Conversion Design of Solar Houses from Active to Passive

Ken-ichi Kimura

Principal. International Research Institute on Human Environment, Tokyo

Professor Emeritus, Waseda University, Tokyo

E-mail: kkimura@waseda.jp

URL: www.f.waseda.jp/kkimura/

INTRODUCTION

- Good design of earlier solar houses with active systems could seldom seen.
- Façade design of solar houses should express the essential beauty of the primary functions of collecting solar energy.
- As time passes, active systems are likely to be degraded and remodelling becomes essential.
- Greater needs are expected for active solar houses to be converted to passive.

Two examples of conversion

- MIT Solar House IV, Lexington, MA, USA built in 1957 with the data acquisition ended in 1961.
- Remodelling design was made by the author in 1962.

- Kimura Solar House, Tokorozawa, Japan, designed by the autho and built in 1972.
- Remodelling was made in 2005.

Original design of MIT SH4

The entire south façade of 60 degree tilt was occupied by flat plate solar collector of 60m^2 against the total floor area of 135m^2.

Well insulated house

- **Double glazed windows all over**
- **Openable windows made small to minimise infiltration**
- **Heavy insulation for walls and roof**

Flat-plate collector cut piece

Copper tubing inserted between

Blackened aluminium absorber plates

Clamped with galvanised iron channel

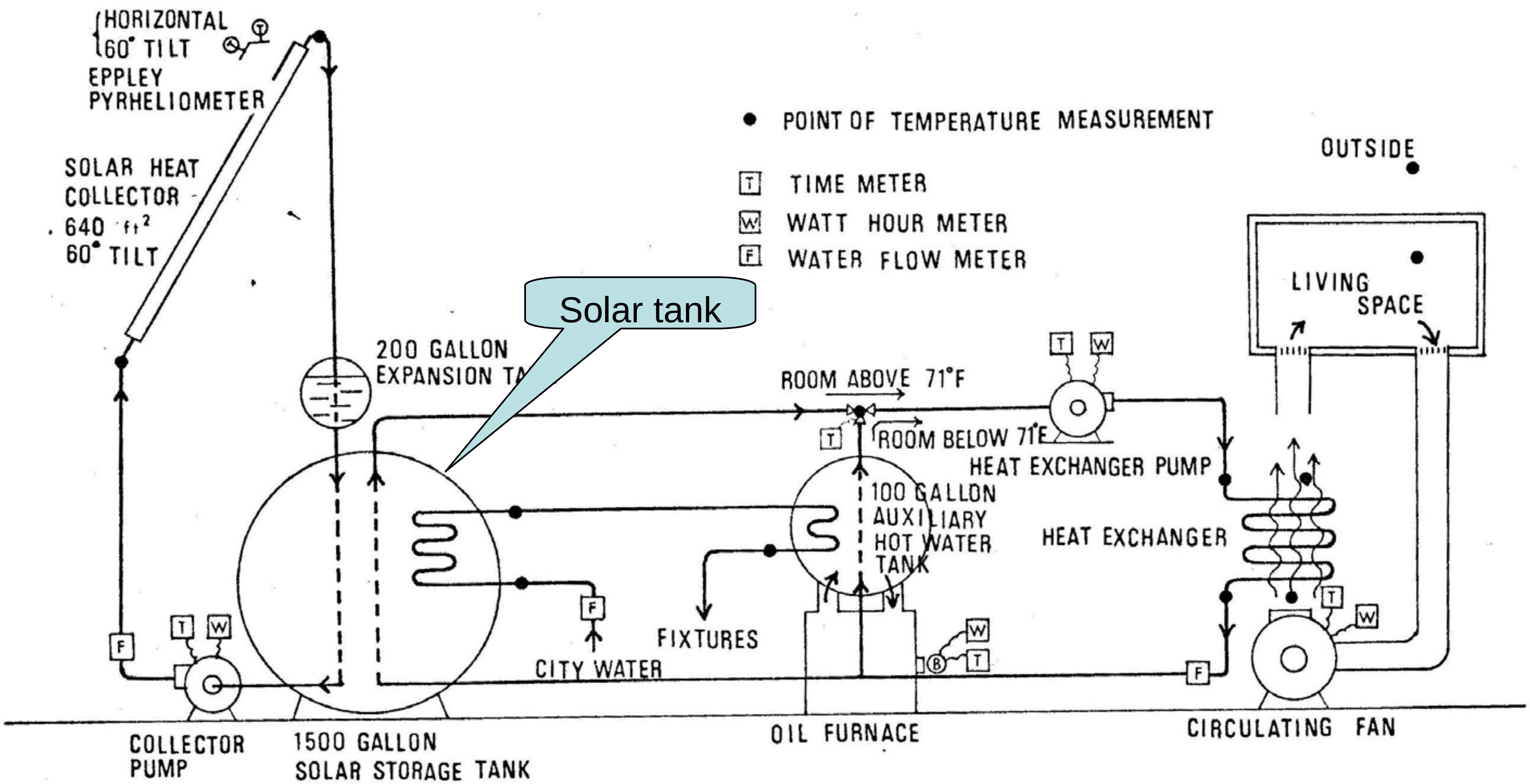
Double panes of glass covering

Flat-plate solar collector

After three years' operation, horizontal wood framing was found slightly rotated because of the weight of the glass.
Some rain water leakage caused deterioration within the collector.
Thus the collector performance turned out degraded.

