GEOTHERMAL ENERGY MARKETS ON THE ATLANTIC COASTAL PLAIN

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ABSTRACT

A Geothermal Energy Market Study (GEMS) has been performed in four selected areas on the Atlantic Coastal Plain. The GEMS efforts have fallen into two categories: market definition, wherein current requirements for thermal energy are assessed, and market penetration, wherein the economics are investigated and projections are made of the extent to which geothermal energy will be used in the defined markets. In the market definition phase, a survey and analysis of potential energy markets for low- to moderate-temperature (up to 250°F) geothermal resources has been completed for southeastern New Jersey, the Delmarva Peninsula, the Norfolk area of Virginia, and for eastern North Carolina. Data have been obtained and analyzed for space and water heating requirements in the residential, commercial and military sectors and for crop drying and space heating requirements in the agricultural sector. In addition, over five hundred companies in the four areas have been contacted for information on energy consumption, and about 175 of these companies have been identified as having process heat requirements that could be satisfied by potential geothermal resources. A final report of the results of the study will be published early in 1979. Current plans are for survey activities to be continued into potential resource areas of South Carolina and Georgia beginning in the spring of 1979.

INTRODUCTION

The Applied Physics Laboratory of The Johns Hopkins University (APL/JHU) has performed a Geothermal Energy Market Study (GEMS) for four areas on the Atlantic Coastal Plain that offer promise of potential geothermal resources. This work is part of a larger program being sponsored by the Department of Energy (DOE) to explore and assess potential geothermal resources on the Atlantic Coastal Plain, to identify potential markets for these low- to moderate-temperature hydrothermal geothermal resources, and to encourage the early commercialization of these resources, especially where usage of substantial quantities of fossil fuels can be supplanted by geothermal energy.

The Applied Physics Laboratory has served as the Eastern Region Operations Research Contractor for DOE's Division of Geothermal Energy for the last three years. In this capacity APL has prepared several planning documents, one of which (Ref. 1) was a preliminary development scenario for the postulated geothermal resources on the Atlantic Coastal Plain. In order to more fully assess the potential markets in the resource areas, the Geothermal Energy Market Study was begun in early 1978 to 1) identify existing energy requirements for space and water heating and for industrial process heat at temperatures below 250°F in each of the resource areas identified by VPI&SU, 2) determine the technical feasibility of supplying these energy requirements with expected geothermal resources, 3) estimate the costs, and the economic viability, of supplying geothermal energy for these applications, and 4) estimate the penetration of geothermal energy into those energy markets that are technically and economically attractive. The first two efforts comprise a market definition study, in which data had to be collected from a variety of sources, including a detailed survey of over 500 industrial companies in the four resource areas. Analyses of these data and engineering studies of the compatibility of energy requirements with expected resources have been performed and selected results are given below. The latter two efforts above comprise a market penetration study and assistance in these efforts has been provided by the Center for Metropolitan Planning and Research (The Metro Center) of The Johns Hopkins University. Some of the results of these efforts will be presented in the next paper by R. Weissbrod and W. Barron. A final report will be published in the near future and will contain more complete discussions of the results of the GEMS efforts.

To date, the four resource areas of southern New Jersey, the Delmarva Peninsula, the Norfolk area of Virginia and eastern North Carolina (see Figure 1) have been included in the GEMS work. Activities are planned to begin in the resource areas in South Carolina and Georgia in the spring of 1979. Once the market studies are complete in an area, the development of a resource-specific prospectus is begun. The purpose of the prospectus is to inform and aid participants and to facilitate the commercialization of geothermal resources. The prospectus identifies near-term and potential long-term users, outlines the necessary tasks required for resource development and applications engineering, lists legal, institutional, and environmental issues that must be resolved, and plans and schedules these activities for development in the resource area. The prospectus is prepared with the cooperation and consultation of many of the parties that would be involved. One such prospectus for the Delmarva Peninsula is nearly complete and will be described in more detail in another paper by F. C. Paddison.

