SEASONAL THERMAL ENERGY STORAGE

Program Area Synopsis:

The objective of the STES Program is to demonstrate the economic storage and retrieval of energy on a seasonal basis, using heat or cold available from solar, industrial or utility sources during an energy surplus season for use during peak demand periods. The initial thrust of the STES program is toward utilization of aquifers for thermal energy storage. Seasonal storage in aquifers will be evaluated in the Aquifer Thermal Energy Storage Demonstration Program, beginning with conceptual design of site specific systems which will store energy from solar, industrial, or utility sources and utilize energy for district space conditioning, process or agricultural purposes, and continuing through the construction and operation of a smaller number of Demonstration Projects. A parallel Technical Support Program will provide data on aquifer behavior, data from field tests, economic and mathematical modeling data. The program will also monitor work on pond, lake, and earth storage; primarily under IEA sponsorship and evaluate the need for additional field tests.

AQUIFER THERMAL ENERGY STORAGE PROGRAM

Kenneth Fox
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PROJECT OUTLINE

Project Title: Aquifer Thermal Energy Storage Program

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Project Goals: To stimulate the interest of industry by demonstrating the feasibility of utilizing an aquifer for seasonal thermal energy storage. Technical, economic, environmental and institutional feasibility are being considered.

This program is divided into two phases:

Phase I - This phase consists of the preparation of conceptual designs for fully integrated thermal energy storage systems which include an energy source, thermal transport, a storage aquifer and a user application. Up to ten conceptual designs will be prepared on a cost reimbursable basis. Each proposal will be specific to one of the following categories: a) High Temperature Heat Storage ($100^{\circ}C$); b) Low Temperature Heat Storage ($100^{\circ}C$); c) Chill Storage; d) Combined Heat and Chill Storage. Proposals are due on December 5. Contractor selection will be completed by March and design work should start July, 1980. The nominal time frame for conceptual design is two years.

Phase II - Upon completion of the conceptual designs, up to five will be selected for final design, construction, startup, and operation. This work will be accomplished on a cost sharing basis between DOE and the operating entity. The nominal time frame for this phase is three years.

Project Status:	RFP Promulgated:	September 7, 1979
	Proposer's Conference Held:	October 11, 1979
	Proposals Received:	December 5, 1979
	Contractor Selection Due:	March, 1980
	Phase I Work Starts:	July, 1980
	Phase I Work Completes:	June, 1982
	Phase II Work Starts:	December, 1982
	Phase II Work Completes:	December, 1985

Contract Number: EY-76-C-06-1830

Contract Period: June 1979 to December 1985

Funding Level: $1,800,000 (FY-1980)

Funding Source: Energy Storage Systems Division
U.S. Department of Energy

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INTRODUCTION

Management of the Aquifer Thermal Energy Storage Demonstration Program is a task assigned to Pacific Northwest Laboratory operated by Battelle Memorial Institute, under the Seasonal Thermal Energy Storage Program. This Program is funded by the Department of Energy, Division of Energy Storage.

OBJECTIVE

The purpose of the Aquifer Thermal Energy Storage Demonstration Program is to stimulate the interest of industry by demonstrating the feasibility of utilizing an aquifer for seasonal thermal energy storage, thereby, reducing crude oil consumption, minimizing thermal pollution, and significantly reducing utility capital investments required to account for peak power requirements. This purpose will be served if several diverse projects can be operated which will demonstrate the technical, economic, environmental, and institutional feasibility of aquifer thermal energy storage systems.

DESCRIPTION OF PROGRAM PHASING

In order to assure that only those programs which have a good probability of success are actually constructed and operated, this program has been divided into two phases. Phase I consists of conceptual design and Phase II consists of final design, construction, startup, and operation for a sufficient period to demonstrate the feasibility of the system.

