~~000-4709-78-1~~

~~000-4709-78-1~~

C00--4709-1

DETROIT LAKES ENERGY SYSTEMS STUDY

QUARTERLY TECHNICAL PROGRESS REPORT
FOR PERIOD FEBRUARY 1, 1978 - APRIL 30, 1978

KENNETH E. DeVILLERS

MAY 8, 1978

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

WORK PERFORMED UNDER CONTRACT ET-78-G-02-4709

950 7454 ✓

WESTERN MINNESOTA MUNICIPAL POWER AGENCY
106 EAST HOLMES STREET
✓ DETROIT LAKES, MINNESOTA 56501

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

MASTER

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

ABSTRACT

The initial phase of the Detroit Lakes Energy Systems Study was designed to assemble and analyze sufficient data from which to recommend specific classes of alternative energy supplies. The grant became effective on February 1, 1978, and contracts with sub-contractors were issued about one month later.

Work began as quickly as possible to gather the needed data. Most of the information on meteorological conditions and biomass materials have been obtained. This is being compiled into a useful form for future evaluation.

Research into legal and economic areas are underway. Analysis of this data is being conducted and results will be used in assessing the impact of alternative energy systems.

Current technical information on solar thermal, solar photovoltaic, wind and hybrid power systems is being evaluated. Potential systems are being considered in light of their impact on the Detroit Lakes region and the northern latitudes in general. Final evaluation of the data is expected well within schedule.

I. Resource Assessment

A. Insolation and Wind

The objective of the assigned task was to provide detailed information on solar radiation reception, wind speed and direction characteristics and associated meteorological variables in the Detroit Lakes area. The only data for Detroit Lakes that are published by the National Weather Service include daily maximum and minimum temperatures and precipitation totals. These data are currently taken by the local radio station.

The nearest solar radiation measurements were taken at St. Cloud, Minnesota, a now discontinued radiation station. At present the nearest stations are Bismarck, North Dakota, and St. Paul, Minnesota, both approximately 180 miles distant from Detroit Lakes, St. Paul to the southeast and Bismarck to the west. The lack of local solar radiation measurements is not a handicap as far as a clear-day radiation reception is concerned, for it can be calculated rather readily. In such a calculation the only unknown is the atmospheric transmissivity. Information from an earlier study enabled this parameter to be determined. Thus the clear-day solar radiation for surfaces oriented both perpendicular to the solar rays and oriented parallel to the earth's surface were readily calculated.

Based upon a regional study of solar radiation that included Minnesota and the Dakotas, the relationship between solar radiation at Detroit Lakes and St. Paul and Bismarck was known. With this information the actual average solar radiation received on horizontal surfaces and surfaces perpendicular to the sun's ray could be closely estimated.

A computer program was developed which calculates the radiation reception on each hour of the day and then integrates the hourly values for a daily total. These values were verified by comparison with both clear-day and average-day values at Bismarck, St. Cloud and St. Paul. They were also compared with values obtained by an empirical formula for clear and average-day reception on surfaces

normal to the sun rays developed by Boes and Hall of the Sandia Laboratories.

The nearest wind measurements are made at the Fargo airport which is approximately 40 miles west of Detroit Lakes. While the immediate topography in the Fargo area is extremely level compared to the rolling topography of Detroit Lakes, there is an appreciable altitude difference between the two stations. This difference tends to compensate for the topographic difference since Detroit Lakes is about 475 feet higher. As a result the Fargo wind data and the wind-power data derived from the wind data should be similar to that expected at Detroit Lakes. At some future date when more precise data are required wind measurements at Detroit Lakes should be made.

The associated meteorological data have come from Detroit Lakes, Itasca State Park about 35 miles distant, and Fargo. Minor modifications were required in the data. For example, daily mean temperatures are available for Fargo, but not Detroit Lakes. A comparison of monthly and annual data indicated necessary corrections so that daily temperatures for Fargo could be modified and used for Detroit Lakes.

B. Bio-mass Survey

The biomass task was divided into four categories including availability, processing, costs, and environmental and social impact.

An eight county region which included Detroit Lakes was selected as the geographical area for analysis. Within this geographical area the various biological materials which had a potential of providing energy were identified and determinations were made of the quantities of the various types of biomass which would potentially be available. The quantities were obtained as a function of type of material and county where available.

With this information the questions of handling the material and transporting it to the plant site were dealt with. The economists were then able to analyze the costs of this part of the operation.

