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Design & Development of Combustion cum Gasification System for Solid Biomass

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Abstract: Biomass resources are the world's largest and most sustainable energy source potential for power generation in the 21st century. Numbers of technologies are available to harness this potential energy from biomass; however, biomass gasification is a promising technology among them. To increase the efficiency and applications of gasification output, modifications have been made in gasification technology.

In continuation of that combustion cum gasification system was designed and developed at the School of Energy & Environmental Studies, Devi Ahilya Vishwavidayala, Indore (MP), India**,** and its performance was evaluated. It was working satisfactorily; however, some problem was noted. Charcoal from the gasification chamber to the combustion chamber was not flowing properly and some interruption in the flue gas pipeline was noted. These problems were solved by creating the proper slope at bottom of the gasifier chamber and providing mild steel (MS) sieve at the outlet of the flue gas pipe. Although the modified combustion cum gasification system gives better performance with medium size biomass (60 x 40 x 30 mm) and gives about 77% cold gas efficiency, however, to be used for industrial application some more systematic study is needed.

Key words: biomass, combustion cum gasification system, biomass size, cold gas efficiency.

I. INTRODUCTION

Biomass resources are the world's largest and most sustainable energy source potential for power generation in the 21st century. About 32% of the total primary energy used in India is derived from biomass and more than 70% of the country's population depends on it for their energy needs. As per one estimate, the current availability of biomass in India is about 500 million metric tons per year. Among that about 120 – 150 million metric tons per annum biomass are surplus, which has the potential of about 17,000 MW electrical power generation [1, 2]. Numbers of technologies are available to harness this potential energy from biomass; however, biomass gasification is a promising technology among them. Gasification has the advantage of low environmental impact, high effective conversion, and reduced global CO_2 emissions [3]. The biggest advantage of the gasifier is its high conversion efficiency up to 80% but it produces tar with producer gas which is the major feedback of the gasifier. To reduce the Tar from the producer gas up to the level of internal combustion (IC) engine quality fuel and different applications of producer gas fuels, numbers of works have been done. In the present study, the hypothesis is made if the combustion zone is separated from the gasifier and flue gas produced from combustion is supplied to the gasifier. It is believed that it may improve the conversion efficiency of biomass.

II. RELATED WORK

Sansaniwal et al 2017 [4] reviewed the recent advances in the development of biomass gasification technology. They suggested that although gasification technologies have been well demonstrated and established by the researchers and the unremitting progress in this direction is also going on but still, incorporation of heat recovery devices, improved tar cracking methods, reuse of bio-char as feedstock, the transformation of ash and tar contents into the value-added products, steam gasification for hydrogen yield, pre-treatment of raw feedstock, etc need to be tried. In connection to that Singh and Dubey, 2019 [5] Developed a gasifier waste heat-based feedstock dryer and reported that it took about 8 to 13 hours to reduce the moisture of biomass up to 12% (recommended moisture for gasification), depending upon the initial moisture content of the biomass. The size of biomass play important role in the drying of biomass. Smaller size biomass took more time than larger size biomass, to reduce the moisture up to the desired limit (12-15% wb), even though the moisture content of the biomass was maintained the same. Singh et al, 2019 [6] also utilized waste heat of producer gas generated from a force-updraft gasifier for the production of low-pressure steam. To harness the heat of producer gas a pipe to pipe counter-flow heat exchanger was designed, developed, and are used for waste heat recovery of producer gas. It was reported that on an average about 3.5 L/h water is converted into low-pressure

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Thermal Performance of Composite Roof Structures with Insulating Layers in Non-Conditioned Buildings for Hot-Dry Climate

Mohan Rawat, R N Singh

Abstract*: *The roof configurations with an insulating layer and their impact on hourly floating temperature analyzed in a hot-dry climate context. A predefined computer program using a modified Fourier admittance method utilized as the primary research. The thermal performance of ten composite roof structures evaluated to obtain optimal roof structure for hot-dry climate, Jodhpur. Nine composite roof structures with an insulation layer and one without insulation layer as the base case were analyzed for the summer months (April-September). The utilization of roof thermal insulation showed a significant influence on the overall thermal performance of roofs. It also revealed that minimum temperature variation found about 8.8 ^{0}C for the composite roof structure of Reinforced Cement Concrete (RCC) with foam concrete insulation (i.e., RF-5) with thicknesses 150 mm and 140 mm respectively. The analysis assessed that composite roof structure with an insulating layer is a useful technique to reduced indoor temperature in non-conditioned buildings of hot-dry climate.

Keywords: Fourier admittance method, Heat Gain, Hot-dry climate, Thermal comfort, Simulation.

I. INTRODUCTION

The energy consumption in buildings accounts for about 40% of total world energy, and residential and commercial sectors of buildings consume 60 % of the world's electricity. Buildings have become the primary source of global greenhouse gases emissions due to the use of an air conditioning system [1].The building generally uses most of the energy is an air-conditioning and ventilation system in hot climates. Heat transmission by conduction through roofs and walls characterizes the significant component of the entire thermal load. The amount of energy utilized in the air-conditioning process directly linked to the buildings thermal load [2].In developing countries, worldwide buildings require the best thermal comfort for the occupants with the lowest energy consumption and greenhouse gas emissions. Therefore, the objective of achieving high energy efficiency is critical, and one of the cost-effective strategies is thermal insulation of building envelope [3]. Roof contributes tremendously to building heat gain compared to walls because it exposed to the sun throughout the day. Heat through the roof can be reduced by applying thermal insulation on the roof or installing insulation under the attic roof. Thermal insulation of roofs is an inexpensive method to save energy and to improve the comfort level [4].

