FIRST ANNUAL WORKSHOP ON ICE STORAGE FOR COOLING APPLICATIONS

Argonne National Laboratory
June 4-5, 1981
ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue
Argonne, Illinois 60439

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Compiled by
Anthony J. Gorski
Chemical Engineering Division

July 1981
The purpose of the workshop was to assemble, for the first time in this country, researchers in this important energy field as well as representatives from various application and funding agencies. Until the workshop, most ice researchers had been working independently and, for the most part, unaware of the activities of others. The workshop was sponsored by the Passive Ice Storage for Cooling Applications Section of the Solar Energy Group at Argonne National Laboratory. The Passive Ice Storage Program is funded by DOE Assistant Secretary for Conservation and Solar Energy, Office of Solar Applications, Project Officer: R. Shibley. The first day of the two day workshop was spent on formal presentations. The second day was a mix of presentations and group discussions in three working groups. At the last workshop session, the participants decided to form in an informal society to be hereby known as The Ice Society. A list of persons attending the workshop is included in these proceedings. In addition to research scientists and engineers, representatives from Government, Utilities, Industry, and National Laboratories were also present.

The major conclusion from the workshop was that cooling by means of winter ice is a concept that can have a meaningful impact on our energy future. The workshop considered residential and commercial applications in some detail and the situation is most encouraging. Future applications can include the agricultural sector (crop cooling) as well as the possibilities of natural gas cooling, desalination, and commercial ice production.

This report was prepared from tapes and notes taken at the meeting. No written papers were provided by the participants of the workshop.

A. J. Gorski
Workshop Director
Argonne National Laboratory
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AGENDA

DAY 1: FORMAL PRESENTATIONS

Ice Storage work in U.S. and Canada

  o Public Works Canada -- Dr. E. Morofsky
  o Princeton University -- Dr. D. L. Kirkpatrick
  Lunch
  o Advanced Energy Technology -- Mr. E. J. O'Hanlon
  o Kansas State University -- Dr. J. Anschutz (scheduled, but unable to attend)
  o Argonne -- Mr. A. J. Corski

Evening -- Social Hour and Dinner

The agenda for June 5, 1981 consisted of three consecutive workshops

DAY 2: WORKSHOPS AND TOUR

  o Technical and Economic Problems
  o Applications and Codes
  Lunch
  o Funding and Future Directions
  o Tour of Argonne's Ice Storage Test Facility, Salt Gradient Pond, and Solar Test Facility
ABSTRACT

The papers presented at the first annual workshop on ice storage for cooling applications by participants from the U.S. and Canada have been summarized. Novel methods of preparing naturally frozen ice and storing it are described. Attention is given to technical and economic problems and related design considerations. Comparison is made with conventional air conditioning methods. Both industrial and residential applications are discussed with regard to cost.
The Workshop overview and welcoming address was presented by Dr. William Schertz. In his talk, Dr. Schertz stated the purpose of the workshop as "the communication and sharing of ideas, progress, and problems -- both technical and financial." This is to be a real "work" shop so the attendees were encouraged to interrupt, object and participate.

Because Dr. J. Anschutz could not attend the workshop, his work and also the work of Dr. Robert J. Schoenhals (Purdue University) was presented to the workshop by Mr. A. J. Gorski. Because of interest in diurnal ice storage by Commonwealth Edison and other utilities, some additional modifications in the planned activities were made in the first day. Ken Pientka from Commonwealth Edison spoke about a diurnal system now being built by Federal Life Insurance Company. Also, Calvin McCracken of Caltmac Industries presented advantages of ice storage that he found as a result of installing ice systems for peak shaving in commercial buildings.

Dr. W. W. Schertz presented a short historical overview of the ice situation over the last 100 years. In the 1880's the ice business flourished in the northern regions of the U.S. From the East Coast, winters ice was shipped to the Southern U.S. and Central and South America. Because of local pollution by the 1880's, the City of Chicago imported some 1.1 million tons from its northern neighboring states. With the advent of mechanical refrigeration in the early the 1920's, the natural ice industry was doomed. Why did natural ice become obsolete? Mainly due to the pollution of local streams and lakes and because the price of natural ice became too high. The price of labor and transportation increased while there existed relatively low energy costs for mechanical refrigeration. Today's situation is one of high labor and transportation costs coupled with rising energy costs. If we intend to use natural ice for cooling applications today and in the future, the labor cost must be kept low. This implies that we cannot cut ice from natural bodies of water. In addition, we have greater pollution problems than in the past. We must keep transportation costs low. This implies regional application and use. Finally, we must have low energy expenditures. This implies natural freezing, letting winter do the freezing for us free of charge. In all the projects to be presented, the ice will be formed near or at the structure to be cooled. All methods that will use natural cooling will be limited to regions with sufficiently cold winters. In addition, all these methods will strive for minimum energy use. The diurnal ice storage systems are not restricted to cold winter areas, and are attractive primarily for peak load reduction rather than from an energy savings. The consumers economic savings from peak load reduction is due to the electric utilities' energy savings. The cooling energy requirement is provided by efficient baseload
generating units rather than by less efficient peaking generators. Thus peak load reduction is energy savings. The methods to be presented in these proceedings will address many different scales of operation. The efforts at Argonne, Kansas, Advance Energy Technology, Public Works Canada are applicable to residential and small commercial buildings. The work of Princeton University and some of the work of Public Works Canada is directed to large commercial applications. Diurnal ice storage coupled to mechanical refrigeration is primarily directed to large commercial (office) buildings.
ICE PROGRAMS AT PUBLIC WORKS CANADA
E. L. Morofsky, PWC
(Compiler's summary of oral presentation)

ICE PROJECTS IN CANADA

The Canadian Government is now preparing to appropriate several billions of dollars for energy R&D. The first speaker at the Ice Workshop was Dr. Edward Morofsky, Acting Chief of Energy Technology, Science and Technology Group, Public Works Canada (PWC). Dr. Morofsky explained that PWC would be similar to a combination of the U.S. Army Corps of Engineers and the General Services Organization. They are now getting into the R&D area. He talked about three projects now being undertaken by PWC.

- Project Ice Box
- Project Snow Bowl
- Cold Storage Aquifer Demonstration Project

With severe winters, and snowfall of 90 inches to 200 inches/year, Canada is ideally situated for ice cooling applications.

PROJECT ICEBOX

Project icebox involves the seasonal storage of winter cold in the form of ice, for summer air-conditioning. The technique used is to naturally freeze water into a large above-ground box. The box is an open venetian-blind type wall structure that is hollow inside. The louver slits that compose the walls are sloped with their lower edges inward towards the inside of the structure. During winter, water is flooded or sprayed into the structure so that ice is formed by the naturally low temperatures and wind factors. As the ice increases in thickness, it freezes onto the louvers, sealing the edges of the box. Further addition of water causes freezing to proceed upwards. The thickness of the block of ice produced is dependent upon the weather and the size of the structure. In the summer the box is enclosed with insulated panels to inhibit natural melting, so that controlled melting can be used for cooling.

