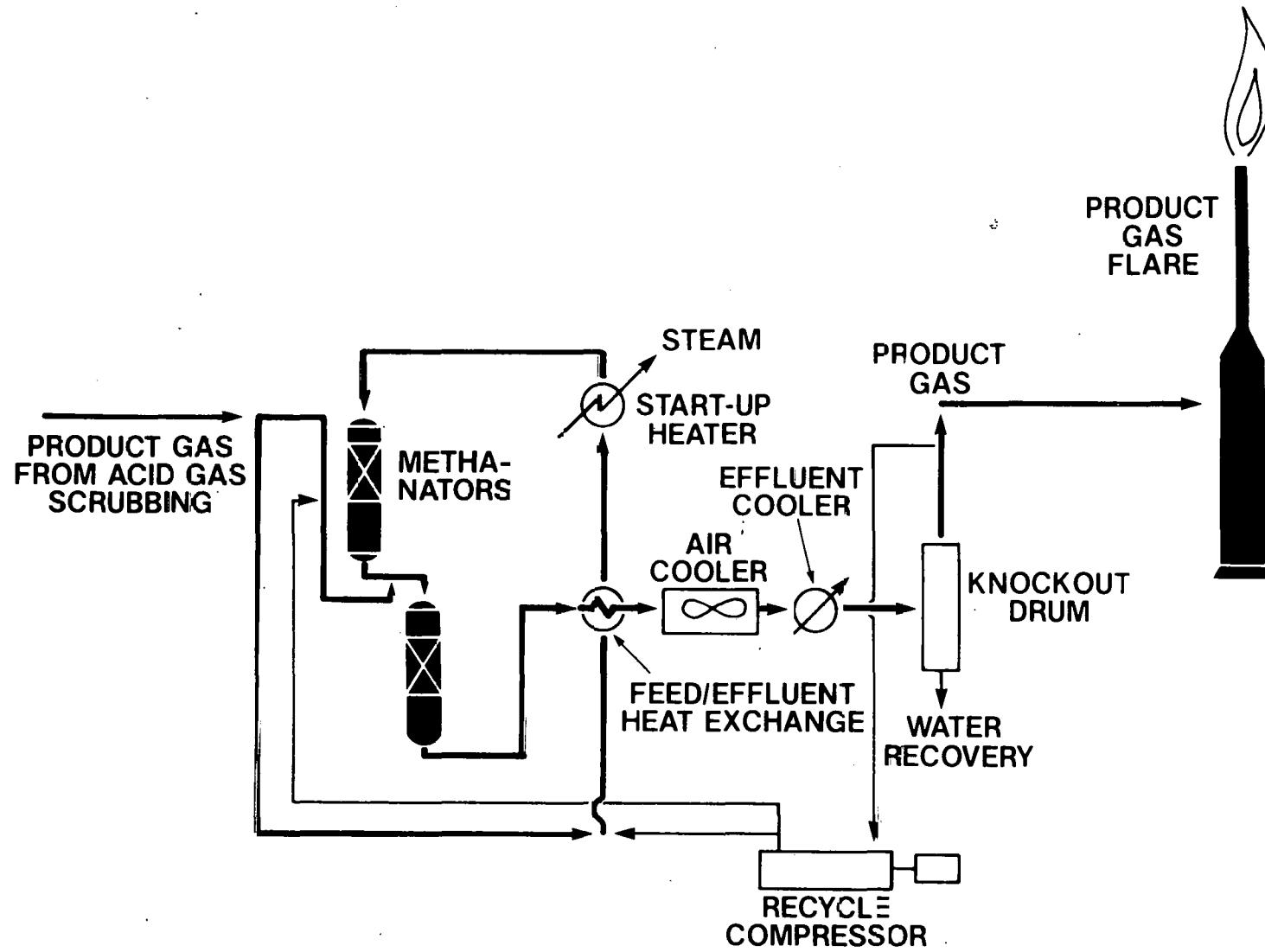


Figure 8  
Methanation.

product gas, which has a heating value of over 950 Btu/scf, is delivered at pipeline pressure.

## **SUPPORT FACILITIES**

The pilot plant includes equipment to treat all waste gases and liquid effluents to maintain environmentally acceptable levels. In addition, a number of utilities are provided onsite, including high- and low-pressure steam, plant and instrument air, and several grades of process water. A package steam/methane reforming plant is operated to provide hydrogen for the initial heat-up period.

## **PEATGAS TESTS**

Fully integrated operation of this large-scale pilot plant began in April 1981 when Minnesota peat was fed to the gasifier during the first reactor flow test (RF-1). The main objectives of this test were threefold: 1) to test the new peat feed preparation equipment during integrated operation with the gasifier, 2) to obtain operating experience with the new reactor configuration using Minnesota reed sedge peat and 3) to check all new and modified instrumentation and data acquisition equipment during actual operation.

The start-up burner on the gasifier was ignited on April 16 to begin heat-up for Test RF-1. This supplemental heat source was used throughout the first test because the gasifier was operated mainly to collect data on solids transport throughout the unit (including a determination of bed and seal leg densities). Oxygen was not added to the fluidized-bed char gasifier during the test. Slurry feeding was used to inject peat into the gasifier because the dry feed system was not scheduled to be installed until later in the year. This method requires that the peat be dried until it contains less than 10 weight percent moisture in the external rotary drum dryer, which ensures that there is enough heat in the reactor dryer zone to vaporize the toluene slurry medium.

Flow test RF-1 met all test objectives. During 81 hours of slurry feeding, a total of 62 tons of peat was processed through the gasifier. A number of significant achievements resulted from this test:

- a. Integrated operation of the new peat feed preparation equipment was demonstrated during the week of gasifier operation. The new drying, screening and crushing system produced a consistent product feed that contained less than 10 weight percent moisture.
- b. Slurry concentrations averaged 20 weight percent peat solids, although slurry containing up to 30 weight percent solids was also pumped to the gasifier. The slurry preparation section performed well.
- c. Stable peat flow was established through the gasifier. Bed levels were easily controlled in the char gasifier, and good bed and seal leg densities were observed at carbon conversions exceeding 50%. A 24-hour period of steady gasifier operation was chosen to provide a material and energy balance during the flow test.
- d. The test provided an operating check of all new and modified instrumentation and data acquisition equipment.

Nominal operating conditions during Test RF-1 were

Pressure, psig	400-500
Peat Feed Rate, lb/hr	1000-2000
Peat Moisture Content, wt %	5-8
Peat Slurry Concentration, wt % solids	10-30
Char Gasifier Temperature, °F	1000-1100
Start-Up Burner	On

Although temperatures in the char gasifier were limited to 1100°F and no oxygen was added, the burner gases containing both hydrogen and steam converted over 70% of the peat fed to the gasifier. Ash concentrations in the peat discharged from the gasifier exceeded 50 weight percent. At these conditions bed densities ranged from 28 lb/ft<sup>3</sup> in the dryer zone to 18 lb/ft<sup>3</sup> in the char gasifier fluidized bed. Test RF-1 indicated the need for additional temperature control in the slurry dryer zone for peat.

After completing Test RF-1, preparations were made for a series of gasification tests (using slurry feed) beginning in June. The objectives of these gasification tests were to

- a. Obtain operating experience in the PEATGAS reactor using Minnesota peat
- b. Determine the effect of steam partial pressure on product yields
- c. Determine the effect of temperature on product yields
- d. Determine the effect of peat feed rate (residence time) on product yields.

Three tests (PT-1 through PT-3) were subsequently conducted - one test each month in June, July, and August. Slurry feeding was used to inject peat into the gasifier in all tests. Tables 1 and 2 list the statistics and conditions for Tests PT-1 through PT-3.

**TABLE 1**  
**GASIFICATION TEST STATISTICS.**

Test	<u>PT-1</u>	<u>PT-2</u>	<u>PT-3</u>
Month	June	July	August
Peat Fed to Gasifier, tons*	30	104	104
Self-Sustained Operation With Peat Feed, hr**	0	31	73
Data Base Period, hr	6	21	57

\* Approximately 5 to 10% moisture

\*\* No supplemental heat or hydrogen added.

**TABLE 2**  
**GASIFICATION TEST CONDITIONS.**

Test	<u>PT-1</u>	<u>PT-2</u>	<u>PT-3</u>
Pressure, psig	500	500	500
Peat Feed Rate, tons/hr	0.5-1.0	1.0-1.5	0.5-1.75
Char Gasifier Temp, °F	1050-1200	1400-1550	1500-1650
Peat Conversion, MAF %	73-74	89-98	91-99

Higher levels of peat conversion were obtained in each successive test. Conversions in Test PT-1 ranged between 73% and 74%, in Test PT-2 between 85% and 98%, and in Test PT-3 between 91% and 99%. The char gasifier temperatures exceeded 1650°F during the last test. Steam-to-carbon (S/C) molar ratios were also reduced during each successive test. During Test PT-3, four steady operating periods were conducted at S/C ratios ranging between 1.8 and 2.5. Data from typical steady operating periods are given in Table 3. Data from a typical screen and chemical analysis for the Minnesota peat processed during Test PT-3 is given in Table 4.

During Test PT-2, IGT also demonstrated the feasibility of feeding single-screened peat to the gasifier (oversize material only removed). Elutriation of solids from the gasifier was within the expected design range of 5% to 15% for this material. With double-screened feed in Tests PT-1 and PT-3 elutriation

**TABLE 3**  
**TYPICAL STEADY OPERATING PERIOD.**

Test	PT-1	PT-2	PT-3
Peat Feed Rate, tons/hr	1.0	1.5	1.75
Dryer Bed Temp, °F	750	775	725
Hydrogasifier Temp, °F	950	1150	1050
Char Gasifier Temp, °F	1200	1550	1626
S/C Ratio, molar	3.9	2.9	1.8
Peat Conversion, MAF %	73	93	96
Steady Period, hr	4	5	12

**TABLE 4**  
**TYPICAL MINNESOTA PEAT SCREEN AND CHEMICAL ANALYSIS**  
**FOR TEST PT-3.**

Screen Analysis, U.S.S., wt %

+10	0.1
+20	3.7
+30	25.7
+40	22.7
+60	31.3
+80	13.1
+100	2.9
+200	0.3
-200	0.2
Total	100.0

Bulk Density, lb/ft <sup>3</sup>	25.2
Moisture	7.2
Chemical Analysis	

Proximate, wt %

Moisture	7.2
Volatile Matter	56.1
Fixed Carbon	23.0
Ash	13.7
Total	100.0

Ultimate (Dry), wt %

Carbon	49.5
Hydrogen	5.2
Sulfur	0.3
Nitrogen	2.2
Oxygen (by Difference)	28.0
Ash	14.8
Total	100.0

was only about 5% - much less than expected. The highest carbon conversion and product gas yields were obtained in Test PT-3, the last in the series of slurry tests. Based on preliminary data, the following gas composition (Table 5) was obtained:

**TABLE 5**  
**TEST PT-3 PRODUCT GAS ANALYSIS.**

Composition (Dry)*, mol %	
Hydrogen	38.0
Carbon Monoxide	15.4
Methane	11.0
Carbon Dioxide	35.2
Ethane	0.4
Hydrogen Sulfide	—
Total	100.0

\* Nitrogen and oil free

This resulted in the following carbon distribution (Table 6):

**TABLE 6**  
**CARBON DISTRIBUTION DURING TEST PT-3**  
**PER 100 POUNDS OF CARBON IN FEED.**

Product Gas (CO, CH <sub>4</sub> , C <sub>2</sub> H <sub>6</sub> )	32
Oil	23
Acid Gas (CO <sub>2</sub> )	41
Ash	4
Total	100

Further improvements in the methane yield are expected when the dry lockhopper feed system is integrated into the pilot plant. Peat with higher moisture contents will be fed to the gasifier resulting in reducing dryer bed temperatures from 750 to 500°F. This procedure will avoid any devolatilization of peat in this zone and will promote the hydrogasification of this volatile fraction to methane.