In hot-dry climates, the buildings built with bricks, stones, cement, and flat roofs constructed of sandstone slabs and steel girders. This climate characterized by high temperatures, low humidity, less rainfall, and intense solar radiation in summer. The mean monthly temperature and relative humidity are 30 ^{0}C and 55 %, respectively. In the summer, temperature varies from 40-45 ^{0}C with diurnal variation 15-20 ^{0}C, which leads to uncomfortable conditions. To maintain thermal comfort for buildings in the summer period is a big concern in these regions [5]. India is a tropical country that received an average annual solar insolation between 4-7 kWh/m^{2}. It leads to a higher temperature and higher cooling energy consumption in the buildings during the day time operation of summer. Roofs received maximum solar radiation among all building envelopes, so energy efficient roof plays a vital role in reducing the energy consumption of buildings in the hot climate. There are three solutions to reduce the heat transfer into the buildings, i.e., roof insulation, cool roof, and radiant barriers. Roof insulation is conventional and widely used in India also it reduces the effectiveness of passive strategies and reduces indoor thermal comfort [6]. The thermal insulation is one of the most valuable techniques in achieving energy conservation in buildings. It also helps to reduce building energy use (heating and cooling of space) and to maintain a required indoor thermal comfort for occupants. The most common thermal insulations used are fiberglass, wood wool, mineral wool, rock wool polyethylene, polyurethane, and polystyrene [7]. In this paper, the study based on a modified Fourier admittance method to see the influence of the different roof structures with an insulating layer and prediction for hourly floating temperature for the non-conditioning building of hot-dry climate, Jodhpur. The study represented a comparative analysis in terms of minimum hourly floating room temperature for the selection of the roof configuration for six months (April-September) including summer season

II. ANALYSIS

A. Admittance Method

The matrix equation related to temperature and energy cycle expressed as [8].

$$\begin{bmatrix} T_0 \\ Q_0 \end{bmatrix} = \begin{bmatrix} A & B \\ D & A \end{bmatrix} \begin{bmatrix} T_i \\ Q_i \end{bmatrix} \tag{1}$$

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Thermal Performance of Roof Structures with Insulation Layer in Non-Conditioned Buildings in the Composite Climatic Zone

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Abstract

This paper focuses mainly on composite roof structures thermal response with an insulation layer in non-conditioned buildings. Roof contributes maximum load in summers in composite climate. Hence, the thermal performance of the non-conditioned building investigated using simulation for nine different roof configurations. Eight composite roof structures with an insulation layer and one without insulation layer as base case analyzed for the summer months of composite climate characterized as New Delhi, India. The modified admittance method used to predict the periodic floating room temperatures for climatic parameters' periodic behavior. Thermal performance analyzed for all roof configurations to reduce magnitude and fluctuations in room temperatures. In India, most of the roof layers of concrete and plaster (named as RF-6) without insulation used in most of the buildings in Indi. This roof structure showed an average maximum temperature variation of 9.1^{0}C in the considered roof structures. The minimum room temperature fluctuation found nearly 2.4^{0}C for the composite roof structure of Reinforced Cement Concrete (RCC) with foam concrete insulation (named as RF-5) with thicknesses 150 mm and 140 mm, respectively.

Keywords: *Composite climate, Roof insulation, Fourier admittance method, Building envelope, Hourly floating temperature,*

1. Introduction

International Energy Agency (IEA) predicted that global energy consumption increased up to 53 % for the next ten years due to the rapid growth of new buildings and the dramatic increase of population size in the world. For developing countries, rising energy consumption in buildings expected to be more due to the significant rise in industrial and urban activities. In a developing countries use of energy efficiency technologies in buildings is often not gaining sufficient attention, which causes energy demand upsurge, environmental issues are becoming more critical [1].Energy consumption in the building sectors for heating, cooling, and ventilation about 60 %, and it increased annually 1.8% over the last forty years. Building sectors represented significant challenges for energy-saving issues; therefore, special attention to be made to the improved thermal quality of the building envelope. Thermal insulation of the building envelopes is one of the effective methods to reduced energy consumption in the peak time of summer [2]

Roofs receive the maximum direct solar radiation among various envelopes of buildings, which lead to high outdoor dry bulb temperature and higher cooling energy in daytime operation, especially for non-conditioning buildings. In a global, many studies have performed to understand the energy-efficient roof to reduce energy consumption in buildings. Two types of techniques followed by surface treatment (Cool roof, Green roof)

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Growth Kinetic Models for Algae: Revealing a Light Factor

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Abstract- Biodiesel production from Microalgae has received collective attention as one of the alternative energy sources. Growth kinetic models are needed to provide an understanding of microalgal growth so that cultivation conditions can be optimized. This review focused on overview of the present growth kinetic models for microalgae cultivation. The existing models were compiled and considering a light factor. There is a requirement for appropriate assimilation of light and temperature in the growth model.