MARKET DEFINITION

The largest requirements for thermal energy at temperatures below 250°F are in space and water heating for the residential and commercial sectors; however, due to the diffuse distribution of such requirements, expensive community distribution networks must be provided to satisfy many individual small loads. In addition, the seasonal and hourly variations of these loads place additional constraints on a community distribution system, all of which manifest themselves in higher costs for delivered energy. Thus, it is necessary to identify areas with high population densities so that distribution systems can be limited in size and cost.

Obtaining space and water heating data for the residential and commercial sectors on a local basis is not practical. Individual building loads can vary drastically, even between identical buildings, since the occupants may have different schedules and activities. A survey to obtain such data, even if limited to very high density areas, would be prohibitively expensive and time consuming. However, useful data can be obtained on a more aggregated census tract or minor civil division level where a large number of buildings are included, since averages for space and water heating are fairly accurate when applied to larger populations. For these reasons, a model developed by J. Karkheck et. al. (Ref. 2) was selected for estimating the space and water heating loads.

Under this model space heating is given on a per capita basis as a function of the number of annual heating degree-days as well as by building type, i.e., single family or multi-family residences or commercial buildings. Water heating for both the residential and commercial sectors is estimated on an average per capita basis. Table 1 summarizes the parameters used.

Heating degree-day information was obtained from the National Climatic Center for selected cities and interpolated values were developed on a county basis. Census Bureau population and housing data were obtained and water and space heating demands were calculated. The results of these calculations were mapped as shown in Figures 2 - 5 to display the spatial distribution of these energy loads.

In the military sector, data on space and water heating for military installations were obtained from the DoD Defense Energy Information System (DEIS) I and II reports. Figure 6 shows the locations of the major military facilities in the four resource areas and the magnitude of their heat loads. Also included in Figure 6 is the heat load for the NASA facility at Wallops Island, Virginia, which is located on the Delmarva Peninsula.

The principal agricultural applications of interest are crop drying and

Table 1

Annual Space and Water Heating Requirements

<u>Space Heating</u>	
Single Family Residences	5640 Btu/Degree(F)-day/person
Multi-family Residences	3740 Btu/Degree(F)-day/person
Commercial Buildings	1000 Btu/Degree(F)-Day/person
<u>Water Heating</u>	
Residential	6.00×10^6 Btu/person
Commercial	1.75×10^6 Btu/person

space heating. Data have been obtained from the Bureau of the Census and the Department of Agriculture on crop-drying requirements. Of the four resource areas, North Carolina appears to have the greatest crop drying requirements (for tobacco), and the Delmarva Peninsula, one of the largest poultry-producing areas in the U.S., has the greatest requirements for space heating. Estimates of heat for crop drying in each resource area are given in Table 2. Nearly all crop drying is done at temperatures of less than 200°F; however, since crop drying is highly seasonal, it would be most practical to use crop drying as an off-peak use of a geothermal system that is dedicated to another use, such as space heating.

Table 2

Crop Drying Requirements

Resource Area	Btu per year
Southeast New Jersey	0.024×10^{12}
Delmarva Peninsula	0.450×10^{12}
Norfolk, Virginia	0.50×10^{12}
Eastern North Carolina	0.950×10^{12}

In areas of large poultry production, space heating of poultry houses appears to be a large potential market. For example, on the Delmarva Peninsula, poultry house capacity exceeds 82,000,000 chickens and production exceeds 380,000,000 chickens per year. Annual heating bills for the 6300 broiler houses exceed $6,000,000 for well over one trillion (10^{12}) Btu. However, because of the wide distribution of poultry houses in rural areas, as shown in Fig. 7, only a fraction of this energy can be economically supplied by geothermal resources, i.e., where such resources coexist with large concentrations of poultry houses. Again, it would probably be most economical to have this use tied into a dual-purpose district heating system.

