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STES Newsletter Vol 7 No 4

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1985-09-01

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STES NEWSLETTER

A Quarterly Review of Seasonal Thermal Energy Storage

Sponsored by the Pacific Northwest Laboratory
Operated by Battelle Memorial Institute for the U.S. Department of Energy

EARTH SCIENCES DIVISION/LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA

Vol. VII, No. 4 September 1985

A NOTE FROM THE EDITOR

In this issue there is an announcement of the establishment of a Council for International Heat Storage Conferences. We believe that this is an important development in our field and may be the beginning of a more definite association and greater cooperation among scientists and engineers working in this field worldwide. We strongly encourage all interested readers to write to the President of the Council to lend their support and encouragement to this International Council.

This issue also contains rather substantial articles from the U.S., West Germany, France, and China. They cover various aspects in the implementation of seasonal energy storage, from system analysis to particular technical results related to water cooling tower design. Thus, this Newsletter serves both to bring together recent developments from different countries, and to inform our readers of results from related work in the multi-disciplinary field of thermal energy storage.

The STES Newsletter is a compilation of written contributions from researchers working in the field of seasonal thermal energy storage. Articles and reviews of current research, recent results and future plans are welcome. Contributions for the next issue, as well as suggestions and changes of address should reach us at the following address by **November 15, 1985.**

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COUNCIL FOR INTERNATIONAL HEAT STORAGE CONFERENCES ESTABLISHED

A significant event took place recently at ENERSTOCK 85, when a resolution was passed by the Conference to establish a new body, the Council for International Heat Storage Conferences. The primary function of the Council will be to assure the orderly continuity of the International Conferences. ENERSTOCK 85, held in Toronto in September, was the third international energy storage conference held to date. Previous Conferences were held in Seattle in 1981, and in Stockholm in 1983.

There was general agreement among the delegates at Toronto that these International Conferences are filling a very clearly felt need, and that formalization of the process for selecting meeting sites is indicated.

The actual resolution passed by the Conference is given below.

> "This Conference resolves that a Council for International Thermal Storage Conferences shall be hereby established.
>
> The Council is authorized and instructed to arrange for the continuity of the Conferences at regular intervals by arranging for and designating, several years in advance, the countries and years in which future meetings will be held.
>
> The Council shall also act to facilitate the transfer of information from the officers of one Conference to those of the next, and generally to promote the success of these Conferences and the advancement of the science and technology of thermal storage.
>
> The Council shall establish its own Constitution, which will assure that its membership will include representatives from those countries in which there is a substantial interest and activity in thermal storage, and that these representatives shall be appropriately selected. The Constitution will provide for the election

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by the Council of its own officers, except for its President, who shall normally be the General Chairman of the preceding Conference, and who shall hold office until the close of the following Conference.

The Council, having designated the time and place of a Conference, shall have only an advisory function. Full responsibility and authority for the organization and conduct of each Conference shall be vested in the host organization."

In accordance with the terms of the resolution, Dr. Edward Morofsky has taken the post of President of the Council, and has set about the work of organizing the group. He can be contacted by mail at Public Works Canada, C456 Sir Charles Tupper Building, Riverside Drive and Heron Road, Ottawa, Ontario, Canada, K1A 0M2.

THE STORAGE CONCEPT OF THE LUBECK SOLAR HOUSE

Contact: H. Weik, Fachhochschule Lubeck, Stephensonstrasse 3, D-2400 Lubeck, FRG

In this article, an unconventional approach to the storage of solar thermal energy for residential heating (space heating and domestic hot water) is described. The approach has been tested since summer 1982 in a one-family home with 130 m^2 of heated area, built on the site of the Fachhochscule Lubeck.

The main goal of the approach was to develop an independent, active solar dual-storage heating system that uses as little (non-fossil) auxiliary energy as possible. This was to be achieved under two conditions: (1) to avoid a summer solar surplus characteristic of conventional solar single-storage systems; and (2) to utilize as efficiently as possible the weak winter insolation typical of high latitude locations with moderate climates like northern Germany. About 70% of the year's total insolation occurs between April and September, while 85% of the total space heat demand of a well-insulated house is needed during the October-March period.