Phase I

Phase I is actually more than merely preparation of the conceptual design. The key element in the storage system is of course, the aquifer itself. No artificial energy repository will be accepted. The storage media must be a naturally occurring geologic formation. This means that during Phase I, in addition to the preparation of a conceptual design for the entire system, "the naturally geologic formation" must be identified and characterized to the extent necessary to assure that it is compatible to the other elements in the system. This characterization of the aquifer will require much more time than the preparation of a conceptual design would normally involve.

The proposers are given freedom in the energy source and user application. For the energy source, possibilities include waste heat from an industrial source, cogeneration steam from a power plant, a solar collector, a heat pump, or chilled water from a winter chill application to be used for summer air conditioning. User application might be district heating, agricultural uses, such as drying, industrial uses which might require chill or heat for a particular process. The entire system is tied together by an energy transport system which carries the energy from the source to the aquifer and from the aquifer to the user application. In most instances, it is anticipated that the transport system will also carry water removed from an aquifer back to the same aquifer or a nearby formation for reinjection.

Phase I will require approximately two years and there will be up to ten contracts for conceptual design. It is anticipated that the aquifer characterization will take the best part of a year and the remainder of the time will be involved preparing a conceptual design which balances the energy source, the aquifer for storage and the user application with a suitable transport system. During this period, a preliminary environmental assessment will be required and an investigation of the institutional restraints will be made. Along with conceptual design reports, we will receive a proposal for Phase II work. It is intended that the timing will be such that all Phase II proposals will be received together and the choice of Phase II contractor will be made in as brief a time span as possible so as to minimize disruptions of the working teams which are to continue. Phase I work will have been carried out under cost reimbursable contracts with entities which will most likely consist of joint ventures between an architect/engineer, a user application such as a district heating association, an energy source which might be a utility or industrial plant, and a municipality in many cases which will manage the system.

Phase II

Up to five of the conceptual designs prepared under Phase I will be chosen for continuation in Phase II. In Phase II, final design, construction, startup, and operation will take place. Phase II will be accomplished on a cost sharing basis in which the cost of design, construction, and operation will be shared between the government and the proposing organization. In the selection process for Phase II, it is hoped that in addition to identifying those projects that have the highest prospect for demonstrating the feasibility of the aquifer thermal energy storage concept, we will also obtain projects that do not duplicate work already underway by industry, climatic and geographic distribution, and those that have the greatest potential for widespread application throughout the country. It is hoped that we obtain a diversity of effort that allows the coverage of four basic technical areas. These are high-temperature heat storage, low-temperature heat storage, chill storage, and combined heat and chill storage.

MILESTONES

Figure 1 shows the milestones and the schedules for their achievement during the entire program. Of particular importance will be the phasing of Phase I contracts such that they all complete in approximately the same time frame. We should thereby be able to make a choice of those that are to proceed to Phase II, such that there will be a minimum disruption in existing organizations. The proposals for Phase II work will be submitted along with the conceptual design work and therefore, the choice of Phase II contracts can be accomplished in a relatively short period of time. However, the cost sharing arrangements are a negotiable item, and therefore, the negotiation of Phase II contracts could require considerable effort and time.

INTEREST

The interest in this program from industry has been most encouraging. The Department of Energy first advertised a Request for Expression of Interest in January, 1979, and from this an initial core of approximately 40 interested companies was received. It is quite clear that from this time on several of these companies have been investigating the possibilities for programs of this nature. The announcement of the Request for Proposals appeared in the Commerce Business Daily on September 7, 1979, and from this nearly 200 requests were received. The distribution of the origin of the requests is shown in Figure 2. It was interesting to note that many of them were from individual companies that recognized the need to form a joint venture in order to propose, and many of these individual entities were searching for partners toward such a joint venture. We, therefore, decided to provide each requesting organization with a copy of our proposer's mailing list. We thus performed a "mating" service which, in at least a few cases, has resulted in consultants, geologists, architect/engineers, potential user applications, and potential energy sources finding a match. Since the technical portion of the proposal is not due until December 17, it would be premature to describe the nature of the proposals that will be evaluated. However, in Figures 3 and 4, I have shown hypothetical but typical proposals of the type we expect to be receiving. I will describe these, as I think they will give a better understanding of the nature of the potential demonstration projects.

