STRATEGY FOR PASSIVE SOLAR HEATING OF BUILDINGS IN COLD REGIONS OF INDIA

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Abstract

Passive solar heating of houses is a clean technology which was made mandatory in the government/semi-government sector in 1994 in the Western Himalayan state of HP (Himachal Pradesh). HP is the first state in India to take such a policy decision for promoting energy efficiency in buildings. A Solar House Action Plan was formulated and is being implemented effectively in the state. A large number of buildings were designed and constructed through a massive awareness campaign among engineers, architects, and the public. Based on the successful implementation, another decision was taken in June 2009, vide which solar passive heating technology features have been incorporated in the building byelaws and solar passive heating features have been made mandatory in the government/semi government and commercial sectors. The strategy adopted, which is promoting energy efficiency, providing comfort, and ensuring sustainability, is outlined in the present study. The results of the field survey of constructed solar passive buildings in Shimla and Spiti valley of the state is presented. A strategy for the implementation and sustainability of the technology is outlined for the cold regions.

Introduction

The state of HP lies in the Western Himalayas and extends from the snow-covered mountains separating Tibet in the north to the plains of Punjab in the South and West. The state, with a geographical area of 55 673 sq km, is located between latitude 30° 22′ 40″ to 33° 12′ 40″ North and longitude 75° 45′ 55″ to 79o 4′ 20″East. The altitude ranges from 250 m to 6975 m above mean sea level. Due to the peculiar topography and snowfall in high the altitude areas, the state experiences severe winters. Areas above 2000 m receive light to heavy snow fall, whereas the alpine zone remains under snow for 5–6 months in a year.

About 92% of the state's population lives in villages and largely depends on fuelwood for space heating, water heating, and cooking. About 4.82 million tonnes of fuelwood is used in the state annually for cooking, space heating, water heating, tarring of roads, and so on, out of which 4.5 million tonnes is used by the rural population. This requirement has resulted in large-scale denudation of forests posing serious threat to the environment. Wood, charcoal, coal, kerosene, LPG (liquefied petroleum gas), and electricity are mainly used for cooking and space heating during winters. In the tribal areas of the state, fuelwood, coal, and kerosene are supplied on subsidy to the public, resulting in serious burden on government exchequer.

In high altitude regions, government buildings like offices, hospitals, require electricity-/fuelwood-/fossil fuel-based heating systems to create comfortable indoor conditions during winters. The installation and annual running costs of such heating systems are quite high. This cost can be considerably reduced if a building is designed incorporating solar passive features. About 250–300 sunshine days per year are available in HP, with 7–8 mean sunshine hours per day. And as such, solar energy can effectively be utilized for space heating.

Solar passive housing incorporates features like orientation, passive heating or cooling systems, and the use of appropriate building materials in order to conserve energy used in heating, cooling, and interior lighting of buildings utilizing Sun's energy effectively. In a cold climate, the strategy is to maximize heat gains from the Sun, make provision for heat distribution, store Sun's energy within the building, and minimize heat losses.

Solar building design strategy also includes use of natural light for day-lighting, which reduces electricity consumption. The government sector is the biggest consumer of energy for space heating and day-lighting in buildings in cold regions. The adoption of this technology not only creates comfortable living conditions but also results in the saving of conventional fuels like fuelwood, coal, charcoal, and electricity required for winter heating.

Implementation strategy

Policy decision 1994

In order to implement the solar passive housing technology in HP, a policy decision was taken by the HP government in 1994 that all government and semi government buildings in HP will be designed and constructed using passive solar design features in a phased manner. Thus, HP became the first state in the country to take such a policy decision. A Solar House Action Plan with detailed implementation guidelines were formulated by the State Council for Science, Technology, and Environment. A Technical Project Management Cell was set up in the Council to implement the Solar House Action Plan in coordination with state housing agencies.

Technology demonstration

In order to demonstrate the efficacy of the solar passive technology for winter space heating, 25 government buildings were identified for which the government funds for construction were available. A team of experts were involved with the architects and engineers of the concerned agencies for the preparation of the building designs after carrying out the detailed micro-climate and site analyses. The constructed solar passive buildings were monitored during winters for thermal comfort evaluation. The solar radiation data which is required for the simulation of solar buildings was generated using sunshine hour data. The retrofitting of houses with passive solar heating systems in high altitude areas of Bharmour, Spiti, and Kinnaur was carried out.