During the winter of 1979-1980, PWC tested such an icebox design. The box dimensions were 8 ft x 8 ft x 12 ft high. The structure was fabricated from wood, and panels of polystyrene were progressively affixed to the outside of the box whenever the ice thickness approached the panel width. The experiment included spraying with different types of nozzles, and flooding/freezing experiments. Actual ice making did not start until January 30th and Ottawa had a mild February that year. Nevertheless, by March 3rd they produced a 9 ft (2.7 m) high block of ice. Projected to a normal winter in Ottawa (8700° F heating degree days) they calculate that a block of ice over 31 ft (9 m) high should be attainable. Their test results show that the icebox approach could be used for most of Canada as well as the northern U.S. states.
At the start of the experiment, spraying was done at 70 gph (0.1 L/s) for test periods of 2-120 min. Temperatures ranged from 18°F to 27°F (-8°C to -3°C) with lows from 3°F to 18°F (-16°C to -8°C). During sunny days, freezing is slow and ice is slushy. In the latter part of February and early March, when the temperatures dropped, spraying was conducted for 3.0 to 5.0 min periods at reduced flow rates. At the colder temperatures the ice grew 2 ft in height in four days. In a continuous 33 day period of good freezing condition 10.1 ft (2.6 m) of ice was produced.

Melting tests were conducted during the last month of May. Water at 60°F (16°C) was poured onto the top of the ice block and drained through a vertical central hole, leaving the block at 36°F (2°C). Under these conditions a melt rate of 35-40 kw (10-12 tons of refrigeration) was established and maintained during the melt time. A minimum melt rate was considered to be 3-4 kw (one ton). Melt rates do not seem to be a limitation with the PWC icebox system.

For complete details, the reader is referred to the publication:

Project Icebox - An Annual Energy Storage System
J. Klassen, P. Eng
ASHRAE Transactions 1981, V. 87, Pt.1

PROJECT SNOW BOWL

At the present time, studies of the use of an adjacent, snow-filled quarry to air-condition the PWC headquarters building in Ottawa are underway. Dr. Morofsky stated that Ottawa receives some 90 to 200 inches of snow each year. During the summer, with temperatures near 80°F (27°C), large mounds of snow remain from the previous winter. The city of Ottawa has been reducing these snow hills recently and trucking the snow outside the city limits, all at considerable expense.

Near the PWC headquarters is an unused quarry that when fully excavated has a volume of approximately 66,000 ft³ (2000 m³). Theoretically this quarry could air-condition some 10⁶ ft² (9 x 10⁵ m²) of building area. They will, however, first attempt to cool the (30,000 m²) headquarters building situated 50 ft (15 m) from the quarry. The quarry depth varies from 20 ft (6.1 m) to 40 ft (12.2 m). The manner of cold extraction is now under investigation. Pipes on the bottom would yield 50 tons of AC, an on open loop heat exchanger would yield 100 tons AC capacity. To fill the quarry with snow, consideration is being given to trucking in city sheet snow and/or using commercial snow making machines as in the Princeton University Project. Dr. Morofsky stated that the salt in city snow should not be a problem as only 10% of it remains in the removed snow with the remainder going down the city drains in melt water. There is a concern about the concentrations of lead in the snow and this question deserves further attention. This concept for snow storage would make an interesting project for the Chicago Area with its many unused quarries.
Dr. Morofsky explained to the workshop that drilling is going on in Toronto that will couple a PWC building to a cold storage aquifer system. Three wells are being drilled, a main well, an observation well, and a geotectonic well. The aquifer is approximately 150 ft (46 m) deep and some 30 ft (9 m) thick.

This is a method of obtaining very inexpensive storage and should yield considerable savings of capital equipment cost and operational costs. Four wells will be able to take the complete load of the building with a capacity of some 350,000 ton-hrs of AC. For further information the reader is encouraged to contact Dr. Morofsky at PWC.
DESIGN OF A NOVEL ICE GENERATION FACILITY
S. Buies, Industrial Research Center of Quebec
(Compiler's summary of oral presentation)

Mr. Sarto Buies an engineer from the Centre de Recherche Industrielle du Quebec (CRIQ) presented to the workshop detailed mechanical drawings for a unique ice generation facility. Mr. Buies wishes to use winter's ice for summer cooling of a portion of his research center in Quebec. He is, however, of the opinion that growing blocks of ice several tens of feet high may not be possible even in Quebec. His scheme is to grow truncated pyramids of ice (7.5 ft (2.3 m) high) one above the other in an insulated warehouse. Mr. Buies detailed drawings are available at Argonne National Laboratory for the interested reader.

The general configuration of the CRIQ system is as follows. An insulated ice warehouse is to be constructed. This warehouse will be 25 ft (7.6 m) high with the lower 8 ft (2.4 m) underground. The walls will be insulated with fiberglass to R-27 and the roof to R-60. Inside the structure two pyramids of ice will be grown one above the other with a 3 ft (0.91 m) space between them. Each pyramid will have a base of dimensions 40 ft by 40 ft (12.2 m). The height of each pyramid will be 7.5 ft (2.3 m). The warehouse is a steel structure supported by columns extending down to bed rock. In this way, the foundation will be independent of ground conditions. The ice will be formed by spraying water and flowing air from above each ice pyramid forming structure. The ice pyramid form is attained by use of a wooden vertical slit configuration. The slits are 40 ft long x 8" (20.8 cm) high x 1" (2.54 cm) thick. They are staggered inward as one approaches the top of the pyramid. The ice is formed in thin layers similar to the PWC icebox method.

The spraying of water and the fan-forced flowing of cold winter air are controlled such that one does not produce snow. In the ice growing season both pyramids will be grown at the same time.

The many fine engineering details of this facility will not be presented here. The serious researcher is again referred to the detailed plans at Argonne or can contact Mr. Buies directly. This is a universal type design such that a structure several stores high can be envisioned. A detailed cost analysis of this design is now underway, and Mr. Buies is of the opinion that the economics are favorable.
AN AIR-CONDITIONING SYSTEM USING NATURALLY-FROZEN ICE
D. L. Kirkpatrick, Princeton University
(Compiler's summary of oral presentation)

The work at Princeton University was given its original impetus by physicist Ted Taylor. The Princeton group was well represented at the workshop with Dr. T. Taylor, Dr. R. H. Socolow, and Dr. D. L. Kirkpatrick who made the formal presentation to the group. Princeton is working with the Prudential Insurance Company on this ice growing project. Their technique shows significant promise of widespread energy and cost savings for large scale building cooling applications.