Hypothetical Aquifer Thermal Energy Storage Demonstration Projects

Project #1 (Figure 3)

A mid-western city with a population base of approximately 200,000 is undergoing an urban renewal program. As part of this urban renewal program, a large section of the downtown area is being supplied with district heat from a central power plant. In the industrial area of the town, approximately five miles from the center of this urban renewal, there is a large food processing plant which currently disposes of waste heat through a heat exchanger which in turn discharges into a large river running near the town. The Chamber of Commerce has approached the contractor in charge of the urban renewal program, the owner of the food processing plant, and a major engineer/architect firm headquartered in the mid-west. They have assembled these three organizations and propose participating in the Aquifer Thermal Energy Storage Program. These three have in turn formed a joint venture and added a geological consulting firm to assist them in the aquifer technology. The geologist has given a preliminary evaluation that indicates a high probability of suitable aquifers in the area between the food processing plant and the urban renewal area. Much of this land is muncipally owned at this time, and therefore, there is a good prospect that the land and water rights will be available. This joint venture is now preparing a proposal which will involve diverting all or a portion of the waste heat from the processing plant into an injection system which will heat the aquifer through direct injection of waste heat. A withdrawal system will be located after the general direction of flow and rate of flow are determined and the heat withdrawn from the aquifer will be run through a heat exchanger at the site and then transported to the district application. The project manager will be the engineer/architect firm who will work with the urban renewal contractor on the interface with the heat supply, with the food processing company on the design and financial arrangements for the waste heat source, and will design the transport system, the heat exchangers and the pumping system to be used. The geological consultant will prepare a plan for the characterization of the aquifer and will pick the sites at which test borings will be made to determine the aquifer characteristics. Meanwhile, the geological consultant will have assembled sufficient data from Federal and State surveys and from well drilling in the immediate area of the municipal land to determine that the project is feasible and worth the investment that must be made in order to prepare a proposal. Some of the other problems which are currently being investigated are these:

1) Is there an alternate source of heat that can be used in the event of a failure of the energy supply system or some loss of the transport system during the critical cold winter months? Should redundancy be built into the system in the form of an auxiliary boiler?

2) Must the current design of the district heating system be revised to increase piping sizes to allow for the lower temperature to be expected from the aquifer fed heat exchanger as compared to direct generation?

3) Are there any environmental impediments toward implementation of this project? For example, are the aquifers in the area being examined likely to be those which feed the municipal drinking water system?

4) Does the economic future for the food processing plant and the management of the corporation look stable enough to warrant a five-year commitment to this energy source?

Project #2 (Figure 4)

A large university located on the outskirts of a small mid-Atlantic city is currently heated by its own boiler plant, which is obsolescent and must be replaced in the near future. At the same time, the university is concerned about the increasing electric bill caused by individual air conditioning installed in each building of the campus. The university has hired an HVAC engineering corporation to make a study of their requirements and to recommend a cost efficient means of providing heating and air conditioning for the entire campus throughout the year. The engineer/architect is currently examining the possibility of a combination heat and chill aquifer system which could provide heating and cooling to the entire campus through separate aquifer systems. Inasmuch as the plan involves replacing the entire heating system for the buildings, the HVAC engineer proposes to replace the existing heating system with a forced air system in which the air is heated or chilled by water from the appropriate aquifer system. One aquifer system would be heated from waste heat received from the power plant, while the other would be chilled in the winter from a heat exchanger system to be established above ground using winter chill to cool the aquifer. The system looks particularly atractive because the air conditioning requirements are relatively small as the entire campus is seldom operated throughout the summer. Inasmuch as a new heating system must be installed in many of the buildings just by virtue of age, the enlargement of the heating system required by the larger volume of flow required from the aquifer system does not substantially add to the cost of the renewal. An economic analysis is being made of the cost benefits, including the capital cost of the aquifer system as compared to the installation of a new boiler and heating plant, and the significant reduction in operating costs which will result from using waste heat as opposed to burning fossil fuel or relying on an increasingly expensive off-campus source of electricity for heating. The same problems must be investigated as were investigated in Case 1, namely the environmental concerns, reliability of the heat source, alternate means of providing energy should there be a failure in the source, the possibility of legal prohibitions against injection or removal of large quantities of water, and other "what if" concerns.

