Building Integrated Photovoltaic Thermal Systems For Sustainable Developments Rsc Energy Series

Net Zero-Energy Buildings have been the object of numerous studies in recent years as various countries have set this performance level as a long-term goal of their energy policies. This book presents a unique study of 30 NZEBs that have been constructed and have had their performance measured for at least 12 months. This book describes exemplary selected projects carried out in the Trentino-Alto Adige region (Italy) exploring numerous building-integrated photovoltaics (BIPV) systems (i.e. modules, construction system, energy systems). It presents 18 case studies analyzing three aspects of PV integration: aesthetic, energy and technology, with information on decision-making, design process and lessons learnt given for each, along with several pictures, including of general system and architectural details. Based on interviews with architects and engineers, experts from façade/glass manufacturers, energy consultants, BIPV experts, PV installers, electricians, private and public building owners and real estate companies, the book provides a source of inspiration and technical knowledge for architects and engineers towards an increased use of PV in architecture.

Air-based, open loop Building Integrated Photovoltaic/Thermal (BIPV/T) systems have proven to be an efficient means for generating renewable energy. They produce electrical energy, converting part of the incident solar radiation, and recover part of that radiation that turns to heat, while acting as the outer shell of the building. However, for the typical BIPV/T design with air entering at the bottom of the installation, flowing within a continuous air channel and exiting at the outlet of the system high PV temperatures may still occur. This is due to the fact that as air moves inside the air channel it accumulates heat and the heat exchange efficiency between the PV panels and the flowing air drops along the flow path of the air channel. In large building integrated PV installations, high PV temperatures may lead to quicker PV panel degradation, as well as lower electrical efficiency. A multiple-inlet BIPV/T system aims to increased heat extraction from the PV panels, with the introduction of several intakes of fresh air along the height of the installation. This may lead to lower and more uniform PV temperatures, enhanced PV panel durability and higher electrical and thermal performance. This study presents the development of a methodology for the modelling and design of multiple-inlet systems, as well as a numerical study of such a system. The modelling component consists of two aspects, namely, the fluid mechanics and the energy balance of the system. A flow model was developed, based on flow networking techniques, in order to assess the inlet flow distributions. The flow model incorporates wind effects in the form of exterior pressures, acquired through wind tunnel testing. The inlet flow distributions were used in a modified energy balance model that accounts for the flow conditions of the inlets and the air channels of the system. This was an improvement on the assumption of uniform flow from all the openings of the system, which has been common in the limited number of studies of multiple-inlet systems so far. The developed models were applied for the numerical investigation of variations of multiple-inlet BIPV/T systems for a potential retrofit project on an office building in Montreal. The investigation was carried out assuming summer and winter conditions, as well as several cases of wind direction and velocity. A multiple-inlet system with optimized geometric features of the inlets was found have up to 1% higher electrical efficiency and 14% to 25% higher thermal efficiency than that of a single-inlet system, also resulting in lower and more uniform PV operating temperatures. The latter can be a crucial factor for the durability of large building integrated PV installations.

ISES Solar World Congress is the most important conference in the solar energy field around the world. The subject of ISES SWC 2007 is Solar Energy and Human Settlement, it is the first time that it is held in China. This proceedings consist of 600 papers and 30 invited papers, whose authors are top scientists and experts in the world. ISES SWC 2007 covers all aspects of renewable energy, including PV, collector, solar thermal electricity, wind, and biomass energy. This volume presents the proceedings of the 9th Cold Climate HVAC conference, which was held in Kiruna, Sweden in 2018. The conference highlighted key technologies and processes that allow scientists, designers, engineers, manufacturers and other decision makers in cold climate regions to achieve good indoor environmental quality (IEQ) with a minimum use of energy and other resources. The conference addressed various technical, economic and social aspects of buildings and HVAC systems in new and renovated buildings. This proceedings volume gathers peer-reviewed papers by a diverse and international range of authors and showcases perspectives and practices in cold climate building design from around the globe. The following major aspects, which include both fundamental and theoretical research as well as applications and case studies, are covered: (1) Energy and power efficiency and low-energy buildings; (2) Renovating buildings; (3) Efficient HVAC components; (4) Heat pumps and geothermal systems; (5) Municipal and city energy systems; (6) Construction management; (7) Buildings in operation; (8) Building simulation; (9) Reference data; (10) Transdisciplinary connections and social aspects; (11) Indoor environments and health; (12) Moisture safety and water damage; (13) Codes, regulations, standards and policies; and (14) Other aspects of buildings in cold climates.