Regardless of the solar collecting principle used, a conventional, economically-sized single storage system for decentralized use has two drawbacks: (1) its storage capacity will be exhausted even before the mid-winter period starts; and (2) due to the weak winter insolation, the temperature level of the collector circuit is too low to be used for the heating system of the house. Therefore, a double-storage concept, with the storage tanks kept at two different temperature levels during the winter months, appears more economically feasible. Figure 1 illustrates this concept. In the figure, the smaller "day" tank is kept at a temperature between 35 and 50 °C (depending upon the ambient temperature) to meet the heating requirements of the house. The large tank ("seasonal tank") is used as a heat reservoir for the day tank, either by direct heat exchange at the beginning of the heating period, or, later in winter, by means of the heat pump, which needs a driving power of only 2 kW. The solar heat for the domestic hot water supply may be furnished independently and/or be coupled to the main storage by a heat pipe connection, as indicated in the figure.

Given the north German climate and insolation, with the heating period beginning before the middle of September, a field of 30 m^2 solar collectors will satisfy the heating demand of a well insulated three-bedroom home until the beginning of October. Then the sensible heat of the large tank (about 1000 kWh with 20 m^3 tank volume) will be extracted, resulting in a 3-4 week heat supply.

After that time, the tank's temperature has dropped to about 35 °C; its energy content, therefore, cannot be used directly for the heating system, even though it amounts to another 1000 kWh when the freezing point is taken as reference. It can, however, be extracted by means of the small heat pump and thus be made available for heating via the day tank. Heat from the collector field will now flow (in general, as mostly overcast skys prevail), into the seasonal tank, and this occurs - due to the low temperature level of the storage water - with high efficiency.

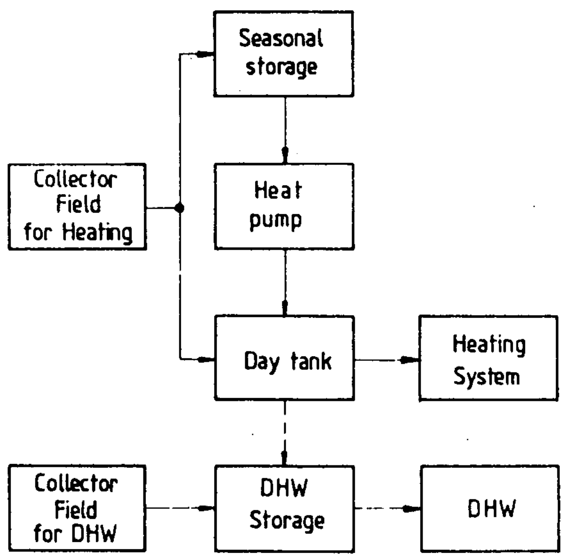

Fig. 1. Block diagram of the storage concept.

The third period of the storage cycle is characterized by the gradual solidification of the water in the seasonal tank, which then acts as phase change (latent heat) storage, providing up to about 2400 kWh heating supply, including some 1000 kWh driving energy of the heat pump. On particularly sunny days with insolation values greater than 2.5 kWh/m^2, the collector field will be automatically switched to deliver its heat directly to the day tank to save the driving power of the heat pump.

During the second half of April, the heat load of the house and the heat gain from the collector field generally balance. The insolation is high enough to serve the day tank, and the heat pump can be shut off. In May, the insolation surplus will be used to fill the large tank, which will subsequently be heated during the summer months (besides taking care of occasional heat load as in summer 1985) to its initial 65-70 ° C temperature for the new heating cycle.

To test the dual-storage concept under real conditions, a one-family dwelling was chosen, with a solar system lay-out as illustrated in Figure 2. There is a 4 m^3 day tank, a 19 m^3 seasonal tank, and a 34 m^2 collector area, including 3 m^3 for the 500 liter domestic hot water tank installed in the attic of the house, thus allowing a thermosiphon circuit.