The Princeton effort can be divided into two phases. Phase I occurred during the winter of 1979-1980. In this phase a earth pit was excavated to be used as an ice reservoir. This ice reservoir was 69 ft (21 m) square at the top and 15 ft (4.5 m) deep, having a volume of 42,000 ft$^3$ (12000 m$^3$). The reservoir is not insulated, but lined with 6 mil thick reinforced polyethylene film. To produce the ice during winter a low energy consumption commercial snow machine (SM) was used. The power requirement for the SM is approximately 25 Kw. Ice-making in Phase I took place during February 1980. After 335 hours of operation, the SM produced some 57,000 ft$^3$ (1600 m$^3$) of ice in the reservoir. The phase I ice production COP was estimated at a COP of 8.9. The researchers state that this is a lower limit as the ice was produced under non-optimal conditions. Large amounts of snow were lost because no cover existed at this phase and the mass was unprotected from the elements. Despite these problems they still had approximately 21,000 ft$^3$ (600 m$^3$) at the start of the cooling season. This stored volume was then used to cool a one-story laboratory building system. Including the SM, the summertime pumping, and the fan energy usage, the system COP was 7.9.

Phase II is intended to develop improved operating procedures and to obtain a better understanding of the physical mechanisms of ice production. In this Phase the reservoir is 60 ft (18 m) in diameter and 15 ft (3 m) deep. The side slope is 1:1.5. A 30 mil thick PVC liner is now being used. Over the basin shaped reservoir a tent-like cover is positioned. The sides of this cover can be partially opened allowing cold air circulation. In addition to a SM mounted above the reservoir the Princeton group is testing atomizing spray nozzles which are on the cover-supporting structure.

The first full scale air-conditioning ice storage system is planned for an energy conserving office building which Prudential Insurance will erect in 1981 at the Princeton Forrestal Center. This building will have a cooling requirement equivalent to 5000 tons of ice. A total annual savings of the order of $12,000 or greater is expected.

For additional details the reader is referred to the Princeton Group paper given below:
A Unique, Low-Energy Air-Conditioning System Using Naturally-Frozen Ice

D. L. Kirkpatrick, M. Masoero, R. H. Socolow, T. B. Taylor
Center for Energy and Environmental Studies
Princeton University
Princeton, N.J. 08544

SOME PROJECTS OF ADVANCE ENERGY TECHNOLOGIES, INC.
E. J. O'Hanlon, A.E.T, NY

(Compiler's summary of oral presentation)

Mr. Edward J. O'Hanlon is the president of Advance Cooler Manufacturing Corporation and its subdivision Advance Energy Technologies, Incorporated. Mr. O'Hanlon has worked in energy conservation and solar applications for over a decade. Some of his early accomplishments are given below.

1969 - Advance started developing ideas on Foam-Lock™ building construction to conserve energy.

1969 - Completed the first 6-sided monolithic Zeroenergy™ building.

1973 - Construction of Advance Headquarters in New York State the first large Commercial Zeroenergy™ building.

1974 - Designed and constructed New York State's first solar heated Zeroenergy™ experimental building.

1976 - Construction of the Halfmoon, NY Town Hall.

The Halfmoon Town Hall near Clifton Park, New York contains many of Mr. O'Hanlon innovations. One feature of this building is the ability to move heat downward without the use of pumps or electricity. Heat is collected in solar collectors and is passively transferred (via SO2) to an underground sand bank below the floor. The Halfmoon Town Hall also has a passive ice storage system. Heat pipes, filled with SO2, passively form ice in an underground water tank. The ice is formed around a cylindrical evaporation network under the water. No provision is made for ice release. The ice system is used primarily for humidity control when the sand bank under the building can no longer adjust the enthalpy of the building air. This allows them to use a relatively small ice tank since they have the very large sand bank for primary cooling.

Mr. O'Hanlon shared with the workshop members his belief that the concept of ice storage has much broader applications than just space cooling. For example, cooling vegetables, industrial cooling, food preservation.

Mr. O'Hanlon is now involved in the planning of a new solar town called New Village. When completed, some 190 homes will populate this small settlement in southwestern Pennsylvania.

Mr. O'Hanlon interests range from solar greenhouses and R-40 garage doors to the construction of a complete community of 600 people. A visit to his company is recommended to the serious investigator.
ICE STORAGE, THE COOLING SYSTEM THAT BENEFITS CUSTOMER AND UTILITY

K. Pientka, Commonwealth Edison

(Compiler's summary of oral presentation)

Mr. K. Pientka stated that the increased demand for electricity in the summer experienced by many utilities can be traced to the extensive use of air conditioning. "This temperature sensitive load has forced utilities to invest in plants that are only necessary for a short time each year. As a result, sharp increases in summer demand rates have to be applied by utilities. These higher summertime charges has caused the cost of air conditioning a building to rise at an accelerated rate when compared to other space conditioning costs. Therefore, the economic incentive for both the utility and their customers to reduce peak cooling demands has become more pronounced with each cooling season. A cooling system that could generate cold BTU's during periods of reduced electrical demand, and then store these cold BTU's for use during peak periods would benefit the utility by reducing peak systems loads, and benefit the customer through reduced cooling costs resulting from lower demand charges.

"Attempting to find a positive solution to this negative and growing trend Commonwealth Edison Company, the electric utility that serves approximately the northern one-third of Illinois, including Chicago, has embarked on a marketing program to promote the concept of ice storage to both new and existing customers. This program has been implemented to help reverse the trend of a declining system load factor by shaving peak demands and to increase the use of electricity in off peak periods. The program is tailored to the company's generating characteristics. Currently, Commonwealth Edison's base load is generated almost exclusively by low-cost nuclear and coal-fired generating stations. The daytime peak load is met with the use of less efficient coal plants, high cost oil-fired generation, and peaking units. The shifting of kilowatt hours to off peak periods with ice storage will allow Commonwealth Edison to supply a much larger percentage of a building's cooling energy requirements with the company's efficient base-load units."

An ice storage system is now being incorporated into the plans for a three story 68,000 ft² (6,300 m²) office building for the Federal Life Insurance Company.

"The ice storage system was designed by Globe Engineering Company of Chicago, and is being installed by Borg Mechanical Contractors, Inc. of Hillside, Illinois. Two 45-ton reciprocating compressors; two evaporative condensors, each having a 10 horsepower fan and a ½ horsepower pump; and two 80,000-pound ice builders, each having a 5 horsepower agitator, are included in the system. On design days it is expected that the system will have to operate 16 hours per day to meet the maximum daily cooling requirements of 1,220 ton-hours. During the entire cooling season it is expected that only off-peak compressor operation will be required to meet the building's cooling needs. Since the demand created by the storage system is less than the normal daytime demands, no demand charge is incurred for the operation of this equipment."
"Federal Life's ice storage system will have replaced a conventional 200 ton chiller at no additional first cost to the owner. It is estimated that the peak cooling demand, including auxiliaries, will be reduced from 259 kilowatts to 143 kilowatts, and the peak billing demand reduced from 259 kilowatts to 7 kilowatts. As a result of this lower billing demand, an annual demand charge savings of $7,080 is expected. This savings equates to a 41% reduction in the total cooling bill. The estimated savings are based only on a reduction in the demand charges. However, the potential for reduced cooling energy consumption with this system may be realized through more efficient compressor operation and lower nighttime condensing temperatures."