Estimates for energy consumption for process heat and space and water heating in the industrial sector are usually obtained from the average energy consumption per employee for particular industries and the number of employees at each plant. This approach in the past has served to provide qualitative estimates for county totals; however, on a single plant basis, these estimates can be grossly inaccurate, e.g., a warehouse and a factory with equal numbers of employees will appear to have the same energy requirements, when in reality their energy consumption is markedly different. Therefore, to provide accurate estimates of energy demand, a detailed industrial survey was undertaken in each of the four areas.

Because the potential resources were expected not to exceed 250°F, not all of the two digit SIC (Standard Industrial Classification) industries were likely prospects for geothermal energy applications. Thus, an initial screening identified six industries that had significant process heat requirements at temperatures below 250°F. These included the foods and kindred products, textile, tobacco products, lumber and wood products, pulp and paper, and chemicals industries. As the survey progressed in the four areas, the largest and best suited industries were found to be the foods and lumber industries. Within the food industry, poultry processing, vegetable canning and crab processing are the largest heat-consuming activities. The first two often are comprised of large companies that could use nearly the entire thermal output of one or more geothermal wells and thus are attractive candidates for early commercialization of geothermal resources. On the other hand, the large number of crab processing plants in the areas are often small concerns that require steam at 250°F, are scattered in sparsely populated areas, and thus are not attractive candidates.

In total, over 500 companies have been contacted, of which 25 to 35% have energy requirements compatible with potential resources. In order to compare the industrial market with resource locations, the supplantable energy consumption and the location of each company can be represented graphically by a symbol showing that portion of a nominally sized geothermal well that the company would use. A nominal geothermal production well is defined as a well that produces 500 gpm of water whose temperature is reduced 50°F by extraction of thermal energy, thus producing about 10^{11} Btu per year. Figures 8 - 11 show these data for the four resource areas. About one-half of the industrial market shown in Figure 9 for Delmarva is related to the poultry industry, which is the largest single geothermally compatible industry in any of the four areas.

A summary of the magnitudes of potential markets in each of the four areas is given in Table 3.

Clearly the largest market areas overall are found in Norfolk, Virginia and New Jersey; however, the residential/commercial markets are the most difficult to serve in the short term. Likewise most agricultural markets are quite diffuse and probably are best served by incorporating them into dual purpose community systems. Military markets are the most attractive in the short term for several reasons: 1) they are "captive" markets, 2) they are large, high density consumers who would need a large number of geothermal wells to satisfy their energy demands, 3) they currently use hot water or steam distribution systems which may minimize conversion costs and time, and 4) they are under directives to reduce energy consumption and are exploring alternate energy sources. Furthermore, a definite commitment by the federal government in developing such resources on such a large scale would provide a great deal of confidence and encouragement in local resource areas for private concerns to become involved in a commercialization of geothermal resources. Unfortunately, there is a great deal of reluctance in some corners to explore this sector; therefore, the sector of the greatest short term potential for geothermal energy applications is the industrial sector, which was investigated in the most detail in this study. As Table 3 indicates, the Delmarva Peninsula has the largest industrial market, a majority of which is made up by the large poultry industry, which is extremely well suited to direct-use applications of geothermal energy. In addition, grain drying facilities are often co-located with processing plants, further increasing potential short term markets.

Figure 12 illustrates a typical system that might be used to deliver geothermal energy to either a community district heating system, or a large industrial user, or both. Hot geothermal brines are brought to the surface by the down-hole pump, stored temporarily in an accumulator to allow for load-leveling, passed through a heat exchanger to heat a fluid in the secondary loop, and then the cooled brine is reinjected either into the original aquifer or into a shallower, cooler aquifer. In the secondary loop, chemically-treated water is heated at the heat exchanger, and passed through a topping system, which provides higher temperatures to allow for peak load conditions or to match higher temperature applications. After the heated water has been piped to users for space, water or process heating, the cooled water is returned to the well for reheating. An alternate approach might use pure water in an open secondary loop where the water is consumed or disposed of by the user.

