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Publisher's version / Version de l'éditeur:

Proceedings, First Canadian Building Congress: Energy and Buildings (NRCC 15870) held in Toronto, October 1976, pp. 9-16, 1977-04

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SOLAR HEATING DEVELOPMENT IN CANADA AND ABROAD

by J.R. Sasaki

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Reprinted from
Proceedings, First Canadian Building Congress:
Energy and Buildings (NRCC 15870)
held in Toronto, October 1976
The Canadian Committee on Building Research
of the National Research Council of Canada
p. 9 - 16

DBR Paper No. 726
Division of Building Research

Price 25 cents OTTAWA NRCC 16112

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1.2 SOLAR HEATING DEVELOPMENTS IN CANADA AND ABROAD

J.R. Sasaki, Division of Building Research, National Research Council of Canada, Ottawa

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ABSTRACT.- The paper reviews ongoing Canadian activities related to utilization of solar energy for heating buildings. These include the formation of the Solar Energy Society of Canada, Inc.; a study on the feasibility of solar heating in Canada conducted by the University of Waterloo; and the initiation of six solar-heating demonstration projects under the Canadian Urban Demonstration Program. New activities reviewed are the $550,000 Federal funding program for encouraging solar heating in buildings; the forthcoming solar-heated Senior Citizen Home sponsored by the Province of Ontario; and the ongoing construction of privately-funded solar-heated homes. International activity on solar energy utilization is reviewed for comparison with the Canadian level of effort.

SOMMAIRE.- Cette communication examine les activités canadiennes en cours ayant rapport à l'utilisation de l'énergie solaire pour le chauffage des bâtiments. Celle-ci comprend la formation de la Société de l'énergie du Canada, inc.; une étude de la praticabilité du chauffage solaire au Canada menée par l'université de Waterloo; et le commencement de six projets de démonstration du chauffage solaire à l'intérieur "Canadian Urban Demonstration Program". Les nouvelles activités revisées sont le programme de consolidation fédéral de $550,000 pour encourager le chauffage solaire dans les bâtiments; de futur foyer pour personnes agées avec chauffage solaire subventionné par la province d'Ontario; et la construction en cours de maisons au chauffage solaire financées par le secteur privé. L'activité internationale de l'utilisation de l'énergie solaire est revisée afin d'en faire la comparaison avec le niveau d'effort canadien.

The trend in Canada has been to rely heavily on fossil fuels and hydro-electricity for current energy needs, and on electricity generated by coal-burning thermal plants and nuclear reactors for future energy needs. It is argued by many, however, that renewable energy sources should be developed as possible alternative solutions to our future energy requirements. Alternative sources that can be used to generate power or simply provide heat include geothermal, tidal, biomass, wind and solar. Of these, solar energy shows the most promise for near-term application in buildings.

FEASIBILITY OF SOLAR HEATING

Solar-heating feasibility studies[1,2,3] have shown that the most appropriate use of solar energy in buildings is as low-grade heat, for loads which tend to be uniform over the year, and which currently use electricity. Thus, service-water heating ranks as the most appropriate use of solar energy in buildings. In areas such as P.E.I. and Nova Scotia with high electrical rates, solar service-water heating could become economical within a few years. Space heating with solar energy, although more appropriate than space cooling, will take somewhat longer before it becomes economically attractive for most parts of Canada.

All building types are not equally suited for solar heating. The suitability of buildings for solar heating can be ranked as follows:

(i) Medium-density dwellings, such as low-rise apartments and row housing units would rank high because of the low heat loss per dwelling unit; the economy of scale of a shared heating system; and a relatively large demand for hot service water.

(ii) Schools and hospitals with a relatively large demand for hot service water would also rank high.

(iii) Single-family dwellings, high-rise apartment buildings and low-rise commercial buildings with a demand primarily for space heating, would rank next in order of suitability.

(iv) Commercial buildings that experience simultaneous heating and cooling demands are more suited for mechanical heat-recovery systems than for solar heating systems. (If, however, a heat-recovery system with a heat storage unit is incorporated in a building, the addition of a solar collector system becomes more economically attractive.)