The building industry is one of the largest energy consumers and countries all over the world are striving to design buildings that satisfy the user’s expectations while containing their energy consumption. In this context, zero-energy buildings have emerged as a technological paradigm that can solve this global issue, but its implementation in different contexts has brought a profound debate about its technical, social, and environmental limitations. Thanks to contributions from a variety of scholars from different countries, this book explores different aspects of the zero-energy buildings and gives the reader a broad view of the feasibility of implementation in different contexts. This book contains selected papers presented during the World Renewable Energy Network’s 28th anniversary congress at the University of Kingston in London. The forum highlighted the integration of renewables and sustainable buildings as the best means to combat climate change. In-depth chapters written by the world’s leading experts highlight the most current research and technological breakthroughs and discuss policy, renewable energy technologies and applications in all sectors – for heating and cooling, agricultural applications, water, desalination, industrial applications and for the transport sectors. Presents cutting-edge research in green building and renewable energy from all over the world; Covers the most up-to-date research developments, government policies, business models, best practices and innovations; Contains case studies and examples to enhance practical application of the technologies.
Building Integrated Photovoltaic Thermal Systems: Fundamentals, Designs and Applications presents various applications, system designs, manufacturing and installation techniques surrounding how to build integrated photovoltaics. The book provides a comprehensive understanding of all system components, long-term performance and testing, and the commercialization of BIPV systems. By addressing potential obstacles with current BIPV systems, such as photovoltaic efficiency bottlenecks and product heat harvesting, the authors not only cover fundamentals and design philosophy of current technology, but also introduce a hybrid system that looks at building integrated thermal electric roofing. Topics covered in this book are useful for scientists and engineers in the fields of photovoltaics, electrical and civil engineering, materials science, sustainable energy harvesting, solar energy, and renewable energy production. Contains system integration methods supported by industry developments. Includes real-life examples and functional projects as case studies for comparison baru System design challenges, offering unique solutions.

This book presents techniques for building and optimizing structures with integrated solar energy systems. It describes active solar systems such as photovoltaics and parabolic concentrators as well as passive solar systems and covers optimal materials to use, daylighting, shading, solar blinds, rock and water energy storage and more. It discusses the best ways to site a solar structure considering exposure, elevation, slope, clearance, wind protection, etc. The book includes numerous full-color figures and more than 100 MATLAB® files.

A complete overview of solar technologies relevant to the built environment, including solar thermal energy for heating and cooling, passive solar energy for daylighting and heating supply, and photovoltaics for electricity production. Provides practical examples and calculations to enable component and system simulation e.g. Calculation of U-values, I-V curve parameters and radiance distribution modelling.

Discusses the new trends in thermal energy use, including the architectural integration of collector systems, integrated ventilation photovoltaics facades and solar powered absorption cooling systems Coverage of cutting-edge applications such as active and passive cooling techniques and results from ongoing research projects. Building energy design is currently going through a period of major changes. One key factor of this is the adoption of net-zero energy as a long-term goal for new buildings in most developed countries. To achieve this goal a lot of research is needed to accumulate knowledge and to utilize it in practical applications. In this book, accomplished international experts present advanced modeling techniques as well as in-depth case studies in order to aid designers in optimally using simulation tools for net-zero energy building design. The strategies and technologies discussed in this book are, however, also applicable for the design of energy-plus buildings. This book was facilitated by International Energy Agency’s Solar Heating and Cooling (SHC) Programs and the Energy in Buildings and Communities (EBC) Programs through the joint SHC Task 40/EBC Annex 52: Towards Net Zero Energy Solar Buildings R&D collaboration. After presenting the fundamental concepts, design strategies, and technologies required to achieve net-zero energy in buildings, the book discusses different design processes and tools to support the design of net-zero energy buildings (NZEBs). A substantial chapter reports on four diverse NZEBs that have been operating for at least two years. These case studies are extremely high quality because they all have high resolution measured data and the authors were intimately involved in all of them from conception to operating. By comparing the projections made using the respective design tools with the actual performance data, successful (and unsuccessful) design techniques and processes, design and simulation tools, and technologies are identified. Written by both academics and practitioners (building designers) and by North Americans as well as Europeans, this book provides a very broad perspective. It includes a detailed description of design processes and a list of appropriate tools for each design phase, plus methods for parametric analysis and mathematical optimization. It is a guideline for building designers that draws from both the profound theoretical background and the vast practical experience of the authors.