Estimating costs of geothermal energy that is delivered by such systems can be a complex task because of the large number of variables and the uncertainty of resource characteristics. Thus, it quickly becomes apparent that computer models are essential to allow the bracketing of costs as a function of resource and market types and to permit studies of the sensitivity of cost to various parameters. APL and the Metro Center have developed such computer models and the results of these studies are presented in the next paper.

CONCLUSIONS

The Geothermal Energy Market Study has defined the potential markets for geothermal energy in each of four resource areas on the Atlantic Coastal Plain. Computer models have been developed to estimate the effects of various resource and market characteristics on the economic costs of geothermal energy. Efforts are in progress to develop methods to determine the market penetration potential for geothermal energy in each resource area. The GEMS results will be useful in justifying further DOE exploration efforts on the Atlantic Coastal Plain, in identifying those resource areas where sufficient markets exist to warrant further resource exploration and development, and in identifying and informing potential near-term users for geothermal energy.

REFERENCES

1. Toth, W. J., 1977, Geothermal energy and the eastern U.S., a scenario for geothermal energy development, the Atlantic Coastal Plain, QM-77-129.

2. Karkheck, J., Beardsworth, E., Technical and economic aspects of potential U.S. district heating systems, in Proc. 11th IECEC, 1976, p. 1669-1674.

Table 3

Total energy demand by sector in each resource area (units of 10^{11} of Btu/yr).

	RESIDENTIAL AND COMMERCIAL	MILITARY	AGRICULTURE	INDUSTRIAL
S. E. NEW JERSEY	290	25	0.2	5.2
DELMARVA	125	8	14.5	14.8
NORFOLK AREA	280	97	0.5	8.3
E. NORTH CAROLINA	80	15	9.5	9.0

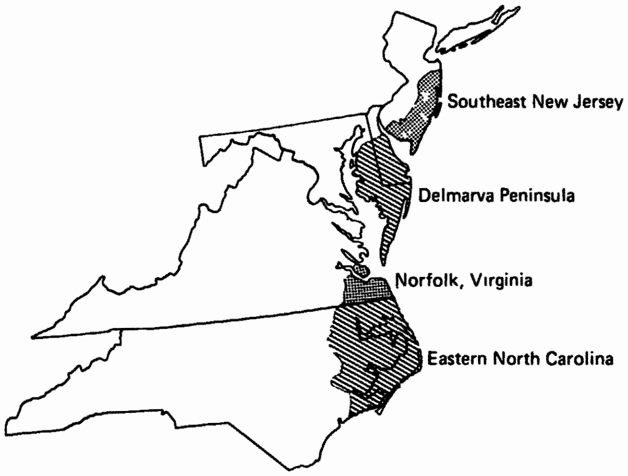

Fig. 1 The four resource areas surveyed in the geothermal energy market study.

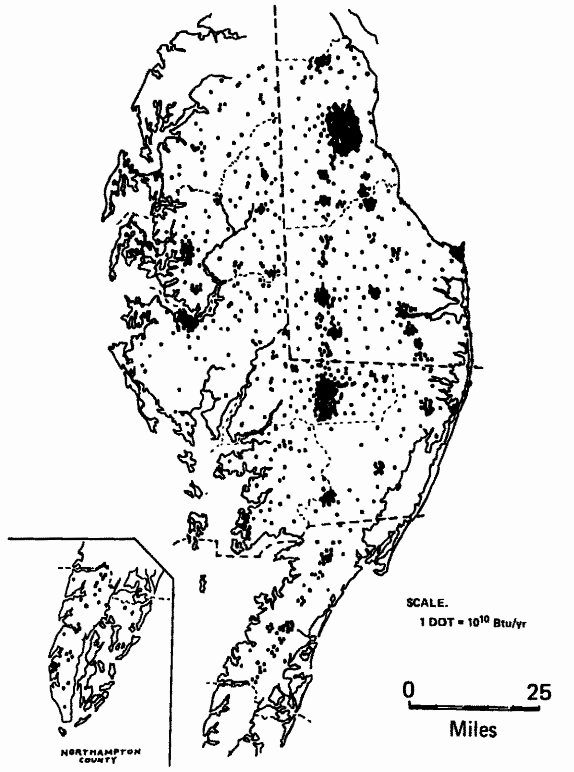

Fig. 3 Residential and commerical space and water heating demand on the Delmarva Peninsula.