The key question regarding solar heating

is where and when it will become economically attractive to use solar heating systems in place of conventional heating systems. The factors that determine feasibility are: the current cost and the rise in cost of conventional fuels; the initial and maintenance costs, as well as the life, of solar heating systems; the interest on capital; and the availability of solar energy. Some of the developments described in this paper will go a long way toward answering where and when solar heating will become economic in Canada. Until these answers are forthcoming, however, some guesses can be made on the current feasibility of solar heating.

In 1975, a Building Research Note on Solar Heating of Buildings was prepared (4), in which an example was given on the cost competitiveness of heating a home in Ottawa with solar energy. The following characteristics were used in the example:

House living area = 140 m^2 (1500 ft^2)
House heat-loss characteristic = 5.3 kW·h/°C-day
(10,000 Btu/°F-day)
House space-heating demand = 25,000 kW·h/year
(85×10^6 Btu/year)
Cost of electrical heating (1975) = 1.55¢/kW·h

It was assumed that a solar heating system with 47 m^2 (500 ft^2) of collectors could save half of the purchased energy for heating; that is, about $200 per year. With an estimated present worth factor of 20, the maximum investment that could be justified for a solar heating system was $4,000.

In 1976, an energy cost of 2¢/kW·h seems more appropriate for electrical heating, and an investment of $5,000 could now be justified for the solar heating system. Consider, however, that the total cost of a system includes collector purchase, delivery and installation costs; piping, pump, insulation and control costs; and heat storage cost. It is this total cost that cannot exceed $106/$m^2$ of collector. Since the purchase price of the collector alone is about $106/$m^2$, a solar heating system using commercial collectors and normal construction practice would not seem to be cost competitive today. However, in a region where the conventional energy cost approaches 4¢/kW·h, the solar alternative would be much more attractive.

The economics of solar heating is also improved with site-fabricated collectors, using local materials and free labour, that is, the "do-it-yourself" approach. This approach is quite important today because it permits the early introduction of solar heating systems in Canada. The approach, however, may not have a significant influence on the penetration of solar heating into the mass housing market. An industrial capability for supplying factory-fabricated solar-heating hardware would appear to be a necessary prerequisite for solar heating to have a large impact on the building industry. Much of the current support from government is, therefore, directed toward establishing such an industrial base.

CANADIAN SOLAR ENERGY DEVELOPMENTS

Prior to 1974, government-funded work on solar energy utilization was virtually nonexistent. Solar energy research was limited to that conducted by the Brace Research Institute of McGill University and by the Universities of Toronto, Waterloo, Western Ontario, Manitoba and British Columbia.

The oil crisis of 1973 saw the commencement of a number of activities related to energy research and development in Canada. The following are some of the activities related directly to the development of solar energy as a viable energy resource.

(a) Solar Energy Society of Canada, Inc.

The SESCI was formed in 1974 by a number of Canadians interested in the future development of wind, biomass and solar energy. The Society sponsored a conference in June 1975 in Ottawa on the Potential of Solar Energy for Canada; it was attended by more than 400 people and Proceedings were published. In August 1976, the Society co-sponsored the annual conference of the American Section of the International Solar Energy Society in Winnipeg.

Membership in the Society is an excellent way to keep informed of activity related to solar energy in Canada. The Society publishes periodic Newsletters which describe ongoing solar demonstration projects as well as future funding programs. The Society has its headquarters in Winnipeg, Manitoba (Box 1353), and has regional as well as local Chapters across the country.

(b) Federal Solar Energy Program

In 1974, an interdepartmental government task group outlined a research and development program for the exploitation of solar energy. The program recommended levels of spending by the Federal Government for the years up to 1980. The aims of the program were to:

(i) develop a data base for the rational design of solar heating systems;
(ii) undertake a feasibility study to determine when solar heating would become economically viable in the various regions of Canada;
(iii) fund demonstration projects to stimulate public interest in solar heating;
(iv) assist universities and the manufacturing industries to develop cost-effective solar heating hardware in Canada; and
(v) assist the development of economical thermal and photovoltaic solar-power systems.