The demand of energy consumed by human kind has been growing significantly over the past 30 years. Therefore, various actions are taken for the development of renewable energy and in particular solar energy. Many technological solutions have then been proposed, such as solar PV/T collectors whose objective is to improve the PV panels performance by recovering the heat lost with a heat removal fluid. The research for the improvement of the thermal and electrical productivities of these components has led to...
the gradual integration of the solar components into building in order to improve their absorbing area. Among technologies capable to produce electricity locally without contributing to greenhouse gas (GHG) releases is building integrated PV systems (BIPV). However, when exposed to intense solar radiation, the temperature of PV modules increases significantly, leading to a reduction in efficiency so that only about 14% of the incident radiation is converted into electrical energy. The high temperature also decreases the life of the modules, thereby making passive cooling of the PV components through natural convection a desirable and cost-effective means of overcoming both difficulties. A numerical model of heat transfer and fluid flow characteristics of natural convection of air is therefore undertaken so as to provide reliable information for the design of BIPV. A simplified numerical model is used to model the PVT collector so as to gain an understanding of the complex processes involved in cooling of integrated photovoltaic arrays in double-skin building surfaces. This work addresses the numerical simulation of a semi-transparent, ventilated PV façade designed for cooling in summer (by natural convection) and for heat recovery in winter (by mechanical ventilation). For both configurations, air in the cavity between the two building skins (photovoltaic façade and the primary building wall) is heated by transmission through transparent glazed sections, and by convective and radiative exchange. The system is simulated with the aid of a reduced-order multi-physics model adapted to a full-scale arrangement operating under real conditions and developed for the TRNSYS software environment. Validation of the model and the subsequent simulation of a building-coupled system are then presented, which were undertaken using experimental data from the RESSOURCES project (ANR-PREBAT 2007). This step led, in the third chapter to the calculation of the heating and cooling needs of a simulated building and the investigation of impact of climatic variations on the system performance. The results have permitted finally to perform the exergy and exergoeconomic analysis.

This book comprises select papers presented at the International Conference on Trends and Recent Advances in Civil Engineering (TRACE 2018). The book presents results of experimental investigations into the latest topics related to energy and built environment. The topics covered include green and clean technologies, zero energy buildings, solar energy, energy conservation and heat recovery, and solar architecture. The contents of this book will be beneficial to students, researchers and professionals working in the area of energy and built environment engineering.

Energy systems are transitioning from conventional energy systems to modernized and smart energy systems. This Special Issue covers new advances in the emerging technologies for modern energy systems from both technical and management perspectives. In modern energy systems, an integrated and systematic view of different energy systems, from local energy systems and islands to national and multi-national energy hubs, is important. From the customer perspective, a modern energy system is required to have more intelligent appliances and smart customer services. In addition, customers require the provision of more useful information and control options. Another challenge for the energy systems of the future is the increased penetration of renewable energy sources. Hence, new operation and planning tools are required for hosting renewable energy sources as much as possible.

The Building Technologies Office (BTO) has identified Building Integrated Solar Technologies (BIST) as a potentially valuable piece of the comprehensive pathway to help achieve its goal of reducing energy consumption in residential and commercial buildings by 50% by the year 2030. This report helps to identify the key research and development (R & D) needs that will be required for BIST to make a substantial contribution toward that goal. BIST include technologies for space heating and cooling, water heating, hybrid photovoltaic-thermal systems (PV/T), active solar lighting, and building-integrated photovoltaics (BIPV).

