SEASONAL THERMAL ENERGY STORAGE PROGRAM

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INTRODUCTION

The DOE Division of Energy Storage Systems is responsible for formulating and managing research and development in energy storage technology. As one element of STOR Division's Thermal Energy Storage Program, Pacific Northwest Laboratory (PNL) was assigned management of the Seasonal Thermal Energy Storage Program in April, 1979. During the latter part of FY 1979, PNL formed a Program Office for this purpose. STES Program plans were formulated, work breakdown structure developed, and existing contract work reviewed. The experimental and demonstration work of the Seasonal Thermal Energy Storage Program will be performed by industry, PNL and other DOE laboratories, and universities.

In this overview, the STES Program incentives, objectives, and long range implementation plan for achieving program goals are described. Procurements in progress in the Demonstration Program will be described in subsequent papers. Specific projects contributing to technical studies will be discussed by PNL Program staff and by contractor representatives.

PROGRAM INCENTIVES

Storage of thermal energy is expected, in the near term, to provide a significant contribution toward achieving the goals of the National Energy Plan. This contribution will encourage a shift from use of insufficient or costly fuels such as oil and natural gas to more abundant or available energy sources such as coal, solar, and nuclear power. Thermal energy storage, when incorporated in energy supply and conservation systems, permits efficient and economical use of intermittent energy sources such as solar or off-peak electrical power. Thermal storage also may allow use of waste heat from industrial and utility sources.

The STES Program is designed to demonstrate the storage and retrieval of energy on a seasonal basis, using heat or cold available from waste or other sources during a surplus period to reduce peak period demand, reduce electric utility load problems, and contribute to the establishment of favorable economics for district heating and cooling systems for commercialization of the technology. Aquifers, ponds, earth, and lakes have potential for seasonal storage. The initial thrust of the STES Program is toward utilization of groundwater systems (aquifers) for thermal energy storage.

During the last decade, the storage of thermal energy in aquifers has received considerable attention. The motivations for storing large quantities

of thermal energy on a long-term basis have been numerous including: a) the need to store solar heat that is collected in the summer for use in the winter months; b) the cost effectiveness of utilizing heat now wasted in electrical generation plants; c) the need to profitably use industrial waste heat; and d) the need to more economically provide summer cooling for buildings. Seasonal aquifer storage should contribute significantly to satisfy the above needs. Most geologists and ground-water hydrologists agree that heated and chilled water can be injected, stored, and recovered from aquifers. Geologic materials are good thermal insulators, and there are potentially suitable aquifers distributed throughout the United States. Recent studies and small-scale field experiments have reported energy recovery rates above 70 percent for seasonal storage. The U.S. Department of Energy predicts that, by the year 2000, seasonal aquifer storage could replace or conserve up to 350 million barrels of oil per year. However, successful demonstration of large-scale aquifer thermal energy storage has not yet been attempted and the concept's economic feasibility and institutional acceptability have yet to be established.

Many potential energy sources exist for use in an aquifer thermal energy storage system. These include solar heat, power plant cogeneration, winter chill, and industrial waste heat sources such as aluminum plants, paper and pulp mills, food processing plants, garbage incineration units, cement plants, and iron and steel mills. For heating, energy sources ranging from 50 to over 250°C are available. Potential energy uses include space heating on an individual or district scale, heating for industrial or institutional plants and heat for processing/manufacturing.

PROGRAM OBJECTIVES

The objective of the Seasonal Thermal Energy Storage (STES) Program is to demonstrate the economic storage and retrieval of energy on a seasonal basis, using heat or cold available from waste sources or other sources during a surplus period to reduce peak period demand; reduce electric utilities peaking problems; and contribute to the establishment of favorable economics for district heating and cooling systems. Aquifers, ponds, earth, and lakes have potential for seasonal storage. The initial thrust of the STES Program is toward utilization of ground-water systems (aquifers) for thermal energy storage.

The program has the further objective of evaluating other methods of seasonal storage, both from existing literature and by following current work in other countries. New program thrusts may be recommended as a result of these studies.

PROGRAM IMPLEMENTATION

The STES Program is divided into an Aquifer Thermal Energy Storage (ATES) Demonstration Task and a parallel Technical Support Task. Seasonal storage in aquifers will be evaluated in the ATES Demonstration Task, beginning with the conceptual design of site-specific systems and operation of a smaller number

of demonstration projects. The basic function of such an energy storage system is to accept, store, and discharge energy in accordance with availability and demand. Thus, the aquifer storage system provides a buffer between the time-dependent energy inputs and thermal loads or outputs. An aquifer thermal energy storage system is an integrated system consisting of an energy source, thermal transport, a storage aquifer, and a user application. Energy may be supplied for storage from a solar collector, heat pump, industrial heat source, a cogeneration power plant, or other sources. Conversely, chilled water may be supplied and stored for future uses in air conditioning.