Early in 1976, funds were made available by the Federal Government to pursue the foregoing aims related specifically to solar heating of buildings.

Part of this money is being used by the Atmospheric Environment Service of Environment Canada to fulfill the first aim. They will undertake to provide weather and solar radiation data for the major urban centres in a format usable by building heating engineers. This will involve a modest increase in the number of weather stations measuring solar data, the development of a method for inferring insolation data for areas with no measured solar data, and the development of a reliable method for translating the value of solar radiation falling on a horizontal surface into a value of radiation falling on sloped surfaces.

The remainder of the money is supporting solar work in the private sector. In March 1976, the Division of Building Research announced a funding program of $550,000 to stimulate public and industrial interest in solar heating. The program consists of four subprograms:

(A) - construction of solar-heating demonstration buildings;
(B) - monitoring of solar-heated buildings;
(C) - research on solar-heating hardware and systems;
(D) - commercial development of solar hardware and systems.

Over 200 proposals from companies, institutions and individuals were received and reviewed. Contracts are now being let in pursuit of this program.

Subprogram A (demonstration) will support the construction of 14 solar-heated houses across Canada. The program will demonstrate solar space-heating systems using commercially-available hardware on new, single-family homes located in housing developments. In subsequent years, it is intended to demonstrate space-heating as well as service-water heating solar systems in new and existing multi-unit dwellings, schools and commercial buildings. Still later, solar space-cooling systems will be demonstrated.

Subprogram B (monitoring) is directed primarily at developing and manufacturing the heat-flow meters for monitoring the performance of the solar-heating systems being constructed this year. A small number of solar-heated houses will also be monitored, including the Mississauga and Provident solar houses. (These will be mentioned later.)

Subprogram C (research) and D (development) will provide support to manufacturers of solar collectors, heat storage units, and space and service-water heating systems. Support will also be given to companies and institutions for research on new designs for collectors and storage units, selective absorber coatings, and corrosion studies; and for preparation of guidelines on the construction of crushed-rock heat storage units and solar air-heating systems.

(c) Waterloo Feasibility Study

Another activity initiated in response to the Solar Energy Program is a feasibility study on solar heating of buildings in Canada, undertaken by the University of Waterloo. The first phase of the study was the development of suitable computer programs for simulating the behaviour of solar space-heating systems using air or water as the heat transport medium. The second phase involves the use of these programs to determine feasibility of solar heating in seven cities: Fredericton, Montreal, Ottawa, Toronto, Winnipeg, Edmonton and Vancouver.

The first phase of the study is completed and computer programs are now available for simulating:

- a system using water, with short-term heat storage,
- a system using water, with seasonal heat storage, and
- a system using air, with short-term heat storage.

The programs have been described in two reports (5,6) prepared by Professor K.G.T. Hollands and J.F. Orgill, and are available from the University of Waterloo, Waterloo, Ont. The strengths of these programs are brevity, the ability to accept the heating load profiles of a variety of building types, and the inclusion of an economic evaluation subroutine.

The second phase of the study is now in progress. It will attempt to determine the economic viability of air and water solar-heating systems as a function of:

- building type (i.e.,heating demand),
- geographic location (i.e., heating demand and solar availability),
- collector size, life and cost,
- thermal storage size, life and cost,
- conventional energy costs, and their annual escalation, and
- interest rate on capital.

The results of the feasibility study, which should be available near the end of the year, will be useful in indicating the direction for subsequent solar demonstration projects. It is hoped that the computer programs developed for this study will also be useful as design aids for building heating engineers. One of the aims in monitoring solar-heated buildings is to evaluate the worth of these programs.