During the first year of operation (1982-83), the dual-storage principle fully satisfied the expectations. Less than 6 MWh of auxiliary energy (driving energy for the heat pump) were needed to furnish the total heat load (space heating and domestic hot water); almost 65% could be supplied by the solar system.

An attractive outcome of the dual-storage concept is the high coefficient of performance (COP) of the collector field during the mid-winter months. Lubeck (54 ° N latitude) has a rather long winter, with an average ambient temperature of 5.3 ° C during the 260 days of the heating period, and a number of degree days of 3580 Kd, when an average room temperature of 20/17 ° C (day/night) is assumed.

The most critical month is December because this is the month with the lowest insolation. Even though the average daily integrated insolation onto the 60 ° inclined south roof of the building in December 1984 amounted to only 0.66 kWh/m^2d - with only 6 days with an insolation higher than 1.5 kWh/m^2d - the COP of the collector field reached a remarkably high value of 0.35.

Our experience thus far with the the Lubeck solar house indicates that the dual-storage heat pump concept can be a valuable tool for the successful utilization of solar energy for space heating of homes even in moderate climates and locations with low winter insolation. To gain full benefit from the concept, however, one must carefully plan the concept and choose the relative sizes of the system components, that is, the collector quality, the area and slope of the collector field, and the storage tank volumes.

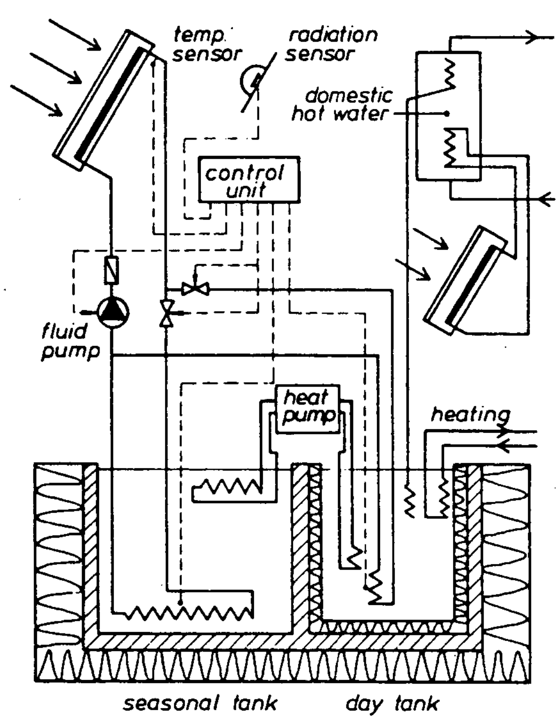

Fig. 2. Simplified storage system (not to scale).

THE HELIOGEOTHERMAL DOUBLET AT AULNAY-SOUS-BOIS

Contact: P. Iris, Ecole Nationale Supérieure des Mines de Paris, 35, Rue Saint-Honoré, 77305 Fontainebleau, France

Aquifers represent an attractive cold source for heat pumps in space heating, because their temperature generally remains constant. However, because they are finite resources, particularly in the hydraulic sense, it is often necessary to inject the water back into the aquifer through a second well, after having extracted the heat. Numerical simulations have shown that a thermal perturbation can occur during reinjection, causing a drop in temperature at the producing well with time, as well as progressive cooling of the underground medium around the injection zone. These problems can be accute in urban areas.

The heliogeothermal doublet system has been developed as a means to avoid these problems. The system is well adapted to confined aquifers with low regional velocity. During winter, water is pumped out of the aquifer at its natural temperature. After heat

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extraction, it is reinjected through a second well in the aquifer. During summer, the flow in the wells is reversed: the cold water stored during winter is pumped out and heated by climatic convectors which collect energy both from insolation and thermal exchange with ambient air. The water is then injected back in the producing well at its original temperature. This process reduces the size of the cooled zone in the aquifer and permits a constant temperature to be maintained in the producing well.

