EuroSun 2010 - Solar houses design for 40-50 degrees latitude North

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Abstract

Experimental design and graphics search allow defining preferable passive solar heating architectural form for temporary-monsoon climate, as it was verified by mathematic modeling by IPMT FEB RAS. The innovation design in the fields of low-storey passive solar forms proposed in 2006, and confirmed by RF patent on invention №2342507 (in 2008). Based on patenting form three main types of passive solar buildings proposed: 57% passive solar heating dwelling Solar-5 “EcoHouse”; 45% passive solar heating eco-tourists Solar-5M “EcoModule”; and latest Solar-S “EcoDacha” as simplify variant.

Introduction

Weather conditions of a southern part of the Russian Far East are not comparable with soft weather of Europe or Japan, but sun heating in our southern latitude is enough to reduce the heating expenses on 50% or more, even during days of the Siberian cold. Frosty days with temperature of air below 12 degrees of a frost and north-north-west wind 8 – 12 m/s we can observe in vicinities of Vladivostok during two – two and half months. But at the same time 1900-2400 hours of sun shine per year (10-12 cloudy days from November to March) is usually situation for southern part of Russian Far East [1].

Russians, Ukrainians and Byelorussians immigrants, coming here from European part of Russian Empire in 1800 -1860, did not study the natives building traditions. Immigrants built the houses also, as well as their ancestors on the East Europe plain centuries ago. The situation was even more worsened by the multistory uniform dwellings which have appeared in the seventies, when Soviet government aspired to provide new settlers the minimum price flats. Central design institutes from Moscow and Leningrad (St. Petersburg) had not full and detail information’s about local climatic conditions. For economize building materials they designed building walls without sufficient heat insulation, and place such buildings on open to all winds peaks of the hills to minimize distance from city center and harbor. 40% of living rooms in such houses as a rule were opening to north part of horizon without sun. In winter conditions air temperature in such living rooms is not exceed +14°C. So, today the problem dares the centralized heating of all dwellings from thermal power stations, burn down thousands tons of Siberian coal and black mineral oil. The purpose of experimental designing was to develop the alternative decision of a housing estate on the basis of low-storey residential buildings with solar heating.

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Experimental design and graphics search allow defining preferable passive solar heating architectural form for temporary-monsoon climate, as it was verified by mathematic modeling by IPMT FEB RAS. The innovation design in the fields of low-storey passive solar forms proposed in 2006, and confirmed by RF patent on invention №2342507 (in 2008). Based on patenting form three main types of passive solar buildings proposed: 57% passive solar heating dwelling Solar-5 “EcoHouse”; 45% passive solar heating eco-tourists Solar-5M “EcoModule”; and latest Solar-S “EcoDacha” as simplify variant.

Keywords: Passive solar house design, sustainable design, solar architecture

Fig.1 Eco-village in Idol bay under Vladivostok (project view).

In view of government intentions to provide considerable growth of the population on Far East Pacific coast up to 2020, the purpose of the author was to offer for region the alternative decision of a housing estate on the basis of low-storey residential buildings with solar heating, social type of building average and low cost.

Low storey solar heating house conception for temporary climate zone basic features we hold on is well known. Everything begins with the original architectural form – "solid face" turned towards the winter wind and stained-glass window openings turned towards the sun – that alone saves 30-50% of heating costs. The use of passive and active solar heating system also imposes restrictions on the architecture of a building.

Space, sheltered from the wind and open to sun, is formed by a wind-break wall radial turned southward, collecting sunbeams, and giving shade from the high summer sun by means of an overhanging roof. The shape and decoration materials inside the surface of the inner wall should contribute to concentration of sunbeams or their absorption of warm thermal arrays, during the low winter solstice. By cutting off the inner "horseshoe-shape" space in the south through the stained-glass window from the external environment, we use the greenhouse effect: when covering a glass surface with a superfine metallic coating or heat-reflective film, the radiant component of heat losses goes back into the room. A thermal mass (a stone wall behind the glass, the floor out of ceramic granite or a massive fireplace under the skylight) should provide comfortable indoor temperature at night, maintaining the solar heat. From the windward side the wall and roof of the solar house can be transformed into a green hill that not only protects you from the cold northern monsoon, diverting the wind upward, but also contributes to additional saving of solar heat accumulated by massive constructions.

The solar house "P" designed by Institute of High Energy USSR Academy of Science for Dagestan republic polygon "Solntse" in 1980th became a starting point for experiences [2]. Characteristic feature of its design was high pitched north part and composite high-low pitched south part of ridge roof, which southern slope has been adapted under placing of solar water collector's line. Such decision very much approaches for protection of solar collectors against a wind; to reflect winter sun beams to solar panels and clerestory windows; to penetrate sun beams to the north oriented rooms and for summer aeration of all house, etc. But some of these possibilities can be realized for a mansard roof only that was impossible in a case with the house "P".