In response to a Request for Proposal (RFP), prospective contractors will submit proposals for ATES Demonstration Project conceptual designs (Phase I). The contractors will develop conceptual designs for integrated systems containing energy source, thermal transport, aquifer storage, and user subsystems. Aquifers will be characterized by geologic exploration and analysis of existing data. Functional design criteria will be developed for each subsystem and for the integrated systems. From the functional design criteria and the aquifer characterization reports, proposals will be evaluated for continuing work in Phase II. Phase II is the detailed design, construction, startup, and operation of ATES Demonstration Projects. Timing of this task is shown in Figure 1.

The parallel Technical Support Task is designed to provide support to the overall STES Program. The initial activities of this task are primarily directed toward support of the ATES Demonstration Task. These activities will include social, economic, environmental assessment, and technical research and development studies to provide a sound technical base for the demonstration projects. The long-range task goals include investigation and evaluation of other seasonal thermal energy storage concepts which may be considered for future emphasis. It is the intent of the Technical Support Task to reduce technological barriers to the development of energy storage systems prior to the significant investment in demonstration or commercial facilities. Through research and testing on novel storage concepts, aquifer characteristics, system designs, and system operating criteria, this task can assist developers in obtaining a successful energy storage facility. This task is designed to not only provide technological information on energy storage systems, but also to assist in identifying systems which are economically sound, environmentally acceptable, and within existing legal and institutional constraints.

A major function under the Technical Support Task is development of one or more Leading Edge Test Facility(s) (LETF). The LETF is a site or sites established to test heating and/or chilling technologies for energy storage in aquifers. This facility is the forerunner of demonstration projects for aquifer thermal energy storage. As a forerunner, the facility will assist in the development of energy storage technology through research and development activities. This facility will have the capability of performing full-scale tests on both heating and chill energy storage technologies. More than one LETF may be required. The aquifer requirements (confined versus unconfined), heat sources and end uses of low-temperature versus high-temperature storage concepts may necessitate the use of more than one leading edge unit.

The Seasonal Thermal Energy Storage (STES) Program will involve industry, other Department of Energy (DOE) laboratories, and universities. Major tasks and subtasks of the program are shown in Figure 2. Figure 2 also shows the responsible organizations working on the subtasks. Figure 3, the Network Diagram, shows the coordination of effort planned to meet program objectives.