This book, based on the research experience and outcomes of a group of international contributors, addresses a range of advanced energy efficiency technologies and their applications in solar heating, cooling and power generation, while also providing solutions for tackling recurring low efficiency problems in today’s systems. It highlights the latest technologies and methods, which can significantly improve the performance of solar systems, enabling readers to design, construct and apply high-performance solar systems in or for their own projects. The contributors provide a systematic introduction to state-of-the-art energy efficiency technologies that demonstrates how to implement innovative solar systems. These technologies include: • heat pipes and loop heat pipes; • phase change materials (PCMs) and PCM slurries; • micro-channel panels; • desiccant/adsorption cycling; • ejector cooling and heat pumps; and • solar concentration and thermoelectric units. The book shows how innovative solar systems applicable to rural and urban buildings can be analysed and demonstrates the successful implementation of these advanced technologies. It delivers the design principles and associated energy performance assessment methods for a range of selected solar heating, cooling and power generation projects. This book offers a valuable source of information for final-year undergraduate students, as well as graduate students and academic lecturers, as it promotes the widespread deployment of advanced solar heating, cooling and power generation technologies applicable for buildings across the globe. The book is also a good point of reference for design engineers and energy consultants who wish to extend their knowledge of advanced technologies used to achieve energy efficiency.

This thesis investigates air-based building integrated photovoltaic/thermal (BIPV/T) systems. A building-integrated photovoltaic/thermal (BIPV/T) system converts solar energy into electricity and useful heat, while also serving as the functional exterior layer of the building envelope and thereby achieving the design of net-zero energy buildings. A comprehensive literature survey of a variety of BIPV/T systems points out the need to develop enhanced air-based BIPV/T systems with aesthetical and mechanical requirements taken into account. This thesis examines improved designs of open-loop air-based BIPV/T systems both numerically and experimentally. A BIPV/T design with two inlets was proposed and a prototype using custom-made frameless PV modules was constructed for feasibility validation. The experiments were performed using a solar irradiance...
simulator and included testing under varying irradiance levels, flow rates and wind speeds. Experimental results validated that the two-inlet BIPV/T concept improved thermal efficiency by 5% compared to a conventional single-inlet system. Detailed BIPV/T channel air temperature measurements showed that the mixing of the warm outlet air from the first section and the cool ambient air drawn in from the second inlet contributes to the improved performance of the two-inlet system. The heat transfer characteristics in the BIPV/T channel between air and PV panel was studied through the development of Nusselt number correlations. Comparative tests were also conducted on a prototype using opaque mono-crystalline PV modules and a prototype using semi-transparent mono-crystalline PV modules. Results showed that applying semi-transparent PV modules (with 80% module area covered by solar cells) in BIPV/T systems increased thermal efficiency (ratio between the thermal energy recovered by the channel air and solar energy incident on the upper surface of PV) by up to 7.6% compared to opaque ones, particularly when combined with multiple inlets. A variation of this two-inlet BIPV/T design that includes a vertical solar air heater embedded with a packing material (wire mesh) was presented and analyzed. The additional solar air heater receives high amount of solar energy during the winter period when solar altitude is low, enabling the outlet air to be heated to a higher temperature. A lumped parameter thermal network model of this BIPV/T system was verified using experimental data obtained for a single-inlet BIPV/T prototype. Simulation results indicate that the application of two inlets on a BIPV/T collector increases thermal efficiency by about 5% and increases electrical efficiency marginally. An added vertical glazed solar air collector improves the thermal efficiency by about 8%, and the improvement is more significant with wire mesh packing in the collector by an increase of about 10%. A case study is performed using this lumped thermal model and showed that the thermal efficiency of a BIPV/T roof of an existing solar house is improved by 7% with four air inlets. In conclusion, this thesis presents validated models for the design of open-loop BIPV/T air systems with multiple inlets and possibly semi-transparent PV covers.