A demonstration project utilizing this system is now working in Aulnay-sous-Bois, near Paris, involving 224 apartments in collective buildings. The system uses a confined, sandy aquifer (the Ypresian aquifer), which underlies the whole northern part of the Parisian Basin at a depth of 80 m, and has a temperature of 13 °C. The average flow rate per well is about 60 m^3/h, with a thermal power of 600 kW. Technically and economically, this aquifer is an interesting target for mid-scale buildings or groups of buildings (300 dwellings or more).

The principal aims of this project are to:

(1) apply the heliogeothermal doublet to control the sizing of the climatic collectors, the thermal behavior of the aquifer, and the hydraulic behavior of the aquifer during injection phases, etc.;

(2) maintain a technical and economical balance between a large scale water heat pump and an aquifer, which is not yet a very common practice, but which should permit important energy savings under acceptable economical conditions.

The project is financially supported by le Plan Construction, l'Agence Francaise pour la Matrise de l'Energie, the Commission of the European Communities, and the F.F.F. Company, owner of the apartment buildings.

The plant itself is described briefly here. Three electricity driven water heat pumps are used, two for space heating, and one for domestic hot water. The two used for space heating provide 250 thermal kW each, which represents 60% of the peak power needed in the buildings. The heat is distributed by radiators and heating floors (maximum temperature 45 °C). During the heating season, the condensers work between 25 ° and 45 °C.

The heat pump used for domestic hot water provides 160 thermal kW. The heat pump is connected to a storage of 25 m^3 (five tanks of 5 m^3 each), which is heated at a low cost at night. During the day, the pump heats the distribution network of hot water. The condenser temperature can reach 57 °C; the heat is distributed at about 50 °C.

Unglazed climatic collectors are placed on the roof: they consist of superimposed flat elements (1275 m^2) made of copper thread (mesh) with copper tubes characterized by a high heat exchange coefficient (k = approximately 45 $W/m^2\,{}^\circ C$).

The collectors are used to recharge the aquifer (from 4 ° to 14 °C) and to collect energy for domestic hot water (with the help of the heat pump) during summer. The collectors can also be used during the warmest days of the heating season together with the aquifer as a cold source for the heat pumps. During the cold days, the aquifer is used alone in order to maintain a correct coefficient of performance (COP). Back-up energy is provided by a central oil heating plant (urban network).

The summarized results of the first complete year of operation, 1983-84, are shown in Tables 1 and 2. The heating period lasted from October 1983, until the end of May 1984; the thermal recharge of the aquifer lasted from the beginning of July 1984, through the end of September 1984.

The economic and energetic results for this first year fit well with previous calculations due to the good performance of the heat pumps. The main problem that occurred concerned the failure of the flow rate regulator of the submerged pump. Consequently, the flow rate was constant and maximum most of the time, without any variation according to the thermal needs. Thus, it was not possible to correctly utilize the climatic collectors during the heating season, and instead of replenishing 40% of the heat at the cold source of the heat pumps as predicted, we extracted less than 10%. As a main result, the net heat extracted from the aquifer was much larger than initially calculated. The regulator has worked correctly since October 1984.

Concerning the aquifer, there were no particular difficulties during the first year of operation; the wells were developed at a flow rate of 100 m^3/h for a nominal pumping and injection rate of 50 m^3/h. The geothermal network is maintained under pressure at all points in order to avoid cavitation or air contact.

Table 1. System Energy Balance.

	Space Heating*	Domestic Hot Water*	Total*
Energy demand:	1893	580	2473
Heat pump:	1691	542	2232
Back-up energy:	202	38	240
COP	4.33	2.75	

*units in MWh

Table 2. Aquifer Energy Balance.