Keywords: kinetics, light intensity, maximum specific growth rate

I. INTRODUCTION

For photoautotrophic microalgae in nutrient saturation conditions, light is a critical factor for photosynthetic activity. Growth of microalgae limits due to insufficient light [1, 2]. Microalgae require a specific light level in order to extent the maximum growth rate, referred to as a saturated light level. If light intensity is far above the saturation level, the growth will be inhibited by light (known as photo inhibition). If light intensity is below the saturation level, the growth will be limited by light (called light limitation). For example, in outdoor mass culture systems (cultivation systems with high concentrations of microalgae), microalgae growth is limited due to light scattering by a thick top layer where increase areal productivity of microalgae occurs [3]. Algae biomass productivity is the result of photosynthesis and endogenous respiration. Expecting the rate of these mechanisms during outdoor cultivation is difficult because algae growth is affected by several factors for example temperature, light intensity, pH, dissolved oxygen concentration and nutrient availability [33].

II. RELATED WORK

The growth kinetic models considering the effect of light plays the key role for the design of photobioreactors and outdoor ponds to optimize the performance. In this paper the growth kinetic models reflecting the single factor of the light intensity are summarized. The models in this group have simple structures with two or three parameters and easy to implement [4]. These models have often been applied in lab-scale studies. The Tamiya model is an eminent theoretical model as well as the most widely applied model, which is similar to a Monod type model in describing the effect of light on microalgae growth [5]. In that model, the growth rate is interrelated to the incident light intensity with two parameters μ_{max} (maximum specific growth rate) and KI (saturation constant with respect to the light intensity). When the incident light intensity (I) is lower than KI, the growth is limited by light according to first order kinetics. When light intensity (I) is far above KI, the growth is independent of light and μ approaches to μ_{max} [6]. The Tamiya model was describing the growth of *Euglena gracilis* under laboratory conditions using fluorescent lamps (about 0-550 μ_{mol} photon m^{-2} s^{-1}) with kinetic parameters of μ_{max} as 0.06 h^{-1} and KI as 178 μ_{mol} photon $m^{-2}s^{-1}$. Under continuous illumination of fluorescent light, the growth of *Spirulina platensis* followed the Tamiya model with the KI = 0.2 klx (about 124 μmol photon m^{-2} s^{-1}) and μ_{max} = 2.0 day^{-1} [7]. Tamiya model was able to accurately explain the growth rate of *Chlorella vulgaris* in the circulating photo bioreactor under different incident light intensities [2]. Several empirical models have been developed by van Oorschot [8], Bannister [9], and Chalker [10]. Van Oorschot [8] used a Poisson function (1-e-I/KI) describing light-limitation. The Webb model is a commonly used model for predicting photosynthetic rates in literature [11]. Bannister et al. adopted the same structure of the Tamiya model with integration of a shape parameter (m) depending on the algae species [9]. Jassby and Platt investigated eight kinetic models to describe the population of marine phytoplankton and reported a hyperbolic tangent model was the best fit to their data [12]. Hyperbolic tangent function is the most popular mathematical form to explain the photosynthetic activity as a function of light intensity [10]. The relationship between the algae growth rate and incident light intensity assuming that photosynthetic activity is the only limiting mechanism of microalgae growth [13]. To determine the best expression of microalgae growth rate, several expressions including the Poisson, hyperbolic tangent and Tamiya models and established that the hyperbolic tangent

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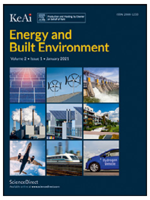

Potential and performance estimation of free-standing and building integrated photovoltaic technologies for different climatic zones of India

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ABSTRACT

The role of Photovoltaic technologies integrated or attached to the building envelope is crucial in managing the building energy demand. In this paper, the performance of PV technologies with the mounting methods of Building integrated and Free-standing (Building attached) is discussed for six different climate zone of the country. A PVGIS program proposed with three PV cell technologies (Crystalline Silicon, Copper indium diselenide, Cadmium Telluride) is used to evaluate monthly energy generation potential and losses of the 2 kW_p grid-connected PV system at the latitude and 90°. A 2 kW_p PV system is chosen for Economic Weaker Section (EWS) housing schemes depending upon the roof area. From the evaluation, the performance parameter has been estimated. A new parameter Energy Deviation (ED), is proposed to choose the best PV technology in terms of performance. The results of ED agree with the parameters Performance Ratio (PR) and Capacity Factor (CF) defined under the IEC Standard 61724. The potential generation of PV technologies at 90° varies from 41% (Warm and Humid) to 64% (Cold and Sunny) when compared with the latitude. In case of Cold and Sunny and Cold and Cloudy at 90°, the generation performance of Copper indium diselenide is found better in Building integrated and Free-standing mounting methods, respectively. For the remaining zones, Cadmium Telluride technology shows better results. The Percentage loss in the system is found to be minimum in the case of Cold and Sunny, varies between 17% and 25%, and maximum is found for Warm and Humid and varies between 23.2% and 33.4% for the proposed PV technologies. The grid feed-in energy from these EWS houses for all the technologies and climatic zones is found above 45%. It is seen that the combined energy generation from the envelopes (Roof, walls, and facades) makes the houses energy plus in nature. The study has important implications for the government to promote the building integrated Photovoltaic policies in the country.

