ICIMOD

Profiting from Sunshine

Passive Solar Building in the Mountains

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International Centre for Integrated Mountain Development
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Foreword

High altitude areas of the Hindu Kush-Himalayans are characterised by low ambient temperatures for most parts of the year. The inhabitants in this region rely on wood, agricultural residue, and animal waste to keep their houses warm, in particular during the winter season. The use of biomass has resulted in deforestation and ecological imbalances. Additionally the use of biomass for space heating without proper heating stoves severely affects the health of the occupants, especially women and children. There is therefore an urgent need to develop alternative options for space heating in the mountain areas of China, India, Nepal, and Pakistan.

ICIMOD, as an international institution committed to the development of mountain regions, recognised the need for appropriate design of buildings to help either to eliminate the use of fuels for space heating or reduce energy consumption. In order to have an overview of the available knowhow, technologies, and house building practices, ICIMOD supported the organization of national workshops on Passive Solar Building Technologies (PSBTs) in China, India, Nepal, and Pakistan. Prior to these workshops very little had been published on PSBT in the HKH, and ICIMOD was requested to present the papers of all these workshops in a comprehensive and concise manner useful to the professionals engaged in promoting PSBTs. The present volume is an outcome of this effort. This document is the first of its kind to provide an overview on (i) Fundamentals of Solar Energy and Solar Radiation, (ii) State of the Art in Solar Passive Technologies, (iii) Solar Passive Building Design in the Mountains, (iv) Building Materials for Hilly and Mountain Areas, (v) Application and Design of Passive Solar Systems for Buildings, and (vi) Issues and Future Directions required for the promotion of PSBTs in the context of mountain areas of the HKH Region. I am confident that this document in its present form will be useful to those who are involved in the application and dissemination of passive solar building technologies. It also provides a good introduction to the subject for those energy specialists who are looking for new options for space heating in the HKH.

I would like to extend my sincere appreciation to the programme coordinators from China, Mr. Wang Gehua, Director, Centre for Energy, Environmental Protection and Technology Development, Ministry of Agriculture, Beijing; to Dr. S.S. Chandel, Principal Scientific Officer, State Council for Science, Technology, and Environment, Shimla, India; to the Centre for Applied Research and Development and Department of Architecture, Institute of Engineering, Kathmandu; and to Aga Khan Housing Board for Pakistan, Karachi, for organizing the national workshops on Passive Solar Building Technologies in their respective countries and establishing a network of institutions on the subject in the HKH Region.

I would like to thank Professor N.K. Bansal, Centre for Energy Studies, Indian Institute of Technology, New Delhi, for consenting to review the papers presented in the national workshops and to be one of the editors of this document.

Finally, I would like to thank Dr. Kamal Rijal, Renewable Energy Specialist, ICIMOD, who, as the Coordinator of the Programme, has been responsible for bringing out this document in its present form.

Mr. Egbert Pelinck
Director General

February 2000

Editorial Preface

Although passive solar technology has been used by builders for three millennia and more (if one considers the techniques used in ancient Egypt and Mesopotamia), its applications in mountain regions are not as well documented as applications in other areas. For this reason we have not followed as strictly as is the norm the custom of listing only references cited. Whenever our authors have been able to give full particulars of a publication that can be used for buildings in mountain areas, it has been listed.

Readers will understand that passive solar technology in mountain areas has two dimensions;viz., the new applications that are being promoted on the market and the hidden part of the 'iceberg' as far as passive solar technology is concerned—the measures used traditionally to capture sunlight and profit from it. It is hoped that this document will enthuse researchers and builders to pursue this topic and search for all the applications possible that will make living and working in the mountains more comfortable in future than it has been in the past.

Abstract

In the Hindu Kush-Himalyan (HKH) Region it is difficult to keep houses warm during winter. Usually biomass fuels are burned for cooking and space heating. Using biomass fuels has resulted in large-scale deforestation and ill effects on the health of mountain people, especially women and children, from the smoke produced. Solar radiation is available in most parts, and it is sensible to take solar energy consciously into consideration in designing buildings in order to reduce the use of biomass fuels for space heating.

The International Centre for Integrated Mountain Development (ICIMOD) is committed to improving the living standards of people living in the HKH Region. In the light of this objective, the Centre organized workshops on Passive Solar Building Technologies in China, India, Nepal, and Pakistan to establish a network of institutions involved in promoting Passive Solar Building Technology (PSBT) in mountain areas. The state-of-the art reviews clearly indicated that concrete efforts had been made in China and India to promote a solar passive heating programme, whereas there have been individual efforts in Nepal and Pakistan to build passive solar homes. The compilation of these papers in a comprehensive and concise manner should help to share knowledge about new developments in the respective countries as a means of promoting PSBTs in mountain areas.