Volume treated during winter:	213,7700 m^3
Average injection temperature:	7 °C
Energy extracted:	1293 MWh
Volume treated during summer:	80,200 m^3
Average pumping temperature:	8.4 °C
Energy recharged:	387 MWh
Auxiliary energy for pumping:	38 MWh
Recharge rate:	30%

We measured the specific flow rate, SFR (flow rate corresponding to a water level change of 1 m) at the injection well, which did not show any sign of clogging. Each week, backwashing was done at the injection well by pumping water back at 70 m^3/h for one hour. We observed the sensitivity of the SFR to the temperature due to variation of viscosity. In the winter injection well, the initial SFR was 9 $m^3/h/m$, and it was maintained at about 8 $m^3/h/m$ with weekly backwashings. We stopped the backwashings before the end of the season, and the SFR decreased to 7 $m^3/h/m$ and stabilized, which can be explained by the viscosity effect of the cold water. In the summer injection well, the SFR was constant at its initial value of 14 $m^3/h/m$.

An incident occurred in November 1984 at the beginning of the second heating season. Due to a modification of the regulator, air was injected in the aquifer; after less than one month, the SFR decreased dramatically to less than 3 $m^3/h/m$ in the winter injection well. Chemical analysis showed that hydroxide of iron had precipitated due to air injection. We injected hydrochloric acid and immediately recovered the initial value with the dissolution of the precipitate. The cost of the treatment per apartment was $4.00. Close control of the injection behavior must be undertaken during exploitation.

From an economic point of view, this type of system can be competitive, especially in the case of heating and cooling. The same installation can provide both, and it is not necessary to have two systems of heat pumps with refrigerating towers for cooling and boilers for heating.

The economical viability of such systems mainly depends on the comparison of oil and electricity costs, and also on the depth of the aquifer compared to the size of the buildings to be heated.

As an example, we have calculated that, in the case of the Ypresian aquifer (80 m depth, 60 m^3/h per well), the payback time of a system of heat pumps with a well doublet providing space heating and domestic hot water is less than 4 years as soon as there are more than 300 apartments connected to the doublet. The investment of the climatic collectors for the thermal recharge of the aquifer increases the return time by 3 years (assuming electricity cost = 0.04 US dollars/kWh; oil = 0.03 US dollars/liter).

We are now continuing to monitor the behavior of the installation. A comparison between field results and calculations of the model is being undertaken.

CENTRAL SOLAR HEATING PLANTS WITH SEASONAL STORAGE: EVALUATION OF SYSTEMS IN NEW ENGLAND USING DUCT STORAGE IN ROCK AND A HEAT PUMP

Contact: D.S. Breger, Consultant, 615 Grove Street, Newton, Massachusetts 02162 USA

An evaluation has been performed that considers seasonal storage of solar energy using duct storage in rock and a heat pump for the New England region of the United States. The seasonal storage technology is of particular interest in the New England region for several reasons. There is adequate bedrock for large scale storage and the climate includes cold, relatively cloudy winters, and summers with substantial insolation. The analysis was performed within the context of the International Energy Agency (IEA), Solar Heating and Cooling Program, Task VII on Central Solar Heating Plants with Seasonal Storage (CSHPSS). The analysis also illustrates an innovative system optimization approach developed by the IEA Task.

The general results of the analysis indicate that the optimized systems provide 75-80% of the low temperature demand load and 60-65% of the high temperature demand load with solar energy, with the remaining portion coming primarily from the heat pump electrical input energy. The annualized cost of the energy supplied by the system to the distribution network, using the base case economic scenario, is $44-52 per MWh and $58-62 per MWh for the low and high temperature loads, respectively. Significant reductions in cost are realized when systems are financed with applicable depreciation and tax credit allowances. These results are encouraging in terms of the system cost-effectiveness relative to energy costs in the New England area, which are comparable to these values.

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Hartford, Connecticut was selected as the most representative climate location with available TMY (typical meteorological year) data, although sensitivity analyses were performed for other New England locations. The regional bedrock is close to the surface throughout most of the New England area. Because exact conditions of the surface layer, bedrock composition, bedrock fracturing, and water table are very site specific, an exploratory study must precede any specific heat storage project. The New England region offers ample opportunity for CSHPSS systems due to new development activity. As further incentive, energy costs are high in the region, and all oil and gas products are imported.