1. Introduction

In recent years the world has experienced the potential of renewable technologies. Most technologies fulfill the demand in electrical form by increasing the energy generation mix [1]. Countries are focusing more on sinking Green House Gas (GHG) emissions by reducing the fossil fuel-based electricity generation and shifting toward generation from renewable technology, contributing to sustainable energy generation [2]. The global renewable generation capacity was amounted to 2472 GW by the end of 2018. The pie chart in Fig. 1 discusses the capacity of the various technologies in terms of percentage. Hydro, with an installed capacity of 1293 GW, has the maximum contribution, while wind and solar have a share of 564 GW and 486 GW, respectively. Other renewable technologies included 115 GW of bioenergy, 13 GW of geothermal energy, and 500 MW of marine energy (tide, wave, and ocean energy) [3].

The dominance of the Asian countries was highest in this global expansion with a contribution of 70%. Along with China, Japan, and the Republic of Korea, India played a substantial role in achieving this growth in global expansion [4].

With the availability of a high amount of solar radiation, India has a vast potential to become a global leader in the solar energy sector. Because of this, the government launched the Jawaharlal Nehru National Solar Mission (JNNSM) on 11th January 2010. Under the mission, the intended target was 20 GW by 2022, later revised to 100 GW, which to be achieved by rooftop and other solar projects. The Additional 75 GW is added in the target to be fulfilled from wind biomass and small hydro projects [5]. As of 2020, Grid-connected renewable energy technologies total installed capacity is 86.32 GW as given by the pie-chart in Fig. 2 [6].

India has experienced rapid growth in electricity generation through solar power with an average generation of 64% per year in the last few years [7]. Despite this steady growth, it is also facing several challenges: less land area availability, high initial investment, and Transmission and Distribution (T&D) losses. The government has introduced various policies such as Grid Connected Rooftop and Small Solar Power Plant Pro-

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Performance of PV integrated wall and roof as a building material

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Abstract. The performance of the Photovoltaic (PV) module as a building material is analyzed by predicting the hourly variation in the room temperature compared to base case (conventional material). A computer simulation model of Fourier admittance method is used for the analysis. The average temperature fluctuation of PV roof and PV wall building compared to base case is 6.58˚C and for PV wall 2.91˚C respectively. The total daily energy generation from PV wall is found in the range of 6.7 kWh to 11.86 kWh, for PV roof its 17.24 kWh to 22 kWh. Due to temperature fluctuation the max additional daily cooling load obtained in PV roof case is 94.7 kWh and 41.97 kWh for PV wall.

1. Introduction

PV technologies can be attached or integrated with the building envelopes termed as Building integrated photovoltaic (BIPV) or Building attached photovoltaic (BAPV). The BIPV technology used as a building material along with the conventional material or fully replaces the conventional one like semitransparent photovoltaic. The concept of the PV as a wall was initially given by [1]. He observed the effect of temperature on the performance of the PV modules. The author concluded that the temperature PV modules could be reduced to 15-20˚C with a ventilated duct of aspect ratio (height/depth) less than 340.

India receives abundant amount solar radiation of 5-7 kWh/m^2 yearly playing crucial role in growth and development of PV technologies. Due to lack of barren land and increase in future energy demand, building can be an option for installation of PV technologies like Rooftops [2]. Apart from rooftop, building envelopes can also be an option for installation of PV technologies. So the study on impact of PV as building wall and roof becomes a necessary part. Agrawal and Tiwari [3] analyze the opaque PV integrated roof using energy balance model, found moderate climate suitable in terms energy and exergy generation. Vats and Tiwari [4] developed first order energy balance model of semitransparent PV integrated with the roof to predict room temperature, they also calculated the thermal benefits in terms of exergy analysis. Taffese et al. [5] performed periodic modelling and simulation of a certain PV-TW (Photovoltaic-Trombewall) for the composite climate of New Delhi. It was found that the optimum thickness of 0.4m was suitable for maintaining thermal comfort inside the room. Tejero-González et al. [6] provides forced ventilation in PV integrated building façade for the

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Impact of roof attached photovoltaic modules on building material performance

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A B S T R A C T

One of the applications of PV technology is to either integrate or attach it with the building envelopes. In this paper, a simulation has been performed for Economic Weaker Section (EWS) housing schemes to see the impact of roof attached PV modules on room operative temperature (T_{opt}) and compare it with the base case roof without PV modules. A Non-conditioned building is simulated for the composite climate of Indore in the DesignBuilder software. For thermal comfort analysis, a simulation for the summer months has been performed (April-September). It has been observed that compared to No PV Roof 1 (RCC) as a base case, the maximum reduction in room operative temperature of PV Roof 1 (RCC) case is 3 °C and 3.7 °C for PV Roof 2 (stone). Due to the reduction in T_{opt}, the simple payback period (SPP) calculated for PV Roof 1 (RCC) is 5.77 yrs and for PV Roof 2 (Stone) it is 4.32 yrs. The Net CO_2 emission gets reduced by 30% and 50%, respectively, for BAPV Roof 1 and Roof 2 compared to the base case. The BAPV cases achieve the Net CO_2 mitigation of 109 tonnes and 113 tonnes. This study shows that PV modules' passive behavior reduces the T_{opt} and provides credibility to the low-cost materials in the building construction.