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Building Integrated Photovoltaic Thermal Systems For Sustainable Developments Royal Society of Chemistry

Energy self-sufficiency of buildings is based on the production of heat and electricity with the systems which are integrated into the building and utilize renewable energy sources. These systems can be built as decentralized units that are simultaneously converting solar radiation into electricity and heat. Researches shows that high efficiency of both electricity and heat production can be achieved in this way. In the thesis, solutions of integrated photovoltaic and thermal systems using solar energy and their efficiencies are presented, analyzed and compared. A numerical model for determination of effectiveness of the device in the year-round operation was developed and analyzes of possibilities for increasing the effectiveness of the device with concentration of solar radiation are shown. In the thesis we have done a research of the importance of solar energy and it's relations with other energy sources in Spain, Slovenia and around the world. While researching types and the usage of solar energy, we were focused especially on the use of thermal systems applications with integrated photovoltaic panels (PV-T systems) and the different ways how to increase their efficiency by installing concentrated applications. Finally, a comparison of three different devices for solar energy exploitation (photovoltaic panel, heat exchanger with metal sheet and photovoltaic thermal PV-T) has been done. We studied their behavior in the cities of Ljubljana, Barcelona and Madrid during one year's period. This study has been made by using of upgraded numerical model developed in the MS Excel program created for a Diploma work "Heat transfer in double ventilated facade" in the University of Ljubljana by Nejc Bozic in December 2009.

This book provides the most up-to-date information on hybrid solar cell and solar thermal collectors, which are commonly referred to as Photovoltaic/Thermal (PV-T) systems. PV-T systems convert solar radiation into thermal and electrical energy to produce electricity, utilize more of the solar spectrum, and save space by combining the two structures to cover lesser area than two systems separately. Research in this area is growing rapidly and is highlighted within this book. The most current methods and techniques available to aid in overall efficiency, reduce cost and improve modeling and system maintenance are all covered. In-depth chapters present the background and basic principles of the technology along with a detailed review of the most current literature. Moreover, the book details design criteria for PV/T systems including residential, commercial, and industrial applications. Provides an objective and decisive source for the supporters of green and renewable source of energy Discusses and evaluates state-of-the-art PV/T system designs Proposes and recommends potential designs for future research on this topic

Energy self-sufficiency of buildings is based on the production of heat and electricity with the systems which are integrated into the building and use renewable energy sources. These systems can be built as decentralized units that are simultaneously converting solar radiation into electricity and heat. Research shows that increase in efficiency of both electricity and heat production can be achieved in this way. In this thesis, solutions of decentralized ventilation unit integrated into lightweight building panel that enable heat recovery and electricity production was presented, analyzed and compared with today known solutions. A numerical model was developed which enable determination and analyzes of effectiveness of the combined or separate devices in the yearround operation. It was found out that integrated photovoltaic and thermal system enables 3% to 5% higher electricity production in case of non-concentrating and up to 7% in case of concentrating solar radiation while heat recovery efficiency remains almost the same. Possible solutions for increasing the effectiveness of the device with concentration of solar radiation are presented and analyzed.
This Special Issue covers a wide range of areas—including building orientation, service life, use of photocatalytically active structures and PV facades, implications of transportation system, building types (i.e., high rise, multilevel, commercial, residential), life cycle assessment, and structural engineering—that need to be considered in the environmental impact assessment of buildings, and the chapters include case studies across the globe. Consideration of these strategies would help reduce energy and material consumption, environmental emissions, and waste generation associated with all phases of a building’s life cycle. Chapter 1 demonstrates that green star concrete exhibits the same structural properties as conventional concrete in Australia. Chapter 2 showed that the use of TiO₂ as a photocatalyst on the surface of construction materials with a suitable stable binding agent, such as aggregates, would enable building walls to absorb NOx from air. This study found that TiO₂ has the potential to reduce ambient concentrations of NOx from areas where this pollutant becomes concentrated under solar irradiation. Chapter 3 presents the life cycle assessment of architecturally integrated glass–glass photovoltaics in building facades to find the appropriate material composition for a multicolored PV façade offering improved environmental performance. Chapter 4 shows that urban office buildings lacking appropriate orientation experienced indoor overheating. Chapter 5 details four modeling approaches that were implemented to estimate buildings’ response towards load shedding. Chapter 6 covers the life cycle GHG emissions of high-rise residential housing block to discover opportunities for environmental improvement. Chapter 7 discusses an LCA framework that took into account variation in the service life of buildings associated with the use of different types of materials. Chapter 8 presents a useful data mining algorithm to conduct life cycle asset management in residential developments built on transport systems.

