

# SOLAR HEATING OF BUILDINGS IN DENMARK

RESEARCH PROJECTS AT THE  
THERMAL INSULATION LABORATORY  
TECHNICAL UNIVERSITY OF DENMARK

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### Introduction

At the Thermal Insulation Laboratory research activities relating to solar radiation have taken place since 1960. In the period 1961-1967 registration has been made of the total and diffuse solar radiation through double glazing. In the period 1964-1972 the research has mainly dealt with the problems to avoid overheating in modern buildings with large windows caused by solar radiation.

Since medio 1972 preliminary studies have been undertaken regarding the possibilities of a project for solar heating of buildings under the climatic conditions in Denmark. The project was started in August 1973 and is expected to have a duration of 3 years. The project will among other things include measurements on an experimental house heated by solar energy.

The research group at present consists of four full-time civil engineers and two associated professors under the direction of professor V. Korsgaard.

The projects are mainly financed by the Danish Council for Scientific and Industrial Research.

## The research projects in progress

### 1. Data for solar radiation

A data collection, the "Reference Year", especially suited for computerized calculations, has been developed within the last two years [1].

The "Reference Year" contains 8760 hourly values of temperature, clouds, solar radiation and other weather data.

### 2. The Zero Energy House

An experimental house called the Zero Energy House has been constructed during the spring 1975 on the experimental field at the laboratory [2].

The house is designed and constructed in such a way that it can be heated all winter without any "artificial" energy supply, the main heat source being solar energy.

With energy conservation arrangements, such as high-insulated constructions (30-40 cm mineral wool insulation), mobile insulation of the windows and heat recovery in the ventilating system, the total heat requirement for the house is calculated to 2300 kWh per year.

With a heat recovery unit installed in the hot water system, the total heat requirement for hot water supply is calculated to 2700 kWh per year.

For a typical, well insulated, one-storied, one-family house built in Denmark, the corresponding heat requirement figures are 15,000 kWh for space heating and 7,000 kWh for hot water supply.

The solar heating system is dimensioned to cover the heat requirement and the hot water supply for the Zero Energy

House during the whole year on the basis of the weather data in the "Reference Year".

The solar heating system consists of a 42 m<sup>2</sup> flat-plate solar collector, a water storage tank with a capacity of 30 m<sup>3</sup> and a heat distribution system.

### 3. Modelling of solar heating systems

A computer program is developed to simulate the system consisting of a flat-plate solar collector, water-accumulators and the heat consumption for space heating and for domestic hot water under the climatic conditions in Denmark.

Another computer programme is developed to simulate the performance of a solar heating system working together with a heat pump.

It will be investigated if it is possible to freeze a part of the water in the accumulator tank using a heat pump and then utilize the melting heat. For thawing the ice is used energy from the solar collector.

On the basis of the analysis of the systems mentioned above, it will be tried to make some practical rules for an optimum dimensioning of solar heating systems under the climatic conditions in Denmark.

### 4. Concentrating solar collectors

As an attempt to reduce the heat loss of the solar collector, a project has been started to make a study on the use of a concentrating solar collector for heating of water. A prototype has been designed and is under construction.

5. Flat-plate solar collector for air heating

As an alternative to water, the use of air as heat-absorbing medium has been investigated.

A model of a solar collector is installed on the roof of the experimental hall, and measurements have taken place during the spring 1975 [3].

6. Energy storage in rocks

In connection with the use of air as heat-absorbing medium, preliminary studies have taken place about the use of rock-beds as heat-accumulator [4].

The research projects planned for the near future

7. Flat-plate solar collector for heating of water

On basis of the computer model mentioned above under point 3, there will be made a detailed computerized investigation of the efficiency of a flat-plate solar collector. The purpose of this project is to construct an optimum flat-plate solar collector under the climatic conditions in Denmark.

8. Performance of an artificial sun for testing

To test the performance of different solar collectors in the experimental hall, an artificial sun will be constructed in co-operation with the Illuminating Engineering Laboratory.

9. Insulation of heat accumulators

In Denmark the heat accumulators are a very important part of the solar heating system. Therefore it is necessary to make out a very efficient way to insulate the accumulators.

A project will be started to study unconventional insulation methods. An example is "vacuum insulation" around the tank. The evacuated space is filled with powder or multi-layer reflective insulation.

10. Energy storage in eutectic salt phase change medium

In connection with the use of air as heat-absorbing medium, heat-accumulating systems as eutectic salt phase change mediums will be studied.

The project will run in co-operation with the Physical-Chemistry Institute.

11. Temperature distribution in the ground

A numerical analysis is in preparation to investigate the possibility of using the ground around a reservoir as an accumulating medium in a solar heating system, where uninsulated water reservoirs are placed in the ground.

The project is running in co-operation with the Institute for Numerical Analysis.

International co-operation

The work with the solar heating research projects takes place in close co-operation with research groups in other countries.

The laboratory participates in the following international co-operations concerning solar heating of buildings:

CCMS Energy Conservation

- a) Climatic Conditions and Reference Year (chairman: Denmark)

CCMS Solar Energy

- a) Project Reporting Format Committee (chairman: USA)
- b) Zero Energy House Experts Group (chairman: Denmark)

International Energy Agency - Solar Energy R & D

- a) Development of Solar Heating, Cooling and Hot Water Supplying Systems (chairman: Denmark)
- b) Thermal Performance Testing of Solar Collectors  
(chairman: Germany)
- c) Inference of Insolation Parameters from Existing Meteorological Records (chairman: Sweden)

A Scandinavian section of International Solar Energy Society is at present under preparation.

Other solar energy activities in Denmark

The Danish Academy of Technical Sciences has appointed a solar energy group with participants from the university research group, from consulting engineers and architect companies, from solar heating system manufacturing companies and from other interested organisations and individual persons.

The main purpose of the appointment of the group is to have a forum for exchange of information.

References

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- [3] S. Svendsen, C. Nielsen, S. Furbo: Report on Performance of Solar Air Collector. Thermal Insulation Laboratory, Technical University of Denmark, May 1975.
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