JEA–SHC–TASK XIII

The Norwegian IEA Task XIII House

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SUMMARY

The Norwegian solar low energy dwelling developed within Task 13 of the International Energy Agency's Solar Heating and Cooling Programme, is a two-storey row house apartment of approximately 120 m² floor area. The IEA dwelling is being constructed at Hamar, 120 km north of Oslo, and it will be used for media personell lodging during the Winter Olympics in 1994.

The IEA dwelling will be superinsulated, with U-values of 0.11, 0.14, and 0.13 W/m^2*K for roof, walls and floor respectively. A new generation of superwindows is employed, featuring 4 glass panes and insulating edge spacers. With a very efficient ventilation heat recovery system, the calculated space heating load is only about 25 kWh/m^2*a.

Space heating and water heating is provided with a heat pump which uses the sunspace in the house, and a ground coil as heat source. The dwelling is also equipped with a grid-coupled photovoltaic system. The calculated purchased electricity amounts to 25 kWh/m^2*a.

1. INTRODUCTION

Housing traditions, the energy situation, and solar conditions set a special framework for development of solar energy buildings in Norway. The most important factors here are:

- Traditionally, buildings are well insulated and provide a high level of thermal comfort. Energy saving measures must not jeopardize this important feature of Norwegian dwellings.

- Norway has abundant energy supplies of all categories. The price of domestic electricity from renewable sources (hydropower) is comparable with the price of energy from fossil fuels. Direct electric resistance heating is common and inexpensive in Norway.

- The steady increase in standard of living has resulted in a general growth in domestic electricity demand for all sorts of appliances, which again adds considerably to the amount of available internal heat gains.

- The high latitude location, with a typically cloudy climate, gives negligable insolation during the most severe part of the winter. In November, December, and January, the daily solar contribution even in the south of the country is only 0.9 kWh/m^2 on the most favourable orientation. A high solar fraction for space heating requires some kind of seasonal storage.

- The high latitude also gives maximum insolation on steeply sloping or vertical surfaces during the heating season, making direct gain windows a favourable solar system.

Off hand, one could conclude that solar energy utilization is rather unlikely to be a success in Norway. But the heating season is long and streches into fall and spring, when appreciable amounts of solar energy are available.

2. THE SOLAR LOW ENERGY DWELLING

Contemporary dwelling developments in Norway are typically low-rise high density semi-detached or row-house type apartments in woodframe construction. Our IEA-dwelling is a row-house unit, the middle one in a row of three, each with two storeys and a fully heated floor area of 100 m^2.

The lay-out is rather conventional (fig. 1). Norwegians prefer cool bedrooms, therefore, in order to avoid unintentional heating by stack effect, they are all placed on the lower floor.

The only unusual feature of the plan is an almost fully glazed sunspace, integrated in the plan on the south side. The staircase is located here, it also functions as an air lock and buffer for the fully heated part of the dwelling. The sunspace itself will only be heated to +15°C.

The intermediate wall between sunspace and the fully heated part of the dwelling is also glazed, thereby providing additional daylight for the deeper parts of the dwelling. The staircase landing upstairs can be used as an addition to the balcony in summer.