CONCLUSION

Aquifer thermal energy storage as a closed cycle energy efficient system is a new, and as yet, an unproven concept in the United States. However, the individual elements in the user application, the aquifer storage systems, the energy transport system, and the energy source are certainly not beyond current technology. While it is still too early to predict the nature of the projects that will be chosen, and therefore, the direction the program will take, we have cause for optimism in our ability to seed industry with the demonstrated effectiveness of this technique.

FIGURE 1. AQUIFER THERMAL ENERGY STORAGE PROGRAM

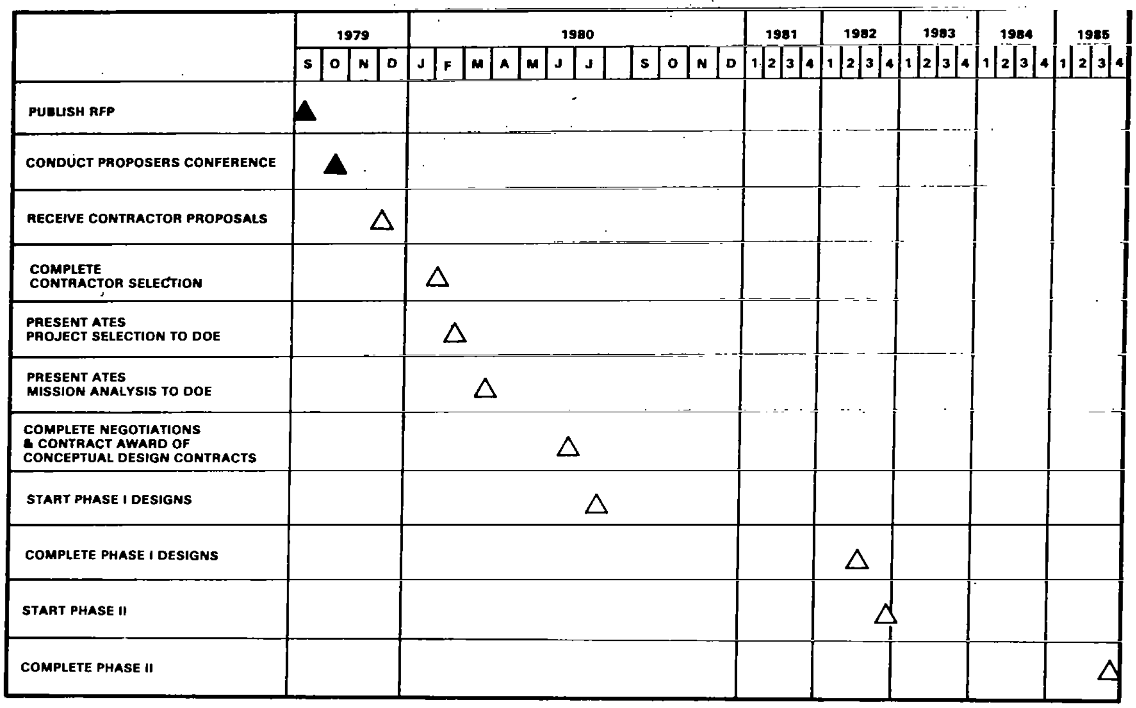


FIGURE 2. DISTRIBUTION OF RFPs BY STATE

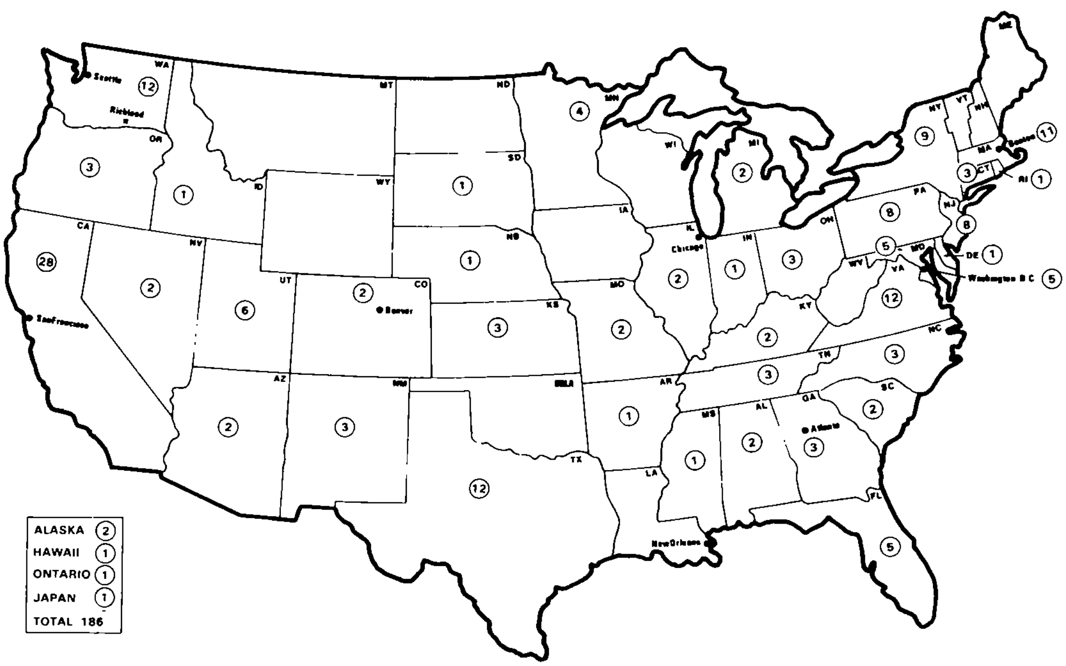
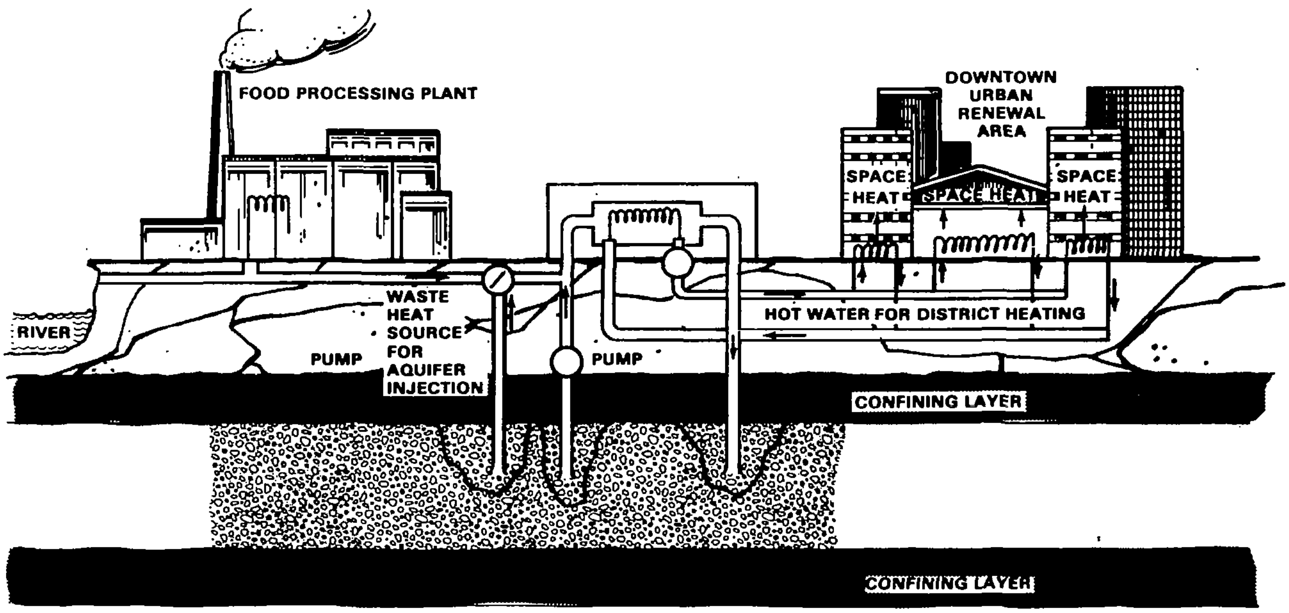
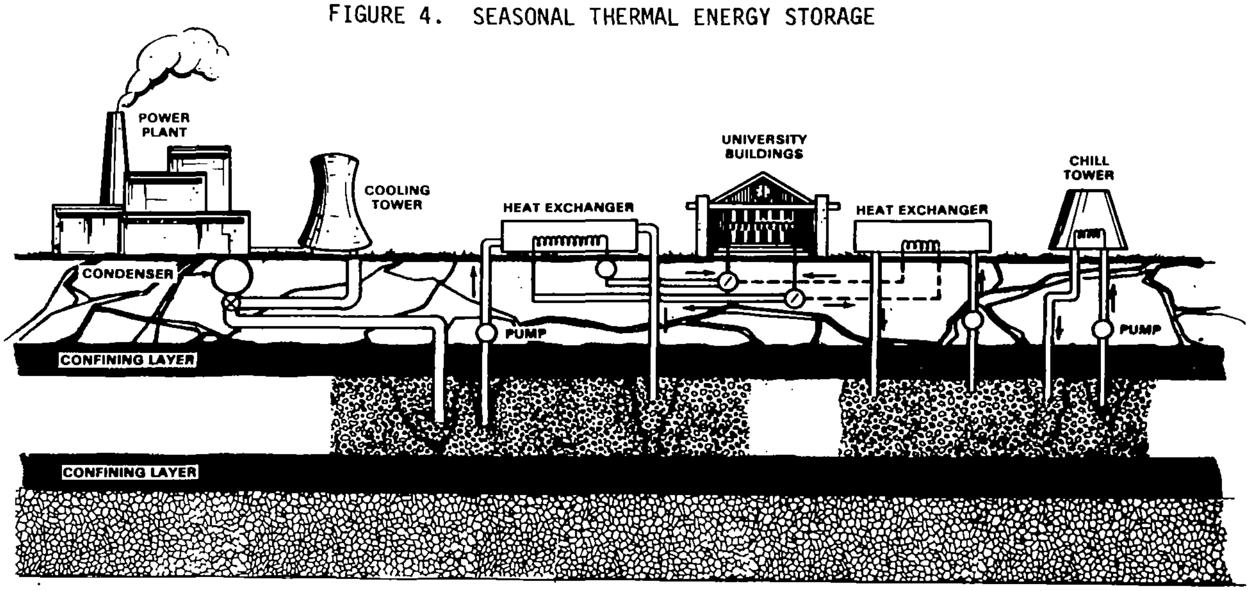


FIGURE 3. SEASONAL THERMAL ENERGY STORAGE



PROJECT #1

FIGURE 4. SEASONAL THERMAL ENERGY STORAGE



PROJECT #2