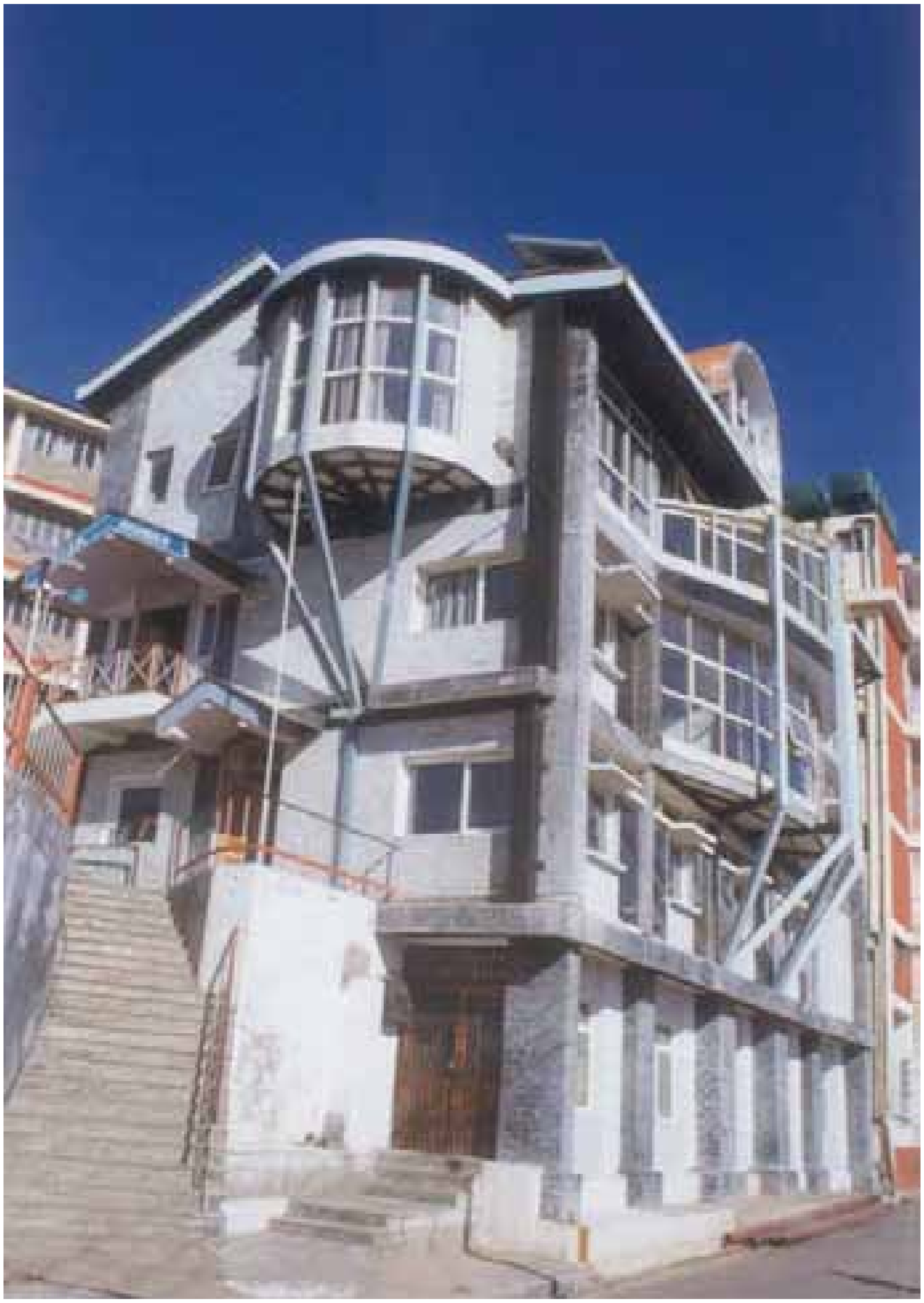
Ensuring trained technical manpower

Specialized training programmes were organized by the Council for the architects, engineers, scientists, masons, carpenters, and builders for the sustainability of the programme. The carpenters and masons were trained in the construction of cavity walls, trombe wall, thermosyphoning air heating panels, and space heating green houses for the sustainability of the programme in rural and high altitude regions.

The solar passive design features have been incorporated in the building byelaws so that the technology is adopted in all buildings like hotels, industry, and houses.

Funding

The solar passive building programme was financed by the HP government, along with the MNRE (Ministry of New and Renewable Energy), Government of India. The funds were obtained only for capacity building, training, and fabrication of solar heating systems. The funds for building construction were provided by the concerned housing agencies or the house owners. The funds provided by the MNRE for detailed project report preparation



Himurja Office Building, Shimla

and for incorporating solar passive features in the buildings were utilized for demonstration buildings.

Policy decision 2000

Based on the successful demonstration of the solar passive housing technology, the HP government took a policy decision on 18 August 2000, vide which all the departments including corporations, boards, universities, public works department, and HP Housing Board were directed to design and construct all the new buildings above 2000 m by incorporating solar passive design features.

More than 200 solar passive buildings, including offices, hospitals, schools, houses, were constructed. The monitoring of the constructed solar buildings was also carried out for thermal comfort and energy saving potential. The experience gained in implementing the technology was shared with some states, namely Uttrakhand, Sikkim, Manipur, Nagaland, and Arunachal Pradesh.

Policy decision 2005

The solar passive building programme was reviewed by the state's chief minister on 14 October 2005 and a decision was taken that all buildings, industrial complexes, tourist resorts, hotels in the government/semi-government and private sectors must incorporate solar passive heating and cooling, earthquake-resistant and rainwater harvesting structure features in all the buildings in HP. It was also decided to set up computerized design cells in government agencies, besides modifying building byelaws for making provision for solar passive features, solar space heating systems, solar access to buildings, colonies, and new townships by the Department of Town and Country Planning, municipal corporations, and other concerned agencies.

