Renewable Energy Technologies in Households

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Energy sources used in households could be divided into the following two main groups: fossil fuels, which include natural gas, oil and coal, and renewable energy technologies, which include both conventional biomass and modern sources such as solar, wind and geothermal energy. Solar photovoltaic (PV) and solar thermal, micro wind, heat pumps and small-scale biomass heating technologies can be distinguished as the main renewable energy technologies in households.

Solar photovoltaic and solar thermal technology | Micro wind technology | Heat pumps technology | Small-scale biomass heating technology

1. Introduction

From a household perspective, the use of renewable energy technologies offers a considerable number of benefits, i.e., it improves living conditions by using energy more productively, contributes to sustainable spatial planning and architecture, helps to protect the quality of the environment, and distributes energy in a balanced way and thus gives financial autonomy [1][2][3][4]. Solar photovoltaic (PV) and solar thermal, micro wind, heat pumps, and small-scale biomass heating technologies can be distinguished as the main renewable energy technologies in households [5].

2. Solar Photovoltaic (PV) and Solar Thermal Technology

Solar power could meet the total annual global energy demand, with an average of 1.6 MWh/m^2 of solar power per year [6], yet the annual solar radiation varies widely across the world. Solar power can be used to produce heat and electricity. Solar radiation is converted into thermal energy in solar collectors, and electricity is obtained directly from sunlight using photovoltaic cells. Thermal energy can be used for both water heating and indoor heating. Solar power plants operate autonomously or when connected to the grid. In the first case, the electricity produced is stored in accumulators, which ensure the supply of electricity in the event of demand. There is no need for a battery if the electrical equipment is connected to the power grid, and the electricity produced can be used for one's own consumption and the unused electricity can be supplied to the grid. Solar power is inexhaustible, abundant, and technological achievements in photovoltaics (PV) in the last decade have significantly increased the efficiency of solar energy production [7] and reduced installation costs [6]. In both solar PV and solar thermal technology, solar collectors in households are usually mounted on the rooftops or in other convenient locations to collect as much

sunlight as possible. By absorbing solar energy, the solar thermal system can heat or cool the water. Solar thermal systems differ from solar PV technology as they do not generate electricity.

3. Micro Wind Technology

Wind power is based on mature technologies and political incentives in many parts of the world. Increased efficiency and capacity of batteries increase the use of this type of energy [7][8]. Micro wind technology involves a much smaller device than is conventionally used for wind power generation, making it suitable for the production of energy for households. The following two types of wind turbines can be installed: vertical-axis or horizontal-axis wind turbines. The majority of households install wind turbines on the rooftop or a pole to produce wind power, and the efficiency of the technology depends on the size of the turbine and the windiness at that time of year in that area. This technology converts wind into electricity, which could be used for both indoor heating and water heating. Electricity generation is largely based on the rotation speed of the wind turbine; therefore, some geographical areas are more (or less) suitable for electricity generation than others. Wind turbines may also be affected by potential obstructions that are nearby to the wind turbines, such as trees or buildings, which stop or deflect the wind and prevent the turbines from operating at full capacity. In contrast to solar power, this technology emits noise (depending on the make and size of the turbine itself); therefore, if the turbine is on the rooftop of the house, it may be one of the drawbacks for some households.

4. Heat Pumps Technology

A heat pump is a device that can supply heating, cooling, and hot water for residential, commercial, and industrial use. Any heat pump equipment can provide heating and cooling at the same time. Depending on the function a device performs, it is called a heat pump, an air-conditioning unit, or a cooling/refrigeration machine [9]. Most of the energy produced is obtained from the environment: heat pumps can use renewable energy from the air, water, or ground. Air source heat pumps use outdoor, indoor, or exhaust air as a source of energy. Ground source (or geothermal) heat pumps use energy from the ground that is generated through a closed-loop horizontal or vertical collector. The energy obtained from the ground is transferred to brine or water and transferred to a heat pump. Water source heat pumps work the same way as ground source (or geothermal) heat pumps. The only difference is that they use the water directly instead of using a closed-loop heat exchanger. Water heat pumps can be connected to rivers, lakes, sewage, cooling water, etc. [10]. There may also be a hybrid heat pump system. Typical combinations are as follows: air source heat pumps and a small gas boiler, heat pump and solar thermal collector [11], heat pump and biomass boiler, and heat pump and direct electric back up. The efficiency of heat pump systems depends on the efficiency of the unit itself and the thermal energy needs of the building in which it is used. Specifically, in the case of a private household, the energy demand of a building largely depends on its energy quality and the climatic zone in which it is located [12].

5. Small-Scale Biomass Heating Technology (Biomass Boilers and Pellet Stoves)

Small-scale biomass heating systems are usually installed in private households. Wood and by-products of the wood industry are the raw materials used for heat production with this technology. Firewood, wood chips, and wood pellets are most commonly used to heat a private household. Firewood is the oldest and most commonly used form of biomass. The popularity of wood chips has been growing rapidly lately due to the possibility of using them in automatic biomass heating systems. Choosing such a system offers more advantages for people who want to save time and seek comfort compared with traditional wood, i.e., firewood. Wood chips are made from wood waste, other wood products, or are directly made from logs. Wood pellets are the most convenient and sustainable choice compared to the aforementioned alternatives. This fuel is made from sawdust and wood chips and pressed under high pressure without glue or other chemical additives. Wood pellets are high in energy, easy to transport and store, and are suitable fuel for small, fully automated heating systems. The newest biomass boilers are distinguished for their efficiency and low carbon monoxide (CO) emissions. The efficiency of new biomass boilers increased from about 55% to more than 90%, while the average CO emissions decreased from 15,000 mg/m^3 to less than 50 mg/m^3 [13].

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