The data collected to date are consistent with the objectives set for the gasification tests using slurry feed. Figure 9 graphically displays the effects of temperature, feed rate, and steam partial pressure observed during these tests. Each line represents a constant S/C ratio and peat feed rate. The

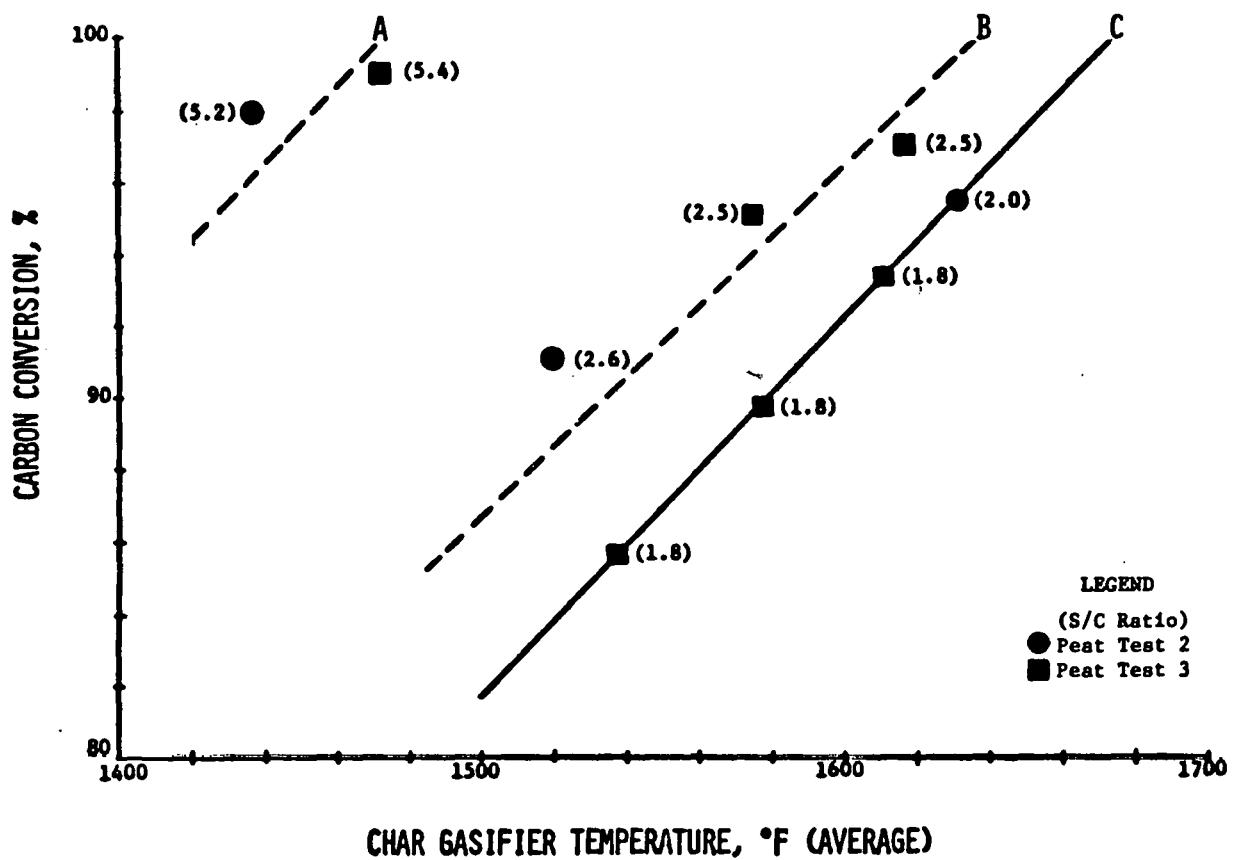


Figure 9  
Carbon Conversion vs. Char Gasifier Temperature.

numbers in parenthesis give the S/C value. Line A represents a feed rate of about 0.5 ton/hr, line B 1.0 ton/hr, and line C 1.5 tons/hr. Note that as the S/C ratios decrease and feed rates increase (lower residence time) higher temperatures are required for similar conversions.

The data collected during these tests have indeed resulted in a substantial data base. A number of significant achievements were realized:

1. The technical feasibility of the PEATGAS process gasification stages has been demonstrated. Both gasification stages of the PEATGAS gasifier can operate smoothly with good solids flow and without ash sintering while achieving high conversion and good product yields.
2. The high reactivity of peat observed in the laboratory and PDU-scale tests was confirmed. Peat conversions as high as 99% have been achieved.
3. Data were obtained at S/C ratios as low as 1.8.
4. The feasibility of feeding single-screened peat has been demonstrated.

The only problem observed in the gasifier's operation has been in the drying zone. It can be attributed to the slurry feed mechanism used to inject the peat into the gasifier, and it has resulted in three limitations. One, it limits the achievable S/C ratios in the gasifier. Because the amount of steam fed to the gasifier is fixed by the requirement of maintaining a superficial velocity of about 1 ft/s in the gasifier, the only variable is carbon feed. Therefore, to achieve lower S/C ratios, the amount of peat fed to the gasifier must be increased. However, the feed rate is limited to 3000 to 3500 lb/hr because additional slurry feed would result in insufficient heat in the drying zone to vaporize the toluene slurring medium. Two, in striving to achieve low S/C ratios, excessive amounts of peat slurry have been pumped into the drying zone, which at times has resulted in wetting of the fluidized bed and solids flow interruption from this zone. Three, the maximum moisture in the peat fed

to the gasifier is about 10% rather than the 30% to 50% desirable in a commercial operation. This has resulted in fluidized bed temperatures of 750 to 850°F in the drying zone. We suspect that some devolatilization occurs, which affects product yields and distribution.

Because of these limitations imposed on the pilot plant's operation, DOE has given IGT approval to proceed with the lockhopper system installation. This will allow future gasification tests to be conducted with dry peat feed. Although adequate amounts of data have been obtained on Minnesota peat to demonstrate the technical feasibility of the PEATGAS process in the pilot plant, further operation with the dry lockhopper feed system should demonstrate optimal and economically favorable operating conditions in the pilot plant.

After receiving approval to proceed with the lockhopper on August 12, a purchase order was immediately released for the fabrication and installation of the lockhopper structure. The purchase order for the surge hopper was released a day later, thus completing procurement of all long-term delivery items necessary to install and operate the lockhopper system. Weekly progress meetings were held to maintain a tight procurement and fabrication schedule for the structural steel. All the necessary steel and grating was procured and fabricated within 6 weeks. The lockhoppers have been set in place, and the supporting structure topped out. Figures 10 through 12 depict some of the installation work during this period.

#### **FUTURE WORK**

Work on the lockhopper modification will concentrate on the piping, electrical, and instrument field installations. Shakedown of the lockhoppers is scheduled to begin in mid-November; the first gasification test using the dry feed system is scheduled for early December.

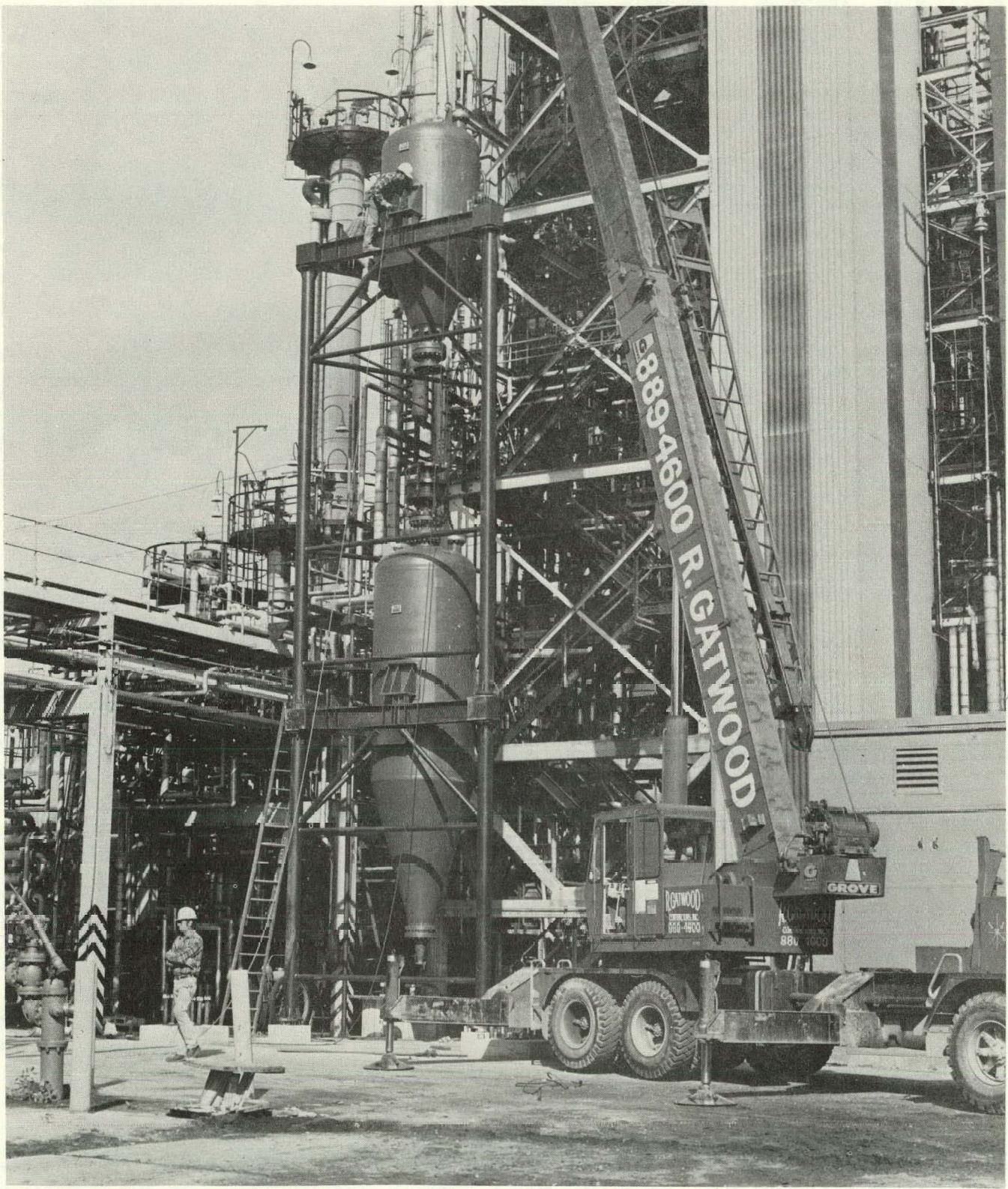
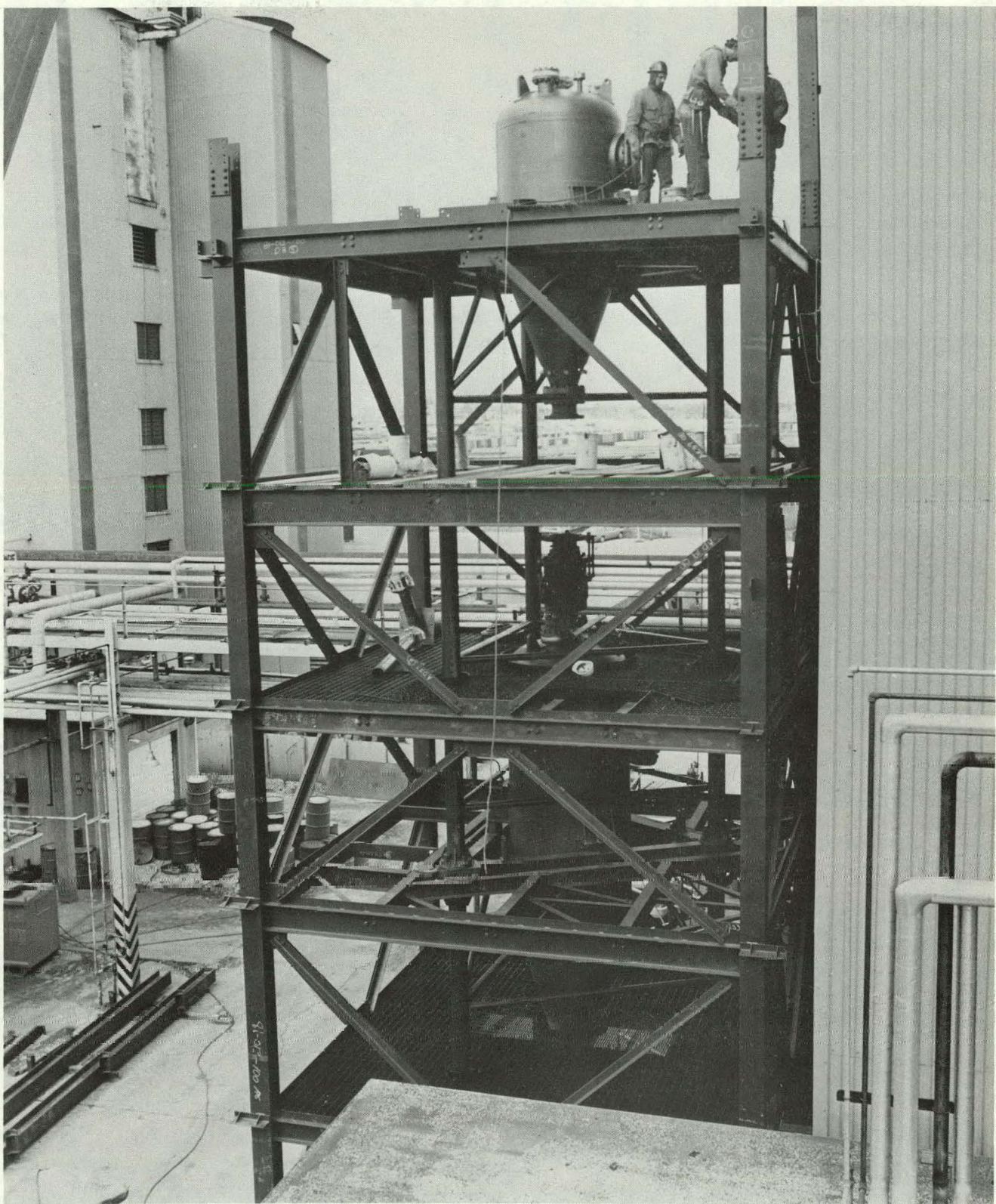


Figure 10  
Installation of Lockhopper Vessels  
on the Internal Support Structure.