This book discusses energy recovery technology, a green innovation that can be used in buildings. This technology reduces energy consumption in buildings and provides energy savings to conventional mechanical ventilation systems. Divided into eight chapters, the book provides in-depth technical information, state-of-the-art research, and latest developments in the energy recovery technology field. Case-studies describe worldwide applications of energy recovery technology and its integrated system for building services. This book will be used as a general and technical reference book for students, engineers, professionals, practitioners, scientists, and researchers seeking to reduce energy consumption of buildings in various climatic conditions. Presents an overview of energy consumption scenarios in buildings and the needs for energy-efficient technologies at regional and global levels; explains models and methods of energy recovery technology performance evaluation; inspires further research into energy recovery technology for building applications.

Solar photovoltaics is one of the most promising renewable energy technologies, producing electricity on site directly from the solar radiation without harming the environment and depletion of materials. The Building Integrated Photovoltaic Thermal (BIPVT) system is a technology which merges PV and thermal systems, simultaneously providing both electric and thermal energy. Through this combination more energy is generated per unit surface area in comparison to the standalone photovoltaics system. Benefits of the BIPVT system include significantly increased electrical performance, faster payback than traditional systems, negligible impact on the environment and the product is easier and less expensive to install with low maintenance required. This book describes the recent developments in PV technologies, solar radiation available on the earth, various BIPVT systems and their applications, energy and exergy analysis, carbon dioxide migration and credit earned, life cycle cost analysis and life cycle conversion efficiency. Presently there is no single book which covers all the basic and the advanced concepts related to the implementation of solar energy for the passive heating and cooling of the building. In addition to the basic concepts, the book includes the technology advances, modelling and analysis and ongoing research in the area of BIPVT. Key features of book include:

- Solar heating and cooling concepts
- Thermal comfort
- Performance analysis of BIPVT system
- Worldwide case studies
- Energy payback period
- Techno-economics and sustainability of the system

The book, written by experts in the field with years of research and teaching, is intended for the specialists, scientists and people involved in research in the disciplines of renewable energy, energy studies, building energy or carbon credit. For the practicing professional, advanced senior or graduate student with work experience, the book should be used as part of an integrative program enabling them to make deep linkages and thus better decisions in the professional world.

Designing with Solar Power is the result of international collaborative research and development work carried out within the framework of the International Energy Agency’s Photovoltaic Power Systems Programme (PVPS) and performed within its Task 7 on ‘Photovoltaic power systems in the built environment’. Each chapter of this precisely detailed and informative book has been prepared by an international expert in a specific area related to the development, use and application of building-integrated photovoltaics (BIPV). Chapters not only cover the basics of solar power and electrical concepts, but also investigate the ways in which photovoltaics can be integrated into the design and creation of buildings equipped for the demands of the 21st century. The potential for BIPV, in both buildings and other structures, is explored together with broader issues such as market deployment, and international marketing and government strategies. In addition, more than 20 contemporary international case studies describe in detail how building-integrated photovoltaics have been applied to new and existing buildings, and discuss the architectural and technical quality, and the success of various strategies. Packed with photographs and illustrations, this book is an invaluable companion for architects, builders, designers, engineers, students and all involved with the exciting possibilities of building-integrated photovoltaics.

Although solar thermal systems are technologically mature and cost effective, they have not yet been sufficiently used in building design to play an adequate role in the reduction of fossil fuel consumption. One main hindrance to adoption is the generally low architectural design quality of the building integration of these thermal systems. Starting from a definition of architectural integration quality and related criteria, this book is intended to help both architects and manufacturers improve their design work.