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Matching Suitability of Solar-Biomass Hybrid Absorption Cooling System for Ecological Restaurants in Different Regions

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Abstract

With the fast-paced urbanization and the development of sightseeing agriculture in China, the issues of energy shortage and worsening environment gradually began looming large. Solar-biomass energy hybrid absorption cooling system was designed for saving the energy and protecting the environment which could be widely used in the areas of the remote rural living, ecological agriculture, etc. In this paper, the suitability of the hybrid energy system of 6 cities from China, India and America had been tested. The heating source suitability study was based on TRNSYS whose data was collected from an ecological restaurant. According to the distributions of the solar energy resources, the optimal solar fractions of different cities ranged 17%~32%. It could be concluded that different cities have their respective mode due to the energy distribution and weather parameters. It indicated that solar-biomass hybrid operating mode (Mode B,C) has been widely used in these cities. In addition, the prediction model was used to analyze the calorific values of biomass fuel and get the daily self-sufficiency rate in different cities. The results of the study provided a reference for the performance of solar-biomass hybrid absorption cooling system applied to different cities. The energy consumption utilization rate and a daily energy plan would be improved.

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Keywords: Solar-biomass air-conditioning;single-effect absorption chiller;biomass calorific value prediction; suitability; ecological restaurants;

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1. Introduction

The sightseeing agriculture has become more prevalent among Chinese people with the fast-paced urbanization. In order to meet their needs and promote the rural economic development, tourism in some rural areas have developed rapidly and provided a good traveling place for leisure. However, these are shortage of electricity supply and unstable network in these places. On one hand, the compression refrigeration can not only increase the tension electricity, but also lead to some harmful effects on air conditioning; on the other hand, these are plenty of solar energy and biomass energy, especially for biomass such as straw, branches, leaves in these areas. However, they were not fully used but had often been abandoned as a garbage dump instead or burned directly causing great pollution to the environment. It's significant for the sustainable development of the rural tourism.

Solar-biomass hybrid absorption cooling system is characterized by the complementary energy, low pollution and regional energy system which can be widely used for supplying the power of tourism, especially in remote rural areas. The suitability of solar-biomass hybrid absorption cooling system has been given more attention by the domestic and overseas scholars recently. Ming[1] used TRNSYS to prove the auxiliary heating source could increase the solar fraction and also proposed the auxiliary heating source could promote solar fraction of 30.4% for supplying 120℃hot water to the absorption cooling unit. Boonrit[2,3] indicated that solar-biomass hybrid air conditioning for tropical locations and residential applications was feasible. The biomass-gasifier boiler system was used as an auxiliary heater which could improve the overall system performance. Although Balghouthi[4] researched the solar powered air conditioning from the aspect of low environmental pollution in Tunisia, no detail was described about the type and energy consumption of the auxiliary heat source. Liu[5] studied that the operating conditions and parallel hybrid heat sources were simulated by using MATLAB and obtaining the optimal mode of the hybrid heat source under multi-operating mode. However, the energy consumption and the role of controller were not discussed in their studies.

However, it is more reasonable for them to take the suitability of the system into consideration in solar-biomass hybrid absorption cooling system for its functionality in different regions. In the thesis, the suitability of solar-biomass driven cooling system in ecological restaurant was analyzed for the purpose of exploring the method. Besides, regional characteristics were also discussed. Different suitability of hybrid energy system was based on TRNSYS in 6 different cities which were taken as examples from all over the world. There were three aspects of issues to be addressed. The first one was involved in different matching modes of the solar-biomass system. The second one was related to the thermal indicators. The last one dealt with the energy consumption and regional adaptability.

2. Method

2.1. Solar-biomass hybrid thermal cycle heating operation mode

In this paper, fuzzy sets about the method of suitability of solar-biomass hybrid heating source system were first briefly introduced. Generally, it was well-known that collectors and biomass stove in this system were significant components and tools for energy delivery[6,7]. However, it could be discovered that the hot storage was a potential method for supplying energy and equally significant. If the storage tank missed its correct position, it would lead to substantial energy loss during the two important components operating at high temperatures. And the calculating data was collected from an instance of an ecological restaurant chosen to analyze the heating source suitability in this paper. Furthermore, the different methods were carried out and the positions of the three components including the biomass heating source, solar flat collectors and the storage tank in this thermal system were discussed respectively. The method suitable for different buildings with kinds of functionaries in different regions by TRNSYS would be expected to be obtained.

A.Solar thermal cycle from biomass auxiliary heating-separated operation mode

(1)Mode A: Solar thermal cycle was separated with biomass and biomass heating source situated after the storage tank. The hot water was heated from the storage tank. The operation mode is as follows.

Solar energy → storage tank→ biomass auxiliary heating→ absorption chiller.

(2)Mode B: Solar thermal cycle was separated with biomass and biomass heating as the auxiliary heating source in