**Figure 11**  
**Installation of Access Platforms.**

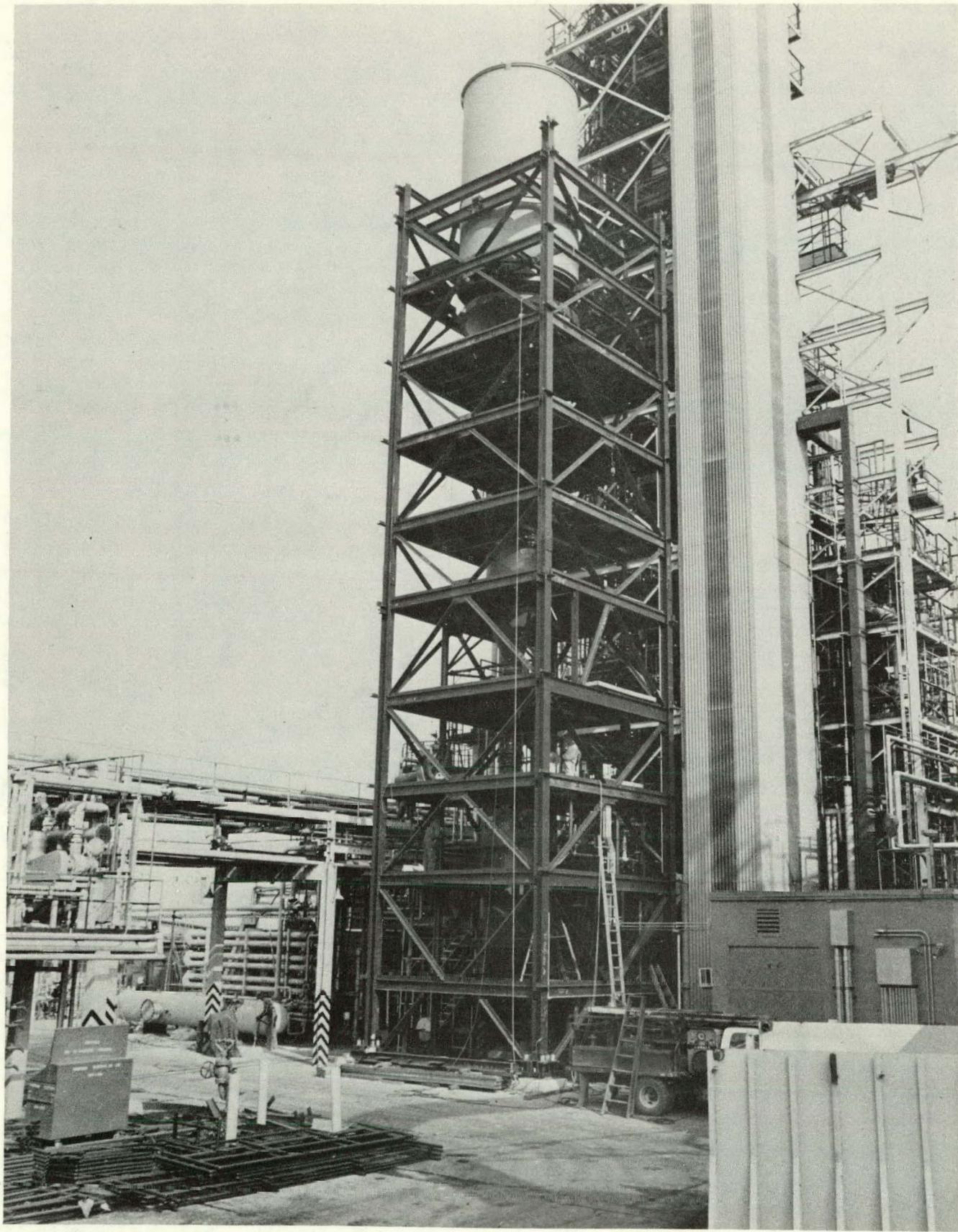


Figure 12  
Lockhopper Structure Topped Out.

## QUESTIONS AND ANSWERS

Q: Approximately what percentage of hydrocarbon liquid yields, as a fraction of the dry peat, can be expected?

A: About 23% of the feed carbon at these temperatures of hydrogasification, which were in the range of about 1100°F.

Q: That is the general figure, then, for those particular runs? That was the operational data?

A: They are averaging about 20%. But you have got to remember that this is a temperature of about 1,000 to 1100°F. As you raise the temperature in the hydrogasification zone, which more or less duplicates what Rockwell is doing and the curves that they showed, as you increase the temperature, you are going to have more gas and less liquid yield. As you lower the temperature, you are going to have more liquid yields, less gas yields.

**COMMENT:** (DR. PUNWANI): I want to add a little bit to that. When we use the lockhopper feed system and try to accomplish 1700°F in the char gasification zone, that will help increase the hydrogasifier temperature.

In addition, with the slurry feed tests, some devolatilization takes place in the hydrogasifier -- hydrogasification reactions are exothermic -- that also will help boost the temperature up in the hydrogasifier. And for the purpose of making SNG, we would like to operate the hydrogasifier at temperatures above 1250°F, which will improve the quality of liquid hydrocarbons we are producing and decrease the quantity. It will decrease it to about 12% of the feed carbon. And it will be mainly light oils.

## QUESTIONS AND ANSWERS

Q: Will be light oils?

A: Yes.

Q: In general, have you run any engine tests of any kind on what might be termed the peat liquids?

A: We have not run any engine tests.

**COMMENT:** (MR. RADAR): I can comment on that. We weren't planning to make engine fuel in this process. Some of the components out of it could be used as gasoline additives. Your benzene, of course, is a very desirable gasoline additive.

**COMMENT:** (MR. BILJETINA): I was going to add that the majority of what we are finding -- and we are just getting the results back now. That is why we did not report them here. They tend to be the BTX fraction, which is again a very salable byproduct. Even if you can't get \$1.55, I'm sure you can sell it for at least a dollar.

**EFFECT OF DEWATERING METHODOLOGY  
ON PEAT GASIFICATION**

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In addition to the two PDU programs that were discussed yesterday and this morning, the wet carbonization program and the single-stage fluidized-bed gasification program, IGT is also conducting two hydrogasification programs under the same sponsorship.

The objectives of these two hydrogasification programs are:

- to study the gasification characteristics of Alaska and Florida peat
- to study the gasification characteristics of peats dewatered by different methods
  - North Carolina sod peat versus the North Carolina milled peat
  - Minnesota peat dewatered in a Sulzer belt press followed by
    - Sulzer's own fluidized-bed dryer
    - IGT steam-tray dryer

The work plans for these two programs are to conduct hydrogasification tests in our coil reactor and also conduct char gasification tests in our thermobalance reactor. These test results will be compiled and then compared with previous data bases.

The following is a basic description of the process flow through the coil reactor. First the peat is carried by reaction gases cocurrently into the coil reactor, which is being externally heated. The product then leaves the reactor and the solids are separated by a cyclone into a solids receiver. The gas proceeds to a condenser, where the liquids are extracted and the product gas measured and sampled.

So far we have conducted two tests with Florida peat and we are in the process of procuring Alaskan peat. We have identified at least one good sample from Alaska, namely lower than 25% ash and over 8,000 Btus heating value.

The two tests that have been conducted with Florida peat used the following operating conditions. The first test was run at around 1400°F, and the second

test at around 1100°F; both at total pressures of 250. In the first test, only hydrogen was used, and in the second test a 50/50 hydrogen and steam mixture was used. These were short-residence-time tests, as for all hydrogasification tests, and they ranged from 5 to 10 seconds in duration.

Here are the operating results from those two tests. We were able to get up to 70% conversion on carbon for the first test where the operating temperature was in the range of 1400°F. On the second test, at the 1100°F operating temperature, we got a 55% conversion on carbon.

We have completed our tests with North Carolina sod peat and we are awaiting the dewatered peat from Sulzer in Germany.

On the North Carolina sod peat we conducted three tests with temperatures ranging from 1200 up through 1475°F, all at pressures of 250 pounds. A hydrogen/nitrogen mixture of about 50/50 was used with a residence time of about four seconds. The peat feed rate, on a dry basis, was about six to seven pounds.

The results of the tests on the North Carolina sod peat were compiled and compared with previous tests, accomplished under similar conditions, on the North Carolina milled peat. The following is a discussion of this comparison.

- It was found that, in a plot of the carbon conversion versus maximum reactor coil temperature, both the sod peat and milled peat fall pretty much on the same curve.
- The hydrocarbon gas yields, the C1's and C2's, were in close agreement.
- The carbon oxide yields also plotted fairly closely to the same line.
- The liquid hydrocarbon yields plotted a little bit scattered, but displayed a definite trend.

In general, the data on both the North Carolina sod peat and milled peat are very similar.

In addition to the hydrogasification tests in the coil reactor, we have conducted tests in the thermobalance work where we studied the reactivity of the base carbon, and here again we compare the sod peat versus the milled peat. The results were fairly comparable.

For our future work we intend to complete the Florida tests and the Alaskan peat tests, and as soon as we receive the material from Sulzer in Germany we will complete our dewatering methodology test with the Minnesota peat.

## QUESTIONS AND ANSWERS

Q: Could you elaborate on the differences that you observed when running with pure hydrogen versus a 50/50 steam/hydrogen mixture?

A: Yes. We have found in the past that when we operate the hydrogen partial pressure in the hydrogasifier above 100 psi, we observe no appreciable difference in the yield. And in most of our cases, we operate above that.

And all we are attempting to do here is to duplicate conditions that we have obtained in the past so that we can compare the results from previous tests.

Q: You have said here you are expecting to carry out these tests with two different types of dryers.

A: Yes.

Q: What is the difference you expect to find in the hydrogasification between the use of one dryer as opposed to the other?

A: In the case of milled and sod peat we don't see much difference. And we are not saying that there will be difference in the dryers, but that is what we want to find out.

Q: Does the method of drying make a difference to the hydrogasification result?

**COMMENT:** (DR. PUNWANI): At one of the meetings where we were making presentations on our work, questions were raised by the Fossil Fuel Advisory Group as to whether it will be changing the characteristics of peat if we change the method of drying.

## QUESTIONS AND ANSWERS

Our initial gut reaction was that unless the temperatures exceed 200°F, there should not be any difference. Their point was that in a fluidized-bed dryer, yes, the average temperature may be 250, 300°F but you are coming in with gases which are much hotter and there might be some hot spots. So in the particles present in those hot spots there might be devolatilization.

They asked us the question, What effect will it have on gasification properties? We said, We do not know because we have not done that study. So we were given the task to determine the effect of dewatering method on the gasification characteristics.

Q: But then, similarly, if you dewater peat by the wet carbonization process or by partial wet oxidation process, you would expect similar differences or some kind of differences in the hydrogasification characteristics?

A: That's right. As a matter of fact, in our wet carb program we also have a subtask to study the hydrogasification characteristics.

## **OVERVIEW OF STATE PEAT RESOURCE PROGRAMS**

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## **OVERVIEW OF STATE PEAT RESOURCES ASSESSMENT PROGRAM**

### **INTRODUCTION**

The United States has large deposits of peat with recoverable fuel value roughly estimated at about 1443 quads ( $10^{15}$  Btu), which is equivalent to 240 billion barrels of oil. Currently, the potential importance of peat as a feedstock for gasification and as a fuel source is being evaluated by the U.S. Department of Energy (DOE). As part of this evaluation, a better estimate of the available U.S. peat reserves is needed. To obtain this information, grants are issued to states to participate in surveys of their state peat reserves. Presently, fourteen states have received grants. This presentation includes an overview of the peat surveys for each state participating in the grant program.

### **DOE PEAT SURVEY PROGRAM**

The objective of the DOE peat survey program is to determine the amount and location of fuel-grade peat in the U.S. that may be harvested in an environmentally acceptable manner. The United States has large areas of organic soils including peat deposits in Alaska, in the northern states including Minnesota, Wisconsin, and Michigan, on the east coast from Maine to Florida, and on the Gulf coast. The approximate locations of most major U.S. peat reserves are indicated on the map in Figure 1 (1). The 14 states that are currently participating in the DOE peat program are outlined on the map. These states include Alaska, Maine, Michigan, Minnesota, North Carolina, and South Carolina, all of which have survey grants initiated in 1979, and Georgia, Florida, Louisiana, Massachusetts, New York, Rhode Island, Alabama, and Wisconsin which have grants initiated in 1980 and 1981.

A recent analysis in 1976 estimated the peat reserves in the contiguous states at 37.8 billion tons (dry basis) (2). This estimate, as presented in Table 1, includes the non-permafrost areas of Alaska for a total of 78.4 billion tons of U.S. peat reserves. Current state estimates of peat reserves for the U.S.



**Figure 1**  
Geographic Regions Containing Significant Amounts of Peat Resources.

are also presented in Table 1, for a total of 61.2 billion tons. Current state estimates are based on the definition of fuel-grade peat. Fuel-grade peat is defined as peat with a minimum heating value of 8000 Btu/lb (dry basis) and a maximum ash level of 25 pct (dry basis). Minimum depth for commercial grade peat is defined as 5 feet with a minimum area of 80 acres per square mile. The current state estimates, such as in Minnesota and Michigan, reflect the detailed survey of the peat resources conducted to date in each state.

**TABLE 1**  
**PRELIMINARY ESTIMATED UNITED STATES PEAT RESOURCES.**

<u>State</u>	<u>Quantity</u> (Billions tons dry basis)		<u>Percent</u> <u>Survey</u> <u>Completed</u>
	<u>Soil Survey<sup>a</sup></u> <u>Estimation</u>	<u>Current State</u> <u>Estimates</u>	
Alaska <sup>b</sup>	40.1	40.1	60
Minnesota	10.7	4.0	55
Wisconsin	4.2	2.3	0
Louisiana	2.7	1.0	10
Michigan	6.7	2.2	20
North Carolina	1.8	0.63	60
Florida	4.5	4.5	10
Maine	1.2	0.7	66
New York	0.98	0.25	10
South Carolina	0.08	0.04	65
Alabama	0.03	0.03	0
Massachusetts	0.52	0.52	10
Georgia	0.65	0.65	0
Other States	4.2	4.2	0
Rhode Island			
<b>TOTAL</b>	<b>78.4</b>	<b>61.2</b>	

<sup>a</sup>Reference 2

<sup>b</sup>Excludes peat in permafrost areas

The preliminary U.S. peat reserves from 1976 include 52.6 million acres. The six states that started peat surveys in 1979 under the DOE grant program comprise about 77 pct of the total estimated reserves. The states added in 1980 and 1981 increase the scope to include about 95 pct of the total estimated reserves.

To meet the objective of the DOE peat survey program to determine the amount and location of fuel grade peat, the grants to each state include four tasks, as follows:

- Task 1. Assess existing data and establish priorities for peat areas to be surveyed.
- Task 2. Identify sampling procedures and strategy.
- Task 3. Procure equipment and supplies; and
- Task 4. Make preliminary estimate of peat reserves.