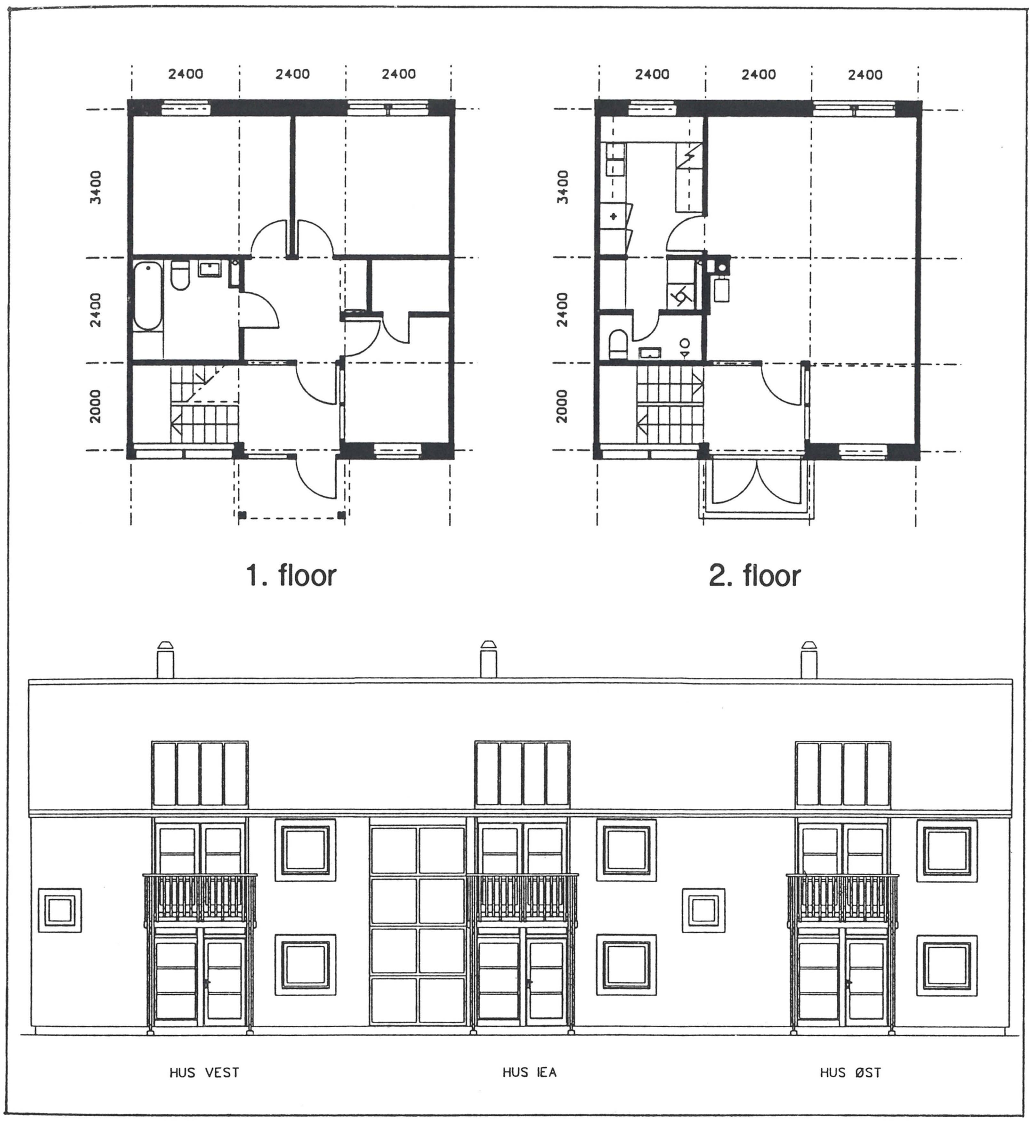

Fig. 1. Plans and south facade of the Norwegian IEA Task 13 dwelling.

3. ENVELOPE CONSTRUCTION

3.1 Thermal insulation

A high level of thermal insulation is required in our climate. The whole row-house is constructed with wood/chipboard I-profile wall studs, floor and roof joists. This type of construction accomodates large thicknesses of insulation with less added cost than conventional dressed timber frame members.

The IEA-dwelling is superinsulated, while the two dwelling units on each side are built to the thermal standard which will be required in the new building code that will be enforced from 1995. The U-values (W/m^2*K) are:

	Building code 1987	End row-house units	IEA row-house unit
Ext. walls	0.30	0.20	0.14
Roofs	0.20	0.15	0.11
Floor (slab)	0.30	0.13	0.13

For the IEA-unit this results in mineral wool thicknesses of 300 mm for exterior walls and 400 mm for the roof. The ground floor slab is insulated with 180 mm of recycled expanded polystyrene foam, the perimeter of the foundation is also insulated on the outside.