"In addition to providing many user benefits, the ice storage cooling system can be advantageous to electric utilities because of its load leveling characteristics. Ice storage will allow utilities to reduce their system peaks, and to more intensively use their existing generation, transmission, and distribution facilities. One way to measure how intensively existing facilities are being used is load factor. In the case of Federal Life Insurance, it is estimated that by reducing its peak demand by 116 kilowatts, the seasonal load factor for the entire building will be improved from 29% to 37%, and that the seasonal load factor on the air conditioning system will be increased from 19% to 35%.

"The reduction in peak cooling demand also results in increased energy consumption in off peak periods. Therefore, the utility is allowed to meet a larger portion of the building's cooling energy requirements with efficient, low cost, base load generating equipment in lieu of high cost peaking units."

"Installation of an ice storage system appears economically advantageous for both the user and the utility. The user benefits from reduced cooling costs, while the utility benefits from lower peak system loads and increased use of electricity in off peak periods. More importantly, the utility's long range advantages are estimated to be even more substantial. If enough ice storage systems are installed, a utility's peak system load growth could be reduced to the point where the commitment to a new generating plant could be delayed or deferred."

Quotations given above are from tape recording of Mr. Pientka's presentation. The interested reader is referred to paper given by Mr. Pientka:

Ice Storage - The Cooling System that Benefits Customer and Utility

K. Pientka

To be published in Electric Energy Management News
August-September 1981
UNEXPECTED ADVANTAGES FROM ICE COOLING SYSTEMS
C. MacCracken, Calmac Manufacturing Corporation, NJ
(Compiler's summary of oral presentation)

Mr. Calvin MacCracken, president of Calmac Corporation, shared with the workshop some observations of working ice storage systems for cooling applications. Mr. MacCracken is of the opinion that cooling storage is really applicable to the commercial-industrial sector and that residential cooling storage "will not fly". Mr. MacCracken is however very optimistic about the commercial-industrial market. His company is now in the process of setting up to mass produce ice storage units. Calmac has installed some 50 cooling systems for Long Island Lighting.

The Calmac cooling technique is to couple a standard prepackaged chiller unit to a plastic tube heat exchanger fitted inside a plastic tank. The tanks have diameters and heights of 4 and 6 feet. Capacities are 33 ton hours and 130 ton hours. The pipe is 0.5 in. polyethene, with a length of approximately one mile in the 4 foot unit. Mr. MacCracken states that they do not have expansion problems with these storage systems. The trick is to give the water an escape route. The expansion is vertically upward only.

Mr. MacCracken than listed some unexpected and encouraging observations from an installation in Braintree, Massachusetts.

- The first cost of an ice system is 30% lower than that of a conventional system.
- Because the air coming off an ice coil is 38°F to 40°F you have in essence more BTU's per lb. of air.
- Savings are realized due to smaller blowers (CFM is lower) and smaller sized duct systems. The duct system amounts to approximately 1/2 of the total system cost. Small-round Owens Corning Fiberglass duct systems are now being used in place of more expensive sheet metal duckwork.
- There is no frosting of the coils problem in an ice system.
- There are two design options as to storage size:
  (1) Small storage coupled to a 1/2 size chiller that runs 24 hours a day. This option saves 1/2 of the chiller cost plus 1/2 of the demand charges.
  (2) Large storage coupled with the transferring of the day load to night time. With the AC load in the night time hours only, one could have no demand charges.
- Air-conditioning with ice saves energy. A conventional system operates normally at 60% RH and 75°F thermostatic setting. With 30% RH off an ice system, only on 80°F thermostatic
setting is required for human comfort. A savings of 5°F can be obtained by the use of a ice AC system.

- It is possible that much less ventilation air is required in a building cooled with an ice system. Indications are that with a cold coil, having close fin spacing, an air wash effect is being observed. Smoke and other particle matter is being removed by the high condensation wash of the ice system. If this is indeed the case, another considerable savings of operating cost would be realized.

- Operation of the Braintree installation indicates that ice AC systems have a very fast response time. In a conventionally cooled commercial building the AC is normally turned on an hour or so before people arrive. In the Braintree installation, 43°F air was obtained in 17 seconds!

Note that all the benefits mentioned above are only for a partial time air conditioned building. Mr. MacCracken states that these advantages would not all be obtained from a building cooled 24 hours a day. He also stated that in a present-day modern office building the main load is the cooling. Modern office buildings do not need much, if any, space heating.
ICE GROWING EXPERIMENTS AT PURDUE UNIVERSITY AND
KANSAS STATE UNIVERSITY

Professor Robert J. Schoenhals and Dr. S. L. Chao have investigated the application of a closed two-phase thermosyphon (gravity-return wickless heat pipe) in a seasonal cold energy storage system. These Purdue University researchers were not able to attend the workshop but some of the details of their work were presented by Mr. A. Gorski from Argonne. Dr. Schoenhals and Dr. Chao have studied, in the laboratory, the effects of various parameters on the volume and shape of the grown ice, the temperature profile along the tube, and the thermal performance of the system. The parameters chosen for investigation include the amount of working fluid, length of pipe, inlet coolant temperature and cooling time. Based on their experimental results, these researchers have come to the conclusion that "the closed two-phase thermosyphon appears to possess very good potential as an ice-producing device". The results of their experimental investigation will be presented at the ASME-AIChE 20th National Heat Transfer Conference, in Milwaukee WI, August 2-5, 1981. For a complete technical exposition of heat pipes, the interested reader is referred to the authoritative book listed below:

Heat Pipes
by P. Dunn and D. A. Reay

Dr. John Anschutz at Kansas State University also was not able to attend. Mr. A. Gorski presented the essential elements of the KSU technique. Dr. Anschutz starts out with an empty open topped insulated tank buried in the earth. Suspended above the bottom of the tank floor is a plywood plate with a hole in the center. A blower at ground level is connected via a hose to the hole in the plate. The plywood plate can be moved upward by means of a motor driven cable assembly. Operation during the winter starts out with an empty tank. Water is injected into the tank such that a layer about 0.2 deep inches is formed. The plate is placed a few inches above the water. The blower is then turned on, and a cold stream of winter air passes through the center of the plate across the surface of the water and out the sides. When the water is frozen, the plate is raised, another thin layer of water added, and the blower is turned on again for another freezing cycle. Dr. Anschutz has a microprocessor controlling the water, plate and blower. He is now developing means of instrumentation for freezing ice in layers. His work will be published at the Meeting of The American Society of Agricultural Engineering in Orlando, Florida this year. The title of the paper is "Making Ice in Winter" by Dr. J. Anschutz and Dr. R. Lipper, paper no. 81-4048.
LONG-TERM ICE STORAGE FOR COOLING APPLICATIONS
A. J. Gorski, Argonne National Laboratory