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1. Introduction

The buildings rely on electrical units for maintaining thermal comfort depending on the heating and cooling degree-day of the location. These degree days units are either provided by conventional sources or by renewable ones like PV technologies. In India, housing schemes like Economically Weaker Section (EWS), Lower Income Group (LIG) lack in providing the necessary amenities, including electrical units [1]. The PV technologies, when installed on the building rooftop in a stand-alone manner, are termed as Building Applied Photovoltaics (BAPV) [2]. In Standalone manner, these technologies become a part of building material. They can also be used as passive cooling technology, reducing room temperature, and providing additional benefits in reducing electrical units consumption. In this paper, we have investigated the effect of BAPV on the building performance in terms of operative temperature (T_{opt}) of the building using the Design-Builder simulation software. The EWS houses with a floor area of 30 m^2 have been selected for simulation purpose. Also, from simulation, the feasibility analysis of high U value roof material (Stone) in terms of construction cost, Net CO_2 emission, and the operative temperature is compared with low U value roof material (RCC) when used along with the BAPV system. This study becomes still more important as the building sector consumes more than 30% of world energy [3]. Further dependence on conventional sources leads to CO_2 emission. Therefore, it is the need of the hour to generate energy from renewable sources, thereby reducing the CO_2 emission and achieving the goal of zero energy building.

2. Methodology

The study evaluate the impact of roof attached PV modules on material performance in terms of room operative temperature (T_{opt}) of Economic weaker Section houses. The comparison of operative temperature will assess the feasibility of low cost roof material having high U value compared to high cost, low U value materials. It will beneficial for EWS houses in terms of reduction in construction cost.

2.1. Building modelling

A EWS scheme house is modeled in DesignBuilder software (see Fig. 1) with no PV as a base case and other as BAPV cases. The

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Performance evaluation of a cool roof model in composite climate

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ABSTRACT

India is the seventh-largest country in the world and ranked second with more than a billion populations after China. The annual electricity consumption demand increased to 8% in the buildings for residential and commercial sectors. The requirement of thermal comfort is a primary need in residential buildings located in composite and hot-dry climates. The thermal performance of cool roof model was analyzed in terms of indoor temperature compared to Reinforced Cement Concrete (RCC) roof for composite climate, Indore, Madhya Pradesh, India. The study aims to assess the impact of the cool roof on the indoor temperature of buildings. The experimental study indicates that a cool roof performed better for indoor temperature profile and maintains a thermal comfort in buildings. The cool roof technology is more economical and easy to implement in all residential and commercial buildings. The study revealed that the roof's interior and exterior surface temperature reduced about 4.1 °C and 9.2 °C, respectively, while indoor room temperature reduced about 2.4 °C.

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1. Introduction

The rate of urbanization in the world enhanced in recent times, and about 80% of the world population will live in an urban area within 50 years. The most significant contributor to world energy consumption is the building sector due to the rapid growth and construction of new buildings and the dramatic increase of populations. International Energy Agency (IEA) predicted that global energy consumption enhanced up to 53% for the next ten years due to the rapid urbanization in developing countries of the world [1]. Building sector is considered a primary contributor in terms of world energy consumption and greenhouse gas emission. Due to the improvement of comfort level and the extension of human activities, the per capita energy consumptions increased by 11.18% in the last 10 years [2]. About 10% of the world delivered energy consumed by residential buildings and it will enhance at the rate of 1.5% per year as per the International Energy Agency (IEA). In India's present scenario, the per capita consumption is less compared to other developing countries and one of the biggest energy consumers are residential sectors of buildings [3]. The roof is an essential attribute of the building envelope and it contributes maximum load (50–60%) in a total cooling load of the building reaching inside from the environment. So the requirement of thermal comfort is needed, especially in summer seasons [4]. The most common construction materials for roofs have a low reflectance values ranging from 20 and 30%. The indoor temperature reduced to 3 °C if an increase in solar reflectance was 50% to 92% of roof paints [5]. India is a tropical country, and climatic zones vary from region to region, and significant amount of heat is absorbed by a roof to enhance discomfort in non-conditioning buildings. By selecting appropriate roofing materials eliminated the need for HVAC (Heating Ventilation and Air-conditioning) systems. Passive cooling methods with low R-value used in hot climates due to their higher energy performance reduced the cooling load up to 37%. Cooling load reduction achieved up to 80% if passive cooling techniques integrated with reflective material and cool roof. [6].

The main properties of cool roofs absorb less solar radiation and transmitting less heat into the building. Moreover, it reduced air-conditioning demand and carbon emission of electricity to operate air conditioners and provide more comfortable indoor conditions. Cooling Energy demand reduced up to 16% using the cool products in summer. Meanwhile, the annual requirement reduced by about 3% [7].For India most of the parts located in a composite climate where heat gains through the roof caused indoor discomfort. Mostly construction materials used in the buildings are reinforced concrete cement (RCC) followed by concrete, brick, tiles, and mud. So the requirement of thermal comfort is an essential need due to

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Design and Development of Portable 5 kW_e Capacity Producer Gas Engine Based Electric Generation System for Rural Applications