Each state makes periodic and annual reports with copies to other states and attends the semi-annual DOE contractors meetings to compare survey techniques and results.

#### **STATES WITH SURVEYS INITIATED IN 1980 AND 1981**

The eight states with surveys initiated in 1980 and 1981 and with DOE funding awards in FY81 include Alabama, Florida, Louisiana, Massachusetts, New York, Rhode Island, and Wisconsin. Alabama, Georgia, and Wisconsin are the latest participants with funding awards in September 1981. The name of the principal investigator or point of contact, an estimate of the potential peat resources, and the status of the peat survey are included in the following summaries for each of these states.

Alabama - Thornton Neatherly, Geological Survey of Alabama. DOE grant awarded in September 1981.

Peat deposits in Alabama are concentrated along the Gulf Coastal zones in Mobile and Baldwin Counties. Potential deposits have been estimated at 27 million tons on a dry basis.

Georgia - Bob Didocha, Technology Applications Laboratory, Georgia Institute of Technology. DOE grant awarded September 1981.

The coastal plains area of Georgia is similar to those of North and South Carolina, but the surveys that have been done in the Georgia plains are very spotty. Figure 2 (from the South Carolina Survey Annual report) indicates the plains area from Virginia through North Carolina, South Carolina, and Georgia into Florida. Ponds and bays exist all along the coastal plains and in the uplands part of Georgia. The southern part of the state, which borders on Florida, is an area that is underlain by limestone. There are two active peat mines presently in the state, with reserves that have been estimated anywhere from 0.1 to 1 billion tons. The types of peat that exist in Georgia are reed-sedge, sedimentary, and woody peat--all good fuel grade peat.

Florida - Doug Roberts, Governor's Energy Officer. DOE grant awarded in March 1981.

Florida includes potential peat deposits along the Atlantic Coast, inland over the Everglades, and near the Gulf Coast as indicated on the U.S. map, Figure 1. Florida has about 5.7 pct of the U.S. peat resources. Preliminary estimates show about 3.0 million acres or 4.5 billion tons of dry peat for Florida. Initial work is being conducted in the Lake Okeechobee region.

Louisiana - Dr. Charles Groat, Louisiana Geological Survey. DOE grant awarded in March 1981.

The Louisiana Geological Survey investigation of peat distribution in coastal Louisiana is directed towards mapping of peat deposits, description of peat characteristics, and evaluation of their potential for commercial production as an energy resource. Louisiana's reserves have recently been estimated at 2.67 billion tons on a dry basis. The Louisiana Geological Survey has reviewed relevant literature and examined logs of existing boreholes that have encountered peat. This information was used to produce a preliminary evaluation of the geologic significance of identified peat deposits and define peat prospect areas for additional mapping and sampling investigations.

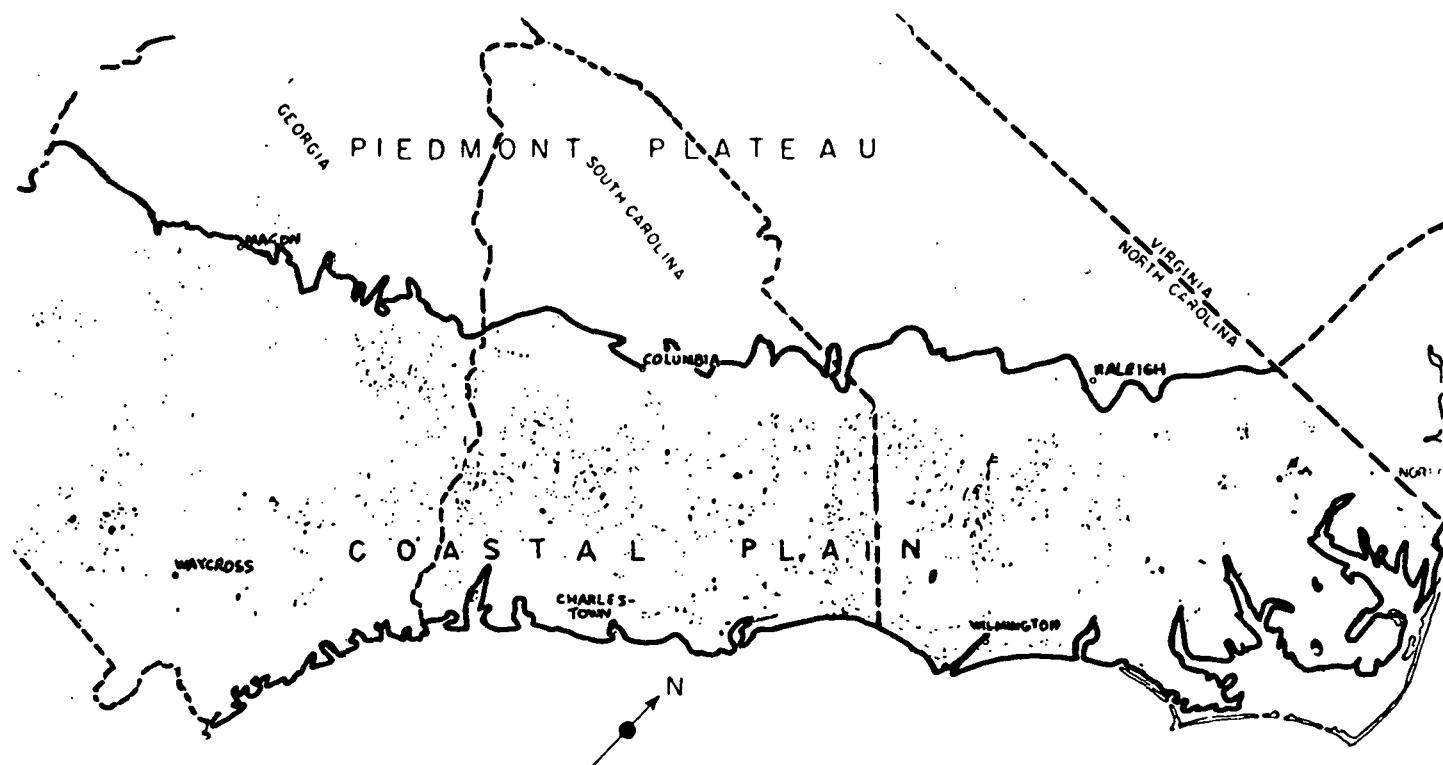


Figure 2  
Distribution of Peat in Coastal Plains of North Carolina, South Carolina and Georgia.

In coastal areas, significant peat deposits can reasonably be expected to occur as surficial or buried organic matter accumulations in marsh and swamp environments (See Figure 3). In south Louisiana, these environments occur mainly gulfward of the youngest coastwise Pleistocene terrace, the Prairie, and correspond closely to the extent of the Mississippi River Deltaic Plain. The selected prospect areas are located within the Pontchartrain Basin, the Barataria Basin, and the Atchafalaya Basin. These basins are interdistributary lowlands formed by cycles of deltaic sedimentation that contributed to a low rate of inorganic sediment input relative to the rate of organic matter accumulation.

The current phase of the program includes detailed mapping and sampling within the identified prospect areas. Initial activities will include field sampling and description of peat sequences and sample analysis. Interpretations of aerial photography, topographic maps, cross sections, and other available map data will be used to extrapolate general peat characteristics throughout and beyond the prospect areas. Maps depicting peat types, peat thicknesses, energy characteristics, and environmental setting of peat deposition will be used to estimate peat reserves within the selected prospect areas. New prospect areas will be identified for detailed study at a later time. Peat resource evaluation will be paralleled by environmental assessment of principal peat occurrence areas to identify the location and quantity of fuel grade peat that can be commercially produced in Louisiana in an environmentally acceptable manner.

The current state estimate of peat resources in Louisiana has been modified to 1 billion tons of dried peat based on samples obtained to date. It has been determined that many peat deposits have ash contents over the 25 pct limit set by DOE. This is in large part due to high sedimentation rates in the delta area where much of the peat is located.

Massachusetts - Linda L. Sutliff, Massachusetts Office of Energy Resources. The DOE grant was awarded on March 1, 1981.

The Massachusetts Executive Office of Energy Resources and the Massachusetts State Geologist jointly identified three primary areas for initial peat sampling



**Figure 3**  
**Louisiana Peat Resource Areas.**

in the eastern portion of the state. These areas are indicated on the map in Figure 4. Parties were in each of the three areas in late April to gather data for site descriptions, and hand coring parties were in the field by mid-May.

Currently, two teams (2 men each) under the direction of Dr. B. Brinkenmayer of Boston College's Department of Geology and Mr. Joseph Russo of the Commonwealth of Massachusetts, who has been associated with the Massachusetts state geologist, are active in the field. These teams are testing procedures used in Maine for doing field surveys and are contemplating other approaches to bog sounding, i.e., the use of seismic equipment.

Peat bogs that have been mapped or cored or mapped to date include the following:

MAPPED AND CORED:

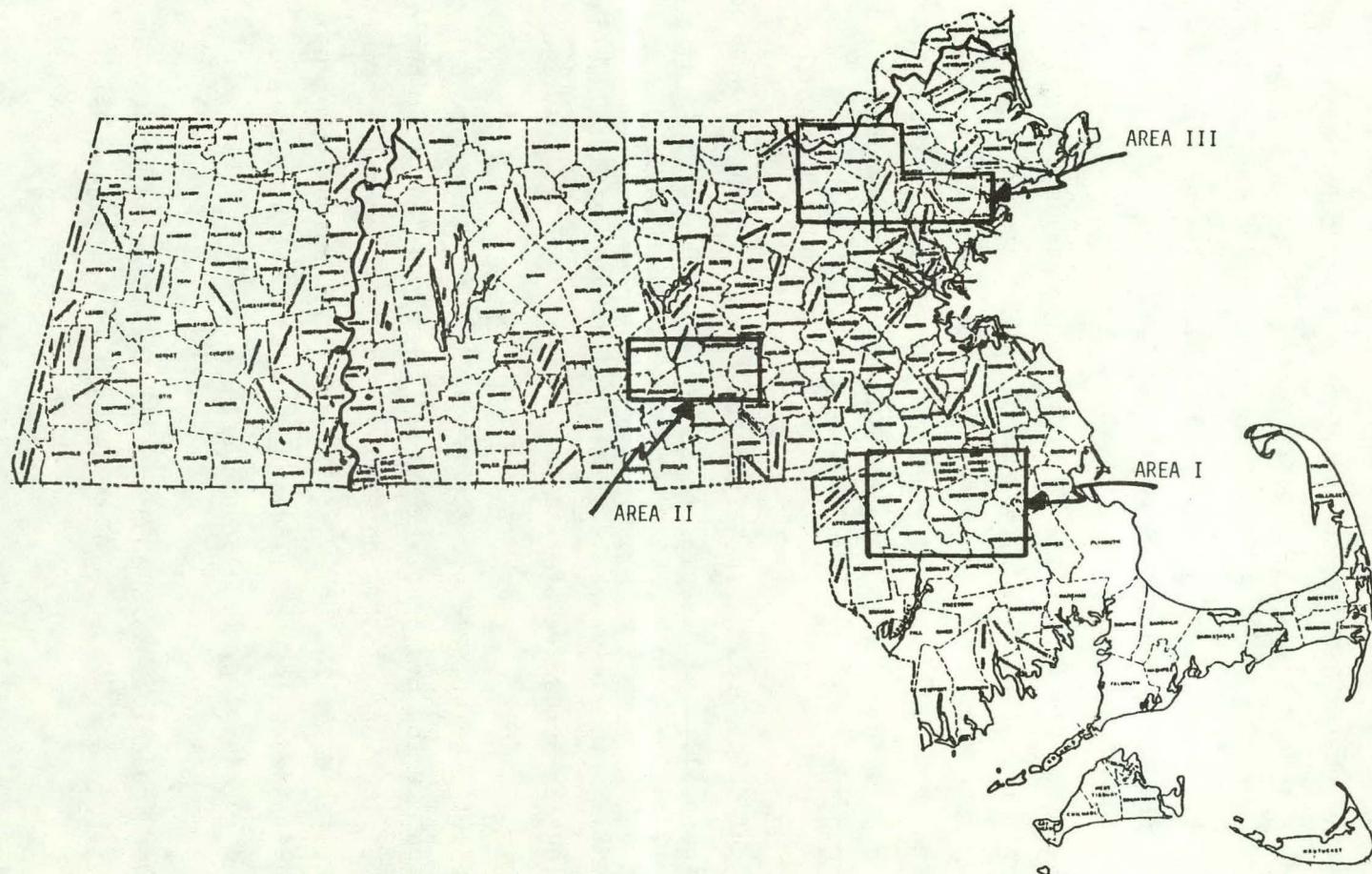
Great Swamp - Tewksbury, MA. Area III  
Peat Meadow - Methuen, MA. Area III

MAPPED - BUT NOT CORED:

Foul Meadow - Norwood, MA. Area I  
Great Cedar Swamp - Hanson, MA. Area I  
Cutler Park - Needham, MA. Area III  
Cedar Swamp - Reading, MA. Area III

New York - Jeffrey M. Peterson, Project Associate, New York State Energy Research and Development Authority. DOE grant awarded with starting date of April 1, 1981.

Based on the preliminary U.S. estimated peat resources, New York has about 0.65 million acres with 1.0 billion tons of dry peat. Carlson & Sweatt-Monenco, Inc., a consulting engineering firm with peat experience, will conduct the peat resources survey for the New York State ERDA. Based on their recent evaluation of literature, areal photographs, etc., they estimate the peat resources to be in the range of 250 million tons on a dry basis.



**Figure 4**  
Massachusetts Peat Resource Survey Areas.

The principal objective for this first year has been to determine the energy potential and distribution of peat resources in New York State. The field sampling program for the 1981 season started in May and focused on peat lands located in the northern and western parts of the state.