System analysis was performed using the MINSUN computer simulation program developed by the IEA Task to simulate and provide economic analysis of CSHPSS systems. An annual load of 10,000 MWh (with 20% domestic hot water) was assumed and both low and high demand temperature scenarios were analyzed. Two collector types were considered, a flat plate and an unglazed flat plate. The system parameters of collector area, storage volume, and number of boreholes were systematically incremented to cover a large range of system designs. System designs and the corresponding performance results were then applied to various economic scenarios to derive the set of optimum systems.

An annual simulation of a system is shown in Figure 1. This system is characterized by 15,000 m^2 flat plate collectors, and a storage volume of 300,000 m^3, with 400 boreholes (100 m deep). The average storage temperature (not shown) exhibits a sinusoidal shape with a maximum of 33 °C in October and a minimum of 11 °C in March.

System economics are based on the System Energy Cost (SEC), which is defined as the annualized solar system capital and heat pump operational cost divided by the solar output from storage and heat pump input energy. The electric energy that must be supplied to the heat pump is considered (both its contribution to the load and cost) since this is necessary in order to make use of the low temperature solar heat and is subject to different price structures than the displaced fuel. This economic term is independent of conventional or auxiliary energy cost or escalation assumptions.

The base case economic scenario is applied to the low demand temperature scenario with flat plate collectors. Each parameter combination produces a value of solar fraction and system energy cost (SEC). All points simulated are plotted in Figure 2, with different symbols for each collector area. The lines drawn illustrate the variation in performance and economics at each collector area due to changes in storage volume and number of boreholes.

The minimum cost systems at each solar fraction combine to form the system expansion path which includes all system configurations of importance in terms of optimization. System optimization then depends on conventional fuel cost. Provided the annualized, delivered conventional heat cost is greater than the minimum SEC, the optimum is determined by progressing along the expansion path to greater solar fraction until the system energy marginal cost is equal to the conventional heat cost.

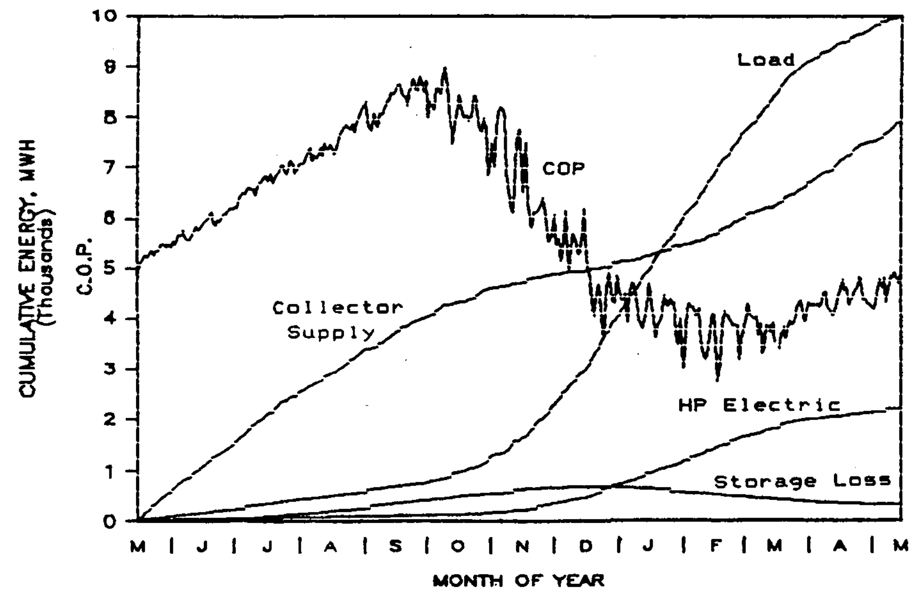

Fig. 1. System simulation over annual cycle.