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Abstract— In a country like India, agricultural residues are in abundance, and availability of biomass is not a problem, and can be utilized for power generation. Among the different rout available for conversion of biomass, thermo chemical conversion especially gasification seem to be more reliable. However most of the works in gasification technologies are focused on development of large system and very little efforts had been made for the development of a portable and small capacity gasifier (1 kWe to 10 kWe gasifier). A portable gasifier system for producing electricity was designed and developed to deliver an electrical power of 5kWe using 100% producer gas engine. The system consists of gasifier reactor, two cyclones (one for removal of particulate matter, other for moisture), one wet scrubber, two filters (one biomass and other jute/fabric); 12HP 100% producer gas based IC Engine with alternator capacity of 6kWe and a solar backup system for initial start of blower. Whole setup is arranged in a transportable lorry for easy transportation as per the need of farmer requirements. Functionality test was carried in the lab, however actual performance would be tested for agricultural operations like pumping and community lighting.

Keywords— Gasifier; producer gas; cyclones; wet scrubber; 12HP 100% producer gas based IC Engine

I. INTRODUCTION

Combustion is the most important invention of the mankind, which starts of the use of thermal energy, useful for cooking, heating, drying, and many other comfort applications. Literature indicates that 80% of all form of energies used by humans comes from fossil fuels [1]. India is fortunate to have surplus biomass, which fulfill the energy demands of about 32% Indians [2]. Conversion of energy stored in the biomass for various applications can be accomplished by combustion, gasification and pyrolysis. Combustion is simply a reaction process of carbon hydrogen with stoichiometric oxygen i.e. conversion of all carbon into carbon dioxide, and hydrogen to water.

Gasification is nothing but decomposition of solid fuel under a sub-stoichiometric oxidizing condition; however, Pyrolysis of solid fuel takes place in absence of oxidizing media. The end product of gasification is producer gas (85%), Char (10%) and liquid (5%). In a country like India, agricultural residues are in abundance, and availability of biomass is not a problem, and can be utilized for power generation. Study conducted by Pathak et al, 2005 [3] showed that total estimated biomass generated is of the order of 1000.17 MT out of which nearly 523.44 MT (52.33%) is agricultural waste, 272.62 MT (27.25%) is livestock dung including poultry liter and 157.18 MT (15.71%) is forest residue, remaining 4.71% are biomass waste generated in wasteland and roadsides. As per estimate these surplus agricultural wastes, can generate more than 16,000 MW of power with presently available technologies.

As per MNRE, 2020-21 contribution of Renewable Energy in total Installed Capacity of Power in India is 87669.19 MW or 23-63% [4], in which gasifier share is about 75.85MW.

And hence gasifier seems to be one of the promising equipment for conversion of energy in biomass to power for various applications. Gasifires are the equipment which is used for producing heat and power with very low environmental hazards. Government of India through Ministry of New and Renewable Energy is supporting entrepreneurs, individual and farmers to set up power projects based on biomass gasification of the order of few Mega Watts particularly in those states which have biomass potential is high. Major beneficiaries are population residing in remote and rural locations. However, the focus on developing and supporting small power generation of the order of 1 kWe to 10 kWe is less compared to bigger units. Most of the works in gasification technologies are focused on development of large system and very little efforts had been made for the development of a small 1 kWe to 10 kWe gasifier. The design parameters for such gasifier has not been studied and developed. Also developed gasifier has not been tested for

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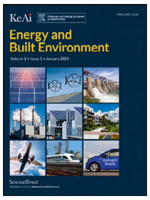

Review

A study on the comparative review of cool roof thermal performance in various regions

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ABSTRACT

Energy demand is growing significantly worldwide to create thermal comfort in buildings. Air-conditioning is contributing to energy consumption at a massive scale in the residential and commercial sectors. The roof is one of the most critical components of the building envelopes, and it achieved maximum heat gain in summer, and it covered nearly 20–25% of overall urban surface areas. In this respect, cool roofs are considered one of the sustainable solutions to maintain thermal comfort in buildings**.** The results achieved from the literature review indicate that cool roof application reduced energy use in the buildings and a useful tool to mitigate Urban Heat Island (UHI) effect. This paper summarizes cool roof thermal performance with different types of surface coatings in different climatic zones for buildings with additional benefits, limitations, and recommendations for future research work. The results of this review can be helpful for engineers, researchers, dwellers, and architectures to have a good understanding of the benefits of cool roofs to mitigate energy consumption demand in dwelling in a sustainable, cost-effective, and energy-efficient way. The average energy-saving effect of the roof is expressed from 15% to 35.7% in different climatic zones (Temperate, Tropical, Composite, Hot and Warm-Humid) as per the literature survey results. Also, the average roof surface temperature reduction is possible from 1.4 °C to up to 4.7 °C using cool roof technology.

1. Introduction

The real estate business growth was inevitable to meet the demand for the shelter of a growing population and faster development of nations. The rising income grows to get higher standards of living. In the world, over 50% population lives in urban areas, and it would be 70% up to 2040. Energy consumption in buildings is growing worldwide at the average rate of 40% in recent years [1].