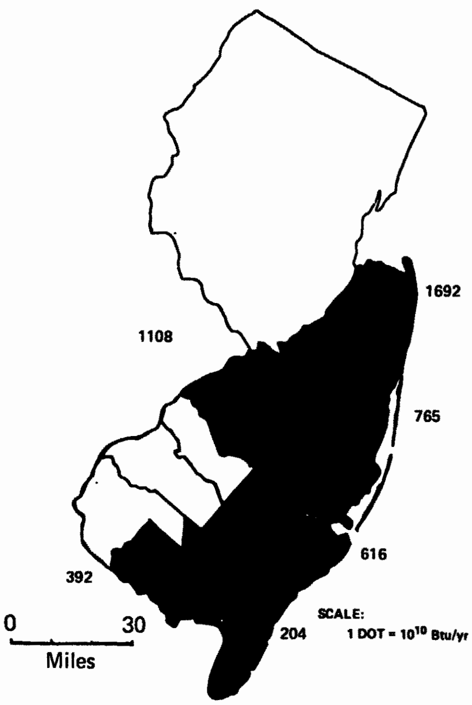

Fig. 2 Residential and commercial space and water heating demand in southeastern New Jersey.

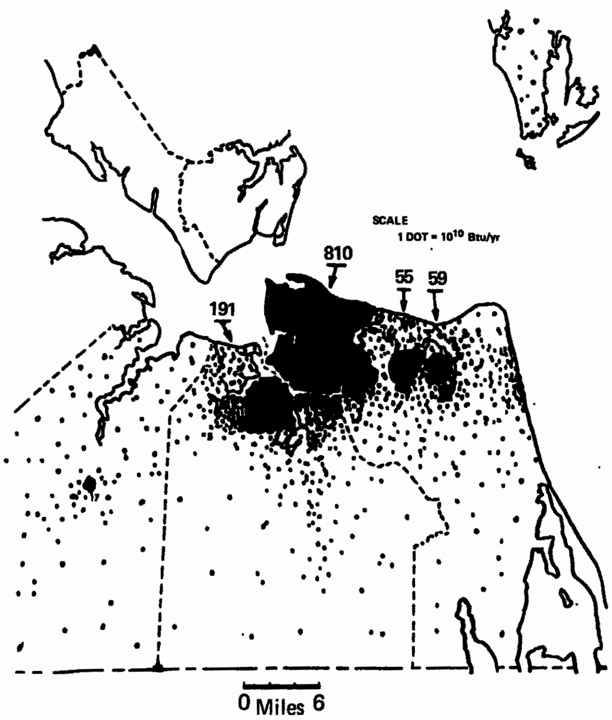

Fig. 4 Residential and commercial space and water heating demand in the Norfolk area of Virginia.