3.2 Windows and glazing

In a superinsulated house, the heating season will be concentrated to the dark no-sun period. This makes it very important to pay attention to the energy balance of all solar apertures. Even south-facing windows will be net losers over the heating season, therefore superior thermal insulation is generally more important than a high solar gain factor.

A interesting solution to this problem, is to use a dynamic system with thermal shutters which add insulation to the windows during the loss period at night. We have explored a system that would react automatically to the energy balance of the windows. A smart controller would compare measured radiation to ambient temperature, and decide when to close the shutters.

However, when we compared the performance of this system to that of the new generation of superwindows, we found that the savings in heating energy was only marginal. With the added costs and mechanical problems taken into account, we concluded that static superwindows was the optimal solution. Our windows have sealed triple glazing with two low-emission coatings and argon gas, and an extra pane of glass with a hard low-emission coating in an extra frame fitted to the exterior side of the window. The sealed unit have insulating spacers, and special mounting details to reduce thermal bridging.

The exterior glazing of the sunspace is also triple sealed units with low-emission coatings and argon. About half of the wall area, in the staircase end of the sunspace, is transparent insulation panels with 200 mm capillary insulation material fitted between glass panes. This gives an overall U-value of about 0.7 W/m^2*K, while the superwindows, including sash and frame, have a U-value of 0.8.

4. VENTILATION SYSTEM

4.1 Ventilation standard

The house will be equipped with a balanced mechanical ventilation system, designed to give an airchange that complies with the expected 1994 building code requirements:

	0.35	$l/s*m^2$	base fresh air supply
+	7.0	l/s	fresh air supply per occupant.

For our IEA dwelling this gives a fresh air supply of about 1.0 ach. The code also gives special high ventilation rates for bathrooms. We have therefore settled for a system where all return air is taken through the bathrooms, with a forced ventilation rate that operates when the bathrooms are being used, controlled by an occupance sensor.

4.2 Heat recovery

The ventilation system will be fitted with a high performance recuperating heat recovery unit. With the fan energy added to the heat balance of the ventilation system, there will only be a marginal heating load associated with the ventilation of the IEA dwelling, when the ambient temperature drops below -5 °C.

5. SOLAR HEATING SYSTEM

5.1 Heating demand

The space heating load of the IEA dwelling has been calculated by simulation with SUNCODE and TRNSYS, the annual load being about 2700 kWh, of which 800 kWh is the demand for sunspace heating. In addition, we assume a domestic hot water heating demand of 4000 kWh/a.

5.2 Heating system

At the outset, a prime target for our IEA advanced solar dwelling was to be selfsufficient with thermal energy (space heating and water heating). As full thermal seasonal storage is really not feasible on the scale of one dwelling unit, we had to compromise and allow some purchased backup heating.

With direct electric backup, it is logical to employ a heat pump, provided that a good stable heat source is available even in winter. We have studied several options, the final solution being a heat pump that uses solar surplus heat in the sunspace and ground heat (fig. 2). A coolant circulation system includes both a collector in the upper zone of the sunspace and a 20 m long coil buried at a depth of 2m in the ground outside the dwelling. The sunspace collector is designed to function both as an active solar and a convective collector.

The heat pump evaporator is always fed from the ground coil. The sunspace collector is only coupled to the loop when excess energy is available, and when there is no heat demand, the energy will thus be stored in the ground.