This book, the first of its kind, provides an overview of the (i) National Workshops; (ii) Potentials for Application of PSBTs in Mountain Areas; (iii) Fundamentals of Solar Energy and Solar Radiation; (iv) State of the Art in Solar Passive Technologies; (v) Solar Passive Building Designs in the Mountains; (vi) Building Materials for Hilly and Mountain Areas; (vii) Application and Design of Passive Solar Systems for Buildings; and (viii) Issues and Future Directions required for the promotion of PSBTs in mountain areas of the Hindu Kush-Himalayan Region.

Overall, concrete solutions are needed to introduce solar passive building concepts in the HKH Region. Understanding climate, traditional architecture, construction materials, and construction techniques is important for optimum passive building designs, and this book attempts to provide some insights.

The following activities are recommended: (i) analysis and classification of climatic conditions in the HKH Region; (ii) study of vernacular architecture and identification of passive building elements; (iii) study of urban architecture; (iv) selection of an appropriate thermal simulation programme; (v) creation of a database and thermophysical properties of building materials and traditional building components; (vi) quantification of individual design patterns, for example, direct gain, indirect gain, thermal storage, solarium, cavity insulation, building form, roof shape, and underground structure; and (vii) preparation of manuals on design guidelines, design context, and construction issues. The information and knowledge thus prepared should then be disseminated to architects, users, and the construction industry, in both the formal and informal sectors. Design guidelines have not been provided for rural mountain areas anywhere in the world. Any initiative in this respect would help improve the health, efficiency, and lifestyles of rural people residing in mountain areas.

Acknowledgements

The International Centre for Integrated Mountain Development (ICIMOD) recognised the need to review the status of passive solar building technologies (PSBT) in the HKH region and has made a conscious effort to disseminate knowledge of passive building science to these regions. The editors are grateful to the ICIMOD authorities for this initiative and for giving them the responsibility of editing the proceedings of four workshops. One of the editors (N.K. Bansal) is personally grateful to Dr Kamal Rijal, the joint editor, for asking him to co-edit the work. Editing was not simple and the help of Dr. M. S. Bhandari of IIT Delhi is acknowledged for his help in collating the written texts.

Acronyms

Ah	Ampere hour
ASHRAE	Association of Heating, Refrigeration and Air-Conditioning Engineers
BTU	British Thermal Unit
CBRI	Central Building Research Institute
COP	Coefficient of Performance
CPWD	Central Public Works Department
CSIR	Council of Scientific and Industrial Research
DD	Degree Day
DDC	Direct Digital Control
EJ	Eta Joule
EMSs	Energy Management Systems
FET	Fluorinate Ethylene Teraphithlate
FLC	Fuzzy Logic Controller
GI	Galvanised Iron
HKH	Hindu Kush-Himalayas
HP	Himachal Pradesh
HVAC	Heating, Ventillation and Air-Conditioning
ICIMOD	International Centre for Integrated Mountain Development
ICS	Improved Cooking Stove
IFA	International Energy Agency
IIT	Indian Institute of Technology
IR	Infrared
ITBP	Indian Tibet Border Post
J	Joule
KJ	Kilo Joule
°k	degree kelvin
kWh	kilowatt hour
masl	metres above sea level
MIT	Massachussets' Institute of Technology
MJ	Million Joule
mm	milimetre

NBRI	National Building Research Institute
NGO	Non-Governmental Organization
NIST	National Institute of Silicon Technology
PCM	Polycrystalline membrane
PMA	Polymethylacrylate
PSBT(s)	Passive Solar Building Technology
Pv	Photovoltaic
R&D	Research and Development
RBC	Reinforced Brick Concrete
RC	Reinforced Concrete
RCC	Reinforced Cement Concrete
SHS	Solar Home System
SIER	Shanghai Institute of Energy Research
TAP	Thermosiphonic Air Panel
tce	tonnnes of coal equivalent
TI	Transparent Insulation
TIM(s)	Transparent Insulation Material(s)
UNDP	United Nations Development Programme
UP	Uttar Pradesh
UV	Ultra-violet
U-Value	thermal insulation
V	Volt

Contents