The energy consumption in buildings is continuously rising, and it is contributing to global warming through the growth of greenhouse gas emission from 1971 to 2004 at an annual rate of 2%. The energy consumption in commercial buildings by air conditioning is 56–60%. Buildings have high-energy consumption due to the lack of energy-conscious designs, the use of inefficient cooling systems, and maintenance, especially in hot and dry climatic zones. The energy consumption will rise in the future with the extension of the real estate sector. High-energy use will also lead to environmental degradation and add the impact on climate change scenarios. The buildings in tropical and semitropical regions have high energy consumption, especially for meeting the demand for cooling. Special attention is needed in reducing the cooling loads to decrease the construction and operational cost of buildings by their energy-conscious designs and techniques [2].

Roofs contribute nearly 50 to 60% load in a total cooling load of the building reaching inside form the environment in hot- dry, warm, and humid and composite climatic zones. Cooling is an essential requirement of the building, especially in these climates. The roof is a primary component of the building envelope which is exposed to solar radiation and contributes to the maximum load of the total cooling load of the building [3]. The roof is an essential interface between the indoor and outdoor environments and to be strong enough to withstand all weather conditions. In the hot and summer seasons, the components of the building envelope must be designed to minimize the discomfort. High mass

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Abbreviations: CRHT, Cool Roof Heat Transfer; CRRC, Cool Roof Rating Council; CFFT, Complex Fast Fourier Transform; CP, Cooling Potential; CES, Chicken Egg Shell; DAIH, Daily Accumulative Inward Heat; DF, Decrement Factor; DSRHT, Double-Skin Roof Heat Transfer; DSR, Double-Skin Roof; ECBC, Energy Conservation Building Code; EPS, Expanded Polystyrene; FFT, Fast Fourier Transform; FR, Flat Roof; HCT, Hollow Clay Tiles; UHI, Urban Heat Island; TRC, Thermal Reflective Coating; MAC, Moving Air Cavity; NIR, Near Infrared Reflectance; PCM, Phase Change Material; SHRCL, Solar Heating Reflective Coating Layer; RCC, Reinforced Cement Concrete; RBS, Radiant Barrier System; TIC, Thermal Insulation Coating; TL, Time Lag; VR, Vault Roof; WC, Weathering Course; WRF, Weather Research and Forecasting.

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Application of phase change material in building integrated photovoltaics: A review

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A B S T R A C T

The Phase Change Material (PCM) reduces thermal load and increases comfort inside the building. The paper discusses how and where PCM's are used in Building Integrated Photovoltaics (BIPV), their impact on the performance of the PV module and built environment. In this review paper, BIPV-PCM system is categorized into two parts either Ventilated or Non-ventilated. Further, the thermophysical properties and temperature reduction in PV modules has been discussed. From the study, it is seen that most of the PCM's were encapsulated with PV modules and building envelopes at the macro level. A significant reduction in temperature of modules and building envelopes occurs in both the categories is observed. However, the implementation of BIPV-PCM at a large scale and its economic viability is to be examined by the researchers in upcoming years.

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1. Introduction

Building consumes around 29% of the overall energy consumed by the other sectors (Industrial, transport) [1]. This increase in demand is due to the increase in population and energy consumed by per capita [2]. Accordingly, one of the needs of the is to limit the energy consumption of buildings. BIPV is one of the alternatives used to cover the building demand when integrated horizontally or vertically with the building envelopes [3,4]. These systems reduce the building demand, also due to their passive behavior, they reduce the building temperature [5]. However, integration of PV with envelopes increases the cell temperature, which degrades cell performance and reduces their life. PCM's as an energy storage material can reduce and regulate cell temperature and maintain thermal comfort inside the buildings. The PCM's in the building started before 1980, which can be incorporated by injecting it in the form of pellets, or by micro and macro encapsulation are used in form of wallboard, concrete, insulation materials [6]. Other building applications are such as solar thermal hot water storage, in double facades for better thermal regulation [7]. In this paper we will discuss one of the PCM applications, where PCM's encapsulated along with PV and building envelopes termed as BIPV/T-PCM system

2. Phase change material

Materials which are used to achieve latent heat storage is a PCM. It is a material that can liberate and store sufficient energy at phase transition to be used for heating and cooling. Abundantly in PCMs, the transition takes place between solid to liquid or vice-versa. It can be divided in four groups: Inorganic PCM's, Organic PCMs, and a mixture of organic and inorganic called Eutectic PCMs, and nanoparticle mixed PCM's is also used now days as shown in the Fig. 1, the essential properties and temperature reduction in PV modules achieved by the PCM's are given in the Table 1.

2.1. Methodology

It is seen during the review process, the PCM can be integrated with the building envelopes and PV technologies in different ways for regulating the PV and building surface temperature. Based on the literature available, the BIPV-PCM system can be classified as (i) Naturally or forced ventilated (ii) Non-ventilated

2.2. Ventilated BIPV-PCM systems

Lin et al. [9] reported the thermal performance of forced ventilated PVT-PCM system integrated with building envelopes. The placement of PV modules and PCM'S (RT18HC, SP21E, and SP24E) is at different envelopes, as shown in Fig. 2. Here both PCM's and PVT were used for maintaining thermal comfort in the room. It

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Energy Saving Opportunities in Buildings Using Cool Roofs for India: A Review

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Abstract. India is a tropical country with vast climatic zones varying from region to region, and from a fast few years, the rate of urbanization also increased. The requirement of thermal comfort in buildings is one of the primary needs in residential buildings in the present scenario. The roof is one of the most critical parts of the building envelopes, and maximum heat gain entered through it. This paper presents the systematic review of cool roofs and its energy-saving opportunities in Indian residential buildings for different climatic zones, identifying the present scenario of cool roof technology in India. The majority of the research work performed in India's composite climate, so more research work based on the cool roofs strategies need to be performed in other climates. The energy-saving achieved using cool roofs vary from 8.4 to 30.4%, and indoor temperature varied from 2.0 to 7.0^{0}C for different climatic zones of India.