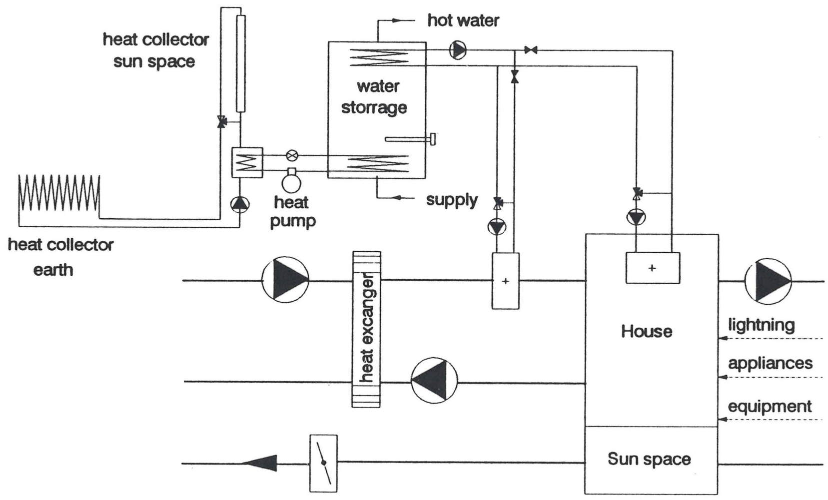

Fig. 2. System diagram of the ventilation and heating systems in the IEA dwelling.

6. ELECTRICITY DEMAND AND SUPPLY

6.1 Electricity demand

In order to demonstrate strategies that could curb the trend towards increasing electricity load for domestic equipment, we set a very low electricity demand target of 25 kWh/m²*a for the IEA dwelling. This requires that very efficient equipment is chosen, including automatically switched compact fluorescent lighting.

6.2 Photovoltaic supply

With an electrically driven heat pump, all energy demands are reduced to electricity only, and further reduction in purchased energy can only be realized with a solar electricity supply.

The IEA dwelling will therefore be equipped with a grid-coupled photovoltaic system, with 20 m^2 of PV panels on the south side of the pitched roof. This system will also give input to Norway's participation in IEA Solar Heating and Cooling Task 16 "Photovoltaics in Buildings". The output of the the PV system is, according to our PV-TRNSYS calculations, about 3000 kWh/a, with a surplus in the summer period that will be delivered to the local utility company. On an annual basis the total demand for electricity is around 3000 kWh, or 25 kWh/m^2*a.

8. CONSTRUCTION STATUS

The Norwegian IEA dwelling, with two other row-house units on either side, is under construction at Hamar, 120 km north of Oslo. These dwelling will be incorporated in a large housing development that will be used to house media personell during the 1994 Winter Olympics which will be arranged in the nearby town of Lillehammer. All houses will be built to a version suited for this purpose, then converted and sold in the spring of 1994. Monitoring will start already in the fall of 1993.

9. ACKNOWLEDGEMENTS

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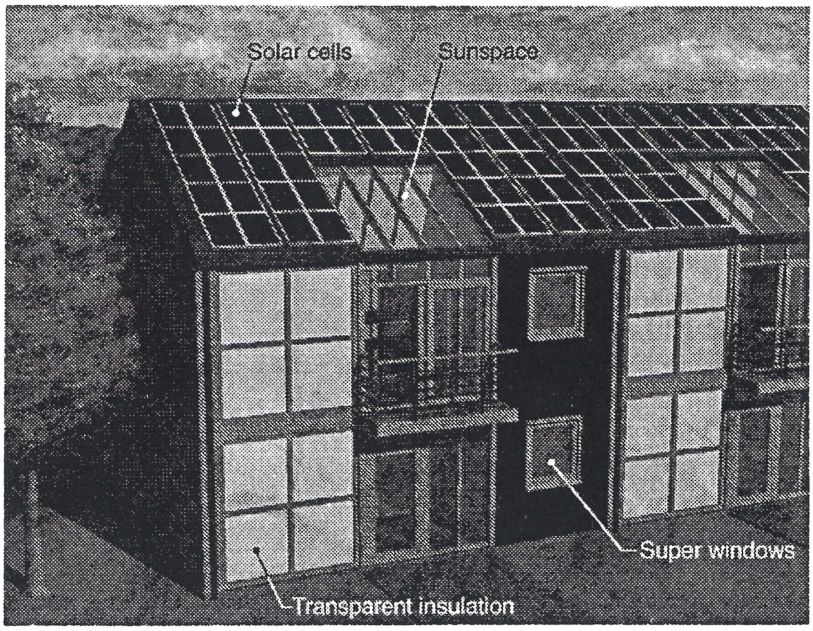

Fig. 3. A computer-generated perspective drawing of the Norwegian IEA row-house dwelling unit.

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