(d) Canadian Urban Demonstration Program

A major solar-related activity begun in 1974 was the short-lived Canadian Urban Demonstration Program of the Ministry of State for Urban Affairs. Before this program was terminated in mid-1975, it initiated the following six solar demonstrations which are now in various stages of development. Funding for these projects in 1975 totalled about $675,000.

(i) Gananoque Solar House.- This is a rural home with a living area of 204 m^2 located near Kingston, Ontario. The solar space-heating system consists of 22 m^2 of water-heating collectors and a latent heat storage unit. The collectors are fabricated of copper tubes with a non-selective absorber coating; two layers of transparent plastic sheets act as the cover. The heat storage unit is made up of two tanks containing 2000 kg of paraffin wax. The water-glycol solution flowing through the collectors transfers its heat to the wax through heat exchangers. The solar-heating system will be a supplement to the electric hydronic heating system in the house. It is expected to be operational before the 1976-77 heating season. The house and solar system were designed by Mr. G. Allen of Stella, Ontario.

(ii) Mississauga Solar House.- This is a suburban home with a living area of 135 m^2, located in Mississauga, Ontario. The solar-heating system consists of 64 m^2 of water-heating collectors, a sensible heat storage unit of 23 m^3 of water, and a water-to-air electric heat pump. Solar energy is used to preheat the service water and to heat the living space either directly or through the heat pump. Supplementary space and service-water heating is by electricity. The collector is single glazed and has a copper absorber with a selective absorber coating. Freezing is avoided in winter by draining the water from the collectors between periods of use.

The solar-heating system is fully operational and its performance will be monitored during the 1976-77 heating season. The house and system were designed by Messrs. Lorriman, Lee and Ferguson of Mississauga Solar Demonstration Project Ltd., Toronto.

(iii) Provident Solar House.- This is a suburban home with a living area of 248 m^2, located north of King City, Ontario. It attempts to satisfy 100 per cent of the space heating demand with solar energy, by collecting and storing solar heat during the nonheating months for use during the heating season.

The solar space-heating system consists of 67 m^2 of water-heating collectors and a sensible heat storage unit of 274 m^3 of water. The collector is single glazed and has a steel absorber with a selective absorber coating. Freezing is avoided by draining the collectors.

Service water is preheated by a separate solar system consisting of 7.4 m^2 of single-glazed copper collectors with a selective absorber coating. The water-glycol solution flowing through the collectors exchanges heat with the feed water through a heat exchanger. Supplementary heating is by electricity.

The demonstration is now operational; its performance will be monitored during the 1976-77 heating season. The house and solar heating systems were designed by Messrs. Hooper and Hix of Envirogetics Ltd., Toronto.

(iv) Housing for Quebec Indian Communities.- The original intent of this project was to build four different houses that were appropriate for different Indian communities. Various degrees of freedom from conventional building services were to be achieved by utilizing design features such as solar-heating systems, wind power systems and composting toilets. The house called the "Cote Nord" prototype is now completed; two other prototypes, called the "Waswanipi" and the "Mistassini" will be completed later this year.

The "Cote Nord" prototype has 98m^2 of living area; 47m^2 of vertical, air-heating solar collectors; and a sensible heat storage unit containing 33 m^3 of crushed rocks. The double-glazed collectors have a corrugated metal absorber plus a wire-mesh screen absorber, both coated with non-selective paint. A fan transfers heated air from the collectors to the storage unit located beneath the house. Supplementary heating is by wood stove. Electric power will be provided by a 6-kW wind turbine. This house will be monitored during the 1976-77 heating season.

The "Waswanipi" prototype has 203 m^2 of living area; 35 m^2 of vertical, air-heating solar collectors; and a sensible heat storage unit consisting of 7.7 m^3 of water in plastic bottles. The collectors are identical to that of the "Cote Nord". Heated air from the collectors is transferred to storage by natural convection. Supplementary heating is by wood stoves. The house has no electrical power, but water is pumped indoors by a small windmill.