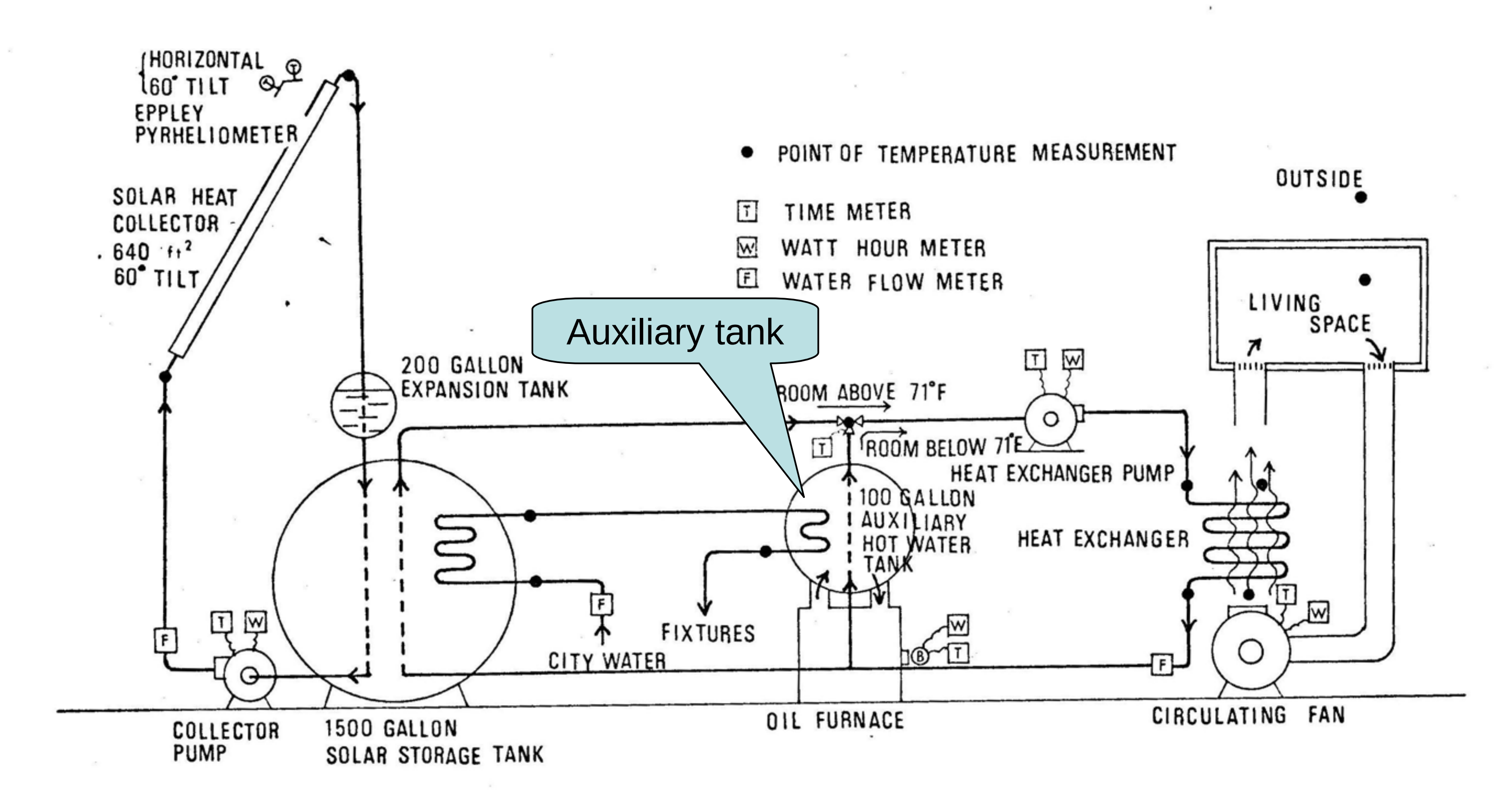
Space heating system

- **Collected solar energy is fed to the solar tank and the warm water is supplied by a circulating pump to the heat exchanger where warm air is produced for space heating.**