The patent subject was north-south section of low-storey solar heating house, more preferable for regional conditions (Russian Federation state patents on useful model №65926 and on invention №2342507 "Ecohouse Solar-5" [3]). Characteristic features of the design offer are submission of architectural form not only season changes of Sun bearing and altitude angles but the directions of strong winter wind also. Composite low-high-high-low profile of mansard roof adopted for wind break as well as for solar heating possibilities and for solar shading. Thermal losses allow reduce following decisions to 37 % comparable with tradition building design in temporary monsoon climate: north façade are with minimal square of glazing (0.5 – 1.0 sq. m.); incline north part of roof to winter wind; wind-break eaves; roof and walls heat insulation with internal heat reflecting surface conditions and others (Fig. 2, Fig. 3).

Fig.2 South-West and South-East view of “EcoHouse Solar-5”.

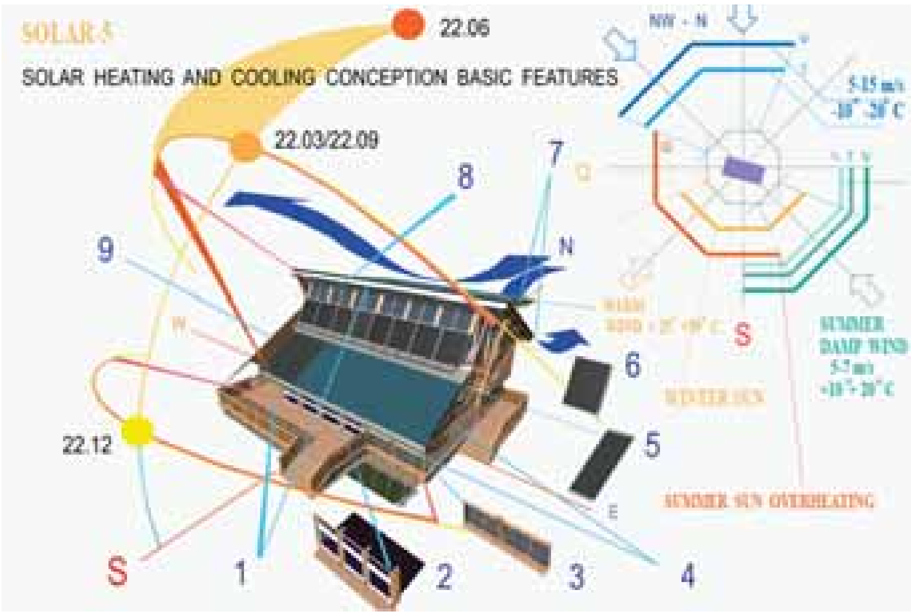

Fig.3 Basic features of proposed design are (Solar-5 example):

1 *- Overhangs to block the sun light in summer;* ***2*** *– Direct gain of “half-wall” thermal mass;* ***3*** *- South facing solar heating air convector;* ***4*** *– External wooden louver;* ***5*** *- 323.0 SQ. FT. south oriented roof can be use for PV placing. In other design finished with galvanized metal South oriented roof reflected low angle sun to solar water panels;* ***6*** *- South oriented active solar heating system panels 129.2 – 172.3 SQ. FT., 58 degrees angle;* ***7*** *- Wind-break eaves and angled to north side wind roof. North side of the house can use earth sheltered and evergreen trees to protect against cold wind;* ***8*** *- summer air filtration around clerestory windows proposes by Solar-5 design. North rooms be lighted directly through clerestory windows by south incoming sunlight;* ***9*** *– Sun-shading from South-West and West;* ***10*** *- South facing LOW-E double-panel open-able windows (IE-IE-I).*

Solar-5 **“Direct gain”** distributed masses are: concrete floor slab 10.0 cubic meters, massive fireplace 3.0 cubic meters, stone filling of partitions wooden frame 2.5 cubic meters. **“Direct gain”** concentrated mass are three brick “half-walls” of kitchen 1.5 cubic meters. **Walls wooden frame insulation** (section internal space – external air) are: internal space - dry wall (or matchboard) – air space (min 0.035 m) – reflecting material/vapor barrier – thermal insulation (0.25 m) – vapor penetrable water barrier – ventilating air space (0.05 – 0.075 m) – different facing surface – external air**. Roof wooden frame insulation** (section internal space – external air) are: internal space – dry wall - air space (0.035 m)

– reflecting material/vapor barrier – thermal insulation (0.30 m) - vapor penetrable water barrier – ventilating air space (0.075 m) - wood-fibrous plate (other)– roofing - external air. South, south-east and south-west facing low-e double-panel (IE-IE-I) open-able **windows** are about 70% of wall surface square. **Maximum heat loses** of building is 7, 6 kWt (- 24°C). 30 degrees angled south facing roof about 30, 0 sq. meters is suitable for PV placing, or use as reflection surface for solar water collector line (Solar-5 "middle size" dates).