The largest of the three houses is the "Mistassini" prototype. It has 231 m^2 of living area and a vertical "solar wall". The "solar wall" combines the functions of collector and storage; it consists of steel oil drums filled with salt water and painted black on the sunlit face. A double-wall transparent acrylic sheet separates the wall from outdoors. The heat loss from the steel drums to the living space constitutes space heating. An insulated curtain can be drawn between the drums and the living space to avoid over-heating, or it can be drawn between the drums and the acrylic cover to minimize heat loss from storage. The collector area is 39 m^2 and the volume of brine in the steel drums totals 9 m^3. A separate solar heater provides hot service water. Supplementary heating is by wood stoves.

All the houses incorporate some novel forms of energy-conserving and construction techniques, such as preserved-wood foundations with exterior insulation for water drainage; south-facing windows and greenhouses to augment space heating; and earth berms for added insulation. The project was undertaken jointly by the School of Architecture and the Brace Research Institute of McGill University, Montreal.

(v) Ark for P.E.I.- This is a family-size food, energy and housing complex that includes solar heating, wind power generation, greenhouse, fish culture and living components. It is an experiment in autonomous living as well as a demonstration of biologically-balanced rearing of fish and plants in an integrated system. The Ark is

located at Spry Point on Prince Edward Island. It consists of four separate spaces; living area - 116 m^2; aquaculture and greenhouse - 242 m^2; laboratory - 14 m^2; and barn - 4 m^2.

The food-culture space has a south-facing transparent roof of double-wall acrylic sheets 232 m^2 in area. Part of the excess solar heat collected in this area is stored passively in the fish ponds (86 m^3 of water); in addition, the heated air is circulated through a heat storage unit of 90 m^3 of crushed rock.

The living area is heated by a solar-heating system consisting of 79 m^2 of water-heating collectors and a sensible heat storage unit of 91 m^3 of water. The storage unit is intended to provide a seasonal heat storage and is segmented into three parts. The single-glazed collectors contain a copper absorber with a selective absorber coating. Freezing is avoided by draining the collectors. A separate solar heating system provides hot service water. A wood stove provides supplementary heating.

The project will have three wind turbines with a total power rating of 25 kW. When the electricity generated by the turbines exceeds the power needs of the Ark, it will be fed into the P.E.I. electrical power grid.

The Ark, with the exception of the wind power system, should be operational for the 1976-77 heating season. The project was undertaken by the New Alchemy Institute headed by Dr. J. Todd.

(vi) Solar Demonstration on Manitoba Legislative Building.- The aim of this demonstration is to create public awareness about methods of collecting solar energy and its application as a supplementary heat source. Four collector arrays, each 23 m^2 in area are being mounted on the roof of the Manitoba Legislative Building to compare the performance of four types of water-heating collectors. The collected heat will be stored in a pair of water tanks having a total volume of 27 m^3 and will be used to heat the lower dome area of the Legislative Building. A water-to-water heat pump will upgrade the energy from one tank to the other.

In summer, 46 m^2 of collectors will be mounted horizontally with their transparent covers removed. The heat extracted from the lower dome area by the heat pump will be rejected to the night sky through these collectors.

The demonstration project will be operational in late 1976 or early 1977. It is being undertaken jointly by the Departments of Public Works, and Industry and Commerce of Manitoba, and by the Office of Industrial Research of the University of Manitoba.

(e) Ontario Senior Citizens Home

The province of Ontario is sponsoring the construction of a solar-heated Senior Citizens Home near London, Ontario. The home will contain thirty living units and will be constructed in 1977. The design for the building and solar-heating system was opened to competitive bidding and 56 proposals were received. The design submitted by Envirogetics Ltd. of Toronto was selected.

The Home will be a two-storey, energy-conserving building with about 550 m^2 of living area. The solar-heating system will use seasonal heat storage in an effort to satisfy 100 per cent of the space heating demand. The solar system will feature approximately 170 m^2 of water-heating collectors, reflectors to augment solar heat collection, and a sensible heat storage unit of about 900 m^3 of water.