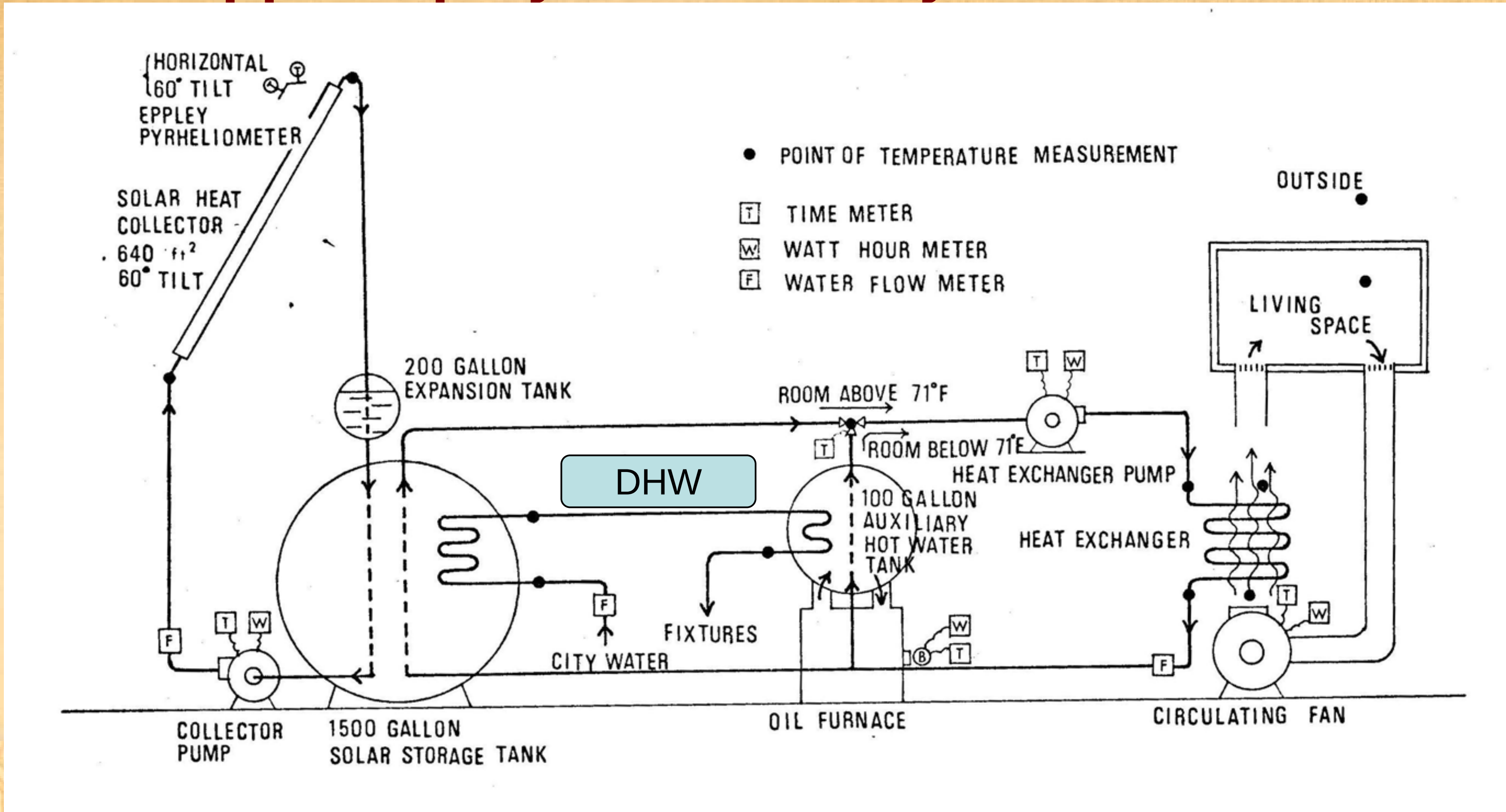
Auxiliary heating mode

- **The auxiliary tank heated by the oil furnace is provided for the case of less solar energy available.**