The objective of this project is to develop a cost-effective passive method of solar cooling using natural ice formation in the winter to provide year-round cooling needs. The technique used freezes ice where it will be stored by means of passive refrigeration devices (modified heat pipes). The essential features of this technique are as follows:

A tank of water is buried underground near or under the building to be cooled. A series of heat pipes extend from the bottom of the tank to above the soil surface. These heat pipes act as very efficient one-way conductors of heat. Along the under-water evaporator section, heat from the water causes thin-film evaporation of the working fluid within the unit. The resulting vapor travels upward and condenses in the above-ground radiator section, releasing the transported heat to the air. During winter months when the ambient temperature is below freezing, the extraction of heat freezes ice along the submerged portion of the heat pipe. When the air is warmer than the water in the tank, the evaporation-condensation cycle stops automatically. The heat pipe thus works as a one-way conductor of heat from the tank to the environment. Ideally the pipes would be designed such that the ice would break off periodically and float to the surface. In this manner the tank would slowly fill with ice from the top down. The ice is thus formed and stored passively in the same container, ready for further use.

In the fall of 1979, construction was started on a full size outdoor facility. Full size heat pipes can now be tested and run during an actual Illinois winter. The thermal performance of a complete system can now be automatically monitored through the winter-freezing summer-cooling season. This facility, known as the AISTF (Argonne Ice Storage and Test Facility) has the following features.

<table>
<thead>
<tr>
<th>Construction</th>
<th>Reinforced Concrete Tank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions</td>
<td>4.9 m (16') x 4.9 m x 4.9 m</td>
</tr>
<tr>
<td>Insulation</td>
<td>23 cm (9&quot;) Stryrofoam™ (inside tank)</td>
</tr>
<tr>
<td>Liner</td>
<td>Shelter Rite XR-5™</td>
</tr>
<tr>
<td>Water Capacity</td>
<td>20,000 gallons</td>
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<tr>
<td>Thermal Capacity</td>
<td>2.2 x 10⁹ BTU's of Cooling Energy</td>
</tr>
</tbody>
</table>

During the winter of 1979-80 two cylindrical type heat pipes were tested in the facility. These pipes were constructed from 1.5" dia. iron pipe, and filled with R-12 (Dichlorodifluoromethane) refrigerant. Indoor experiments with a small 4 foot long prototype indicated that by adding two fins axially, 180° apart, to the underwater evaporator section ice release could be attained. This was not observed outdoors due to limited winter freezing conditions. This design has the major disadvantages of relatively small evaporator area, and expensive condenser fin area.

In the summer of 1980, the use of Roll-Bond™ panels was considered for the heat pipes. These commercially available panels have several
advantages. First, they have a large effective area (8 ft long by 12" or 34"
wide). They are also available in copper or aluminum and are relatively low
in price. These panels are now widely used as solar collector absorber
plates. Using these panels a new type of ice freezing heat pipe has been
developed. The underwater evaporator section now consists of a central
vertical PVC pipe to which is connected four equally spaced, vertical fins of
Roll-Bond™ panels. These four fins are the heat pipe panels upon which the
ice is grown. These panels are connected to refrigerant supply and return
lines (inside the PVC pipe) which are in turn coupled to condensing panels
mounted outdoors. Around the edges of the fin panels, rubber edging is
applied to prevent ice from locking on. Although complex at first glance,
these evaporator units are quite simple and can be made with only common hand
tools. The completed facility consists of four such units. Each evaporator
section is connected to an outdoor condenser section mounted on the wooden
shelter structure. A condenser unit consists of four (d' x 34") panels
plumbed together. The refrigerant liquid return is at the bottom of the
panels and the vapor input line at the top. Condensers are mounted on the
north wall of the shelter as well as on the east and west facing roof
sections.

Only limited operational experience has been obtained this winter. Due
to unavoidable delays, the system was not completed until the last two weeks
of January, 1981. During these two weeks, the Chicago-land area experienced
an unusual mid-winter warm spell with temperatures up to 10°C (50°F). The
first two weeks in February had temperatures in the range -12°C (10°F) to
-26°C (-15°F). After that an extended warm spell with temperatures up to 16°C
(60°F) completed the month.

Large amounts of ice were grown from all pipes during the two week cold
spell. Ice release has been observed from all pipes but not as yet in a
totally consistent manner. More operational experience is needed to determine
the effects of refrigerant charge, and condenser orientation on ice production
and release.

An economic analyses indicates that a residential Ice Storage System in
the range of $6K to $9K should be economically competitive with conventional
AC units. This price range can be attained by incorporating the tank under
living quarters during new home construction. Cost estimations indicate a
stand-alone system in the range of $10K to $14K, and a system under the garage
$7.7K to $11.5K. An ice system under the living area should cost $4.6K to
$8.2K. By using the crawl space under the same homes the range would be $6.4K
to $10.5K.

For more information, the reader is referred to the following two papers:

Long-Term Ice Storage for Cooling Applications
Using Passive Freezing Techniques
A. Gorski, et. al.
Proceedings of the Fourth
National Passive Solar Conference
October 3–5, 1979
Kansas City, Missouri
Page 462
and

Cooling by Means of Passively Grown Ice
A. Gorski, et. al.
AS of ISES Solar Rising Conference
Philadelphia Civic Center
May 26-30, 1981
Paper No. 574
TECHNICAL AND ECONOMIC PROBLEMS

The workshop leader for the section was Dr. W. McIntire of ANL. Dr. McIntire introduced to the workshop Mr. R. Giese from Argonne Energy and Environmental Systems Division, who then presented some results from their work for the Office of Advanced Conservation Technologies, U.S. Department of Energy. The title of Mr. Giese's presentation was Cool Storage in Commercial Buildings for Electric Load Leveling. The objectives of this report were:

- Identify Cost-Effective TES Systems
- Identify R&D Work
- Perform Regional Market Assessment
- Make Electric Rate Recommendations

Mr. Giese concentrated his presentation on the first objective given above. The system design concepts and variables are listed below:

- Full vs. Partial Storage
- Ice vs. Chilled Water Storage
- New vs. Retrofit Applications
- Integral-with-building vs. Detached Location of Storage
- Duration of Design-Day Cooling Load

The cool storage systems considered in this work are commercial chillers coupled to chilled water storage and commercial ice makers coupled to ice storage in water. The design characteristics for the chilled water systems are:

- Cast-in-place Concrete Tank Fabrication
- Nozzle Matrix Stratification Technique
- 100 gals of water storage provides 1-ton-hour of cooling capacity
- Fully charged Temperature = 40°F
- Fully Discharged Temperature = 58°F
- Tank Stratification = 80%

The ice storage characteristics included cost vs performance data from Caloskill and Continental commercial units. The chilled water system cost vs performance data is based upon screw-type chillers using manufacturers performance data. Using the rate structure of Commonwealth Edison, PEPCO, and an Avoided Cost Analysis, a total rate analyses was calculated for a commercial building in Washington, DC and Chicago, IL. For each location the annual utility bill was calculated for a conventional system, a partial Storage system (both water and ice), and a full storage system (both water and ice). The major conclusions of the calculations are as follows.