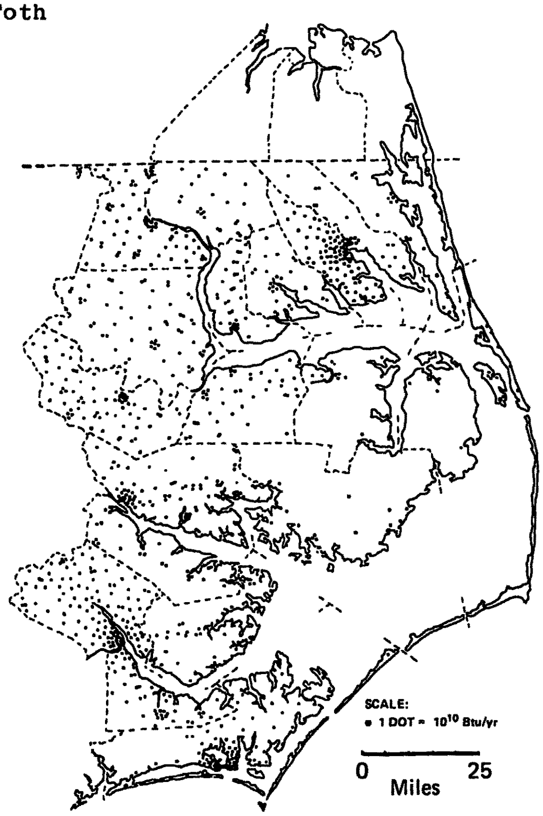

Fig. 5 Residential and commercial space and water heating demand in eastern North Carolina.

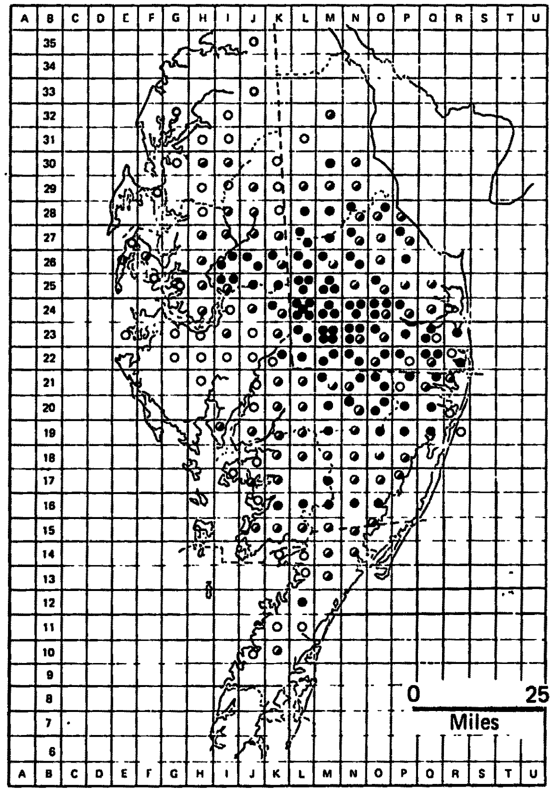

Fig. 7 Poultry house capacity by 5 mi x 5 mi grid araes for the Delmarva Peninsula. Based on data reported by 11 of the 13 companies. (Base map courtesy of the Delmarva Poultry Industry, Inc.).

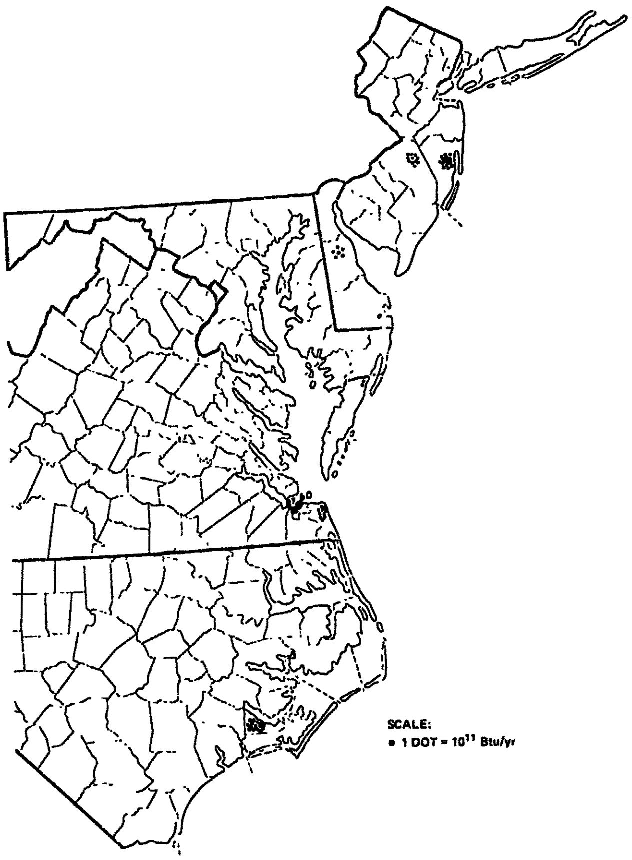

Fig. 6 Military space and water heating demand in the four resource areas.