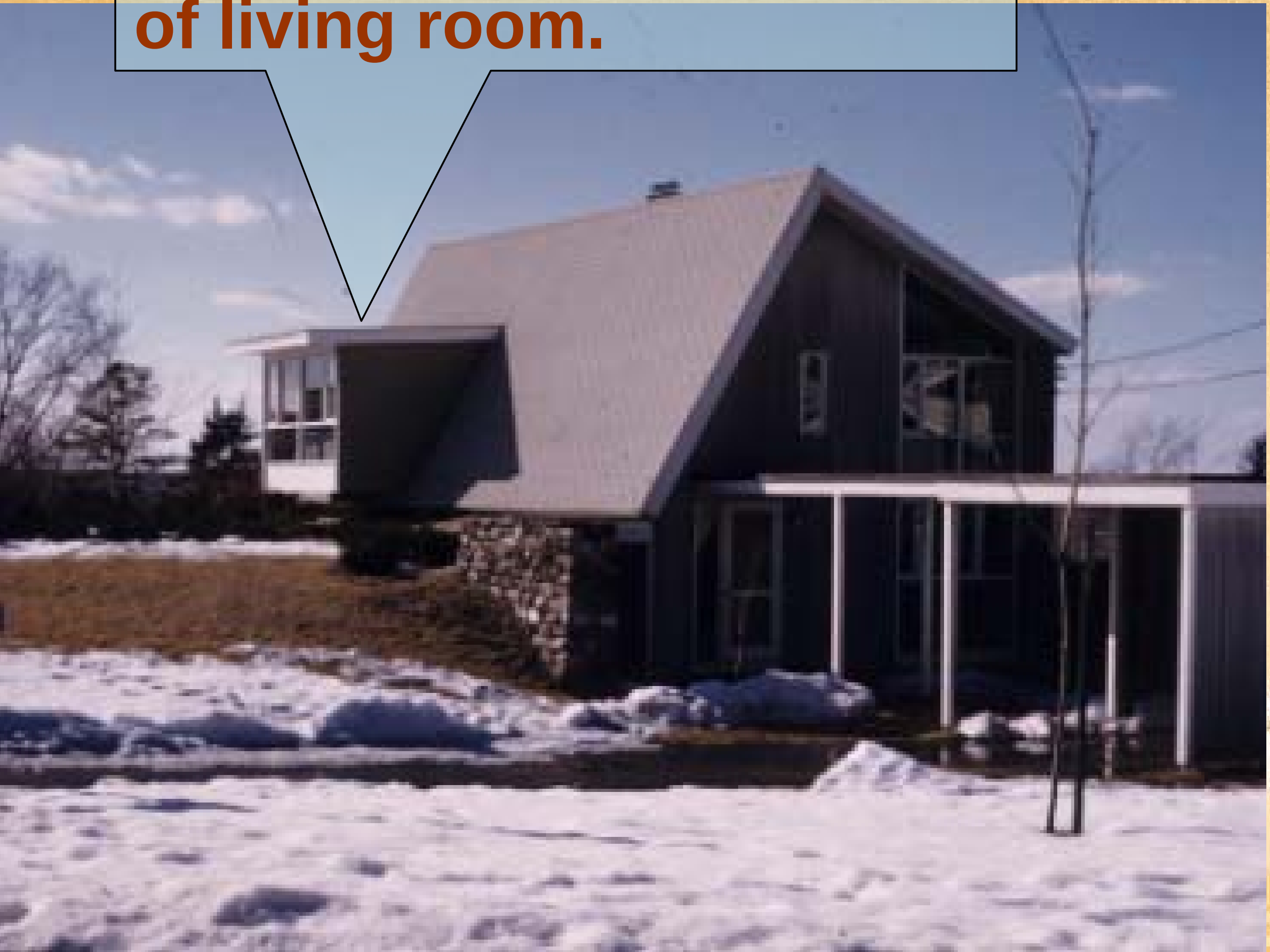
Domestic hot water system

Domestic hot water is supplied by passing the city water through the heat exchanger within the solar tank topped up by the auxiliary tank.



Remodelling design

Cantilevered protrusion is identified by an extension of living room.



Living room behind collector

- **Since the area behind the large collector was living room with the window only to the west, it was considered necessary to provide a large opening to the south.**
- **Much larger sun space could have been provided, but excessive glass area might cause a large amount of heat loss in winter.**

Remodelling completed

Behind the east of the protruded portion there was a staircase, where window was regarded unnecessary.