Rhode Island - Mr. Richard Goldfine, State of Rhode Island, Energy Administration. Initial DOE grant awarded on March 9, 1981.

Prior to this DOE grant, Rhode Island performed a detailed survey of peat resources on Block Island. The survey of Block Island indicated 63,564 tons of potential peat resources in seven peat bogs. The best quality peat (10-20 pct ash and greater than 5500 Btu/lb air-dried) was located in the Ambrose Swamp and New Meadow Hill Swamp, with a total estimated peat resource for the two swamps at 26,670 tons, air-dried.

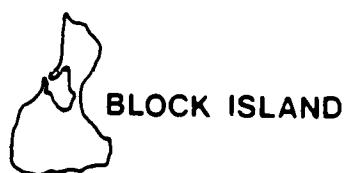
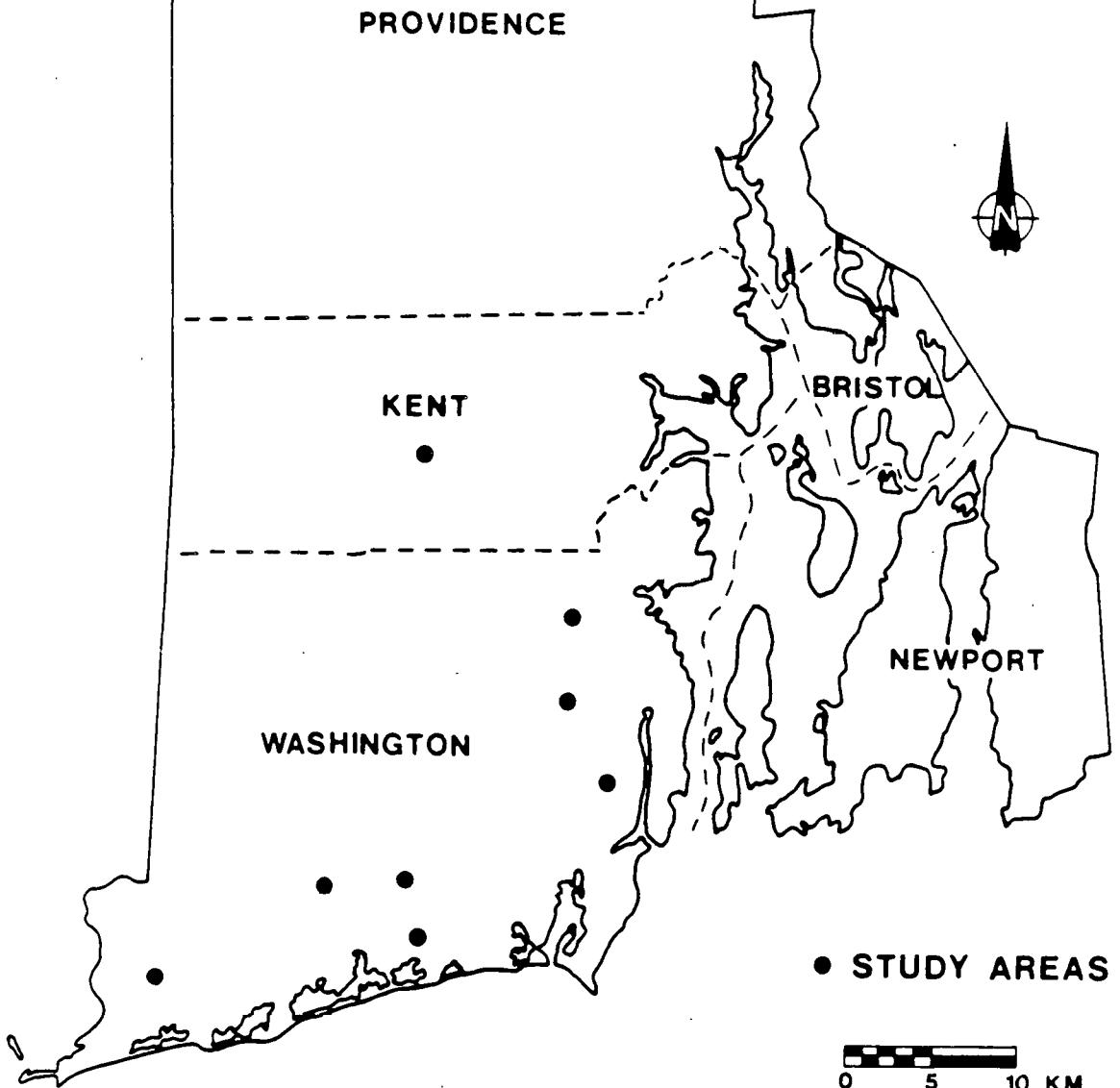
At present eight peat deposits in Washington and Kent Counties have been examined in detail (Figure 5). The deposits range from 178-808 acres in size and cover a total area of 3070 acres. Other peat deposits will be inventoried through the fall of 1981 until fieldwork is prohibited by bad weather. Wetlands with areas exceeding 125 acres are of first priority.

Cores are presently being selected for proximate, ultimate, and calorific analysis and will be sent to the Grand Forks Energy Technology Center. The location of core and probe sites are plotted on maps of the peat deposit as fieldwork progresses. Detailed distribution and thickness maps and quality mapping will commence when fieldwork is curtailed and when analyses of samples are received from the Grand Forks Energy Technology Center.

Wisconsin - Dr. Frederick Madison, Principal Investigator, Wisconsin Geological and Natural History Survey. DOE grant awarded in September 1981.

Peat survey activities in Wisconsin started in October 1981. Peat deposits occupy nearly 3,000,000 acres in Wisconsin and, as such, represent its most abundant fossil energy resource. These deposits were surveyed as a potential

**RHODE ISLAND  
PHASE 1  
PEAT DEPOSITS**



**Figure 5**  
Peat Deposits Surveyed in Rhode Island.

energy source by Huels (1915). Fifty scattered deposits, 1 to 20 or more feet in depth and 10 to 30,000 acres in size, were inventoried in 1903 and 1908. These areas occupied 121,000 acres and contained 151,000,000 tons of peat worth \$155 million 1908 dollars. The total volume of peat in Wisconsin was estimated at that time to be between 2 and 3 billion tons. This figure differs from the figure provided by the soil survey estimation study but is considered to be more accurate by Wisconsin peat survey investigations at this time.

#### **STATES WITH SURVEYS INITIATED IN 1979**

The six states with surveys initiated in 1979 include Alaska, Michigan, Minnesota, Maine, North Carolina, and South Carolina. The potential peat resources and status of the peat survey are included in the following summaries for each of these states.

North Carolina - Dr. Roy L. Ingram, Department of Geology, University of North Carolina. The initial DOE grant was awarded in May 1979.

Major peat deposits in North Carolina are indicated on Figure 6. The peat occurs in pocosins, river flood plains, and Carolina bays. Most of the survey work up to this field season concentrated on the pocosin deposits. A summary of work completed and estimates of peat resources for North Carolina is presented in Table 2. The estimated area of peat deposits is about 0.7 million acres or 630 million tons on a moisture-free basis. The detailed survey of the peat resources in North Carolina has indicated less reserves than originally estimated.

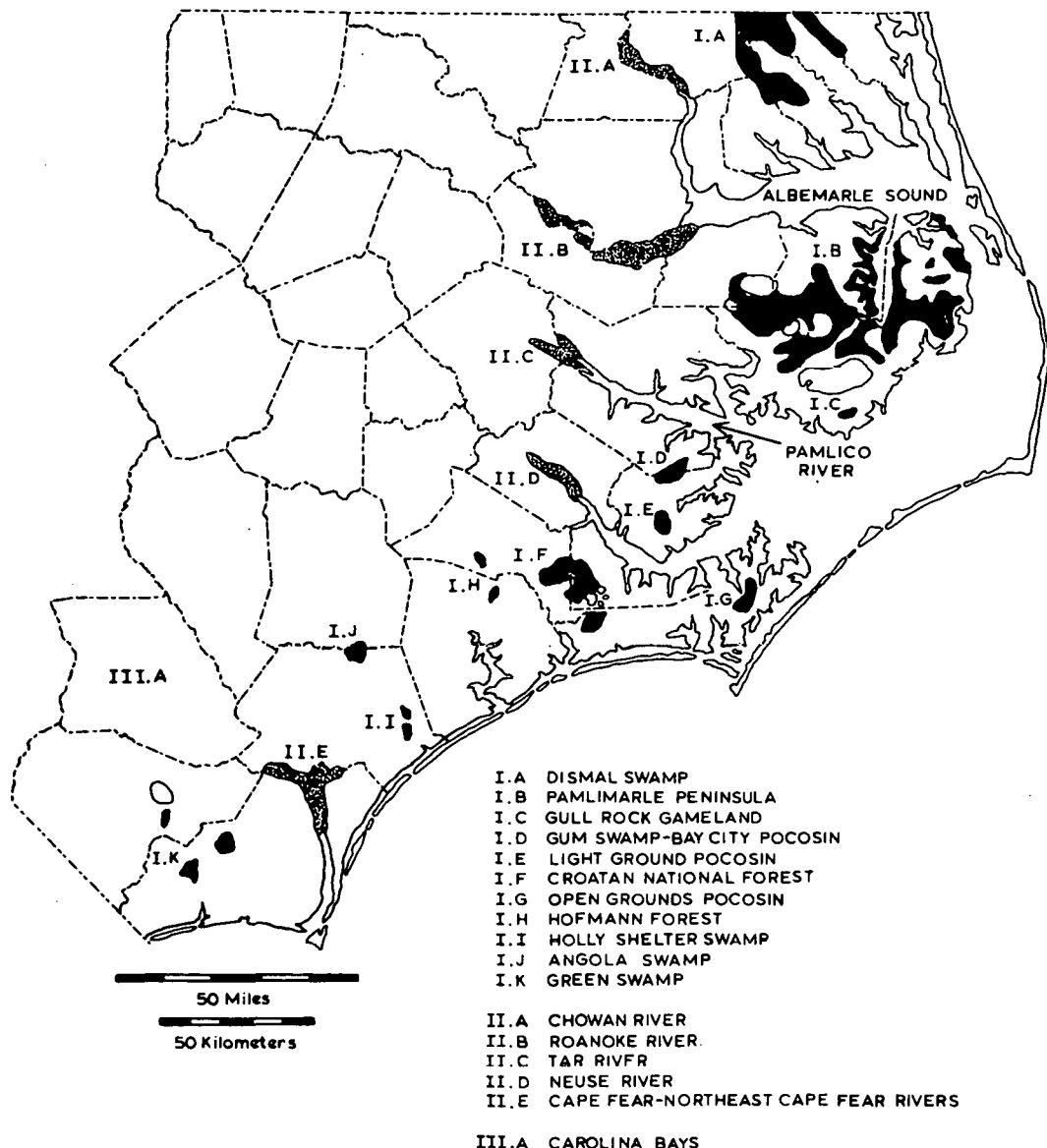


Figure 6  
 Location of North Carolina Peat Deposits.

TABLE 2  
NORTH CAROLINA PEAT RESOURCES.

Deposit	Area MI <sup>2</sup>	Weight Moisture-Free Peat 10 <sup>6</sup> Tons
I. COASTAL SWAMPS (POCOSINS)		
A. Dismal Swamp	120	68-E*
B. Pamlimarle	360	210-G
C. Gull Rock	6	4-F
D. Gum Swamp-Bay City	11	5-P
E. Light Grounds	9	5-E
F. Open Grounds	15	9-F
G. Groatan	55	27-E
H. Hofmann Forest	10	6-F
I. Holly Shelter	6	4-F
J. Angola	20?	12?-F
K. Green Swamp	10	6-F
II. RIVER FLOODPLAINS		
A. Chowan	40?	25?-P
B. Roanoke	50?	29?-P
C. Tar	10?	6?-P
D. Neuse	10?	6?-P
E. Cape Fear	20?	11?-P
III. CAROLINA BAYS	<u>350?</u>	<u>200?-P</u>
TOTAL	1102	630
	(0.7 x 10 <sup>6</sup> Acres)	

\* Quality of estimate: E - Excellent, G - Good, F - Fair, P - Poor

During the 1981 field season the peat potential of the Carolina bays was investigated. There are over 500 of these bays larger than 100 acres. Preliminary work indicates that peat will be found mainly in bays located on the broad floodplain complex of the Cape Fear River.

Most North Carolina peat is a black, fine-grained highly decomposed hemic to sapric peat. For most pocosin deposits, the thickness of the peat is 7 to 8 feet in the center, with a median thickness of about 4-1/2 feet. The median

properties for moisture-free peat (based on 200 samples with less than 10 pct ash) are as follows: heating value, 10,200 Btu/lb; ash, 4 pct; volatiles, 61 pct; fixed carbon, 60 pct; hydrogen, 5.2 pct; oxygen, 20 pct; nitrogen, 1.4 pct; and sulfur, 0.2 pct.

An annual report on peat resources in North Carolina was published in November 1980. Based on survey work completed to date, considerable interest has been generated, including a proposal by the N.C. Electrical Membership Corporation to use peat as a boiler fuel, an application to mine a 3600-acre tract in the Light Ground Pocosin, and a pilot project to extract methane gas from water in swampy peat bays. First Colony Farms in Creswell, NC own approximately 300,000 acres on the Pamlico Peninsula and have been actively developing peat deposits since about 1975.