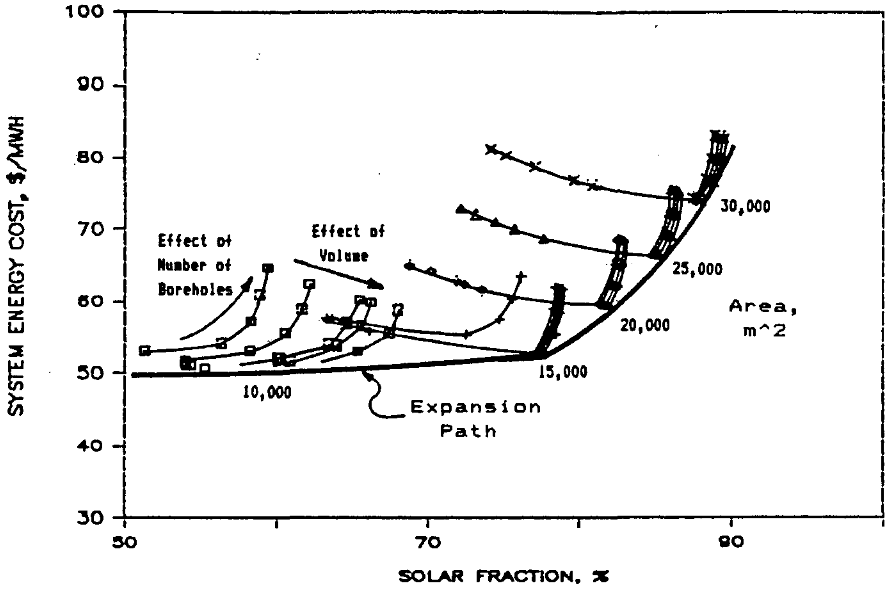

Fig. 2. Base case economic results and expansion path (flat plate collectors).

The expansion paths for this base case flat plate collector system have been derived for the remaining economic scenarios. The high and low cost scenarios span a wide range of likely costs. The financing scenarios, which consider applications of depreciation and tax credits to the base-case costs, provide significant energy cost reductions.

The high temperature distribution scenario is a very likely design option, particularly for retrofit conditions. A comparison among the expansion paths for both collectors and both distribution temperatures under the base-case economic scenario shows a significant increase in high temperature energy cost and a reduction in the feasible solar fraction. The effect is more pronounced for the unglazed collectors. The reduction in solar fraction is mainly caused by the lower heat pump coefficient of performance (COP), which is reduced from approximately 5 to 3 for the higher load temperature. These COP values imply a maximum solar fraction of 80% and 67%, respectively.

The results of this evaluation are very encouraging in terms of the cost-effectiveness of CSHPSS using duct storage relative to present energy costs in New England. A great deal of uncertainty remains, which makes the diffusion of this technology into the private sector difficult. A primary source of uncertainty remains regarding the bedrock geology at a given site, and particularly the extent of water movement through the storage region. These systems must be built on a rather large scale to attain adequate performance and economics. The large capital requirements are difficult to achieve from private sources given the present degree of uncertainties.

This work is fully described "An Assessment of Solar Heating Systems with Seasonal Storage in New England: Systems Using Duct Storage in Rock and a Heat Pump," D.S. Breger and A.I. Michaels (Argonne National Laboratory, ANL/EES-TM-279, Jan. 1985).

A NEW TYPE OF WATER COOLING TOWER FOR USE IN WINTER

Contact: Z. Baizhong, Dept. of Thermal Engineering, Northwest University of Technology, Shenyang, P.R.C., and Z. Rongyi, Dept. of Thermal Engineering, Tsing Hua University, Beijing, P.R.C.

Theoretical studies of systems using chilled water storage in aquifers have been carried out by researchers at Tsing Hua University. To date, we have carried out the following work:

1. Calculation of the performance of water storage in aquifers, (temperature distributions, etc.);
2. Feasibility analysis of an air-conditioning system with chilled-water storage in an aquifer;
3. Optimization of an air-conditioning system with chilled-water storage in an aquifer;
4. Research on a new type of winter cooling tower for low temperature water, including (a) separate studies on water spray cooling and water film cooling, and (b) analysis of a new type of cooling tower, a "mixed" tower, using both types of cooling.