Remodelling completed

All collector panels were taken away and replaced by shingles.

Kimura Solar House

- **Kimura Solar House was designed based on the experience at the solar energy project of MIT.**
- **Total floor area :145m^2**
- **Built in March 1972, one and half year before the oil crisis.**
- **The collector panels were installed in March 1973.**

Original façade design

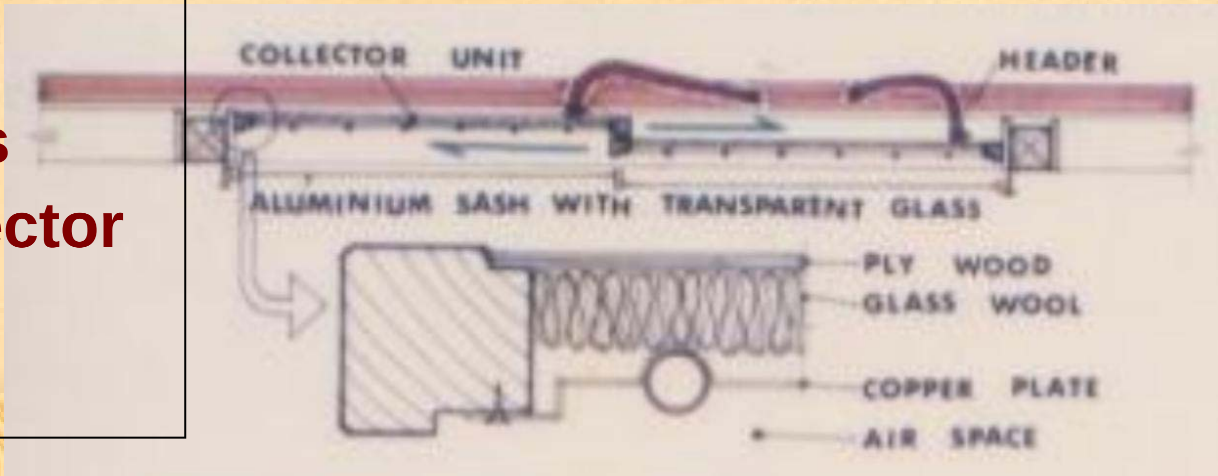
Flat-plate collector panels on the south vertical surface because the total amount of solar radiation during the winter months on the south vertical surface was found only 10% less than that on the tilted surface of the most optimum tilt angle.   This could allow for easier house plan.