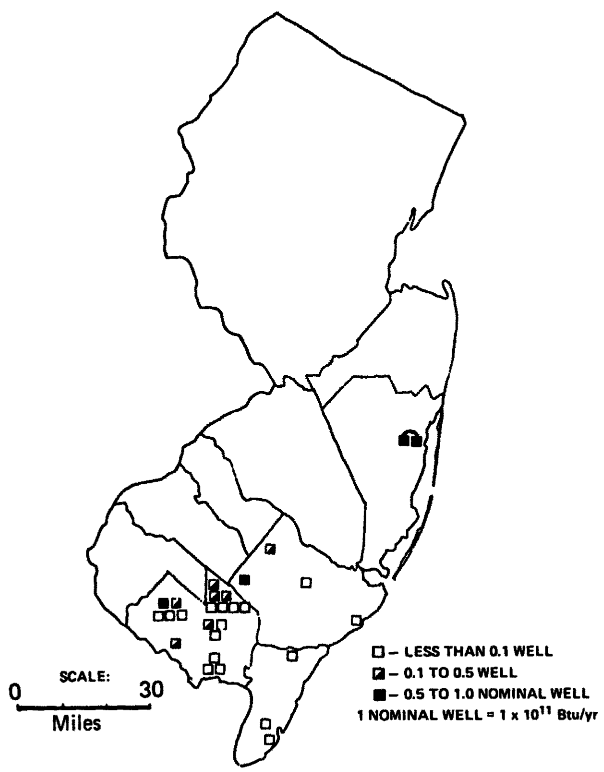

Fig. 8 Industrial process heat demand below 250° F in southeastern New Jersey.

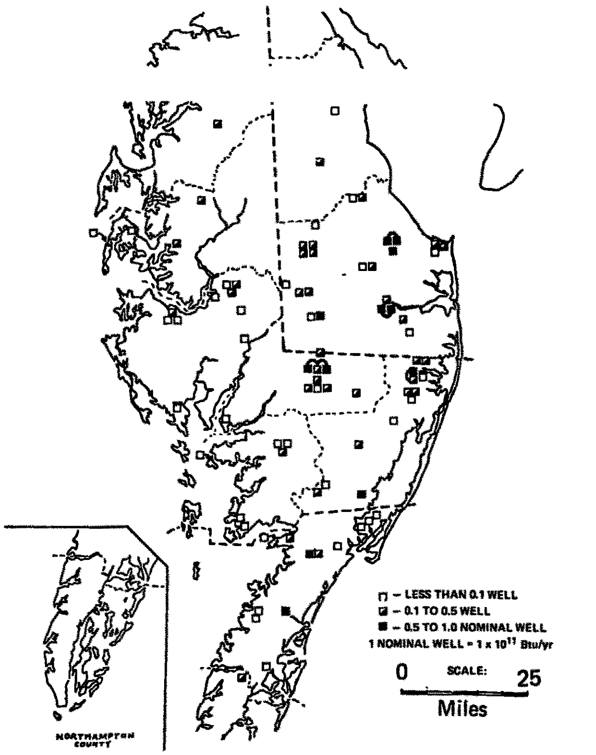

Fig. 9 Industrial process heat demand below 250° F on the Delmarva Peninsula.

