Renewable and Sustainable Energy Reviews 57 (2016) 776–785

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Solar power and application methods

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ARTICLE INFO

Article history:
Received 28 September 2015
Received in revised form
14 December 2015
Accepted 15 December 2015

Keywords:
Energy
Renewable
Solar power
Application methods

ABSTRACT

Solar energy conversion and its application methods varies in wide range from passive solar to heat building to complex concentrated form to generate electricity. It is crucial to know these structures in detail and to classify them in methodical order. The constituent mechanism of primary energy sources have been briefly mentioned. Hereafter the classification of renewable energies, various application methods of solar power, the amount of solar energy falling on the earth, the main effects created by solar energy, and energy conversion methods, inclusively concentrated solar power, have been discussed.

Contents

1. Introduction

The rapid increase in the world population and evolving consumer habits can be enumerated among the main reasons of increasing energy requirement and electricity consumption nowadays. The boost in the use of clean and renewable energy sources, generating electricity from renewable, and improving energy efficiency are gaining importance because of the rapid decline of fossil fuels and their negative effects on the environment. They are among strived topics for investigations today [1,2]. The sun's contribution to our energy needs is substantial. Its availability far exceeds any conceivable future energy demands [3]. Exploiting the sun's power includes some challenges [4]. Harnessing these for electricity depends on the cost and efficiency of the technology which is constantly improving and reducing costs per peak kilowatt. Utilizing electricity from solar in a grid requires

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http://dx.doi.org/10.1016/j.rser.2015.12.055
1364-0321/

some back-up generating capacity due to their intermittent nature [5].

The sun creates its energy through a thermonuclear process that converts about 650,000,000 t of hydrogen to helium every second. The process creates heat and electromagnetic radiation. The heat remains in the sun and is instrumental in maintaining the thermonuclear reaction. The electromagnetic radiation (including visible light, infra-red light, and ultra-violet radiation) streams out into space in all directions. Only a very small fraction of the total radiation of the sun produced reaches the Earth. The radiation that does reach the Earth is the indirect source of nearly every type of energy used today [6].

Energy is the power and ability to be physically and mentally active [7]. There are five ultimate primary sources of useful energy.

- Solar (radiant) energy.
- The motion and gravitational potential of the Sun, Moon, and Earth.
- Chemical energy (combustion process) from mineral resources.
- Geothermal energy from cooling, chemical reaction and radioactive decay in the Earth.
- Human-induced nuclear reactions [8].

Solar radiation is the main factor for several natural motions (wind, wave, heat, light, etc.) [9]. The effective and competitive conversion of these motions into electricity, which is the most useful form and can be easily turned to the other forms of energy, is an intensively researched subject. The energy in sunlight is introduced into the biosphere by a process known as photosynthesis, which occurs in plants, algae and some types of bacteria [10]. Temperature differences occurring due to dissimilar heat absorbing properties of various materials between areas, producing wind, which can drive wind turbines. Water evaporates because of the sun shine heat effect, raises on high elevations, and as rain falls to earth, which is routable for spinning hydroelectric turbines. Moreover, the sun shine energy can be used to directly generate heat, lighting, and electricity. Chemical energy is stored in the structures of compounds and released when their structures are changed. Thermal energy increases the motion of atoms and molecules, thus it provides the mechanism of heat transfer and phase changes (heating water in order to produce steam). There are many different classifications of energy resources. For the beginning phase, it seems plausible to make a topic-related classification of energy sources from the viewpoint of sustainability, such as exhaustible (depletable), and renewable (non-depletable). Renewability or non-renewability of a solar driven process is distinguished based on the energy storage or cycling time involved. Renewable resources have a cycling time less than 100 years, while for non-renewable resources; it is greater than a million years [11].

2. Classification of renewable and solar energy

Natural renewable resources may be divided into two types. The first category comprises of renewable resources, such as fish and forests. The second category is the renewable resources which depend on sunshine directly such as water [potential (water vapor density is smaller (lighter) than atmospheric air-buoyancy force), kinetic (marine current)], wind, or the motion and gravitational potential of the Sun, Moon, and Earth such as tide. Moreover, both the categories may be divided as critical and non-critical zone resources [9].

Renewable energy may be divided into categories such as wind power, solar energy, geothermal energy, ocean energy, hydropower, and biomass-waste energy [12]. Sunshine flux can be used thermally (for heat engine or process heating), photo chemically (photovoltaic), and photo physically (photosynthesis) [13]. The renewable solar energy is subdivided into direct and indirect types [9,13]. Most energy sources on Earth are forms of indirect solar energy [13]. On the directly used systems, the solar energy can be captured to generate electricity or heat through a system of panels or mirrors. Photovoltaic cells convert sunlight directly into electricity. Solar thermal collectors use heat-absorbing panels and a series of attached circulation tubes to heat water or buildings. Solar concentration systems use mirrors (parabolic troughs, a large round dish, or Fresnel lenses) to focus the sun's reflected rays on a heat collecting element [14]. The concentrated sunlight heats water or a heat transferring fluid such as molten salt to generate steam, which is then used conventionally to spin turbines and generate electricity. Manipulating the solar energy to our demands, without changing them to electrical power is known as passive methods. It is possible to effectively harness natural solar radiation by proper using windows, skylights, and sunrooms, building site and orientation, and thermal construction materials [15]. A well-designed passive solar home first reduces heating and cooling loads through energy-efficiency strategies and then meets those reduced loads in whole or part with solar energy [16].

3. Solar radiation on the Earth surface, and the conversion methods of solar energy

Solar radiation reaches the Earth's surface at a maximum flux density of about 1.0 kW/m^2 in a wavelength band between 0.3 and 2.5 μm. This is short wave radiation in visible spectrum. For inhabitant areas, this flux varies from about 3 to 30 MJ/m^{2}day, depending on place, time and weather conditions [17]. Designing a system for solar energy conversion into thermal energy or electricity is based on accurate assessment of the solar radiation in the given location and on the knowledge of solar radiation properties. Average distance between The Sun and the Earth is 1.5×10^{11} m. The solar core, with a radius of about 0.23 R is a thermonuclear fusion reactor. Its temperature is estimated at $(8–40) \times 10^6$ K. At a distance of 0.7 R from the Sun core, the temperature falls to 130,000 K. The area between 0.7 and 1.0 R is called the convection zone. The temperature falls to 5000 K at the surface [18].

The Sun is the main source of energy that defines the climate on the Earth. Theoretical potential of solar energy is estimated 89,000 TW. Every square meter of the outer covering of the atmosphere receives 342 W, of which 31% or 106 W is immediately reflected into the space by the clouds, the atmosphere and the land surface. The rest, i.e. 236 W/m^2, is absorbed by the land, ocean surface water and partially by the atmosphere, warming them [18].

Three conversion processes are normally associated with the sunshine.

- Heliochemical, which is principally the photosynthesis process.
- Helioelectrical, which is commonly exploited in solar cells (photovoltaic).
- Heliothermal, which is a conversion of sunlight into thermal heat as employed within concentrating solar power (CSP) plants [19].

All routes for utilizing solar energy exploit the functional steps of capture, conversion, and storage [20]. Solar energy can be converted generally in two ways commercial purposes:

- By using the photovoltaic effect (directly convert solar energy into electricity).
- By thermal conversion (hot water production, drying of agricultural products, and residential space heating, or electricity