Original collector panels

Collector panels made of vertical sliding doors with wooden framing, in which copper tubes soldered with blackened copper plates were mounted with glass wool insulation behind.

Ready made aluminium sliding doors of single glazing were used for glass covering.

Eight units of collector panels were installed upper and lower floors each with the net collector panel area of 24m².



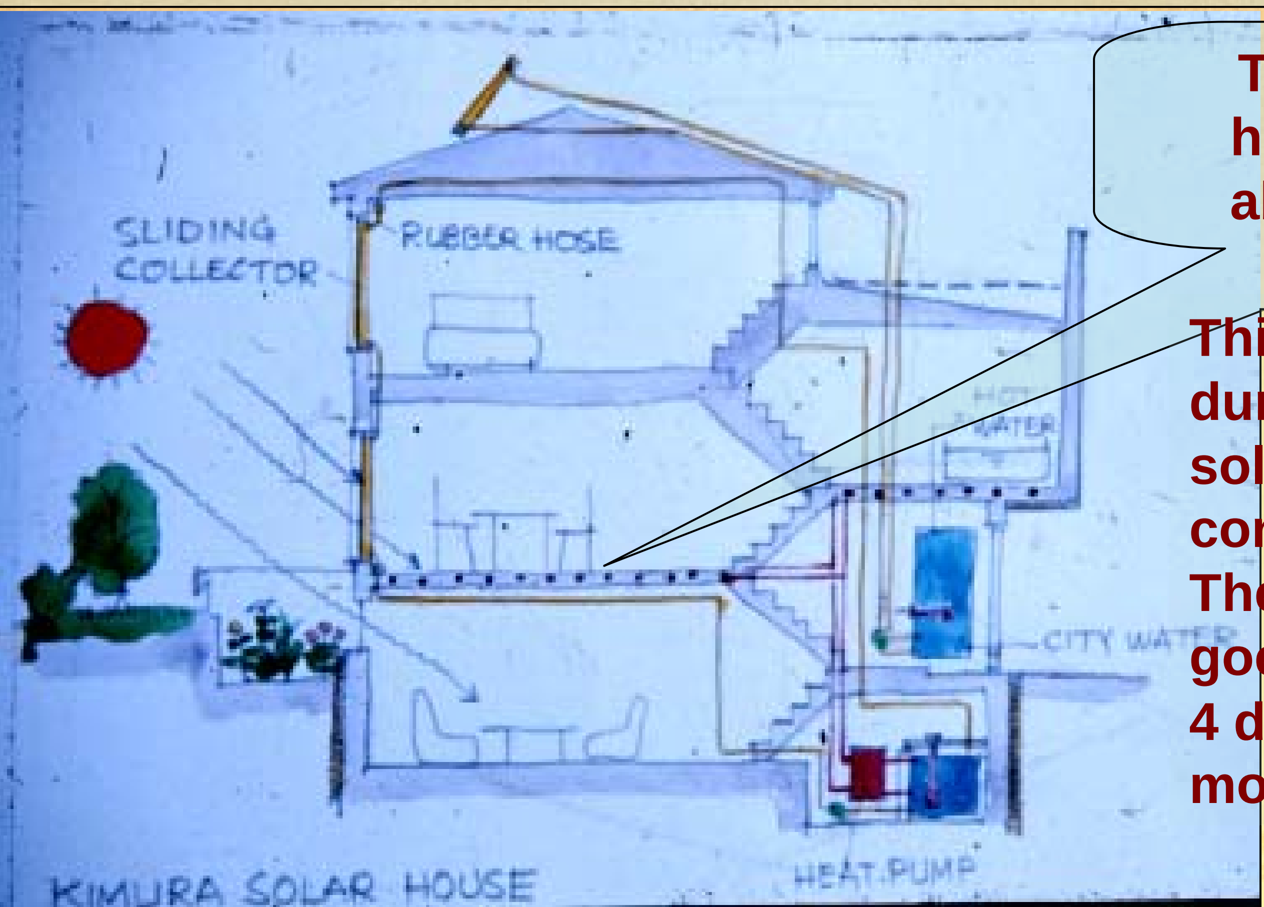
Movable collector

Rubber hoses connecting the inlet of collector panels to the header below as well as to the collector on the above floor.

These flexible hoses allow for the doors to be slid sideways to open in the sunny daytime for direct gain and the collector panels function as insulated panels during the night.

Solar space heating system

The solar energy collected by the collector panels of 24 m^2 in total is brought into the solar tank of 1 m^3 made of concrete in the basement. The water-to-water heat pump of 1.5kW takes the solar water out of the tank to warm up and to supply the warm water into the pipes embedded in the concrete floor.



This allows for panel heating to the spaces above and below.

This operation is performed during the night to store solar energy within the concrete slab.
The water temperature goes down to as low as 4 degrees C in the early morning.

Solar water heaters on the roof

Later solar water heaters of 6 m^2 in total area were installed on the roof for domestic hot water.

Renovation of façade

- After 33 years have passed, renovation was planned in 2005 with the main part of façade design.

Movable insulation

Two pairs of collector panels of lower floor were replaced by movable insulation. but wooden doors themselves were reused with plywood face board with insulation increased.
Aluminium sashes were reused with new panes of low E coated glass.

Thus, the quality of insulation during the winter night could be improved.

Glass block walls

- Two pairs of the original collector panels mounted sliding doors were replaced by glass block walls of 1.8m wide and 1.8m high each of the first floor.

Laying work of glass block