"EcoHouse Solar-5" is developed together with IPMT FEB RAS (active solar system design) as single family house of average cost based on wooden cross frame construction. Changing number of cross-section wooden frames with 6 to 8 owners will receive three types of houses of the different living area: 78,7; 93,7 and 108,7 sq. m. Passive solar design has allowed to reduce the area of collectors twice, that has lowered cost of active solar system on 12 500.00 Euro. In final decision for "middle size" house (93, 7 sq. m.) solar hot water system panels are about 15, 0 sq.m. with hot water tank 0, 75 cubic m. and electric boiler 6 kWt as duplicate heating system. The building price without active solar heating system is about 650.00 Euro per sq.m.

As it has been confirmed by mathematical modeling by Non-traditional energetic laboratory of IPMT FEB RAS, Solar-5 design will allow to compensate 38 % of requirements for building heating by passive solar design and passive house design only during the five most cold winter days (air temperature 24°C below zero). In usually winter conditions (14°C below zero and N-NW wind 5-10 m/s) solar insulation of thermal mass and passive house design will allow compensating 57% of heating requirements. Including solar active system water collectors we suppose to compensate 81% of heating requirements from November to March (calculating dates by ing.-reseacher Alexandr V. Volkov, Solar-5 example [4])(Fig.4).

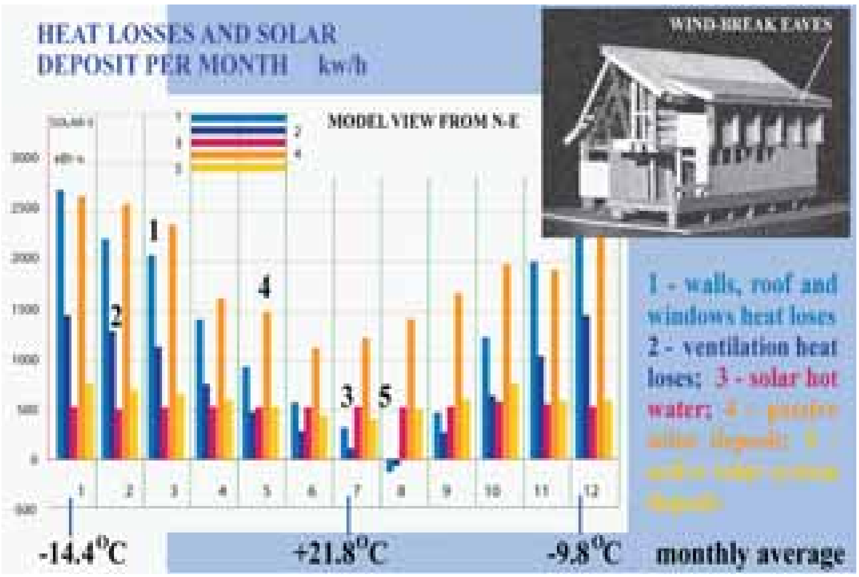

Fig.4. Heat losses and solar deposit per month (Solar-5 example according IPMT FEB RAS modeling); summer passive solar deposit dates without external summer shading, and ventilation without "Inverter" effect.

Being based on the patented form two types of buildings was offered also for the last two years: 45% passive solar heating eco-tourists Solar-5M "EcoModule" are about 36,0 and 48,0 sq.m. (in cooperation with "Technopark" FENTU)(Fig.5); and latest Solar-S "EcoDacha" are 55.0 and 65.0 sq.m as simplify variant of patenting form (Fig.6). All types propose for "Hundegger" Speed-Cut SC21 wooden frame technology and first Solar-5M "EcoModule" under construction.

Fig.5. “EcoModule Solar-5M” under construction in “Technopark” FENTU.

Fig.6. “EcoDacha Solar-S” views from North-West.

Conclusion

Three main “social” types of passive solar houses projects work out in 2006 – 2010 for climatic conditions of southern part of Russian Far East. There are 57% passive solar heating dwelling Solar-5 “EcoHouse”; 45% passive solar heating eco-tourists Solar-5M “EcoModule”; and latest Solar-S “EcoDacha” as simplify variant.

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