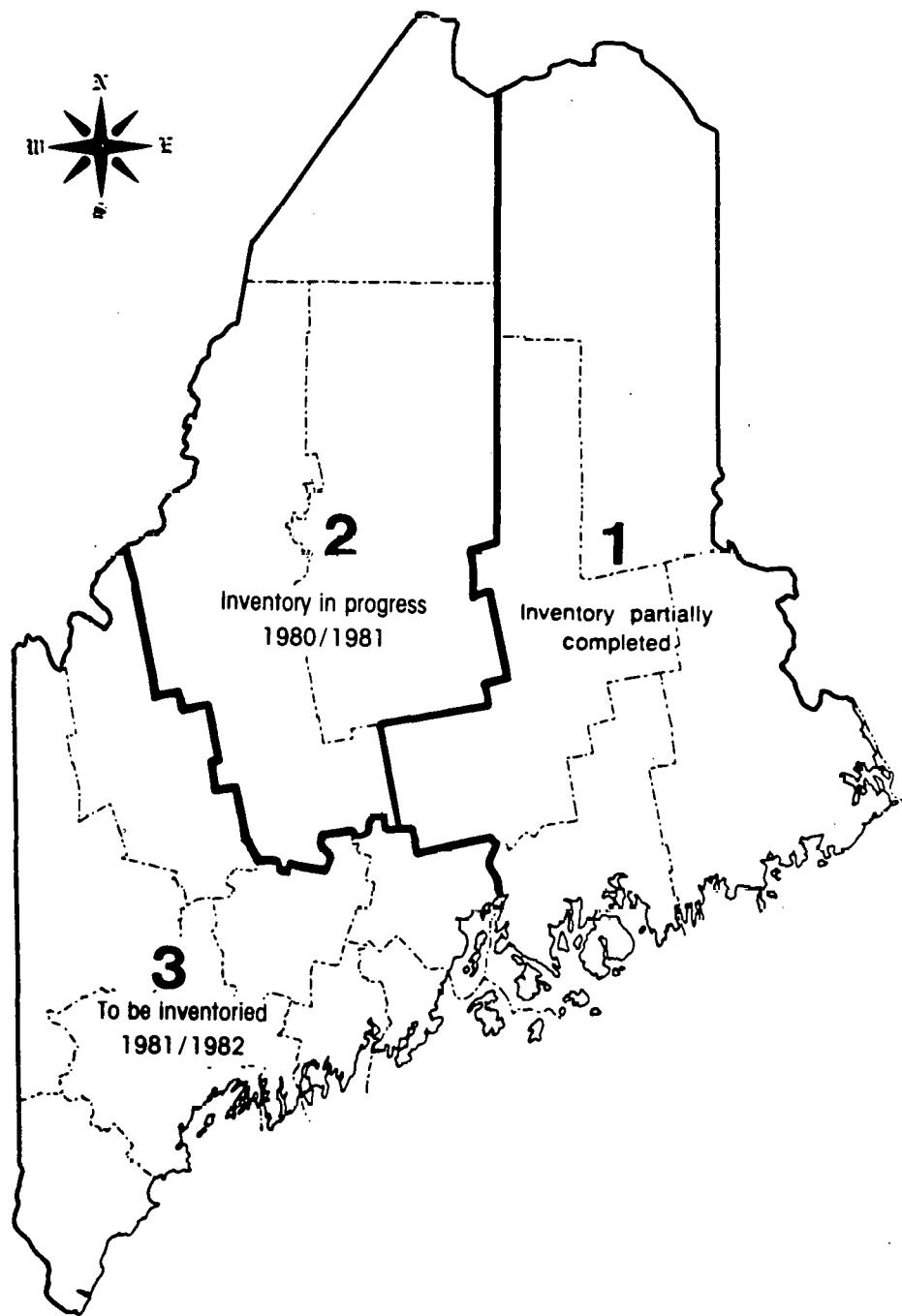
Maine - Dr. Joel Davis, Peat Program Manager, Maine Office of Energy Resources. Initial DOE grant was awarded in July 1979.

The Maine survey is being conducted in three phases, essentially as indicated on the map in Figure 7. Tasks 1, 2, and 3 were completed in Phase I.

The Phase I (FY79) survey covered the following county areas: eastern Aroostock, northern Penobscot, eastern Piscataquis, Washington, and part of Hancock. A total of 57 peat deposits was surveyed. Analytical results for 81 samples from the Great Heath (2645 acres) in Washington County are of special interest since trace element analysis was included along the peat type, thickness, proximate and ultimate analysis, and heating value.

The Phase II (FY80) survey covered the following county areas: northern Aroostock, western Piscataquis, Somerset, Kennebec, and Waldo. Fifty-one peat deposits were surveyed during the 1980 field season ranging in size from 40 to 1350 acres.

The Phase III (FY81) survey covered the following county areas: York, Cumberland, Lincoln, Knox, and Waldoboro. Forty-eight deposits were surveyed during the 1981 field season ranging in size from 55 to 751 acres.



**Figure 7**  
**Maine Peat Resource Evaluation Mapping Areas.**

Estimates to date of fuel-grade peat resources are 94 million tons of air-dried peat, with 45 million tons from Area I, 25 million tons from Area II, and 24 million tons from Area III. These peat resources are predominantly high-quality sphagnum moss peat underlain with reed-sedge peat. The peat properties include heating values between 8600 to 10,500 Btu/lb and ash contents below 8 pct on a moisture-free basis. Ranges of values for other properties on a moisture-free basis include: volatile matter, 60 to 75 pct; fixed carbon, 20 to 30 pct; sulfur, 0.1 to 0.6 pct (0.2 pct average); nitrogen, 0.6 to 2.0 pct; hydrogen, 4.8 to 5.9 pct; and oxygen, 28.9 to 40.9 pct.

A final report on Phase I was published in July 1980. This report includes peat distribution and thickness maps, analytical results, and fuel-grade peat resource estimates for the 57 peat deposits surveyed in Phase I. A large-scale quality map for the Great Heath is also included.

Cartographic work on the distribution and thickness maps for the 51 deposits surveyed in FY80 is in progress and will be included in the final report for Phase II.

Michigan - Dr. John E. Mogk, Principal Investigator, Michigan Energy and Resource Research Association. Initial DOE grant was awarded in July 1979.

To provide the framework for a comprehensive peat survey in Michigan, the state is divided into 16 soil-geomorphic provinces, as shown on Figure 8. Individual peat types, defined by the U.S.D.A. Soil Conservation Service as organic soil series, are methodically investigated within each province. Field and laboratory investigations have been undertaken to evaluate the energy potentials and classifications of each organic soil series found within a province. During the first phase of the project, Province III was selected for pilot testing as a Michigan area with substantial peat deposits offering high potential as an energy resource. The 1980 field work also concentrated on Onaway-Emmet Drumlins, Province III. Some field studies were conducted in neighboring Provinces IV - Kalkaska-Rubicon-Peat Plains, and II - Iron River-Michigamme Hills. During the 1980 field season, eight bogs were surveyed in Menominee County (Province III).



Figure 8  
State of Michigan Soil-Geomorphic Provinces.

Three of these bogs were mapped as Greenwood and five were mapped as Rifle in the original soil survey of Menominee County. Thirty soil samples were collected from 24 pedons that were studied in detail in the areas mapped as Rifle peat. Sixty-three Rifle peat samples were collected for laboratory analysis. A total of 300 depth observations were made in 30 transects of eight separate bogs.

Preliminary data have indicated significant differences in energy potentials among soil series. The Greenwood Series and the Rifle Series meet criteria for fuel-grade peat. On a moisture-free basis, the Greenwood Series averages 9382 Btu/lb heating value, 3.9 pct ash, 0.8 pct nitrogen, 0.2 pct sulfur, 72.7 pct volatile matter and has a bulk density of 0.12 g/cc. The Rifle Series has 8367 Btu/lb heating value, 12.5 pct ash, 2.0 pct nitrogen, 0.53 pct sulfur, 57.6 pct volatile, and 0.15 g/cc bulk density.

The organic soil acreage within each county studied during FY81 is listed by soil series within Table 3. These acreage figures represent the combined acreage of all sections within each survey area containing at least 80 acres of potential fuel-grade peat. A dot grid is used to count the section acreages as delineated on the soil survey map sheets.

A final report concerning the peat resources of Provinces III and IV will be compiled in the Spring of 1982 upon receipt of analyses from the DOE Sample Analysis Laboratory.

The plan for FY82 includes completion of Provinces III and IV. Several large areas of potential fuel-grade peat in the Lower Peninsula of Michigan may be investigated this winter. The remaining Provinces in the Upper Peninsula of Michigan are scheduled for completion during FY82.

South Carolina - Dr. Torgny J. Vigerstad, Project Manager, South Carolina Energy Research Institute. The initial DOE grant was awarded in August 1979.

The map in Figure 9 indicates the large peat deposits in South Carolina. The status of the peat surveying is also indicated on the map for each deposit.

**TABLE 3**  
**ACREAGE OF POTENTIAL FUEL-GRADE PEAT BY SOIL SERIES**  
**FOR COUNTIES WITHIN PROVINCES III AND IV SAMPLED DURING FY81**  
**(>80 ACRES PER SECTION, BASED ON DOT GRID COUNTS OF PUBLISHED SOIL SURVEYS)**

County	Province	Soil Series			Total Acreage
		Carbondale Muck	Spalding and Greenwood Peats	Rifle Peat	
Monominee	III	-	-	183,320	-
Alger	IV	40,740	15,230	6,650	2,040
Schoolcraft	IV	31,850	53,840	1/	15,480
Luce	IV	70,260	43,640	-	1/
Chippewa	IV	2,690	24,940	77,840	1/

1/ Acreage tallied with Carbondale Muck.

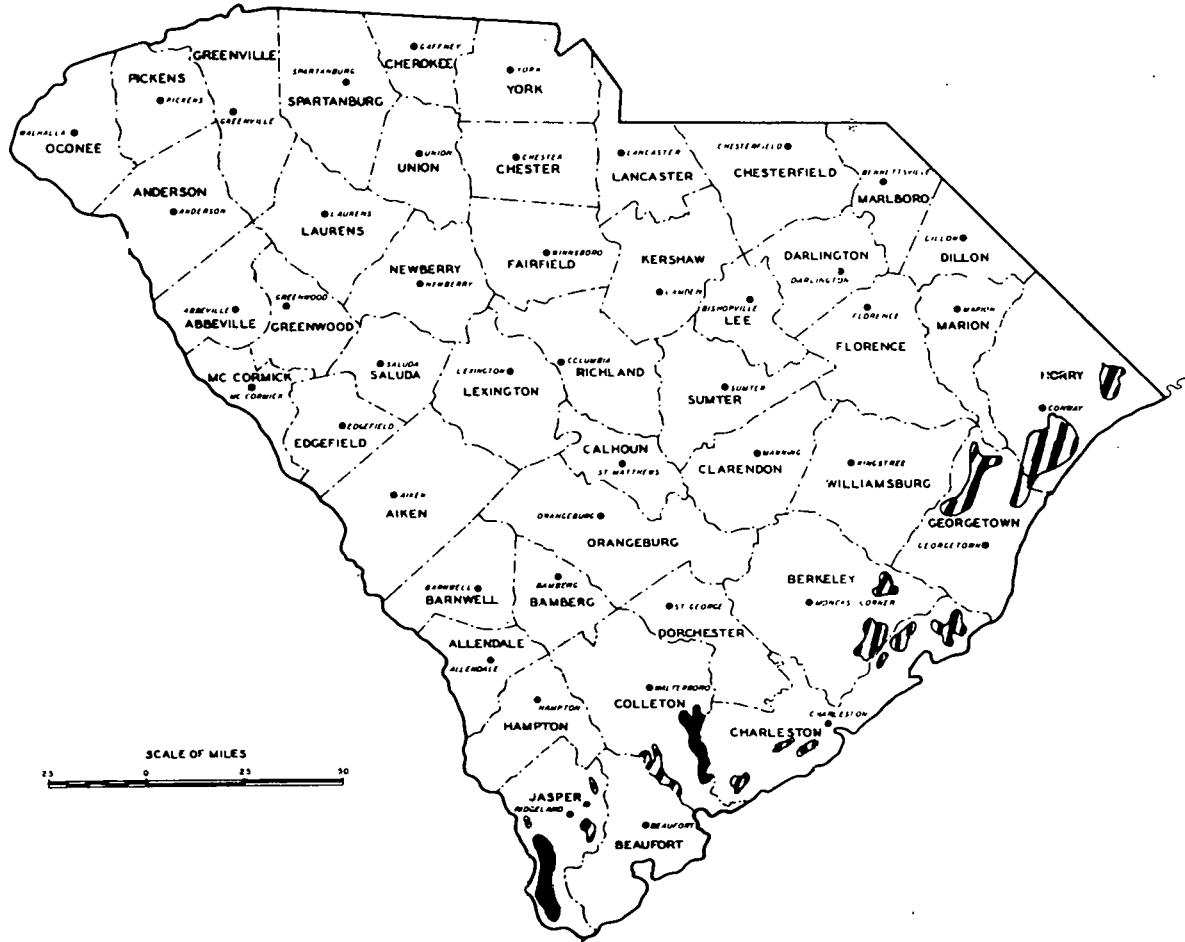


Figure 9  
Approximate Locations of Major Peat Deposits in Coastal Plain Counties of South Carolina.

Evaluation of the major deposits in Colleton, Jasper, Berkeley, Horry, Charleston, and Georgetown Counties has been completed. Preliminary samples have also been taken from other peat deposits in the state. A summary of the preliminary peat resource estimates based on limited surveying and sampling is presented in Table 4. The estimated total resource is about 74,218 acres or 0.142 billion tons (air-dried at 35 pct moisture).

**TABLE 4**  
**PRELIMINARY ESTIMATED PEAT RESOURCES**  
**IN SOUTH CAROLINA.**

<u>County</u>	<u>Acres</u>	<u>Dry Weight</u> (million tons)
Colleton	17,026	26.0
Jasper	13,000	21.0
Charleston	5,102	5.3
Berkeley	4,590	4.7
Horry	19,500	20.0
Georgetown	<u>15,000</u>	<u>15.5</u>
TOTAL	74,218	92.5

Note: 92.5 million tons (dry) = 0.142 billion tons air-dried at 35 pct moisture.