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In some chilled-water storage applications, it is not possible to acquire naturally chilled water. In these cases we must cool underground water to meet the storage requirements.

There are many ways to cool water, but because of various limitations, we decided to construct a special water cooling tower to chill low-temperature groundwater.

As we know, there are differences between cooling high-temperature water in summer and cooling low-temperature water in winter. First, because of the difference in contact enthalpy, the difference in the initial temperatures of water and air becomes greater in winter. Second, because of the increased temperature difference, sensible heat transfer is very important. Third, since the wet-bulb temperature of environmental air is below 0 °C, ice would be formed in some parts of the tower. Experience has shown that the use of a summer-type cooling tower is not suitable for this case, so it was necessary to investigate a new type of tower.

The new type of cooling tower we have developed is a "mixed" tower, which incorporates both spray cooling and film cooling. In spray cooling, air/water contact is created by inducing air flow through the water spray. Two regions of cooling occur: cooling of free spray, and cooling on the spray tower. In the former, water droplets are in direct contact with environmental air; in the latter, some of the droplets remain as droplets, and some of them form a water film on the wall of the tower; both regions continue to interact with the induced air flow. By theoretical analysis, combining heat and mass transfer and the aerodynamics of spray, as well as experimental investigation, we have obtained the relationship of air-water ratio and cooling efficiency.

In film cooling, the cold water flows down an inclined steel plate, creating a thin water film. This film is in contact with cold air that flows through the tower, so the water is cooled again. With the help of experiments and theoretical analysis, the cooling efficiency of the water film has been determined.

Because of the difference between these cooling methods, there must be an optimal combination of spray and film cooling. In addition, since the tower will be used in winter, the operating time is limited to that period of time in which water will not form ice. From local weather conditions, we are able to compute this period of time.

Experiments on the test tower have shown that underground water at a temperature of about 15 °C can be cooled to about 6-7 °C, which cannot be achieved by using a traditional summer-type cooling tower.

THE 21ST INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE: Thermal Energy Storage Technology Topical Symposium on Energy Storage Technology

A special topical symposium on thermal energy storage technology will be held as a part of the 21st IECEC in San Diego, California, at the Town and Country Hotel, August 25-29, 1986. Topics to be included in this symposium include the following, with one or more sessions in each area:

- Seasonal Thermal Storage
- Thermal Storage for Solar Systems
- Low Temperature Thermal Storage
- Transport of Thermal Energy (thermochemical, latent, or sensible)
- Panel Session of Invited Speakers.

Papers concerning thermal energy storage applications and systems analysis will be included, as well as papers addressing the design, testing, and analysis of energy storage and transport components related to thermal energy storage systems.

In addition to the topical symposium on thermal energy storage technology, other forms of energy storage will be addressed in sessions at the 21st IECEC. The topical areas will include mechanical, large-scale compressed air, stationary battery, and magnetic energy storage; both short-term and long-term applications will be included. The conference will also include displays and demonstrations of energy systems. The ASME Energy Storage and Transport Technologies Committee will award the best paper(s) on energy storage and transport.

Authors should submit four copies of their abstract to Dr. Robert Copeland at the Solar Energy Research Institute, 1617 Cole Boulevard, Golden, Colorado, 80401 [Telephone: (303) 231-1012], by January 7, 1986. Abstracts should be approximately 500 words in length, and should include an introductory statement indicating the purpose and significance of the work. Within the body of the abstract, the author should discuss the results of the effort, and, if appropriate, how it differs from or extends work that has been previously reported.

Authors will be notified of abstract acceptance and provided with further instructions in February 1986. The deadline for manuscripts is May 12, 1986. Only those papers accepted for publication may be presented orally at the conference. Papers will then undergo peer review for publication in an appropriate

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This work was supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.