view from inside with allocating steel bars

finishing of joints from outside

Glass block characteristics

Glass block itself has mortar joints on top and bottom as well as right and left so that it can function just as overhangs and side fins of egg crate type of louvers.

This form intercepts direct solar radiation and yet allows for diffuse light into interior spaces.

Moreover it has air space between two thick glass faces with some thermal insulation characteristics.

Photovoltaic system

- **Photovoltaic panels of 2.25kW are installed on the roof in 2003 to assist electricity requirements of the all electric house.**
- **The annual results of measurement showed about 13% of total household energy was fed from this PV system.**

Discussion 1

- The case of MIT Solar House IV seems quite straightforward, because it was an experimental house lived by the family of three.
- The solar energy project could not afford to continue to maintain the house.

Discussion 2

- **The case of Kimura Solar House may be identified as a representative of the old system that had to be remodelled after 33 years for a continuous living.**
- **Even ordinary houses would have been renewed or reconstructed after lived by family for a long time because of different reasons.**

Discussion 3

- **It is quite difficult to make the façade design maintaining or improving the energy performance and yet giving an impressive appearance as a solar house.**
- **It is, therefore, quite interesting to attempt conversion design in comparison with the case of designing a new solar house.**

Conclusion 1

- **Conversion design of solar house from active to passive is presented with the two examples that the author experienced.**
- **It is of primary importance to try to maximise the energy performance considering aesthetics in the façade design of a solar house.**

Conclusion 2

- **The façade having any kind of moving parts, like water flows, would eventually terminate in use, while passive solar features would generally remain longer.**
- **Passive system could not fully suffice the occupants’ needs and some kind of auxiliary energy systems would be necessary.**