- Pay back of 2 to 5 years are possible under all three rate schedules
- Partial Storage Systems provide faster payback then full storage systems.
- In new buildings applications chilled water systems provide
faster payback than ice systems
- Achievement of low storage cost is the most important determination of cost-effectiveness
- Rate schedules with large demand charges provide fastest payback
- Chilled Water systems can save kilowatt hours as well as kilowatts

For the complete details of this work, the reader is referred to Mr. Robert Giese at ANL. The title of his report is:

COOL STORAGE IN COMMERCIAL BUILDINGS
FOR ELECTRIC LOAD LEVELING

prepared for
Office of Advanced Conservation Technologies
U.S. Department of Energy

by
Energy and Environmental Systems Division
Argonne National Laboratory
February 6, 1981

(Compiler's summary of oral presentation by R. Giese)

Note that the third conclusion above is only true for the commercial ice maker units considered in the study. Systems such as produced by Mr. Calvin MacCracken are much lower cost and should be considered separately.

Dr. McIntire then stated to the workshop that in any system comparison one must know what the competition is today. Modern chiller units such as sold by York are much more energy efficient than units sold a few years ago. 70% of chiller units now being sold by York have peak COP's around 4.0, for the chiller alone, and with various options can reduce energy costs by some 30%. It is essential for a true system comparison to avoid taking the worst case situation for the competition.

One member of the workshop stated that one must also consider roof-top AC units. These units are widely used in shopping centers and are very competitive in cost. They are normally rated at 85% of the design load and are low in price as well as COP.

Another workshop member was of the opinion that total energy management must be considered even in residential applications. The coupling of cold and hot sides of various home appliances is a very interesting concept and should be investigated.
The last section of the Technical and Economic Workshop was given by Mr. A. J. Gorski, who presented an economic analysis of the Argonne residential ice cooling system.

Two competing AC systems were considered in this analysis, active solar cooling and conventional air-conditioning. For an active solar system, the present day economic situation is as follows.

<table>
<thead>
<tr>
<th>Component</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-Ton Absorption Chiller</td>
<td>$4,000</td>
</tr>
<tr>
<td>450 ft$^2$ of Solar Collector</td>
<td>$15,750</td>
</tr>
<tr>
<td></td>
<td>$19,750</td>
</tr>
</tbody>
</table>

With a $20,000 investment in a system that cannot supply 100% of the cooling load, this option does not seem cost effective at the present time.

Consider the standard AC system found today in most suburban homes today. Capital cost is assumed to be the outside compressor unit at $750 to $1,050 depending on the COP of the unit. The cooling coils and air handling system are assumed to be the same for this AC system and the ice storage system to be compared. Operating costs are a function of electricity rate ($0.055/kw-hr, Chicago Area), fuel escalation rate, interest rate, and lifetime of the unit (assumed 10 years). To compare this conventional system's capital and operating expenses, to an ice tank or solar option with only capital expense, we used a present worth calculation, bringing all future savings/expenses to the present and then comparing present values. Fuel escalation rates, interest rates, and inflation rates are shown below.

<table>
<thead>
<tr>
<th>ELECTRICITY</th>
<th>Chicago</th>
<th>9 YRS.</th>
<th>+ 8.6%/YR.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bismark, ND</td>
<td>3 YRS.*</td>
<td></td>
<td>15.0%/YR.</td>
</tr>
<tr>
<td>Boston, MA</td>
<td>3 YRS.*</td>
<td></td>
<td>15.0%/YR.</td>
</tr>
<tr>
<td>New York City</td>
<td>3 YRS.*</td>
<td></td>
<td>22%/YR.</td>
</tr>
<tr>
<td>(Average)</td>
<td>3 YRS.*</td>
<td></td>
<td>15%/YR.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>INFLATION</th>
<th>Chicago</th>
<th>13 YRS.</th>
<th>5.6%/YR.</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Rate</td>
<td>3 YRS.</td>
<td>7.3%/YR.</td>
<td></td>
</tr>
</tbody>
</table>

**INTEREST RATE 4% ABOVE INFLATION RATE**

With a conventional system, the first year fuel costs (Ao) must be obtained.

If we assume the same amount of cooling from conventional and ice storage system

67-TON-DAYS OF COOLING

OR
67-TON-DAYS X 12,000 \(\frac{\text{BTU}}{\text{TON-HR}}\) X \(\frac{24 \text{ HR.}}{\text{DAY}}\) = 19.3 \(\times 10^6\) BTU

\[ = 5.65 \times 10^3 \text{ KW-HR OF COOLING IS NEEDED.} \]

AT A COOLING COP OF 2, WE MUST BUY 2.83 \(\times 10^3\) KW-HR

"          " 2.5, "        2.26 \(\times 10^3\) KW-HR

NOW, USING

1) CHICAGO SUMMER RATE OF 0.055/KW-HR

\[
\text{COP} = 2.0, \text{ Ao} = \$155 \\
\text{COP} = 2.5, \text{ Ao} = \$124
\]

2) N.Y. SUMMER RATE OF $0.139/KW-HR

\[
\text{COP} = 2.0, \text{ Ao} = \$393 \\
\text{COP} = 2.5, \text{ Ao} = \$314
\]

FIRST YEAR COST CAN RANGE FROM

$123 to $393

These factors are now used to bring the fuel and maintenance expenses back to a common time frame (present) where a comparison can be made. The standard equations for such time shifts are given below.

\[
\text{PRESENT VALUE FUEL} = \text{Ao} \frac{(1+E)}{(1-E)} \left[ 1 - \frac{(1+E)^N}{(1-I)^N} \right]
\]

\[
\text{P.V. REPLACEMENT UNIT} = \text{COST} \left\{ \frac{1}{(1+I)^N} \right\}
\]

The present value of an conventional AC system was assumed to be the initial cost, plus the present value of the fuel used, plus the present value of the replacement compressor (10 years). Results for Chicago and New York with various values for the incremental fuel and interest rates are listed below. The last column is the present value of the fuel used in the total lifetime of the system (20 years).
The replacement compressor 10 years from now has a present value of

\[ \text{cost} \left( \frac{1}{(1+1)^{10}} \right) = \text{cost} (0.68) \]

The total present value of a conventional AC system is:

<table>
<thead>
<tr>
<th>CASE</th>
<th>COP</th>
<th>LOCATION</th>
<th>I.C.</th>
<th>P.V. COMP</th>
<th>P.V. FUEL</th>
<th>TOTAL P.V.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>2.5</td>
<td>CHICAGO</td>
<td>1,050</td>
<td>709</td>
<td>2,244</td>
<td>$ 4,003</td>
</tr>
<tr>
<td>II</td>
<td>2.0</td>
<td>CHICAGO</td>
<td>750</td>
<td>506</td>
<td>2,805</td>
<td>$ 4,061</td>
</tr>
<tr>
<td>III</td>
<td>2.5</td>
<td>N.Y. WITH L.E.</td>
<td>1,050</td>
<td>709</td>
<td>5,682</td>
<td>$ 7,441</td>
</tr>
<tr>
<td>IV</td>
<td>2.0</td>
<td>RATES</td>
<td>750</td>
<td>506</td>
<td>7,113</td>
<td>$ 8,369</td>
</tr>
<tr>
<td>V</td>
<td>2.5</td>
<td>CHICAGO AVERAGE ESCAL.</td>
<td>1,050</td>
<td>709</td>
<td>3,773</td>
<td>$ 5,532</td>
</tr>
<tr>
<td>VI</td>
<td>2.0</td>
<td>AVERAGE ESCAL.</td>
<td>750</td>
<td>506</td>
<td>4,717</td>
<td>$ 5,973</td>
</tr>
<tr>
<td>VII</td>
<td>2.5</td>
<td>N.Y. AVERAGE ESCAL.</td>
<td>1,050</td>
<td>799</td>
<td>9,556</td>
<td>$11,315</td>
</tr>
<tr>
<td>VIII</td>
<td>2.0</td>
<td>AVERAGE ESCAL.</td>
<td>750</td>
<td>506</td>
<td>11,960</td>
<td>$13,216</td>
</tr>
</tbody>
</table>

The average rate for 16 utilities was $0.054/kW-hr with an average escalation rate of 8% above inflation.

Cases V and VI below represent a "target value".

The solar (ICE) system probably qualifies for the tax credit, therefore, 40% of the initial cost can be deducted, giving the following tale of competitive values:
The conclusion of this analysis is that if a residential ice cooling system can be built for $6,000 to $9,000 it should be economically competitive with conventional air-conditioning systems.

The next question is, of course, is it possible to build a system for this price range? In order to answer this question Argonne contacted a local home builder and priced out various system siting options.

Option A - Stand alone system in backyard
Option B - System under garage*
Option C - System under living area*
Option D - System using crawl space*

*(SYSTEM BUILT DURING NEW HOME CONSTRUCTION)

The results are shown below:

<p>| EXCAVATION | $202.00 | $101.00 | $103.00 | NONE |
| BACKFILL | ($2.00 YD.) |
| CONCRETE | $2,392.00 | $235.00 | $869.00 | NONE |
| ($100 YD.) | |
| COVER | $3,355.00 | $3,355.00 | NONE | NONE |
| (FLEXIBLE) | |
| DIMENSIONS | 15'X26X7' D | 15'X26X7' D | 20'X20'X7' D | 40'X26X3.5'' D |
| VOLUME | 20,420 GAL. | 20,420 GAL. | 20,944 GAL. | 27,227 GAL. |
| CONCRETE TANK COST | $5,949.00 | $3,691.00 | $972.70 | NONE |</p>
<table>
<thead>
<tr>
<th>Option</th>
<th>Stryrofoam Insulation</th>
<th>Stryrofoam Labor</th>
<th>Stryrofoam Liner</th>
<th>Urethane Insulation</th>
<th>Urethane Labor (Spray)</th>
<th>Urethane Liner</th>
<th>Insulated Concrete Tank Cost</th>
<th>Heat Pipes (16)</th>
<th>Total Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$4,576.96</td>
<td>$4,576.96</td>
<td>$4,050.55</td>
<td>$3,154.36</td>
<td>$3,154.36</td>
<td>$2,843.92</td>
<td>$4,576.96-$10,525</td>
<td>$50 -- $200</td>
<td>$9,903-$13,725</td>
</tr>
<tr>
<td>2</td>
<td>$3,154.36</td>
<td>$3,154.36</td>
<td>$2,843.92</td>
<td>$5,550.00</td>
<td>$5,550.00</td>
<td>$5,550.00</td>
<td>$6,845-$8,267-$3,816-$5,023</td>
<td>$5,550-$7,304</td>
<td>$7,645-$11,467</td>
</tr>
</tbody>
</table>

Note that such a system can be built in the price range of $6,000 to $9,000 if the system is incorporated into the house during new home construction. Option C, sitting the tank under the living quarters, would seem to be the most cost effective, being in the range of $4,600 to $8,200.
The workshop leader for the Application section of this workshop was Dr. William Schertz of ANL. Dr. Schertz started the group discussion by presenting a viewgraph showing some applications of ice cooling. These are listed below:

- Natural Gas Cooling
- Air-Conditioning
- Load Shaving
- Dairy Industry
- Produce Cooling
- Desalination
- Commercial Ice Production

Other applications and comments from the workshop members included:

- Industrial Process Cooling (IPC) (Using about 2 Quads nationally)
- IPC would require inexpensive ice at approximately 20¢/ton
- Water purification by freezing
- Possible modification of alcohol production using ice cooling
- Large-Scale Temporary Uses. The cooling of large man-made monoliths such as concrete dams, MX missile structures
- Bottoming cycles for power plants. This would be hard to do, requiring large amount of ice at few ¢/lb.
- Office water cooler. Has the energy consumption of this common appliance has ever been studied?
- Grain storage at 50°F. The cooling process would slow down the chemistry and biology of the decay processes.
- Mine Cooling. In mining operations cooling of the incoming air is necessary. (Underground Air-Conditioning).
- Telephone Company Applications. The cooling of telephone switching gear is another possible application.
Community Systems

It was also noted that the general application of air-conditioning should be separated into residential and commercial/industrial. Each requires special considerations and different techniques, i.e., the Calmac and Princeton methods would be more applicable to commercial installations, while the Argonne method is more suited to residential use. For very large applications the use of empty quarries is very attractive. Here the use of snow machines or snow from city streets would be considered.

In general, the consensus of this workshop was that these various methods of using winters ice for summer cooling can have a major impact on our nations cooling energy consumption. One member of the workshop stated that these techniques have the potential of saving "billions of dollars" annually.

The workshop leader for the Codes section of the workshop was Dr. Chuck Roberts. Dr. Roberts stated that the matter of codes is usually not considered much of a problem, but that he has seen major projects stopped due to code violations. The matter of codes must be taken seriously. Some of the major code considerations pertaining to ice cooling are given below:

- Structural Problems -
  - Inspection of materials
  - Drainage from ice reservoirs
  - User rights

- Looks - The system must be attractive to the user and general public

- Installation personnel - Serious consideration must be given to the technical qualifications of the installer. Many solar installation problems have been traced to improper installation. Many times Code Officials are trained by the system vendor.