(f) Shediac Office Building

The New Brunswick Electrical Power Commission is proceeding with the design and construction of a solar heated building in Shediac, N.B. The building will have 650 m^2 of office space and 465 m^2 of warehouse space. The solar-heating system will feature 117 m^2 of water-heating collectors; a sensible heat storage unit of 18 m^3 of water; and two water-to-air heat pumps. Supplementary heating will be with electrical resistance heaters. The building is scheduled for completion in 1977.

(g) Private Solar Homes

In addition to the solar-heated buildings already described there are a number of solar-heated homes in Canada which have been or are being constructed with private funds.

The oldest solar-heated home in Canada is that built in 1971 by E. Hoffman near Vancouver. A solar-heating system consisting of 43 m^2 of water-heating copper collectors and 3 m^3 of water as the heat storage unit, provide about 50 per cent of the space-heating needs of a house with a living area of 140 m^2.

Two other solar-heated houses have been built in British Columbia within the past two years by Solar Applications and Research Ltd. of Vancouver. One house built in Duncan, B.C. uses water-heating solar collectors of the "trickle" type, developed originally by H. Thomason, in which water is trickled over the sunlit absorber surface. The heating system consists of 74 m^2 of double-glazed collectors and 23 m^3 of water as heat storage, and heats a home with 140 m^2 of living area. The second house, in White Rock, B.C., has an air-heating solar system in conjunction with a crushed-rock heat storage unit. Heated air is transferred from collector to storage by a fan.

There are a number of privately-funded solar homes in Ontario, including at least two near Ottawa, one near Peterborough, one in Terra Cotta, and one in the London area. One of the Ottawa houses (G. Mason) uses "trickle"-type water-heating collectors and a large water storage tank. The other Ottawa house (M.L. Stanley-Jones) uses 21 m^2 of commercial water-heating collectors and 23 m^3 of water as heat storage to heat a home with a living area of 170 m^2. The home near

Peterborough (L. Van Dyck Construction Ltd.) uses 56 m^2 of water-heating collectors and 180 m^3 of water as heat storage to heat a home with a living area of 111 m^2.

The home in Terra Cotta, Ont. (R. Symmes) differs from the others in that it utilizes a "solar -heating furnace", an approach that may prove suitable for retrofitting existing buildings. The furnace used consists of 13 m^2 of air-heating collectors mounted on an insulated container for 9,000 kg of crushed rock. A fan transfers the heated air from collector to storage. The furnace stands free of the house and is oriented for maximum solar collection. Insulated air ducts and a fan connect the furnace to the existing hot-air heating system of the house.

There are at least two solar houses in Quebec. One, in Lorraine (W. Steward), uses 13 m^2 of "trickle"-type water-heating collectors. Another, near Sherbrooke (N. Nicholson), uses forced-circulation air-heating collectors in conjunction with a crushed-rock heat storage unit.

This is by no means a comprehensive listing of solar-heated homes in Canada, but it indicates the great variety of solar-heating systems being constructed.

(h) Solar Research at the Division of Building Research/NRC

The Division is the source of the $550,000 funding program on Solar Heating of Buildings; the sponsor of the University of Waterloo solar feasibility study; and the monitor for the Gananoque, Mississauga and Provident Solar Houses. Only two solar-related activities are being conducted in-house.

One is the development of a solar collector calorimeter for evaluating the thermal performance of collectors under natural weather conditions. The calorimeter, which can test two collector modules at a time, was developed primarily to compare the performance of commercially-available collectors under Canadian conditions; and for conducting research on collector testing methods. Several collectors are now being evaluated, and the results of the tests will be published in 1977. Upon completion of this comparative study, the facility will be made available for limited commercial testing. This service will only be provided, however, until a commercial testing capability is provided by a Canadian company or institution.

The second solar-related activity is a joint effort between the Division and Housing and Urban Development Association of Canada (HUDAC). Plans are for the construction of four similar houses in Ottawa, one built to current residential standards and three with additional energy-conservation features. Of these three, one will be electrically heated, one will incorporate an air-heating solar system, and one will have an air-to-air heat pump. Supplementary heating in all houses will be by electricity.