Based on this decision, a committee was constituted by the government consisting of representatives from the Science and Technology Council, HPPWD (HP Public Works Department), HIMUDA (Himachal Pradesh Housing and Urban Development Authority), Town and Country Planning Department, and municipal corporation, Shimla, to incorporate passive solar features in building byelaws. The committee recommended the modification of building byelaws.

Policy decision 2009

Based on the recommendations of the committee, the state government took a policy decision on 27 June 2009 vide which solar passive features have been made mandatory throughout the state government/semi-government and


A closer view of the solarium at Himurja Office Building

commercial sectors, including in hotels, residential colonies, and industrial complexes which are large consumers of energy. Thus, for the effective implementation of a technology, a long-term strategy has to be worked out with a continuous back-up of policy decisions by the government.

Thermal comfort evaluation

The monitoring of the constructed solar passive buildings was carried out to study the thermal comfortable conditions, efficacy of solar passive features, and actual energy savings. The monitoring of constructed solar passive buildings in the state shows that the buildings are comfortable in winters and the dependence on electricity for heating has been reduced considerably. The users have also expressed satisfaction over the comfort level.

Himurja office building

The building located at Shimla exposed to winter Sun has day-lighting features, sunspace, thermo-syphoning heating panels, double-glazed windows, solar water heating, and solar photovoltaic lighting features. This building does not require any auxiliary heating in winters. The monitoring of building shows the inside temperatures as 18 °C to 28 °C with ambient temperature variation from 9 °C to 15 °C.

Solar passive buildings in cold desert regions

A number of solar passive schools, teachers' hostels, and rural houses have been constructed in Tabo, Kaza, Sagnam, Dhankar, Rangrik, Kibber, Hansa, and Losar in Spiti Valley at altitudes from 12 500 ft to 14 500 ft, where the minimum temperature drops to -40 oC in winters. The Solar Trombe wall, which is effective in providing nighttime heating, was installed at the Tabo Monastry Residential Complex.

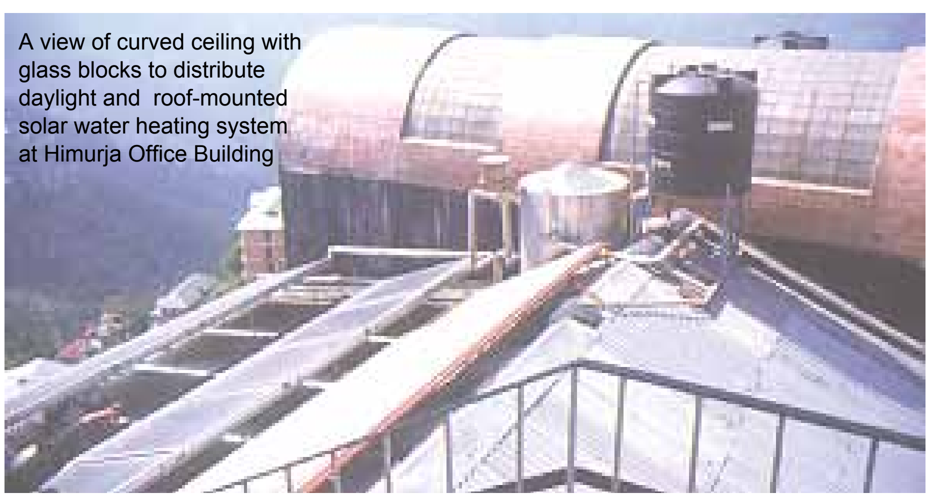
Retrofitting of traditional houses

Under the plan, a number of traditional houses were retrofitted with thermosyphoning air heating panels, sunspace, and Trombe wall heating systems in Sangla Valley, Kinnaur district, and Bharmour, Chamba, which resulted in wider awareness and acceptability by the people. A training centre for women was retrofitted with a sunspace which resulted in providing comfortable working space for rural women during winters.

Discussion and follow-up

In the solar passive buildings constructed in the state, there is only a marginal, increase in the cost ranging from 0% to 10% depending on the nature of solar passive features adopted. This minor increase in the cost further reduces if proper site planning, designing, and selection of materials are done at the initial stages. Due to continuous saving of fuel/electricity required for space heating/cooling in such buildings, this additional cost can be recovered within 2–3 years. The solar passive building programme has been implemented in the western Himalayan state of HP successfully and the experience gained can be replicated not only in the hilly states of India but also in other cold regions of Asia, like Tibet, Nepal, China, Afghanistan, and so on. The adoption of environment-friendly solar passive housing technology for space heating in the entire Himalayan region countries will lessen the burden on fuelwood, saving the forests from extinction besides creating a pollution-free environment and decreasing greenhouse gas emissions.

Although it is difficult to change the mindset for adopting the new technological inputs and orient the architects and engineers, especially in the government sector, long-term technological backup, continuous thrust and zeal to promote this technology, and ensuring the availability of motivated technical manpower are essential to sustain the programme.


A view of curved ceiling with glass blocks to distribute daylight and roof-mounted solar water heating system at Himurja Office Building