FIGURE 1. AQUIFER THERMAL ENERGY STORAGE PROGRAM

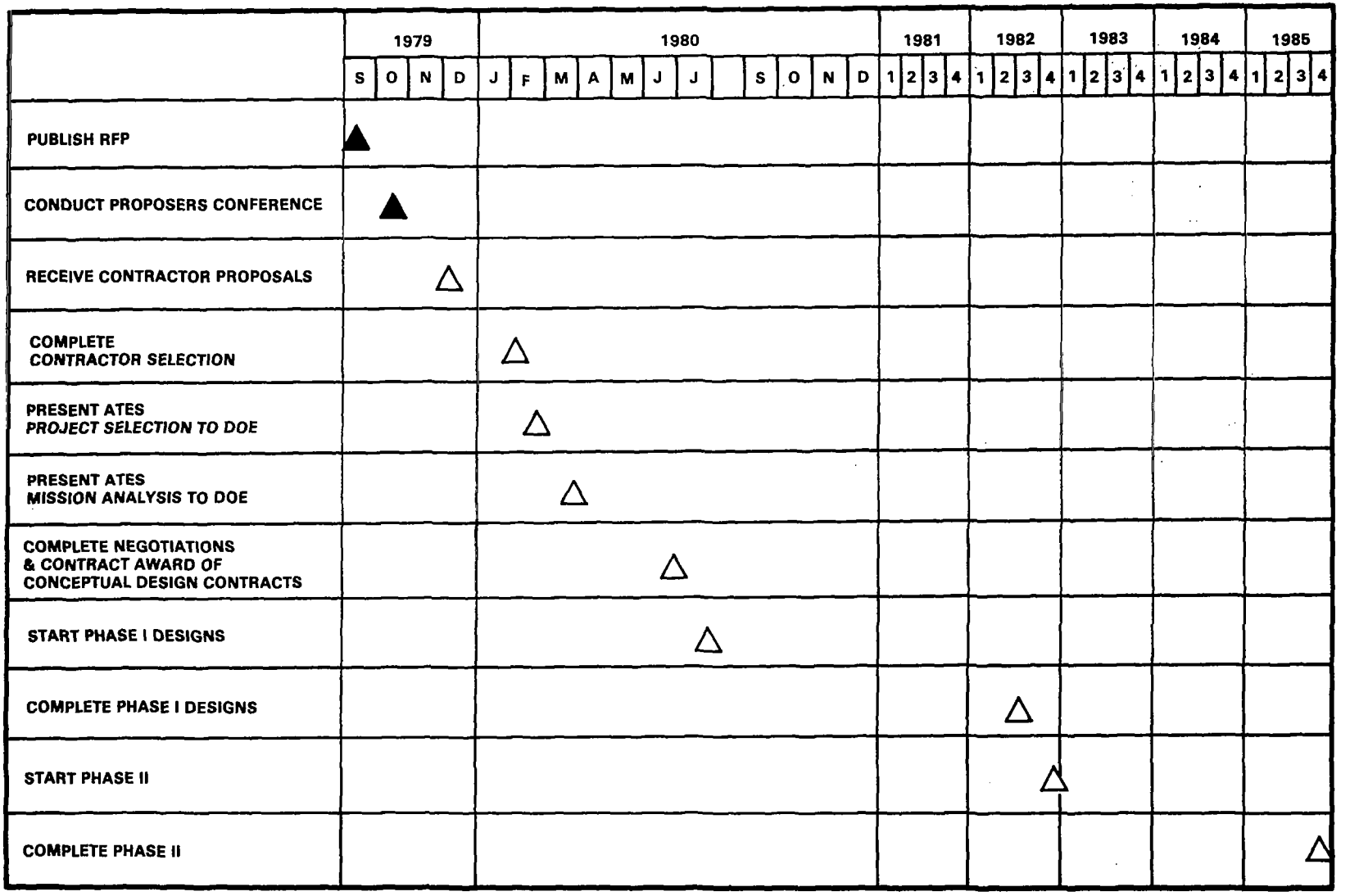

FIGURE 2. STES PROGRAM ORGANIZATION

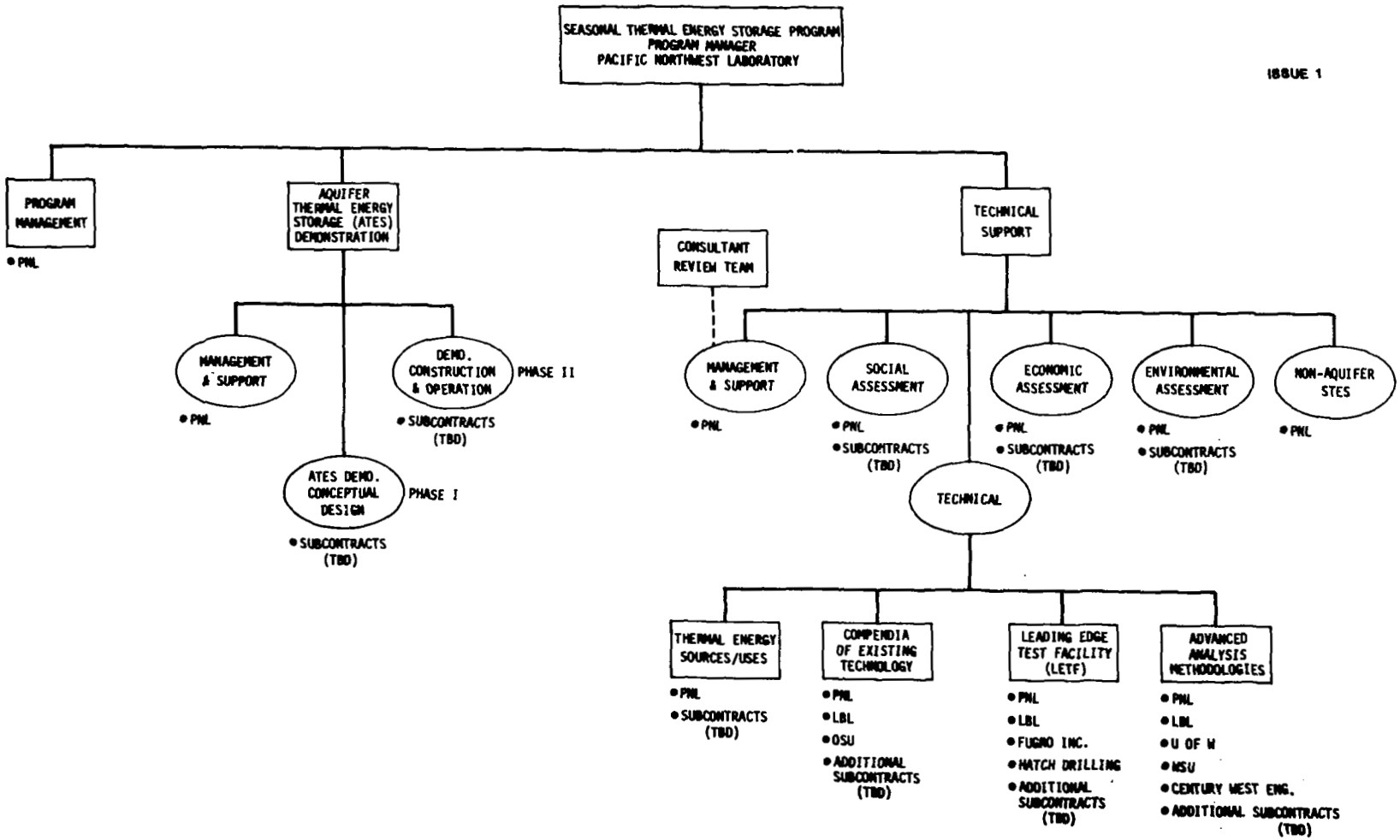

FIGURE 3. SUMMARY NETWORK

SEASONAL THERMAL ENERGY STORAGE