The study will determine the efficacy of various energy-conservation features applied to residential construction and compare the energy savings achieved with a solar-heating system and with a heat pump system. Monitoring of the experimental houses will furnish information to achieve these aims, but will also be sufficiently detailed to be able to check the validity of solar system simulation programs and of a house heat-load calculation program now being developed.

INTERNATIONAL SOLAR ENERGY DEVELOPMENTS

A number of countries have had many years' experience with solar-heating systems, especially with service-water heaters.

Australia.- In Australia, solar service-water heaters have been manufactured commercially for over 20 years. It is estimated that over 30,000 m^2 of collectors are now installed, primarily in houses but also in hotels and apartments. Ongoing research is directed toward the use of air-heating solar collectors and rock storage for wood and crop drying, as well as for building air-conditioning.

Israel.- The history of solar heating in Israel is similar to that of Australia. Over a period of 20 years, solar service-water heating systems have been installed in more than 150,000 apartment units. It is estimated that these heaters save 1.2 percent of the annual consumption of electrical energy. Current projects are aimed at commercial development of solar space heating and cooling systems, and development of solar ponds as a source of heat.

Japan.- The sale of solar service-water heaters is very large in Japan where an estimated 2.5 million heaters were sold in 1973 alone. Since then, the number of units sold has increased substantially. A national program in support of energy development was inaugurated in 1973, entitled "Sunshine Project". One element of the program is aimed at the development of solar heating and power systems. Funding for this subprogram in 1975 amounted to $3 million, of which $850,000 was for research and development on solar heating and cooling systems for buildings. This work is conducted primarily by universities and very large industrial groups, and tends to be concentrated on high-technology systems.

France.- In Europe, France has the longest experience with solar heating. Industrial involvement in the manufacture and sale of solar heating hardware is well established, with more than 10 companies manufacturing solar-heating systems for homes. The federal Solar Program supplements this industrial effort by developing analytical methods for optimizing the design of solar-heating systems for buildings. This program, operated by the National Centre for Scientific Research (le Centre National de la Recherche Scientifique), will also sponsor research on high-temperature collectors, solar cooling systems and solar thermal power generators.

Germany.- Federal sponsorship of solar research

in Germany began in 1974. The solar program provides half the funds for a research, development or demonstration project and the sponsored party supplies the other half. For this reason, most of the funds have gone to large companies such as Dornier and Philips which have the necessary capital. The federal input to research and development of solar space-heating systems in 1975 amounted to $3 million. Sponsored projects ranged from development of retrofit space-heating systems, to construction of experimental solar houses. Current projects place greater emphasis on solar-heating demonstration buildings. As in Japan, much of this effort in Germany appears to be directed at development of high-technology solar-heating systems.

U.K.- Solar research in the United Kingdom is also fairly new. Even so, there are 12 companies engaged in the manufacture of solar-heating hardware. There are currently seven solar demonstration buildings in existence or being constructed, most of which incorporate only solar service-water heating systems. The Building Research Establishment is now building two experimental energy-conservation houses that include solar space-heating systems.

U.S.A.- The United States has the greatest amount of government-sponsored activity related to solar energy. In 1975, 29 demonstration projects were funded, ranging from the revision of a publication on solar heating, to the installation of solar heating and cooling systems in two federal office buildings in Manchester, N.H. and Saginaw, Mich. In the same period, 59 research and development projects were funded, ranging from sponsorship of workshops, to development of solar hardware.

In 1976, the Energy, Research and Development Administration (ERDA) will spend $86 million on solar projects. Of this amount, $49 million is for development of electric power generation systems using solar thermal and photovoltaic means, wind energy, and ocean thermal gradients. The sum of $25 million has been allocated to development of solar heating and cooling systems for buildings.