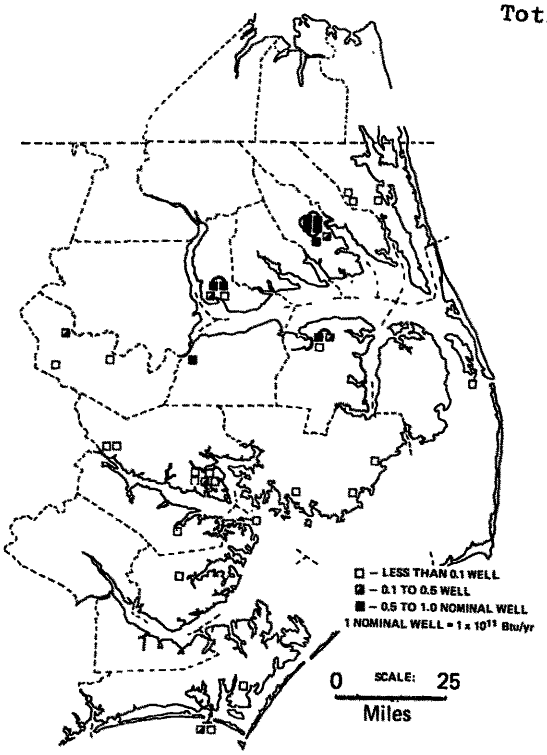

Fig. 11 Industrial process heat demand below 250°F in eastern North Carolina.

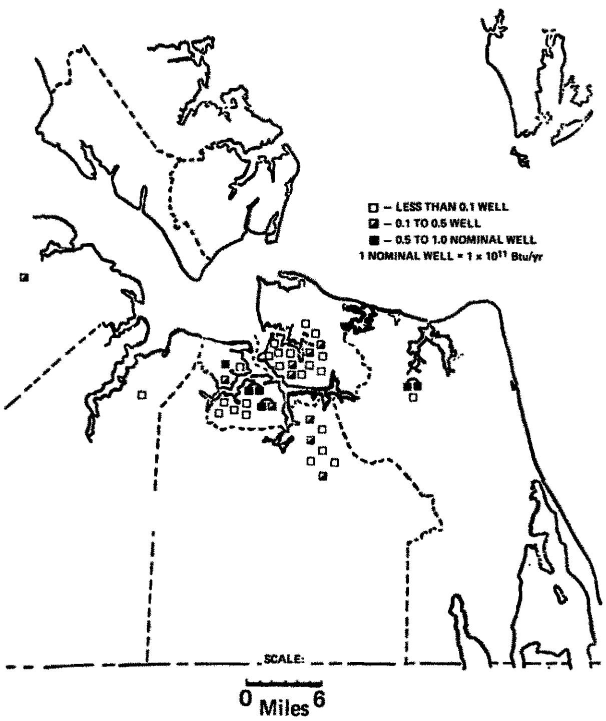

Fig. 10 Industrial process heat below 250°F in the Norfolk area.

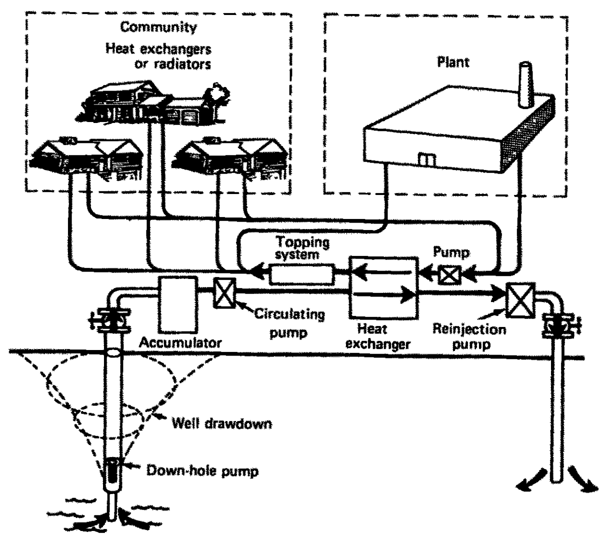

Fig. 12 Illustration of heating from a hydrothermal resource for community or industrial users.