Based on the Snuggedy Swamp samples, South Carolina peat is woody and grass-sedge peat that is highly decomposed hemic with some sapric. On a dry basis, the mean peat properties are as follows: heating value, 9853 Btu/lb; ash, 4.5 pct; volatile matter, 58.5 pct; fixed carbon, 36.9 pct; hydrogen, 4.2 pct; carbon, 59.4 pct; oxygen, 27.9 pct; nitrogen, 1.1 pct; and sulfur, 0.7 pct.

A final report for the first year of the peat resource estimation in South Carolina was published on August 31, 1980. This report includes maps, tables of analytical results, and preliminary estimates of peat resources for the six counties with major peat deposits -- Colleton, Jasper, Charleston, Berkeley, Georgetown, and Horry Counties.

A final report for the second year of the peat resource assessment is in progress and will be available this Fall. The program is on schedule for completion in one additional year (approximately August of 1982).

Minnesota - Dr. Dennis Asmussen, Department of Natural Resources. The Minnesota peat program started in 1976 and a DOE grant was awarded in September 1979.

Counties with large peat deposits that have been or are planned to be surveyed are indicated in Figure 10. In 1979 and 1980, detailed surveys were conducted in Kochiching, Aitkin, and southwestern St. Louis Counties. The survey estimates for Koochiching County are 1 million acres of peat with 0.87 million acres of fuel-grade peat (greater than 5 ft thick). Aitkin County had 0.42 million acres of peat with 0.12 million acres greater than 5 ft thick.

The quantity and energy potential of Koochiching County peat is summarized in Table 5. Sixty-five pct of the peat in the County is less than 150 cm (~5 ft) deep, and 35 pct is deeper. The average depth of all peat in Koochiching County is 143 cm (~ 4.68 ft). Most of the peat surveyed is hemic, reed-sedge peat. Only 2.4 pct is fibric peat, and 0.6 pct is sapric peat.

A progress report on "Inventory of Peat Resources in Minnesota" was issued in January 1977. Many reports and maps have been published since then, including an "Inventory of Peat Resources" report for southwestern St. Louis County in May 1979 and an "Inventory of Peat Resources" report for Koochiching County in 1980. A report on Aitkin County is scheduled for completion in 1981.

At the present time, peatland surveys have been completed for Koochiching, Aitkins, Lake of the Woods, Carlton, and the northern Beltrami Counties.

Work to be completed includes publication of the results from some of these counties and other peatland surveys of remaining areas within Minnesota that have potential for fuel sources.

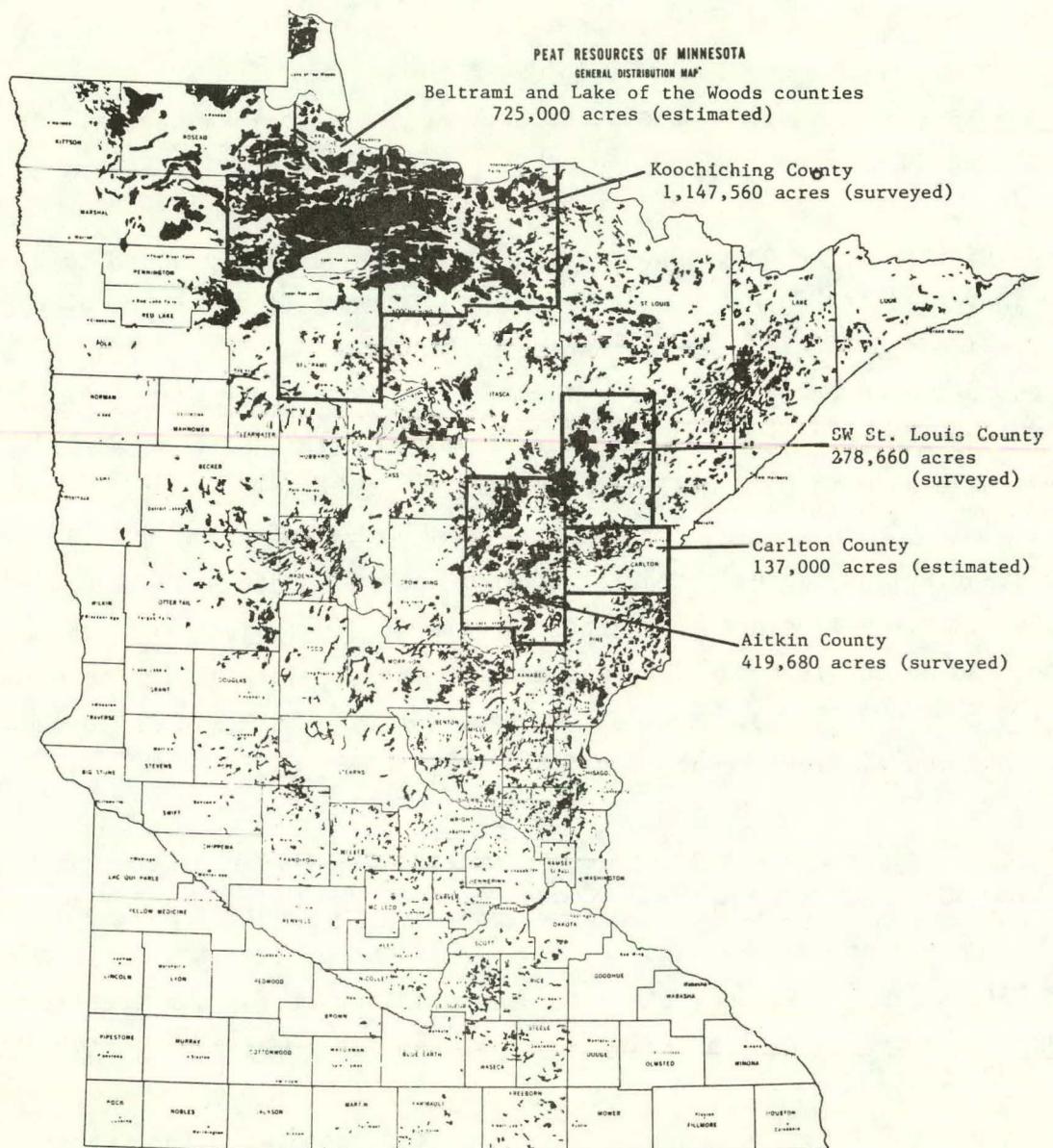


Figure 10  
Peat Resources Map of Minnesota.

TABLE 5  
QUANTITY AND ENERGY POTENTIAL OF KOOCHICHING COUNTY PEAT.

	Hectares	Acres	Tons-Dry Metric (thousands)	Tons-Dry U.S. Short (thousands)	Btu's	Quads*
<b>By Depth</b>						
<150 cm (~5 ft) Deep	303,080	748,360	273,576	305,874	$5.47 \times 10^{15}$	5.47
>150 cm (~5 ft) Deep	<u>161,676</u>	<u>399,200</u>	<u>503,816</u>	<u>563,419</u>	<u><math>10.11 \times 10^{15}</math></u>	<u>10.11</u>
<b>TOTAL</b>	<b>464,756</b>	<b>1,147,560</b>	<b>777,392</b>	<b>869,293</b>	<b><math>15.58 \times 10^{15}</math></b>	<b>15.58</b>
<b>By Type</b>						
Fibric			19,216	21,230	$0.38 \times 10^{15}$	0.38
Hemic			753,510	842,843	$15.11 \times 10^{15}$	15.11
Sapric			<u>4,666</u>	<u>5,220</u>	<u><math>0.09 \times 10^{15}</math></u>	<u>0.09</u>
<b>TOTAL</b>			<b>777,392</b>	<b>869,293</b>	<b><math>15.58 \times 10^{15}</math></b>	<b>15.58</b>

\* One Quad =  $1 \times 10^{15}$  Btu

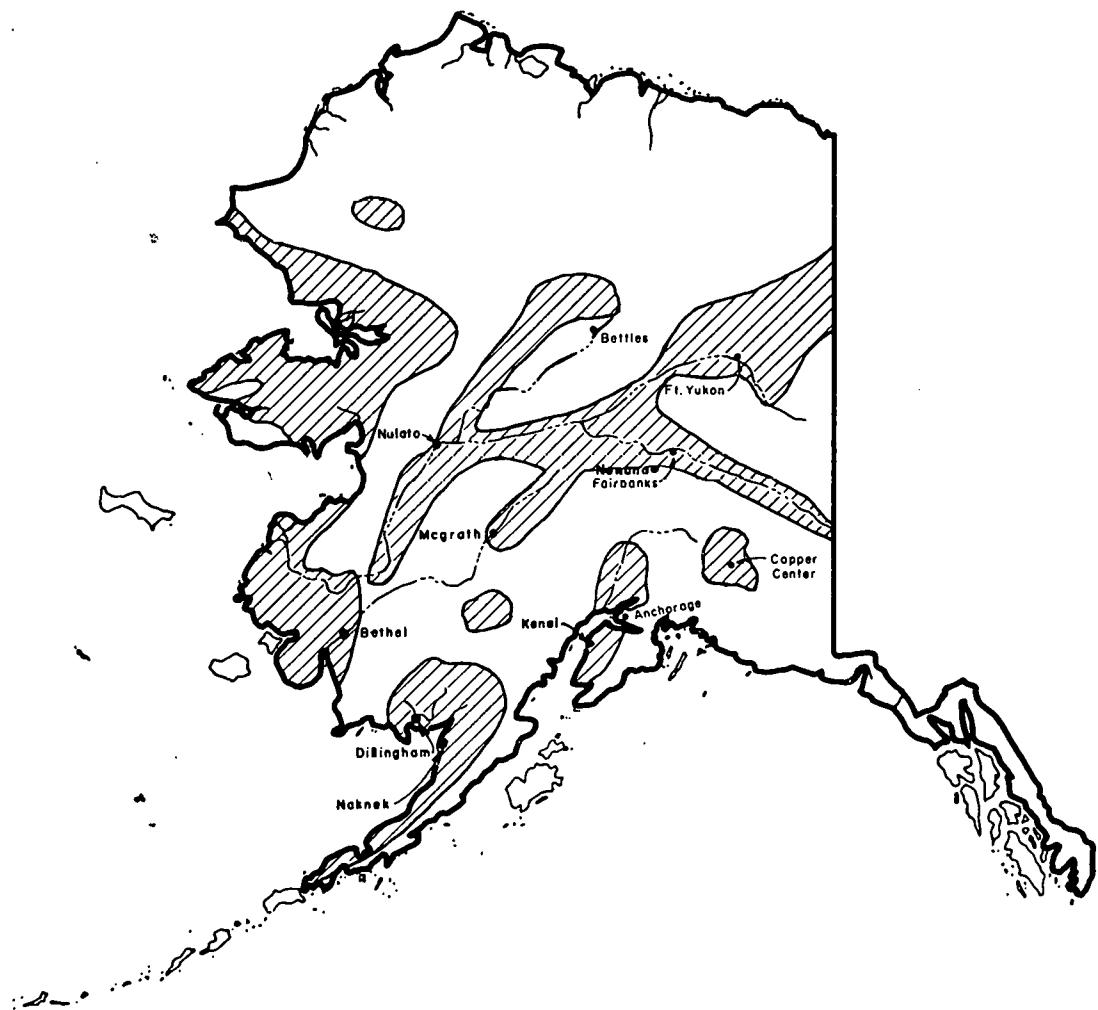
Alaska - Don Markle, Alaska Division of Energy and Power Development, and Stuart E. Rawlinson, Geologist, Division of Geological and Geophysical Surveys, Alaska Department of Natural Resources. Initial grant was awarded on September 9, 1979.

The Phase I, first year study was conducted jointly by Northern Technical Services and Ekono, Inc. The purpose of Phase I was to determine the location, area, quantity, and fuel characteristics of the Alaskan peat resource. A map of Alaska indicating the fuel peat probability provinces and ratings of the peat was completed in 1980. Detailed surveys were completed for several areas adjacent to communities that could use additional fuel for energy. These areas are indicated on the map in Figure 11. The results for the peat sites surveyed in 1980 are summarized in Table 6. Areas surveyed (1.858 million acres) included the Anchorage area, Susitna Valley, Matanuska Valley, and Kenai Peninsula.

A Final Report, Volume I, on Peat Resource Estimation in Alaska was published in August 1980. Two maps on fuel peat probability provinces were included. For Phase II, Alaska Division of Energy and Power Development has awarded a contract to the Alaska DNR, Division of Geological and Geophysical Surveys. The purpose of Phase II is to determine the energy potential of the peat resource of Alaska available for local utilization. The tasks to be completed under this contract are as follows:

- I. Compile and retrieve background information necessary to conduct detailed field studies of peat resource in Alaska.
- II. Design a field program in the Susitna Valley and Dillingham area.
- III. Procure field equipment.
- IV. Conduct field program, prepare peat distribution and quality maps and prepare reports of findings.