Part of the $25 million for demonstration projects will be spent as follows. The Department of Housing and Urban Development (HUD) has granted $1 million to support the purchase and installation of solar heating and/or cooling systems for 143 residential units, both old and new. Included are 102 single-family dwellings and 41 multi-unit dwellings. ERDA will provide $7.5 million for the introduction of solar heating and/or cooling systems in 34 non-residential buildings, 15 of which are new. The demonstration units include offices, schools, hotels and factories.

ERDA intends to spend $116 million for solar projects in 1977, including $34.5 million for heating and cooling buildings.

We in Canada are very fortunate to be so close to the spending effort in the U.S.A., since many of their projects are directly applicable to Canada. Information related to these projects will be gained through our membership in the Solar Energy Project of the Committee on the Challenges of Modern Society initiated by NATO.

Canadian effort in the future should be aimed at those applications of solar-heating technology that are uniquely Canadian. Repetition of American experiments should be limited to that necessary for stimulating the interest of the Canadian public and building industry in solar heating.

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DISCUSSION

K.F. Tupper (Consultant): Mr. Sasaki's paper gives a comprehensive view of what is taking place in Canada in harnessing solar radiation for the heating of dwellings.

A much easier problem to solve is solar energy for the supply of domestic hot water. This energy demand is virtually continuous throughout the whole of the year. The energy storage problem is much less in quantity and time. On a national basis the total amount of energy now used to heat water to a temperature well below the boiling point is impressively large.

It would seem that on a number of counts solar water heating should have a clear priority over space heating for attention in Canada. It there some reason for its neglect?

J.R. Sasaki: Heating of service water with solar energy has not been neglected; we appreciate its energy-saving potential and plan to begin studies in 1977. A decision was made this year to demonstrate an application of solar heating that would make the greatest impression on the general public. Solar space-heating systems were, therefore,

chosen over solar service-water heating systems, since space heating represents the largest energy cost to the home owner. Similarly, single-family detached dwellings were chosen over buildings such as medium-density dwelling units that are more appropriate for solar heating, because owners of detached homes are generally more energy conscious than apartment dwellers. In the current year, there is only one demonstration of a solar service-water heating system, that on an existing single-family detached home.

J.H. Collyer (A.D.I. Limited): Other considerations being equal - what are the effects upon a building's heating and/or cooling load of different colours of the exterior (and/or interior) surface of the building envelope? It might well prove to be a more significant factor than generally supposed, particularly perhaps with low profile, flat roof structures and small industrial metal skin (pre-engineered) buildings, and possibly with single-family dwellings. The effects could probably be easily and cheaply monitored in model simulation and it is suggested that a research project be carried out at N.R.C. to find out what the effects are, if any, on energy expenditure on an average annualized basis.

J.R. Sasaki: The influence of the colour of the exterior building surfaces on the energy demand of buildings such as houses will be looked at with the house load program being developed at DBR. It is anticipated that the effect of the exterior and interior surface colour on the heating and cooling loads of a building will depend on the amount of insulation in the walls and roof. The effect should be less for well insulated buildings than for poorly insulated buildings.

E. Haseler (Consultant): In Mr. Sasaki's slide showing worldwide activity in solar energy development, the list of countries does not include New Zealand. I think that it should as I have seen for myself the successful achievements in solar energy utilisation by the Department of Scientific and Industrial Research at Wellington.

Mr. Sasaki has given an excellent paper devoted to solar energy collectors on isolated buildings. Is he planning future R & D work for built-up urban areas? The capital expense can be shared by many, the vast storage capacity in the existing district heating systems is ideal for solar energy purposes. The taking up of house space by storage vessels is thus obviated. There is a bonus of energy gains from spaces on each building otherwise shielded by solar energy collectors. The small towns with a multiplicity of solar energy collectors look absurd so centralised schemes now being developed would obviate this unsightliness.

J.R. Sasaki: I thank Mr. Haseler for the information on solar heating activity in New Zealand. The concept of a central solar collection and heat storage system serving a number of dwelling units is currently under study, and should be demonstrated within the next year or two in Canada.