INTRODUCTION

In the present scenario, about 50 % of the populations live in urban areas, and it would be increased by up to 70 % by 2040. Energy consumption in buildings is growing worldwide at an average rate of 40% because of the growing population and faster development of nations [1]. India ranked third for energy consumption in the buildings and in which about 56-60% of the energy consumed by air conditioning. High-energy use will also lead to environmental degradation and put the impact on climate change. The buildings in tropical and semitropical regions have high-energy consumption, especially for thermal comfort. Special attention is needed to reduce the cooling loads of buildings, so energy-conscious designs and techniques may decrease buildings' construction and operational cost [2]. Due to the improvement of comfort level and the extension of human activities, the per capita energy consumptions increased by 11.18% in the last ten years [3]. The building envelope components (windows, doors, walls, roofs, etc.) define the energy interchange between the outdoor and indoor environment and manage the building's overall energy performance. The accurate design of building envelopes plays a crucial role in building and improving energy efficiencies [4]. The roof is a primary component of the buildings. The maximum heat gain entered through it, and roof surface treatment with high solar reflectance and high emissivity paints is one technique to accomplish comfort conditions in buildings [5]. Cool roofs could reduce peak temperatures up to 3 0C during day time, and direct energy saving achieved between 20-70% using a cool roof of albedo greater than 0.70 [6]. The application of a cool roof could reduce about 54% cooling energy demand. It was also reported that cool roof is one of the most efficient surface treatment techniques than other cooling technologies. It retained the building, close to comfort conditions during the summer seasons [7]. It also reduced the heat gain and indoor air temperature between 11-60% and 1-7 0C, respectively [8]. Literature indicates that proposing an optimum combination of surface reflectivity and insulation of the roof may give the best results in energy saving for buildings. Cool roofs with adequate insulation used by some countries to meet their requirements especially in hot-dry climates [9].

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REVIEW ARTICLE

Review on the progress of building-applied/integrated photovoltaic system

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Abstract

Integration of photovoltaic (PV) technologies with building envelopes started in the early 1990 to meet the building energy demand and shave the peak electrical load. The PV technologies can be either attached or integrated with the envelopes termed as building-attached (BA)/building-integrated (BI) PV system. The BAPV/BIPV system applications are categorized under the building envelope roof and facades as PV-roof, PV-skin facade, PV-Trombe wall, PV claddings, and louvers. This review covers various factors that affect the design and performance of the BAPV/BIPV system applications. The factors identified are air gap, ventilation rate, a tilt angle of PV shading devices, adjacent shading, semitransparent PV (STPV) glazing design, cell coverage ratio (CCR), transmittance, window to wall ratio (WWR), and glazing orientation. Furthermore, the results of the possible factors are compared to building locations. This review article will be beneficial for researchers in designing the BAPV/BIPV system and provides future research possibilities.

Keywords Photovoltaic · Double-skin facades · Trombe wall · Glazings

Introduction

The energy demand in residential and commercial buildings was 2.25 Btoe in 2016 and is expected to be more than 3 Btoe by 2040 worldwide. This demand increases daily due to the overburdened population and extensive energy gadgets, such as heating, ventilation, and air conditioning (HVAC) (Global and Outlook 2018), which increases the rising price trends of conventional energy generation and may create price affordability problems, especially in developing countries (Timmons et al. 2020). Further, emissions from these primary energy sources will degrade the environment, causing natural climate change, which is also a severe issue. Photovoltaic integrated building envelopes technology can play a significant role in mitigating these energy and environmental issues. The integration of PV with the building envelopes has started in the early 1990s to fulfill the building electrical demand and shortage inland availability (Hagemann 1996; Clarke et al. 1996). The potential of PV-integrated technologies for European countries is about 840 TWh, fulfilling 22% of energy demand alone (Defaix et al. 2012). However, the market growth rate of these technologies in the Asia/Pacific region is 10% higher than in European countries for the year 2014–2020, playing an essential role in developing countries (Tabakovic et al. 2017). The technologies performed well in higher solar irradiance areas (Singh et al. 2020). Further, with the predicted increase in efficiency of about 22% for PV wafer–based and 17% for thin-film technologies by 2030 (Defaix et al. 2012), the BIPV/BAPV technologies will be gaining more attention in upcoming years. In recent years, the review on the topic by the authors is discussed. In a review, Jelle et al. (2012) initially categorize BIPV products in PV foils, tiles, and modules and identified the PV foil as the first commercial BIPV product.

Further, they discussed the electrical parameters of different BIPV products. The authors also hint at the evolution of organic and dye-synthesized solar cell (DSSC) technologies in BIPV applications. Shukla et al. (2018) discussed the BIPV-based buildings in Asian countries, concluding that factors like ambient temperature, direction, and the slope of the PV

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