Tasks I, II, and III of the project objectives are in progress and near completion. Task III, the field activities, begin in mid-July starting with the Susitna Valley near Talkeetna and proceeding southward to interface with work being



**Figure 11**  
**Potential Alaskan Fuel Peat Areas.**

**TABLE 6**  
**DISTRIBUTION OF PEAT SERIES IN MANTANUSKA-SUSITNA**  
**VALLEYS AND KENAI PENINSULA**

Resource Areas	Soil Series										Total Acres Surveyed	
	Salamatof		Clunie		Doroshin		Starichkof		Acres	Cover		
	Acres	%	Acres	%	Acres	%	Acres	%				
Anchorage Area	4184	3.53	-	-	4489	3.79	1844	0.15			120,000	
Susitna Valley	224,090	33.4	10,280	1.4	-	-	-	-			730,390	
Matanuska Valley	62,590	13.9	10,040	2.2	-	-	-	-			499,300	
<b>Total Mat-Su/ Anchorage Area</b>	<b>310,864</b>	<b>23.0</b>	<b>20,320</b>	<b>1.5</b>	<b>4489</b>	<b>0.33</b>	<b>1844</b>	<b>0.14</b>	<b>1,349,690</b>			
Homer-Nirivilchik	39,081	14.4	-	-	11,660	4.3	4060	1.5			271,700	
Kenai-Kasilof	46,294	19.4	3371	1.4	4108	1.7	4407	1.8			238,248	
Kenai Peninsula	85,375	16.7	3371	0.7	15,768	3.1	8467	1.7			509,948	
<b>Total Area (Mat-Su + Kenai)</b>	<b>396,239</b>	<b>21.3</b>	<b>23,691</b>	<b>1.3</b>	<b>20,257</b>	<b>1.1</b>	<b>10,311</b>	<b>0.6</b>	<b>1,859,638</b>			

done in the Matanuska Valley and southern Susitna Valley by the U.S. Geological Survey investigators. Next, a specially limited (working from existing roads) but detailed sampling program will be set up for the Dillingham area.

#### SUMMARY

The geological data available and the characteristics of the peat deposits in each state are factors in the approach the state takes to assess its resources. There has been an exchange of information among the states during this program that has helped in developing procedures and analyzing data that will provide a reasonably good basis for establishing the quantity and location of fuel grade peat within the U.S.

Some states have just begun their assessment program and others, such as Minnesota and Michigan, are almost finished. The data obtained to date are a good start on defining the extent and characteristics of our peat resources. It is estimated that another 4 years at similar funding levels will be required to complete this survey. Future budget considerations will determine how fast and to what extent the resource assessment program will be conducted.

#### REFERENCES

1. Third Technical Contractor's Conference on Peat - Overview of State Peat Resource Programs, Dr. F.I. Honea, DOE/Grand Forks Energy Technology Center.
2. Data from U.S. Dept. of Agriculture, Soil Conservation Service, Conservation Needs Inventory, 1967, Dr. R.S. Farnham, Professor of Soils Science, Univ. of Minn.

## QUESTIONS AND ANSWERS

Q: I am a non-geologist, so I really don't know this photographic technique. You are able to determine the deposits by the shade of the coloration? Can you just briefly explain how that is done?

A: A lot of it is on the morphology. In other words, you have to know basically what you are looking at in terms of, say, fluvial versus glacial versus eolian, that is, sand dunes and things like that. And if you have the training, that is fairly easy to do. You also base it on your vegetation and your wetness. And you can pick that out very easily on the color infrared.

So a lot of our study will be based on air photo interpretation, but I assure you that the people who are doing that are pretty experienced at it.

Q: I notice that some of your soil/geomorphic provinces have political boundaries. Could you explain what is happening there?

A: We conveniently did that when we knew the line was going to straddle. Because our basic data are all available by political boundaries. Most of our county-published maps are on a county basis. So in order to simplify the job of trying to decide how many acres you have within a geomorphic province, we would use the county boundary as a line so that would eliminate the trouble of trying to figure out how many acres are not in the county or are out of the county. Wherever we could do that, we took advantage of the boundary as just sort of a means of trying to use data that were available.

Q: Could you tell us how much the project will cost and how long it will take?

A: The schedule is 12 months and they wanted to start on October the 1st, but they actually started about a week before that. I am trying to get it

## QUESTIONS AND ANSWERS

switched to October 1st because that is a nice convenient date all the way through. They prefer to schedule on the 1st.

The cost is a little bit below \$100,000.

Q: And it will be laboratory scale?

A: Yes. And they have an autoclave system. Their autoclave system is quite a bit different from most of them. They have shakers almost like paint shakers, and they will seal these at different pressures and temperatures. And they will run essentially the same pressures and temperatures as would be run in the wet carbonization PDU.

Q: Where will this take place, the location of this test?

A: It's in Rothschild, Wisconsin.

## OPEN FORUM

MR. BRIAN HORSFIELD (Weyerhaeuser, Inc.): I wonder if anybody could comment on the performance of the Finnish deep miller machine, the one that can reach 40 centimeters, about its characteristics, its productivity? Somebody who has seen it.

MR. TOMICZEK: I've seen it this past summer and it's quite effective. It will go through a tree 8 inches in diameter standing and it will knock it right down with the tractor that they have. The tractor has, as I recall, 400 horsepower that uses 60 horsepower for movement of the tractor itself. The other 340 goes back through the differential system to the milling drum. The milling drum rotates at a speed of 800 rpm. And although we're saying 40 centimeters, we were led to believe in talking to Mr. Eichler that the milling drum can mill all the way down to a half meter depth.

I think that's about all I could tell you on it, off the top of my head.

MR. ISMAIL: I would like to ask a general question to anyone that can answer.

In Canada there is quite a difference of opinion between the horticultural peat operators and the people who would like to mine fuel peat. This is difficult to resolve, because horticultural peat overlies the fuel peat, which cannot be harvested without disrupting the horticultural peat. The moss peat operators feel they have a stake in that and nobody should touch the fuel peat until they have the horticultural peat out. And that can take quite a bit of time.

I wonder if somebody can tell me what the policy is in the States and how this works out.

MR. DAVE OLSEN (Minnesota Department of Natural Resources): Within Minnesota the moss peat deposits occur on relatively small areas. Only about 2% of the total peatlands in Minnesota have sphagnum deposits. Therefore, we really have no problem in siting operations for different uses.

MR. ISMAIL: That happens to be the case in certain bog areas in New Brunswick where the moss peat overburdens are fairly negligible. The moss peat operators don't mind your going in and taking out fuel peat. But there are other areas where there is considerable moss peat over the fuel peat, this is where the problem exists.

So I wondered if anybody can tell me what happens here in the States where there is considerable moss peat over the fuel peat?

DR. BARTELLI: In Michigan the way it is handled is that one who digs agricultural peat or horticultural peat gets a license to mine peat. It is a license to mine organic peat or to mine horticultural peat. So if you are interested in digging a peat bog, you just get your permit to dig that peat and you use it as you see fit. There are no restrictions on how you use it.

There is no definition in our peat that one is agricultural peat and the other one is fuel peat.

MR. ISMAIL: Except that the agricultural peat sells for about three or four times the price. So that is where the investment value lies and the moss peat operators don't want the fuel peat below dug up before the horticultural peat, which can't be harvested and stored because it deteriorates.

DR. BARTELLI: I think there is a difference, you see, the Canadian horticultural peat is highly fibrous, and ours is probably more decomposed, which makes it more like our fuel-grade peat.

It's classified as horticultural peat, but it stills meets all the specs of fuel-grade peat. It is not a unique moss like the horticultural peat of Canada.

MR. ISMAIL: Thank you.

MR. DEBAKKER: From a slightly different point of view, we will be making an economic analysis, for instance, of the systems that we are designing. And the

issue you bring up about horticultural peat being worth so much more will most likely play a very important role in the economic evaluation of large-scale systems.

DR. KOPSTEIN: I think if we want to look at it from the perspective of how much horticultural peat is used in the United States now, it is somewhere around a million tons of air-dried peat. And at that rate of consumption, we will probably have enough peat to last well beyond your lifetime, several hundred million of years.

So I think you would have to look very closely at how much more horticultural peat is needed. And even though it is much more valuable, if you greatly expanded your horticultural mining operation, I think you would find the price of that horticultural peat would drop down pretty quickly, because you only have a certain demand. You don't have an inexhaustible demand or as inexhaustible a demand as you might have for fuel peat. So it is not a limitless demand.

So I wouldn't expect that to be any problem at all here.

That is just an opinion.

DR. PUNWANI: I have talked to several horticultural peat producers and tried to find out why they are offering resistance to using peat for energy. They are afraid that if large scale mining operators start selling the horticultural grade peat as a byproduct, because it is more valuable, the horticultural peat price will drop very significantly because the large scale operation would be able to produce such a large quantity. This would flood the market and they are afraid they will be out of business.

There should be a negotiable position where the mining operator could sell the horticultural grade peat, for a higher value than it is worth to him as a fuel, to the horticultural peat operators, who could then distribute this peat for a reasonable profit of their own.

MR. BILJETINA: Just another quick aside.

When we started purchasing peat from Northern Peat Company, which is a horticultural operation essentially, they were more than thrilled, because it essentially almost doubled their production rate. And income is determined by quantity times price. If you all of a sudden can make a hundred million a year compared to maybe a million a year, that is a lot of incentive.

DR. KOPSTEIN: I have another comment to make along that particular subject also. And that is that I don't think there is any obligation on the part of the developer of peat for fuel purposes for the interests of somebody who is developing peat for horticultural purposes. They have had it their way for quite a while. And, quite frankly, if you listen closely to the President, let the market forces determine which ways things go. And if the horticultural people want to expand their operations to fuel peat, they are quite able to do so.

Where do you draw the line? If a gasification plant is built and you have a major byproduct of benzene and say you build four or five gasification plants, that may be enough to make a dent in the benzene market. Then are you going to protect the people who manufacture benzene now and say Well, you're going to drop the price of benzene and you can't do this for that reason? Market forces change through the years.

If this is one of the byproducts, if you are manufacturing fuel peat and somebody tells you you can make a very profitable byproduct and that byproduct is horticultural peat, then you are going to listen. And why not? It increases your profit margin. If I were doing it, that is what I would do.

DR. GEORGE GRIFFIN: This morning I did a little calculation on the price of peat just for my own interest.

I think they were figuring it a 75 cents per million Btus, which turns out to be in the neighborhood of \$15 a ton.

Is that a reasonable figure, does anybody know what peat is selling for now? How much is ag peat selling for now?

DR. BARTELLI: Do you mean horticultural peat?

DR. KOPSTEIN: There is not a fixed price for peat, and what we have is a lot of estimates. 75 cents is one figure and it would range up to probably several dollars per million Btus, depending on where it's harvested, the method of harvesting, and method of dewatering. And there is really not commercial peat harvesting operation in the United States. So 75 cents is a figure and is a figure that was used in this case by Rockwell, and IGT used that as their baseline case for their economics also. But they realize, as we all do, that nobody is going to guarantee them peat for 75 cents per million Btus, and that is why the sensitivity of final product cost to the cost of the fuel peat was figured in. It was just a baseline. I don't think anybody is maintaining that they can realistically buy large quantities of peat for that price.

DR. GRIFFIN: How much is horticultural peat selling for?

DR. KOPSTEIN: Where? At the hardware store?

DR. HONEA: \$15.

DR. GRIFFIN: Not in little bags, but per ton.

DR. KOPSTEIN: It's selling for a heck of a lot more than that. Western Peat is making --

DR. HONEA: \$15, I think.

DR. KOPSTEIN: How much?

DR. HONEA: 10 or 15.

DR. KOPSTEIN: Okay.

DR. HONEA: That price is 7 and 1/2, not 15. That figure is for 50% moisture peat. It is 75 cents per million Btus. It is not \$15, it's 7.50.

MR. KALEVI LEPPA (EKONO, Inc.): I have some figures if anybody wants them. I happen to remember the figure of 1979 for horticultural peat was \$19.44 per ton. This was back in 1979. That was from the U.S. Bureau of Mines Yearbook.

DR. GRIFFIN: Then the price that you are quoting for that isn't much higher than the price they are fighting for the fuel grade peat.

MR. LEPPA: This figure was a few years back.

DR. GRIFFIN: It was \$15 this morning and you're saying about \$19 in 1979.

MR. ISMAIL: The figures I have are based upon conventional dry mining of peat. One figure is for a 40-megawatt power project where the amount of peat to be run was based on that requirement, and we came up with \$1.90, Canadian, for a million Btus. But this was a very large number of small bogs.

And we had another study done for about a 17-megawatt power station, not so many bogs, a few large bogs, and it came to \$1.19, Canadian, per million Btus.

So you can see there is quite a large variation, depending upon the size of the operation.

So 75 cents, U.S., for a million Btus for an operation as large as the one they are talking about, which is -- 250 million Btu per day or something like that, was it? --

MR. GAREY: A billion Btu per day.

MR. ISMAIL: -- a billion Btu or a million cubic feet per day may not be too far out, or maybe 80 or maybe 85, or something like that.

DR. PUNWANI: The 250-million-cubic-feet-of-SNG-per-day plant is equal to a thermal power plant of 1500 megawatts in terms of input of energy. In terms of output it is equal to 3,000 megawatts. So it is a very large-scale operation.

The basis of using 75 cents per million Btu in some of our initial estimates was numbers published by First Colony Farms for the studies done by Bechtel Engineering for large-scale production of peat in North Carolina by the milled peat method for power plants of 450 megawatts.

We knew that our scale of operation would be larger than this. But then the environment in which the Minnesota Gas Company is interested in is different. And we are not in the business of estimating harvesting costs, so we just used that number as a guideline and then showed the sensitivity of the peat cost to the gas cost.

So in the large-scale operations it should be possible to reduce the cost of peat production, but the environmental condition under which you are producing this peat will be a significant factor.

**CLOSING REMARKS**

**MELVYN KOPSTEIN**

**U.S. DEPARTMENT OF ENERGY  
GERMANTOWN, MARYLAND**

I won't take up too much more of your time. I know you are all anxious to depart for your respective destinations.

I believe that this Conference was very successful. We were very fortunate to have had Birgitta Palmberger, Olle Lindstrom and Jaako Okkonen tell us about peat technology in Sweden and Finland. Many thanks also to the participants from the gas industry, Wheelabrator-Frye, and state and local governments. I hope you benefited from the conference and have a better appreciation for the current status of the technology development in peat. Many of you are familiar with the current budget issues within DOE and of all the uncertainties that are associated with them. In all probability, we will have one more conference in about six months.

Once again I want to thank UOP/SDC for the highly professional job they have done in arranging this Conference. They are getting to be experts at it.

Thank you again.