The processing of the biomass into a useable fuel was analyzed by bacteriologists and chemists. This task involved an extensive survey of the state of the art of converting biomass into a dry solid fuel that could be burned directly or into a gaseous or liquid fuel. More specifically, this effort included the study of drying processes, direct burning, fermentation, various methods of methanation, second law efficiencies, and possible cycles.

Throughout the data collection period individuals have watched for constraints and potential impacts of such a project. To supplement this work a group of sociologists have been specifically looking at the sociological constraints and impacts of using biomass as well as other solar sources.

In order to coordinate this work, weekly meetings have been held for reporting progress and exchanging information.

The major portion of this work has been completed and the information will soon be reported.

In the process of conducting this task some problems have arisen. In particular it is difficult to obtain current data on forest species and peat resources. Also, costs for processing biomass are difficult to project from existing data.

Some tentative conclusions can be presented. We feel that there is sufficient biomass available for generating electricity for Detroit Lakes. Wood represents the greatest potential but there are also agricultural wastes that could be used. We are also studying a drying process that has the potential of being able to economically handle any and all types of biomass.

The likelihood for using both wood and peat as an energy source for a biomass supported gasifier has been appreciably enhanced in the last several months. Upgrading of water laden fuels into high BTU (11,000 - 12,000 BTU/lb.) products significantly enhances the economic and technical feasibility of a gas turbine electrical generating system. It now appears that dewatering

processes will not only work but will produce an economic fuel.

Several processes for dewatering peat are now at the pilot plant stage. Ingersoll-Rand has built a dewatering machine for the paper pulp industry that is capable of handling 1000 tons dry weight peat/day. It is expected that the peat would be sufficiently dewatered so as to make the product useable in a hydrogasification scheme. IGT has found that it is possible to use a 50% moisture peat if it is properly sized. Previous results from other gasification studies suggested that a maximum level of 30 - 35% moisture would have to be met for gasification to be feasible.

Current studies by SRI involving beneficiation of lignite, peat or wood suggest that a high BTU product with a moisture content as low as 1.5% could be produced via a reactor operated at about 1500 psi and 1000°F. A low moisture level fuel product would make it easier to optimize gasifier operation. SRI lignite beneficiation economics compare favorably with the cost of mining high BTU coal. Preliminary economic studies with peat and wood also look promising.

A major problem to be solved if peat is the sole gasifier fuel is one of maintaining a fuel supply during the winter months. Current European methods of mining peat would not be workable in the winter time. Thus, stockpiling of partially dewatered peat would be necessary for a period from November to April when the ground is frozen. Another possibility would involve the use of wood during this period. This would substantially reduce operating costs.

II. Evaluation of Impacts and Constraints

A. Energy Demand

The survey of the current and projected energy demands of the service region is nearly completed.

At this point the electrical consumption and peak load for the years 1990 and 2000 for Detroit Lakes have been tentatively projected. Hourly load readings for the electric and steam systems have been compiled. From this

*CALCULATIONS FOR PROJECTION OF WOOD REQUIREMENTS FOR
A 1600 MW ELECTRIC GENERATION PLANT

- (1) 3,413 BTU/Kwh
 - (2) Wood yields 8,500 BTU/lb (oven dry)
 - (3) One cord = 1.5 tons (including bark)
 - (4) ** One dry ton of fiber yields 17×10^6 BTU
 - (5) Available energy at 30% plant efficiency = 5.1×10^6 BTU/ton
 - (6) One MW requires 6.12×10^3 tons of wood/year
 - (7) 1600 MW requires 6.52×10^6 cords/year
-

*Wood fiber can be produced by energy plantations for about \$1.15 per million BTU.

**Aspen stands will produce from 0.30 to 1.25 dry-tons per acre per year for rotations under 20 years.

Source: Minnesota Energy Agency. 1977. Energy from timber--subcommittee 7 report. Minnesota Energy Agency, St. Paul, MN. p. 113.

1000 MW Electric Generation Plant

peat requirements
 5×10^6 tons for 1 year supply

Estimate of Peat Resources in

Ottertail Co. (tons)
259,200,000 - 518,400,000

Source: Minnesota Energy Agency. 1978. Energy from peat--subcommittee 8 report, Minnesota Energy Agency, St. Paul, Minnesota. pp. 12, 18, 26.