- DOE Energy Grants - In general diurnal ice cooling systems save demand charges more than energy. A question to be yet answered is whether these systems will be eligible for energy-saving government grants.

- Liability
  - Safety
  - Insurance Considerations
  - Suits
  - Complaints in courts
It was also stated by Mr. Calvin MacCracken that DOE has funded a Code Recommendation Document for the solar industry that would be useful to the ice cooling effort. Working with the Council on American Building Officials (CABO), as well as many other building groups and users, DOE has published this document as a recommendation to the various states. Storage requirements are covered in this document and it is recommended that interested workshop members obtain a copy. For more information contact Mr. Dave Parrish of DOE or Mr. Calvin MacCracken at Calmac.
In this period of severe federal budget restrictions, the problem of funding is of the upmost importance. Dr. William Schertz stated the opinion, shared by most of the workshop, that diurnal ice storage is commercial now—but seasonal storage needs more R&D funding. The following possible sources of funding were then discussed.

- Department of Energy (DOE)
- International Energy Agency (IEA)
- National Laboratories
- Department of Defense (DOD)
- Electric Power Research Institute (EPRI)
- Saudi Arabia
- Department of Agriculture (DOA)
- Housing and Urban Development (HUD)
- States

The representative from DOE stated the funding situation for this year is not good. Small amounts of dollars will be available this year for non-aquifier storage but there is heavy competition for these limited funds. The DOE representative did give the workshop encouragement in the statement that some portion of these funds will go for ice storage work. There is some hope that the financial situation will improve next year.

There does not seem to be hope of obtaining funding from the IEA.

Representatives from ANL and PNL stated that the national laboratories have no source of contingency funds by which they could fund ice storage work. Although it is often thought that the Department of Defense would now be a good funding source, this may not be the case. DOD seems to be cutting energy dollars while increasing defense dollars.

The Electric Power Research Institute (EPRI) may be a possible source of funding. One workshop member stated although they have been primarily in the utility side of storage, they are now getting into the user side.

Saudi Arabia may be a possible funding source. The world's largest solar installation will be there and water and "cold energy" are very valuable. It was stated that the south-western part of the country has snow covered mountains some 10,000 feet high bordering the red sea. (Hadur Shuagl is some 12,336 feet above sea level.)

The funding situation of the Department of Agriculture (DOA) is not known.
Workshop members stated that Housing and Urban Development (HUD) would probably not be a viable funding source. Although the individual states are under funding restrictions they may be a possible source. The state of Arizona was mentioned especially.

Because the present day funding situation is not good, it is essential that every possible source be explored. The vast potential of this cooling technology to the nation's energy needs can not be reasonably denied.

The final activity of the workshop was the decision to join together in a formal society to be known as The Ice Society. The society base will be the Argonne National Laboratory which will act as a clearing house for information exchange and dissemination. The vehicle of this information exchange will be the International Ice Newsletter. It is the intention of this newsletter to disseminate ice cooling information as quickly as possible. If you have research results or suggestions or comments about ice storage for cooling applications we invite your submission. Your information will be included without lengthy review and transmitted to a wide range of interested organizations. Our numbers are small but ours is an idea whose time has come.

If you have a submission, or would like to be added to the Newsletter mailing list contact:

THE ICE SOCIETY
c/o Mr. Anthony J. Gorski
Argonne National Laboratory
9700 South Cass Avenue
Argonne, IL 60439
LIST OF PARTICIPANTS

<table>
<thead>
<tr>
<th>Name</th>
<th>Affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. George W. Austin</td>
<td>Commonwealth Edison</td>
</tr>
<tr>
<td>Mr. Sarto Buies</td>
<td>Secteur Materiaux et procedes Industriels (Quebec) GLV4C7</td>
</tr>
<tr>
<td>Mr. Leslie Burris</td>
<td>Argonne National Laboratory</td>
</tr>
<tr>
<td>Dr. Edgar H. Buyco</td>
<td>Purdue University</td>
</tr>
<tr>
<td>Prof. C. E. Francis</td>
<td>Illinois State University</td>
</tr>
<tr>
<td>Dr. William R. McIntire</td>
<td>Argonne National Laboratory</td>
</tr>
<tr>
<td>Mr. Brian Gallagher</td>
<td>University of Wisconsin</td>
</tr>
<tr>
<td>Mr. Robert Giese</td>
<td>Argonne National Laboratory</td>
</tr>
<tr>
<td>Mr. Anthony J. Gorski</td>
<td>Argonne National Laboratory</td>
</tr>
<tr>
<td>Ms. Arlene A. Juracek</td>
<td>Commonwealth Edison</td>
</tr>
<tr>
<td>Dr. Donald L. Kirkpatrick</td>
<td>Center for Energy and Environmental Studies</td>
</tr>
<tr>
<td>Mr. Calvin D. MacCracken</td>
<td>CALMAC Manufacturing Corporation</td>
</tr>
<tr>
<td>Dr. Allan I. Michaels</td>
<td>Argonne National Laboratory</td>
</tr>
<tr>
<td>Mr. Edward L. Morofsky</td>
<td>Public Works Canada</td>
</tr>
<tr>
<td>Mr. Edward J. O'Hanlon</td>
<td>Advance Energy Technologies Incorporated</td>
</tr>
<tr>
<td>Mr. Joseph J. Peerson</td>
<td>Argonne National Laboratory</td>
</tr>
</tbody>
</table>

Chicago, IL 60690
Argonne, IL 60439
Princeton, NJ 08544
Englewood, NJ 07631
Hammond, IN 46323
Normal, IL 61761
Washington, DC 20585
Ottawa, Ontario K1A 0H2
Clifton Park, NY 12065
Argonne, IL 60439
Mr. Kenneth Pientka  
Commonwealth Edison  
P.O. Box 767  
Chicago, IL 60690

Dr. John R. Raymond  
Battelle-Pacific Northwest Laboratory  
Box 999  
Richland, WA 99352

Dr. Charles C. Roberts  
C. Roberts Consulting Engineering  
27 West 776 Greenview  
Warrenville, IL 60555

Dr. William W. Schertz  
Argonne National Laboratory  
9700 South Cass Avenue  
Argonne, IL 60439

Dr. Robert H. Socolow  
Center for Energy and Environmental Studies  
Princeton University  
Princeton, NJ 08544

Mr. Brian E. Swaiden, P.E.  
Civil Engineering Laboratory  
Department of the Navy  
Port Hueneme, CA 93043

Dr. Theodore B. Taylor  
Center for Energy and Environmental Studies  
Princeton University  
Princeton, NJ 08544

Mr. Prince Walker  
Argonne National Laboratory  
9700 South Cass Avenue  
Argonne, IL 60439