COMPARISON OF FUELS*

<u>Material/Species</u>	<u>Btu/lb</u>
Peat (oven dry)	9,170
Sunflower Stalks	8,543
Cattails (oven dry)	7,850
Scirpus Sedge (oven dry)	7,720
Wheat Straw	7,644
Phragmites (oven dry)	7,320
Machine Peat (30% moisture)	7,290
Calamagrostis Grass (oven dry)	7,265
Carex Sedge (oven dry)	7,215
Sphagnum Moss (Oven dry)	6,840
Lignite Coal	6,580
Norway Pine	6,360
Balsam	6,135
Red Maple	5,970
Aspen	5,875
Pitch Pine	5,780
Hemlock	5,770
Red Spruce	5,770
Elm	5,710
Sugar Maple	5,590
Red Oak	5,565
White Oak	5,558
White Ash	5,395
Hickory	5,391
Beech	5,360
White Pine	5,260
Yellow Birch	5,225
Gray Birch	5,000
Paper Birch	4,790

*BTU/lb figures for trees are based on air-dry process.

Sources: LaRue, J. L. 1975. Briqueting organic wastes. American Society of Agricultural Engineers, St. Joseph, Michigan. p. 6.

Pratt, G. and J. LaRue. 1977. Utilization of sunflower stalks. Proceedings of Second Sunflower Forum (January 12-13), Fargo, North Dakota. p. 8.

Minnesota Energy Agency. 1977. Energy from timber--subcommittee 7 report. Minnesota Energy Agency, St. Paul, Minnesota. p. 139.

Minnesota Energy Agency. 1978. Energy from peat--subcommittee 8 report. Minnesota Energy Agency, St. Paul, Minnesota. pp.21-31, 63.

information tentative electric system load duration curves for 1990 and 2000 have been developed. These are being compiled in tabular form for use in the evaluation process and final report.

The electric hourly load trends for 1977 equinoxes and solstices were obtained. From these, tentative hourly electric load trends for 1990 and 2000 equinoxes and solstices were also compiled into tabular form. These were then developed graphically for use in evaluating the use of alternative energy sources.

The Detroit Lakes' steam consumption and peak load for the years 1900 and 2000 have also been tentatively projected. The steam system load duration for the projected years has been developed in both graphic and tabular form. Also, drawings have been completed for the field check, steam system, plot plan, one line electrical diagram and steam flow diagram.

The data acquisition on the existing Detroit Lakes electric utility has been completed. Included in the information on the utility company was transmission line electrical fault data for interfacing and bus fault capabilities. Using this information, bus fault capabilities and physical constraints of interfacing a DC system with existing steam and electric utilities is being developed.

B. Constraints

All state agencies who have possible jurisdiction in the energy impact of this project were contacted and asked for any relevant regulations. In response numerous Minnesota regulations have been received and are in the process of being reviewed. A summary of legal constraints which are found to be applicable is being developed. The summary will be in a checklist format showing times, review periods and flow charts.

C. Impacts

The potential impact within the domain of influence of using alternative energy sources is under study. This should be completed in mid-May.

The probable economic consequence of using alternative energy sources is under consideration. Conventional system costs have been developed and projected into the 1990 time frame. These will be used as a basis for cost comparisons with a hybrid energy system.

III. Energy Conversion Concept Evaluation

All information needed to perform the system evaluation will be in final form in early May. Analysts from TEAM and WMMPA have already begun the design phase, and preliminary sizing of each system will be started soon.

Research is being undertaken to assess the technical and economic status of the following general system classes:

(a) Photovoltaic central station plants

- (1) utilizing high concentration components such as GaAs (500X or greater)
- (2) utilizing medium concentration components such as 20-100X silicon system
- (3) using low concentration (1-10X) silicon or cadmium sulfide systems

(b) Solar thermal central station plants

- (1) using high concentration - high temperature collector
- (2) using medium concentration collector

(c) Wind energy generation systems

- (1) vertical rotor system
- (2) conventional horizontal rotor system
- (3) translational lift systems

(d) Biomass energy system

- (1) methane production
- (2) direct combustion system
- (3) mixed system

(e) Hybrid system

- (1) PV - wind system
- (2) PV - biomass system
- (3) solar thermal - biomass system
- (4) solar thermal - wind system
- (5) PV - solar thermal - wind - biomass systems

Quantification of candidate systems within each system class is underway and will lead to rank ordering of candidate systems within each class. Upon completion of this investigation and integration of the resource data being developed under other project tasks, the relative rank order between system classes will be accomplished.

Subsequently, feasible candidate systems will be selected and rank ordered so as to facilitate selection of prototype candidates for the Phase II construction.